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"LET KNOWLEDGE GROW FROM MORE TO MORE
AND THUS BE HUMAN LIFE ENRICHED."

A New Survey of Universal Knowledge

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Volume 22

TEXTILE TO VASCULAR SYSTEM

1768

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TEXTILE TO VASCULAR SYSTEM

TEXTILE PRINTING, the process by which a decorative pattern is applied to a woven or knitted fabric in at least one colour different from the body of the fabric itself. This mode of decoration differs from the formation of a pattern by weaving and knitting processes that employ threads that are already coloured or have different capacities for taking up dyes. The four main methods of textile printing are block printing, copperplate printing, roller printing and screen printing.

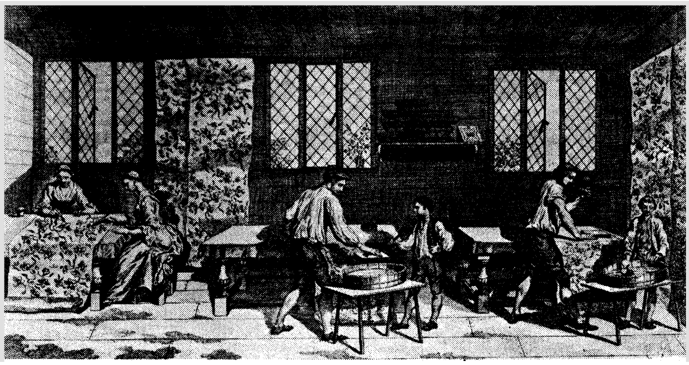
EARLY METHODS

Block Printing. — The origin of block printing on textiles is somewhat obscure but it is clear that the printing of textiles by means of blocks was developed from free-hand painting with a brush. Wooden blocks believed to have been used for textile printing have been found in burying grounds at Akhmim, upper Egypt, and are said to date from the 4th century A.D. No textiles printed by means of these blocks have, however, been found. In Europe block printing of fabrics does not appear'to have begun much before the end of the 12th century A.D.; the chief centre appears to have been the Rhineland of Germany.

In blocks used for printing, the spaces between the lines or devices forming the pattern were cut away, leaving the design standing in relief, as in letterpress printing. The colour was then applied to the surface of the block and the coloured block pressed down on the cloth. An interesting description of early block printing on textiles is given in *The Book of the Arts or Treatise on Painting* by Cennino Cennini. a document that dates from the end of the 14th century. According to Cennini, the thickened colour was applied to the block by means of a glove, probably made of leather. The pigments were mixed with starch, gum (tragacanth) or a mixture of these, or even with varnish, so that the colour was in a viscous state and did not run from the raised portions of the block. Cennini describes how the outlines of the patterns were printed by block and additional colours added by means of a brush. Later the colour was applied by a pad, either directly or by pressing the block down on a pad impregnated with colour. Wax resists were also printed by metal or wood blocks for indigo-resist dyeing. This method was used in Egypt in the 9th–10th century A.D. and in Germany in the 17th century. Apart from these indigo-resist dyed textiles. until the end of the 17th century all European block-printed textiles were printed with surface pigments or oil stains that were fugitive (not fast to washing). About 1676, however, more or less simultaneously in England. Holland and France, the European textile printers mastered the secrets of the complex problems of mordant dyeing with madder — the basis of the fast-dyed, hand-painted Indian chintzes that had begun to be imported into Europe during the early 17th century. Thereafter, most European block-printed textiles were produced in what was known as the "madder style."

One of the clearest expositions of block printing in the "madder style" is given in the supplement to John Barrow's *New and Universal Dictionary of Arts and Sciences* (1754). The cotton or linen was printed with chemical substances known as mordants, which on immersion in the vat reacted with the soluble dye to precipitate an insoluble colouring on the cloth fibres so that the colour remained permanently fixed in the mordant-printed areas while the dye taken up by the unmordanted parts could be easily removed by washing. In madder dyeing different mordants can produce various shades of reds, pinks. purples and browns from a single immersion in the dye. The different mordants were printed one by one; the printer moved along the whole length of the cloth printing the first mordant from one wood block, then the second mordant from another block, and so on, until the whole pattern was completed. The mordant-printed cloth was then immersed in the dye. The reds, browns and purples were produced by printing varying strengths of alum and iron mordants, followed by immersion in the madder dye. Yellows and drabs (light brownish colours) uere produced by the printing of similar mordants followed by dyeing with weld, also known as dyer's weed. Blue was produced by "penciling-in" indigo with a brush. This operation was usually carried out by women or girls. All greens were produced by the penciling-in of indigo over yellow. To save expense, the yellows were often blocked or painted in to avoid an additional dyeing but with this method the yellow dye was fugitive and in many extant 18th-century textiles the yellow has almost entirely disappeared.

The standard method of printing madder mordants by wood block involved the use of a "tub" and a "sieve." In England the tub consisted of a sawed-off barrel but on the European continent



FROM J. BARROW'S "SUPPLEMENT TO THE NEW AND UNIVERSAL DICTIONARY OF ARTS AND SCIENCES,' LONDON. 1754, PHOTOGRAPH BY COURTESY OF VICTORIA AND ALBERT MUSEUM

FIG. 1.—CALICO BLOCK PRINTING. 18TH CENTURY

a specially constructed square tub was more usual. The tub was filled with a viscous paste, called the "swimmings," made from discarded colour and gum; the paste provided a sort of elastic cushion on which rested the sieve, a wooden drum only fractionally smaller than the tub The bottom of the sieve was a sheepskin the upper surface a tightly stretched fine woolen cloth An assistant. known as "tireur" or "tearer," kept the upper surface of the sieve constantly and evenly supplied with the thickened mordant, which was spread on with a large brush. When the printer pressed his block on the sieve. the swimmings in the tub provided just enough "give" to ensure a satisfactory colouring-up of the block The cloth to be printed was supported on a stone concrete or iron structure covered with a thick blanket; this arrangement provided a firm but resilient surface so that the raised surface of the block contacted the cloth with uniform pressure over the whole area Between the blanket and the cloth was a layer of unbleached calico (the back gray) that absorbed the mordant forced through the cloth When the block was placed on the cloth the printer pave it one or two sharp blows with his mallet or maul to impress the mordant firmly into the cloth Pins known as pitch pins were inserted into each corner of the block as a guide to the printer in matching the repeats. The blocks were generally made of layers of strong durable woods, such as pear wood. arranged so that the grain in each layer ran at right angles to that in the layers above and below: this arrangement prevented warping during the successive wetting and drying. For fine details. such as thin stems and the outlines of flowers or leaves, strips of metal or metal pins were inserted into the wood blocks. Elaborate "pin grounds," also called "picoté" or "sable" grounds, were achieved by inserting metal pins into the block.

A method of mechanical block printing was invented in 1834 by a French mechanic called M. Perrot. This machine, known as the perrotine after its inventor, employed ordinary wood blocks and was widely used in the 19th century. particularly in France, for printing up to four colours. Each block of the design is impressed simultaneously in the cloth at a distance of two repeats apart. The cloth is stepped through the machine, one repeat at a time, to emerge with the full numbers of colours printed upon it. Although the original machine needed five men to tend it, one machine could print as much cloth as 24 printers and 24 assistants using hand methods. By 1836 about 60 perrotines were in operation in Europe; and even in the early 1960s when, in spite of the expense of the process, block printing continued to be used for certain classes of goods. the perrotine was not quite obsolete.

Copperplate Printing.— Copperplate printing on textiles was invented by Francis Nixon at the Drumcondra printworks near Dublin in 1752. Although prior to 1752 maps and embroidery designs had been printed from engraved copperplates with ordinary printer's inks, it was not until Nixon's invention that it was possible to print textile designs in fast colours by printing the cloth with thickened mordants. The designs were printed from a single engraved copperplate. usually with a repeat of about three feet square. in red. purple or sepia. using the madder dye; or in blue, using indigo. by a method known in England and the United States as "china-blue" and on the continent of Europe as "bleu d'Angleterre." This method inv ved p inting th indigo on th cloth in an undissolved stat and arranging f it simultaneous reduction and solution on th cloth after p t This was done by im- g the printed cloth in a bath of lime (to dissolve the indigo) and a bath f ferrous sulfate (t reduce it) as many times as was necessary t achieve t desired strength of blue.

Copperplate printing was eminently suited for the production f large torial designs and a fineness of detail and li acy f drawing not possib with the c ar tively coarse technique of wood-block cutting. It was also d for floral , both for furnishing an ess, ar for the printing of handkerchiefs.

The textile printer's copperplate press was little different f t he y, flat-bed, rolling press used for the ti g of engravings on paper. The plate was first inked up with the th ke d mordant and then was passed through the rollers in contact with the cloth being printed. Various improvements. however. were introduced by the textile printers to make the press more suitable for their purposes. An important innovation was the "D" roller, patented by Robert Kirkwood of Edinburgh in 1803. which overcame the difficulty of getting the plate through the rollers to its original position without winding the cloth back at the same time. Kirkwood's invention consisted of substituting for the lower roller a special roller shaved flat on one side (hence the name "D"). On the forward passage of the plate. the round part of the roller squeezed the plate up against the cloth for printing in the normal way; but on the reverse passage the roller rested with its flattened surface uppermost, thus allowing the plate to go through without touching the cloth.

With the introduction of roller printing copperplate printing began to die out. although it continued in use, particularly for the production of printed handkerchiefs. well into the 19th century.

Roller Printing.— The first commercially successful patent for a roller-printing machine was taken out in 1783 by Thomas Bell, a Scotsman. So fundamental was Bell's invention that the principle of his machine has been retained throughout the numerous improvements and refinements introduced since that date Before 1783 several attempts had been made to replace hand printing by mechanical means but none of them had been commercially successful. As early as 1743 W. Keen and M Platt had taken out a patent for a three-colour roller-printing machine but it does not appear to have been developed. In France a textile printer named J. A. Bonvallet introduced a primitive type of roller-printing machine at his factory in Amiens about 1775. It consisted of two rollers; the upper one was made of wood, the lower one of hollow iron covered with a copper mantle on which the pattern was engraved. The lower roller was filled with red-hot iron or burning coals and revolved in a dye bath. The cloth was passed over the upper, wooden roller and the lower roller pressed up against it by means of weights, levers and a cog wheel. The machine was operated by hand. Bell's original specification (patent no. 1378, 1783) describes his invention as "a new and peculiar art or method of printing with one colour or various colours at the same time, on linnens, lawns, and cambricks, cottons, callicoes, and muslin, woollen cloth, silks, silk and stuffs, and any other species or kind of linnen cloth or manufactured goods whatever."

A second patent taken out by Bell (no. 1443. 1783) contains a similar specification for printing "one, two, three, four or five, or more colours," and by the following year he was able to put the machine into practical operation with the firm of Livesey, Hargreaves and Co near Preston, Lancashire. Strangely enough, however. the indiscriminate use of the new machines contributed to the collapse of the firm in 1788. Bell's machine for rotary printing from engraved metal rollers was fitted with a "doctor," or steel blade, designed to remove the surface colour from the printing rollers while allowing the recessed, engraved parts to retain enough colour to print a continuous length of fabric. The machine was said to be capable of doing the work of about 40 hand printers. Although the machine was theoretically capable of printing five or six colours at a time, mechanical and chemical difficulties that existed as late as 1840 made it difficult to print more than two or three colours simultaneously. At first the new roller-printing machines were used mainly for small-scale dress prints, and it was not until the early 19th century that large-scale furnishing patterns were produced by machine. Many of the furnishing fabrics of the 1820s were produced from a single, stipple-engraved metal roller, with additional colours being printed by wood blocks or surface rollers. With James Burton's and Adam Parkinson's union-machine (1805) it was possible to print simultaneously with engraved metal and wood surface rollers. (See also TEXTILES: Printed Textiles.) (B. J. Mo.)

MODERN INDUSTRIAL PROCESSES

General. — Textile printing on an industrial scale consists of two fundamental operations: (1) the impression, *i.e.*, the mechanical and physical stages in which the colouring matters are distributed on the cloth; and (2) the coloration, *i.e.*, the choice of the appropriate colouring matters (dyes, dye-generating chemicals, pigments and the necessary auxiliary chemicals), the conditions for their application, their preparation in suitable forms for presentation to the cloth and their fixation against removal during use and wear.

Textile printing in some of its aspects differs greatly from the corresponding methods for printing on paper and other materials, although the mechanical methods for bringing the colour to the surface may be similar. Inks and paints used for printing on paper usually contain colouring matter in the form of pigments (*i.e.*, finely divided solid powders insoluble in the medium by which they are applied) ; such pigments are attached by adhesive media to the surface to be coloured; they cannot penetrate between the molecules of the fibres. In much textile printing, however. the various coloured areas that make up the print are, in fact, dyed. The dye is dissolved, usually in water alone or in aqueous solutions containing other reagents, and the molecules thus separated can be induced to enter between the molecules of the fibre in a much more intimate association. In general, a textile print in which the coloured areas are dyed in this way may be found to be faster to washing and similar treatments than a print resulting from the use of pigment in an adhesive. The presence of adhesive may also tend to stiffen the fabric. Improvements in adhesives, though, have made it possible to obtain reasonable fastness and softness and to obtain prints of great brilliance.

Cloth. either woven or knitted, may first be singed to burn off surface fibres, desized to remove weaving sizes. scoured to take away natural impurities and the soils of manufacture, bleached to destroy residual colouring matters, impregnated with solutions of dyes or other necessary chemicals by padding, dried and. occasionally, given extra smoothness by passage through a calender. Drying may be brought about by passing the cloth over steam-heated cylinders or by running it through a stenter. The latter operation fixes the width, ensures that warp and weft are at the correct angle and renders the selvedges straight and parallel. The cloth is wound under even tension on wooden shells to give cylindrical batches.

The pattern is impressed by hand blocks, stencils, silk screens or engraved or relief rollers. Drying is done in a hot flue or by steam-heated plates or cylinders. The cloth is then passed through a chamber (steamer, ager or flash ager) filled with steam. During the passage a limited amount oi water condenses on the print, the dye is redissolved without being spread and the fibre swells The dye molecules are thus enabled to penetrate into the fibre substance so that they can become fixed there. The high temperature of the steam also initiates or speeds up reactions by which some dyes are turned into soluble forms, are actually produced in situ from intermediates or are fixed more firmly within the fibre. Steaming for short periods is called aging or, for very short periods, flash aging. Volatile acids can be introduced into the steam (acid steaming or acid aging) if this is required. Dyes that are themselves volatile can be fixed in man-made fibres—Terylene (Dacron), Orlon, etc.—by dry heat. The adhesive medium in some pigment printing is also set by dry heat. (See also COTTON MANUFACTURE: Converting of Cotton Goods.)

Before and after (and sometimes instead of) steaming. the printed cloth may be passed through certain solutions. *e.g.*, of chromates, to fix the dye. Unfixed colour may be removed by washing or soaping. This minimizes the tendency to bleed off on other cloth during wet treatments and to rub off when dry.

Impression.—This is the essential part of the printing operation. With several exceptions, dyes, dye-generating substances and auxiliary chemicals are dissolved or suspended in water. When applied to a fixed area of a microporous structure like cloth the solutions would spread by capillary attraction (flush) beyond the boundaries of the pattern and so give prints of unsatisfactory definition. The viscosity of the solutions is therefore increased by the addition of thickening agents. These are usually substances of high molecular weight that yield colloid dispersions in water. They include the natural starches, starches that have been altered by regulated depolymerization (for example, by the action of heat or acids to furnish dextrins), chemical derivatives of starch and cellulose, and natural vegetable gums such as gum tragacanth and gum arabic. locust-bean gum, etc. There are other vegetable mucilages, such as sodium alginate (sodium polymannuronate) from seaweed, as well as egg and blood albumin and various synthetic resin products. A more recently developed form of viscous medium is a stabilized emulsion between water and another non-miscible liquid (emulsion thickener). It is possible sometimes to use colloid aqueous dispersions of the mineral bentonite.

The thickening agent for a given printing paste is chosen for its specific thickening power, its compatibility with the dyes to be used, its freedom from interference by the other chemicals that have to be added, its stability and its general flow properties. The flow property of the entire paste is adjusted to the printing method, the shapes of the impressions to be made, the intensity of colour required, the weight and structure of the cloth, the fixation methods to be employed, and the severity of treatment that can be allowed in order to remove the exhausted paste from the print after the dyes on it have been fixed. Many dispersions of thickening agents are thixotropic; *i.e.*, they become more fluid when they are subjected to the stresses that they receive in the printing operation. and this property has an important bearing upon the quality of the impression.

Block Printing. — This, the oldest method of textile printing, is also discussed above under Early Methods. The blocks normally consist of wood with the design carved to stand above the block surface. Alternatively, or in conjunction with these projections (pegs), fine details such as different shaped dots are provided by short lengths of copper wire (pins) of various cross section partly driven into the wood. Lines are provided by shaped copper strip (fillet) driven edgewise into the wood. Large areas of uniform colour known as blotches are produced by filling in an enclosed area with wool felt, which thus gives an extended printing surface. Areas corresponding in size to those produced respectively by pins, pegs or blotches in block printing are given the same name in screen or roller printing. Where the form of the design is suitable, where prolonged use of the block is anticipated or where a number of block sets of the same design are required, the relief printing surface may be cast in type metal. In most cases every distinct colour must be applied as a separate paste from a separate block. Further. since blocks have to be handled during the printing operation, those that are too heavy to be lifted easily are inconvenient; if the repeat of the pattern is large, more than one block may be needed for a single colour, and to print big, detailed and florid patterns the number of separate blocks may exceed 100. Block prints are thus laborious and expensive to produce but they are prized for their full, deep colourings and for the deviation from the exact design, which shows them to be "handmade." Since printing costs per yard are high, expensive cloths (*e.g.*, heavy linens for upholstery and pure silks for dress goods) are generally chosen for block printing. Designs tend to be traditional and may be "kept on the table" for many years.

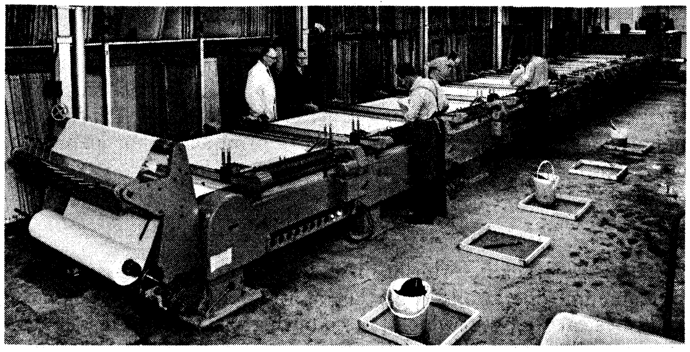
The perrotine is still used occasionally while in some firms the surface, or peg. printing machine, the forerunner of the roller printing machine (see below), is in continuous use. In this machine the circumference of one roller carries an exact number of the repeats of the pattern: a second roller guides the blanket. the back gray (back cloth) and the cloth itself and acts as the printing surface. The pegs of the patterned roller run in contact with the printing roller and are furnished by touching, at another part of the periphery, an endless band spread with paste. As with all cylinder machines, printing is continuous but the length of the repeat that can be printed is limited since the diameter of the printing cylinders cannot be increased indefinitely.

Stencil and Screen Printing.—The stencil printing method uses stencils made from paper impregnated with wax or from thin sheets of ductile metal. The method has been known for centuries but in modern times it has been employed only to a limited extent; some stencil printing is carried out with lacquers on nets and gauzes to give beadlike effects. The stencil may be cut from zinc foil and mounted on a frame that is laid over the fabric; the colour medium is applied through the stencil with air-spray, brush or squeegee.

Silk screen printing (*q.v.*) is the most commonly used form of what is essentially stencil printing. Fine, open-mesh gauges woven from yarns made of silk or nylon, or from fine bronze wires, are stretched with even tension upon rectangular frames of wood or light metal. The printing areas on the gauze are left open, the rest being blocked up with a lacquer. The design can be hand-painted on the screen directly with lacquer but this procedure is slow, especially for large areas, and a photographic method usually is used. The repeat is drawn in black and white on transparent film and this serves as a negative from which a number of positives are made by the ordinary procedures of exposure and development. The positives are pieced together to make up the printing area desired in the final screen, and from the composite a full negative is made on photographic film. The screen itself is coated with a solution of gelatin to which a soluble dichromate (bichromate) has been added and is dried in the dark. It is then exposed to light behind the composite negative, and the part of the gelatin that is exposed to light becomes insoluble in water. When the negative is removed the gelatin on the unexposed areas is washed away with warm water and the deposits are reinforced by coating them with a layer of lacquer. When the lacquer is dry, the screen is ready for use. As in the other printing methods, one screen is prepared for each colour in the pattern.

Screen printing by hand is carried out on tables wide and long enough to accommodate the cloth to be treated. The tables are covered with a resilient blanket on top of which is a smooth impervious fabric. A length of the cloth is rolled off to occupy the full length of the table and is fixed to the impervious cover with starch paste or other adhesive. The screen to be printed is laid on the cloth at one end of the table, gauze side downward, with the frame therefore forming the sides of a shallow trough. Printing paste is poured into the trough and driven through the open areas with a squeegee, which is a stout strip of wood with a firm lip of rubber along the lower edge. The longest side of the screen is usually placed across the cloth (weftwise), and the line in which the squeegee is moved is parallel with the shorter side. Two operatives do the printing, one at either side of the table, passing the squeegee from one to the other in the middle of the stroke. When one impression has been made with the screen, it is lifted and laid down on the next repeat and so on until all the cloth on the table has been printed with one colour. Then the operation is repeated, using another screen and another colour, until the full design is printed. Correct positioning of screens along the length and width of the cloth is obtained by projections on the screen frame that are made to engage with stops correctly adjusted on a metal bar (pitch rail) on one of the long sides of the table. After one table-length of cloth has been fully printed it is pulled from the table and succeeding lengths of the roll are printed by the same procedure.

Screen printing is never as swift as roller printing but the preparation of screens is easier, speedier and cheaper than the engraving of a set of copper rollers. The skill required is not nearly so great as that needed to operate a roller printing machine. While a roller printing machine can best interpret designs in which sharp definition is needed. the screen method may give superior results more easily when full colouring and a full gradation of shading is needed. There are distinctions connected with the nature of the design; *e.g.*, it is easier to get plain longitudinal stripes by roller printing and lateral stripes by the screen method. The screen method is better adapted for the classes of commercial printing in which short runs and quick changes of design are called for.



BY COURTESY OF THE COTTON BOARD

FIG. 2.— TWELVE-COLOUR AUTOMATIC SCREEN-PRINTING MACHINE

Many machines have been introduced to mechanize the screen printing operation. Some imitate mechanically the operations of hand printing. In others, continuous working may be achieved by supporting the screens on rollers whose faces are perforated so that the screens can be furnished from inside; such machines approach the action of the roller printing machine.

Roller Printing.—This is the method by which the greatest percentage of cloth is printed. In general it is faster than other methods and produces a more accurate impression. The printing area is engraved in recess (intaglio) on a smooth copper roller. This is coated with the colour paste and then the unengraved surface is scraped clean with a steel blade (doctor), leaving the engraving filled. The roller then comes into contact with the cloth carried on a supporting roller and transfers the paste in the engraving to it. The number of engraved rollers employed depends upon the number of colours required in the design and may be from one to fourteen. With the exception of a few of continental origin, modern roller printing machines do not differ fundamentally from the one invented by Thomas Bell in 1783 (see fig. 3 and 4).

The engraved copper rollers, or shells, each rotate on a steel mandrel to which they are keyed by a tongue and groove arrangement. The drive is transmitted from one large crown wheel, driven by an electric motor, to a box wheel at the end of each mandrel. Different prints need to be printed at different speeds according to the quality of the engraving and the paste used, and the structure and composition of the cloth itself. The printing machine should be able to run at very slow speeds (inching) at the beginning of a printing in order that final adjustments in the fit of the different coloured impressions can be made before a substantial yardage of cloth has been printed.

The shells themselves are usually made of high-quality copper, but where a long life is called for, and especially where the paste contains hard, solid particles (*e.g.,* pigments and crystals), the surface may be chromium plated. The appropriate part of the total pattern is engraved on each shell by direct manual engraving, by milling or by acid etching, including various adaptations of the photogravure process (see GRAVURE). When another pattern is desired, a new series of shells is fitted on the mandrels.

The central cylinder, or printing roller, is made of cast iron; the larger the number of colours printed, the greater the diameter of the cylinder. It is wrapped with several layers of springy cloth (lapping) to impart resilience. The back gray and the cloth to be printed are carried through the rollers at a steady tension on an endless printer's blanket, which may be made of felt with a smooth resilient surface or made of cloth coated with rubber or a plastic substance. If it is rubberized it will be washed after the impression with water sprays or rotary cylindrical brushes to remove adhering paste, and dried by being passed through hot air or over steam-heated cylinders or by being dusted with talc before being passed forward again to support more cloth. Modern blankets, which are covered with compositions designed to resist wear and chemical attack and are embossed with fine lines, can be used without the back gray for some designs; the depressions hold the small amounts of paste pushed through the cloth and in addition increase the grip between cloth and blanket; such blankets exhibit better springiness than do the older forms.

The cleaning doctor consists of a straight strip of steel fixed in a pivoted clamp or shears, with an edge pressing at an angle against the surface of the shell. It removes the paste from the unengraved portions of the shell surface. The pressure of contact is obtained by weights that act on the shears through a lever. The adjustment of the doctor is one of the most exacting tasks of the printer since the variety of blade and the angle and pressure of contact have to be adjusted to meet the particular quality of the engraving and other conditions of printing. The edge is sharpened so that it is accurately linear, and, although it may receive an initial mechanical grinding. it always has to be finished by hand. Special adjustments (springing) of the steel strip in the shears are required to overcome bowing when wide cloths are printed.

As the shell rotates it is supplied with printing paste by a lapped or coated roller (the furnisher) that rotates in contact with the shell and also runs partly immersed in paste contained in a colour box. As the shell moves round it is cleaned by the doctor and then makes contact with the cloth. Before it completes a revolution. it passes under the edge of a second, or lint, doctor that is similar to the cleaning doctor but is made of a softer metal. Here the smooth portion of the copper is freed from lint and from printing paste of other colours transferred by the cloth from an earlier shell. This operation prevents paste of one colour from passing into the boxes of subsequent colours and falsifying the shade and removes solid impurities that might otherwise wedge between the edge of the cleaning doctor and the copper surface, letting through unwanted colour and giving rise to lines and smears in the print. Furnishing is sometimes effected with a stiff cylindrical brush instead of a roller. The brush is often rotated at a different surface speed from that of the shell; the brushing action prevents permanent clogging of the engraving.

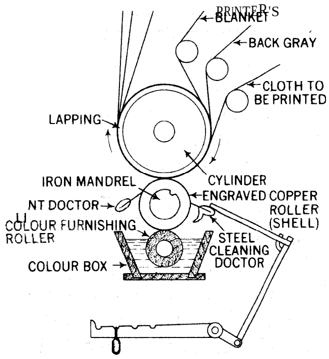


FIG. 3.—WORKING PARTS OF A ONE-COLOUR TEXTILE PRINTING MACHINE

In multicolour printing, the units, each consisting of a shell printing a single colour with its own doctors and furnishing arrangement, are fixed at intervals round the lower part of the periphery of the central cylinder, which is horizontally disposed. As the cloth passes around the cylinder, it is impressed in succession with the different colour components. Careful fitting is needed as each impression must fall accurately upon the appropriate area within the complete pattern; inconspicuous pitch marks are engraved as a guide at the appropriate place on each shell of the set. Adjustments are made after the first few feet of cloth have been inched through the machine: to correct the fit across the width of the cloth the bearings of the mandrel are displaced sideways: adjustments at the box wheel can turn the mandrel slightly relative to the wheel itself and make the impression from one shell fall a little earlier or a little later within the repeat, so ensuring longitudinal fit. Some adjustment of this kind may also be needed while the pattern is being printed. since the cloth may stretch a little unevenly under tension. The diameters of all the shells are the same and all are driven at the same rotational speed. so that the surface printing speed of each shell is therefore also the same. An integral number of repeats of the pattern is engraved around the circumference of each shell so that these repeats are printed without change of spacing regardless of the length of the cloth. With the older box-wheel mechanisms. adjustments in the fit were made manually and the slowing up necessary to effect them sometimes led to changes in the stretch of the cloth. However, more elaborate mechanical and electrical types of box wheels have become available; these allow the shift for fitting to be accomplished while printing at full speed.

Not all the rollers on a machine may be engaged in impression. Sometimes perfectly smooth, unpatterned rollers furnished with a paste containing no dye may be interposed in the sequence of engraved rollers when impressions of greater colour area, or with more intense colours, are printed on the cloth in front of impressions of smaller area or paler colours. This counteracts the danger of contaminating the pastes in the colour boxes toward the end of a series when the action of the lint doctor may not be adequate. The starch roller receives any loose colour from the cloth on its smooth surface, goes around to be coated with plain paste and then has its surface scraped clean by the doctor. When a multicolour machine is used to print a design with fewer colours than its maximum capacity, the engraved rollers may be too few to pull the cloth. blanket and heavy cylinder by frictional contact in the usual way and in this case additional plain rollers are run on the machine for driving purposes.

Three important modifications of the roller printing machine are made to meet special requirements of pattern or quality of impression:

1. Surface printing machines have already been mentioned: they are used to give prints of blocklike quality. Since the printing is from rollers in relief, modifications of the furnishing arrangements are needed.

2. Duplex printing machines are in effect two separate single-sided machines incorporated in the same structure and printing simultaneously on both sides of the cloth with the pattern on the one side in perfect fit with that on the other. Less perfect double-sided effects can be produced with single-sided printing in a push-through operation where the structure of the cloth, the pressure of the roller and the consistency of the paste allow the colour to go right through the cloth and give a reasonable impression on the underside.

3. Jumping machines are used for large repeats that are surrounded by an unprinted border. The machine is provided with gearing that checks the printing operation at the necessary intervals while the cloth moves forward by a distance equal to twice the width of the crosswise border. This obviates shells of inconveniently large diameter.

Transfer of the Repeat to the Shell.—*Milling.*—Patterns with small simple motifs and uncomplicated repeats such as spots, stars. rings, stripes, etc., are engraved by mounting the polished shell in a lathe and rotating it against a hard-steel, wheel-shaped die with a number of the design units in relief; these units indent the copper surface.

Hand Engraving.—To a limited extent, rollers are hand engraved by conventional methods. More frequently, hand engraving is employed to perfect rollers engraved by other methods and to correct defects caused by wear. (See also ENGRAVING, LINE.)

Etching.—This is the method used most frequently for engraving rollers. The original cartoon from the designer is projected optically onto a zinc plate and the repeat is incised on the plate, each detail being then coloured up to match the cartoon. An operator then follows the lines corresponding to one of the component colours on this plate with a stylus that forms part of a machine called a pantograph (or, less correctly, a pentagraph). Mounted in the pantograph is a smooth copper shell, covered with a layer of protective varnish; the movements of the stylus rotate the roller and also actuate a series of diamond points spaced along the length of the roller. As a result. the desired number of repeats are scratched at intervals along and around the shell. The roller is then rotated in a bath of suitable acids that penetrate the scratches and etch the repeats into the copper. If the engraving is a deep one it is not desirable to etch it in one stage, so the roller is revarnished and the scratching and acid treatment are repeated. When one roller of the set has been made. another is inserted in the pantograph, the lines on the zinc corresponding to a different colour are followed, and so on until the whole set has been completed.

Photogravure *Methods.*—A number of acid etching methods have been developed that follow the methods used to produce photogravure rollers for magazine printing. They reduce the time required for engraving and are specially suited for certain pictorial subjects.

Scale.—For all shapes of appreciable area, simple engraving of a depression in the roller will not give satisfactory impressions since the paste that it contains after furnishing is not under adequate control and the printed area consequently will not be uniformly coloured. Such areas are therefore engraved as a series of parallel diagonal grooves. In printing, each line spreads laterally into the impression of its neighbour. The width and depth of the lines must be properly related to each other; these measurements are jointly specified in a number called the scale. In some engravings made by photogravure methods the impression is broken into dots by photographing the original image through a screen (rectangular disposition of lines), and the effect of the screen is the same as that used in photomechanical methods for printing pictures on paper.

Colourings.—A set of engraved rollers, blocks or screens can be used to produce a series of different and distinct decorative effects by (1) changing the combination of colours; (2) using only part of the set; (3) using the set in conjunction with rollers having small "all over" patterns that do not need fitting with the rest of the pattern and modify the ground or the blotches; (4) printing in conjunction with dyeing. Each modification of the use of the set of rollers in this fashion is called a "way."

There are also several more unusual methods for continuous printing. In one group of related methods. the colours are thickened until the printing medium is of the consistency of stiff dough. This is rolled out into sheets and cut into shapes that are mounted in mosaic fashion around the surface of a roller. This roller prints onto cloth damped with water or other solvent; the cloth is supported on another roller with a very resilient surface. The water or other solvent dissolves a small amount of the thickened colour, which is thus transferred to the cloth. Only a limited yardage can be printed with one roller because the roller coating is slowly consumed. The process has been used to produce beautiful and unusual prints that cannot be obtained in any other way; there is no limit to the number of colours that can be printed from the one roller. The usual difficulties of fitting are not present, since these have been dealt with in preparation of the roller itself, but there are restrictions in the kinds of dye that can be used.

In another unusual continuous method the design is first printed on paper with appropriate dyes in special media. It is transferred to the fabric by running the cloth and the paper through a heated calender together. Once the transfer has been obtained, the dyes used are fixed in the normal way.

Colouristic Features.—The choice of dyes and their adaptation for use in a given print depend upon a large variety of conditions, some chemical and some economic: the fibre or fibres from which the cloth is made, the colour requirements of the design to be reproduced and its durability in the expected conditions of use, the relation between the printed effectand later processes of manufacture (*e.g.*, finishing), the cost of production and the length of time before delivery. Most commercial printing is a compromise between the ideal interpretation of the design and the need to produce it at an acceptable price. The choice of dyes for a print, and to some extent the chemical and processing procedures used in their application and fixation, are known as styles.

The relations between the kind of fibre in the material to be printed and the dyes used are in general similar to those that are obtained in dyeing but the physical differences in printing and dyeing systems may greatly modify the conditions of application. Two important differences are: (1) the dye and chemical assistants used in printing have to be applied in a much smaller volume of medium and are therefore concentrated; (2) the stage of diffusion and fixation in printing must be made to occur after the impression and in the relatively short, well-defined period of steaming or chemical aftertreatment. For this reason the formulations of a dye bath and of a printing'paste containing the same dye may be very different.

The following groups of dyes are used in printing:

I. Direct cotton dyes, mainly for cellulose fibres; acid dyes for viscose. wool, silk. and nylon and certain other synthetics; basic dyes for wool, silk, cellulose esters; and disperse dyes for all hydrophobic fibres (those that swell very little in water).

II. Vat dyes. predominantly for cellulosic fibres but also (with special procedures) for other natural and synthetic fibres; insoluble azo dyes, mostly for cellulosic fibres, and often in special chemical forms to meet the special conditions of printing; phthalocyanine dyes, again for cellulosic fibres but again applicable in some chemical forms to other fibres.

III. Mordant dyes, in which the sequence of application of the dye, the mordant and the reagents that control the interaction of the two are specially chosen for printing conditions.

IV. Reactive dyes, which are mostly applicable to cellulosic fibres.

V. Pigment colours applied to the surface of the fibres and fixed with synthetic resin preparations so designed that. when fixed, they are not easily removed in washing and do not stiffen the fabric. They are applicable to a wide range of fibres. are simple to use, give full colorations and are particularly useful in screen printing.

A distinctive feature of much textile printing as compared with dyeing is that it is often necessary to use dyes from different classes to provide the different coloured areas in the same print and, for this reason. great ingenuity is needed in exploiting the chemical properties of individual dyes so that one fixation treatment, *e.g.*, steaming. is appropriate for all of them and so that the reagents used with one colour do not interfere with the other colours.

Two widely used styles that have no exact counterpart in dyeing are: (1) Discharge printing, in which the cloth is first evenly dyed before printing and then is printed with a paste that contains either an oxidizing or a reducing agent. Steaming causes the agent to destroy the dye on which it falls or to convert it to a soluble form so that it can be removed by washing. This therefore gives a white print on a coloured ground. An extension of this method is the use of the illuminated discharge in which a dye indifferent to the discharging agent is incorporated in the paste so that it takes the place of the ground dye that has been destroyed and gives a coloured print on a ground of a different colour. (2) Resist or reserve styles, in which the cloth is printed with a preparation (*e.g.*, wax or a synthetic resin) that protects the fibre from a dye solution, or with a reagent that chemically inhibits the fixation of a particular dye (*e.g.*, an acid for a dye that requires alkali for its fixation). The entire cloth is then dyed and the resisted areas remain undyed. As with discharge styles. the resist may be plain (white on a coloured ground) or coloured. A traditional example is the batik of Java and its analogue in west African styles. (H. A. T.)

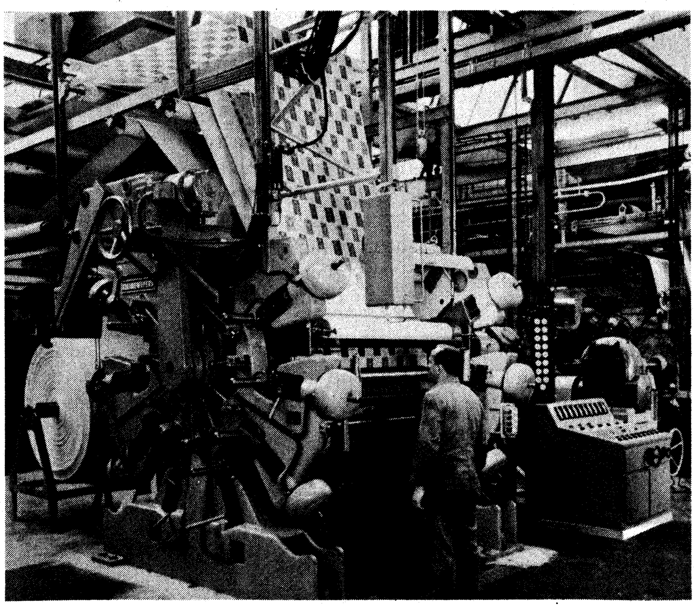


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FIG. 4.— MODERN ROLLER GARMENT-PRINTING MACHINE

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(H. A. T.)

TEXTILES are woven fabrics. The term also means all spinnable fibres or materials suitable for weaving, in addition to fabrics produced by knitting and felting, and all laces. The Latin *textilis* meant a woven fabric, but the word *textile* was also used as a transitive verb for plaited, braided, woven or constructed. This article deals largely with decorative textiles. Other articles related to the subject include SPINNING; YARN; WEAVING; and WEAVING, HAND for the making of textiles; DYES, for one process in their finishing; TEXTILE PRINTING for a detailed discussion of commercial aspects of that subject. There are also numerous articles on individual fabrics—*e.g.*, CALICO; CHALLIS; CHIFFON; DAMASK; DIMITY; etc.—which describe these fabrics and deal with them as items of commerce. COTTON MANUFACTURE; SILK MANUFACTURE; and WOOLEN MANUFACTURE similarly are concerned with textiles as industrial products.

This article is outlined as follows:

I HISTORICAL OUTLINE

1. Early History.—Since textiles are easily torn, burned or eaten by insects, the oldest surviving specimens probably date from long after the time when weaving was first practised. Whorls or weights for spinning have been found on Keolithic sites. indicating that thread was spun and therefore that cloth was made. The weaving of textiles for clothing, as a substitute for the skins of wild animals, was a corollary of settled life and the breeding of domestic animals. The four natural fibres, wool, linen, cotton and silk, originated in different parts of the world. Woolen textiles have been found in early Bronze Age sites in Switzerland and Scandinavia. In Egypt plain linen textiles of about 5000 B C. have been found Cotton scraps have been discovered in India on sites of about 3000 B C. and in Peru on sites datable to 2000 B.C. Silk may have been used in China in the 2nd millennium B.C. and was certainly woven by 1000 B.C. Cloaks, tunics and caps from Scandinavian sites show that a high level of skill had already been reached there, even though tools were few and primitive. The preparatory processes of carding and combing raw wool were known, for the threads are well and evenly spun. Felt caps and narrow braids were also made, and sprang, a technique between knitting and netting. was used.

Flax was grown in the Nile valley. The natural colour of flax fibres is brownish. and since whitish linens have been found in very early tombs. methods of bleaching must have been discovered. Spinning was done by hand. using a simple weighted spindle, and cloths were woven on three types of loom: a horizontal loom fixed to the ground, an upright loom with a beam at the top and bottom, and an upright loom with the warp threads bunched in groups and weighted at the foot. Variants of this last loom are seen on ancient Greek vase paintings, and this type was probably used to weave the textiles found in Scandinavia Tablet weaving for making narrow braids, netting, sprang and other techniques were developed. Normally cloth was woven in tabby (plain weave). In Ptolemaic Egypt very fine counts of linen have been found in textiles probably woven for the courts of the Pharaohs. Strangely analogous to the garments found in the north are tunics woven to shape.

The Romans wore both linen and wool, but as the empire extended so did the variety of textiles they imported. Pliny described the Roman toga of wool or linen. and later writers deplored the fashionable clothes made of silk from China. From two sites in Mesopotamia, Doura-Europus (deserted A.D. 256) and Palmyra (sacked A.D. 272), there are textiles showing the weaving repertoire of the ancient world to have comprised chiefly plain wool or linen—though at Palmyra some linens were dyed in true purple and among the wrappings of the dead were some imported cottons. Several of the earliest patterned materials made outside China were also found. These are the tunics and fragments woven in plain linen with tapestry-woven insertions.

The designs of the fragments from Doura-Europus are comparatively simple; on the other hand, for several centuries after the 3rd century A.D. Coptic weavers of Egypt produced an extraordinary variety of decorative textiles, chiefly for clothing. The dry sands of the burying grounds of Akhmim and Antinoe have preserved a profusion of such textiles dating from the 4th to the 10th centuries. The patterns reflect the cultural life of the entire Mediterranean. The bands of decoration, which were narrow on the fronts and shoulders of the tunic fragments at Doura, were larger and more elaborate, with roundels containing mythological and biblical scenes. Naturalistic birds, animals, gods and mortals in fresh, bright colours influenced by Hellenistic art were gradually transformed in subject and in style. Long after the conquest by Islam in the 7th century the Coptic weavers continued to look back to Christian subjects for their inspiration. The influence of other countries and other media can be detected, and the patterns of woven silks were copied in wool. In time, however, whatever their origin, the motifs forming the designs were subordinated to a general decorative effect until they became almost unrecognizable.

Many animal-fibre (vicuña, llama, etc.), agave and cotton textiles have been found in the sands in the narrow coastal strip of South America between the Andes and the Pacific, relics of the pre-Columbian civilization of Peru. The earliest of such relics date from about A.D. 1000, though their chronology is uncertain. Without any further modification of the loom than the weaver's fingers could provide, the inhabitants wove complex patterned textiles in tapestry. double cloth, brocaded gauze and other techniques for belts, blankets, bags and clothing. Anthropomorphic subjects are common.

2. Advances in Weaving.—One of the most important developments in the history of textiles was the invention of a method of making free designs that could be repeated indefinitely once the loom was set up. It is certain that the Chinese had found a means of achieving this early in the Han dynasty (202 B.C.–A.D. 221). The Chinese loom probably had treadles and rotary cloth and warp beams before those in the west, both of which presuppose the weaving of large quantities of fairly complex materials. The invention of a drawloom implies a civilization so advanced that expensive textiles were produced for a wide commercial market—it would not be worthwhile otherwise to set up the pattern. Chinese silks have been found not only on the old silk road from China. at Loulan. Turkestan, and other sites by Sir Aurel Stein but also a group of silk damasks were among the textiles excavated at Palmyra.

On the drawloom it is possible to lift the warp threads required for the pattern irregularly across the textile in each line of the design. In China a drawboy sitting on top of the loom pulled a set of cords attached to all the warp threads necessary for that line of the pattern each time the weaver opened a new shed. The warp threads thus pushed to the back of the textile the weft not required on the surface. The setting up of such a loom was laborious and the work very slow and tiring for the boy or girl helping the weaver. Though several important modifications very much later made the drawloom a more efficient machine — by the 17th century, for instance, the introduction of lashes and simples permitted the boy to work at the side of the loom — fundamentally the drawloom remained unchanged until the late 18th century. In the early Chinese silks the pattern was made either by a form of damask in which a warp-faced weave contrasted with a weft face, or by different-coloured warp threads entered in sequence in the loom and brought to the surface as required by the design. The patterns of the early Han textiles were often similar to the geometric cartouches on the backs of bronze mirrors or were derived from a repertoire of exotic fauna, dragons and birds being especially common.

Farther west the first drawloom patterns appear in woolen textiles found in the Egyptian burying grounds and perhaps dating from the 4th–5th century A.D. A group of these show small birds within compartments, woven in compound tabby. The word compound indicates a two-warp system: the main warp, controlled by the drawboy, is hidden between the front and the back of the textile and the binding warp appears on the surface to bind the wefts in tabby. These textiles were probably woven in the near east but it is not known where.

3. *4th–15th* Centuries. — Middle East. — After the fall of the Roman empire textiles continued to be woven in the traditional centres and exported abroad. Following the Muslim conquests of the 7th century new textile centres appeared in Syria and Arabia. At the western end of the silk route across central Asia from China, silks were woven in Sogdiana and in Sasanian Persia (3rd–7th centuries A.D.). Important patrons of silk weaving were the Seljuks who ruled Persia, Asia Minor and Syria in the 11th and 12th centuries. Apart from a group excavated at Rayy, few Persian textiles can be certainly attributed to an earlier date than this. A number of important silks can be attributed to Egypt in the time of the Mamelukes.

Most of these near-eastern textiles are known only from literary sources but from the 7th–8th century onward woven silks have survived in some quantity in the tombs and reliquaries of saints and other important figures, opened at later dates, and from the 12th century onward as the seal bags of treasuries and as vestments. Such silks often came from far-distant countries; thus silks from central Asia have been found in French and Flemish churches, and Chinese silks have even been found in Viking burial grounds. The designs of near-eastern silks owe little to China but much to the traditions of Sasanian art. In roundels fabulous monsters such as the *senmurv,* half-bird half-dog, are typical. The sculptures of the Sasanian monuments, especially at Taq-e Bostan, prove that such patterns, themselves based on Achaemenid art, originated in Persia. The roundel became the set form of decoration for several centuries, though the motifs it contained and the ornament from which it was composed varied considerably.

A magnificent series of woven silks can be attributed to Byzantium. Silk weaving may not have been very important in the city until the 6th century but very soon afterward imperial workshops were established which controlled the industry. The capture of Ctesiphon, the Sasanian capital of Khosrau II, in 624 and the booty taken by the Byzantine troops may have influenced the development of silks made in Byzantium. Early Byzantine silks were made in compound twill — that is, with the hidden main warp making the pattern and the binding in twill, allowing longer floats of weft than in tabby and thus exploiting the lustrous quality of the silk. Subjects owing much to the inherited tradition of Rome included the Quadriga silk showing a charioteer, and the lion strangler, perhaps Samson. Byzantine silks have been preserved in the tomb of Charlemagne at Aachen. This was opened in 1000 A.D. and new silks added — the elephant silk found there was probably made not long before the opening and is similar in style to lion silks elsewhere with 10th-century inscriptions. These were made in the golden age of Byzantine silk production. A group of silks were woven in the 11th century in which the pattern appeared as a penciled or engraved outline in a self-coloured material, the vestments of Pope Clement II (1046–47) at Bamberg, Ger., are remarkable examples.

While the richest silks fit for kings and emperors have survived, the ordinary wool and linen materials worn every day have perished. The history of textiles between the terminal dates of the Egyptian burying grounds and the 16th century tends to be divided into the history of vanished products based on documentary evidence on the one hand and the history of luxury silks on the other.

Among the rare textiles whose origin is known with certainty are those from the *tiraz* factories. which are inscribed with the names of the place and of the caliph in whose reign they were made. Some of these are tapestry-woven, most have embroidered inscriptions and date from the 8th–11th centuries.

Western *Europe.*—The Low Countries were the centre of a large and politically important cloth industry from the early middle ages. Already in the 8th century England was exporting wool to Flanders, but this trade did not become important till the 11th century. The Cistercians were important sheep farmers. Most districts in northern Europe made cloth of various qualities for local consumption, but by the 12th century the Low Countries were weaving cloth from imported Spanish and English wool and exporting it to other parts of Europe. In the later middle ages English royal policy sought with some success to prevent the export of wool in favour of that of unfinished cloth. Flax was similarly grown and linen woven in a number of European countries, but the only linen textiles to survive in any number are the towels with decorative ends said to have been made in Perugia, It., in the 15th century. Silks and linens were also made in Germany, especially in Cologne and perhaps in Regensburg.

Silk was certainly being woven in Mediterranean countries by the 9th–10th centuries. Although at first raw silk was imported from the near east, the cultivation of the white mulberry tree essential to the silk worm soon followed. Some time after the establishment of the western caliphate in Spain (8th century) silk weaving was established in Córdoba; later it was carried to Almería, Zaragoza, Málaga and elsewhere. In Hispano-Moresque textiles ornament from the near east was combined with a wholly distinctive style of decoration originating in Spain. Emphasis on the purely decorative form of interlacing patterns reached its climax in the last Moorish factories of Andalusia. The Norman conquerors of Sicily established silk-weaving workshops, but it is difficult to distinguish silks from Egypt, Sicily or Asia Minor for all drew on the same cultural sources. The traders of Venice and Genoa imported silks into the mainland whence they were distributed throughout Europe. An accessible source of raw material together with the early growth of compact city-states favoured the establishment of silk weaving in Italy. A treaty between Lucca and Genoa in the mid-12th century gave Lucca access to the Levant and also to the fairs in northern Europe. Merchants of Lucca traveled to the Levant to buy silk and to northern Europe to buy woolen cloths and to sell woven silks. In the 14th century, however, political difficulties displaced the town from its preeminence. Guilds of silk weavers were established in Venice, Florence, Bologna and Genoa.

A comparatively large number of silks can be attributed to northern Italy in the period from the 12th to 15th centuries, though few are known to come from any particular city. Their designs reflect the general style of Gothic art, with animals, rinceaux and heraldic devices of unfailing invention. During the 14th century the route to China was reopened, and many silks woven after that time incorporate decorative details showing Chinese influence—dragons, exotic birds, palmettes and cloud bands. Some of these may be seen in contemporary paintings; *e.g.,* the robes worn by St. Edmund Martyr in the Wilton diptych (*c.* 1395) in the National gallery, London.

The technique with which these silks were woven was advanced; the main warp appeared on the surface of the textile and was combined with a second (or ground) weft to form a texture contrasting with that of the pattern. Damasks were woven, and during the 14th century velvet weaving was established. There were plain-cut pile velvets, cut and uncut pile together, voided velvets in which part of the ground was left without pile but brocaded, often with gold thread, and velvets woven with two heights of pile, sometimes further enriched with gold loops. Many 15th-century velvets probably made in Venice have survived as chasubles and copes.

Velvets with the typical curving pomegranate in silk pile and gold thread may be recognized in paintings both by Italian artists and by those of the northern schools—evidence of the popularity of Italian velvets in Germany and the Low Countries.

4. 15th Century to the Industrial Revolution.—A great variety of textiles have survived from the 16th century. Among woven textiles the silks produced under the Safawid dynasty in Persia are outstanding. The silks of this renascence owed much to the stylistic tradition of Persian illuminated manuscripts in design, colouring and subjects depicted. Hunting scenes, subtle in technique and splendid in effect with lifelike hunters, animals, flowers, trees and birds, were rendered with accuracy and great decorative appeal. Several of the greatest were made in the court factories of Shah Abbas I (1587–1629). Persian treatment of floral design had a profound influence on European art but not on silk design until the period of its greatest inspiration had passed.

The Ottoman Turks also produced a fine series of silks in the 16th and 17th centuries. Brusa (Bursa) was the chief city weaving silks, though others are known. Turkish velvets were especially successful, owing their inspiration to those of Italy, though the designs were often treated on a larger scale.

In Europe Italian silks drew much from those of the 15th century. although by the late 16th century newer forms of ornament can be detected More remarkable is the fine table linen produced in the Spanish Netherlands from the end of the 15th century (and perhdps earlier, though none survives). Special sets were woven to order for such clients as Henry VIII of England. Courtrai was the centre of the linen damask industry, though Haarlem became increasingly important in the 17th century Damask cloths with napkins to match were woven with biblical scenes or coats-of-arms from the 16th century onward. Seventeenth-century damasks include commemorative designs, views of cities and some more original designs such as that of the cloth with a design of plates, knives and forks set for dinner, woven in Haarlem by Paschier Lainertin and now in the Victoria and Albert museum, London.

The War of the Spanish Succession at the beginning of the 18th century provided a rich source of subject matter, particularly beleaguered cities and equestrian portraits to commemorate the victories of Prince Eugene of Savoy and the duke of Marlborough. Such damasks were large, finely woven on a drawloom and expensive. Cheaper diapered or plain linen for napkins, cloths and sheets was also woven in great quantities in the same towns.

From the 17th century there survive some of the textiles made for a wider distribution than the court silks of Persia or the expensiye Italian velvets For those who could not afford the luxury of tapestries or silk hangings, certain northern towns in Italy made strong, coarse, woolen and hempen hangings. In the late 17th century this industry had shifted to Rouen and Elbeuf in France. Moreover during the 17th century the foundation of the English, Dutch and later French East India companies brought an increasing supply of cotton from Bengal into Europe for the making of fustians and other mixed fabrics. ("Cottons" until the 17th century and even later were usually low-grade woolen materials rather than true cottons.) The plantations in the American colonies were growing cotton for export by the second decade of the 18th century but probably little before then.

The establishment of important silk industries north of the Alps was a feature of the 17th century. While the woolen and worsted industries-the latter much developed in the 16th century—continued to produce the most important textiles in northern France, England and the Low Countries, the silk industry began to be significant in southern France. Although some silk had been woven in France in the 16th century and earlier, it could never compete with Italian imports. Under J. B. Colbert, minister of Louis XIV, however, the industries of Tours, Avignon, Nimes and above all Lyons were supported by a rigorous policy of protection and the growth of raw silk was encouraged in southern France. The wars at the end of the reign of Louis XIV diverted French resources for a time from such capital investment, and during this period silk industries were firmly established in Holland and England. In London the industry spread from the City to the district of Spitalfields in the east, which greatly expanded with the industry in the first 60 years of the 18th century. Fine dress silks were woven by a large number of prosperous master weavers, many of them, especially the weavers of patterned silks, being of French Huguenot origin.

The London industry was subject to the general control of its medieval guild, the Weavers' company, but this exercised little influence on the types of silks produced. In France the Grande Fabrique de Lyon had a complex organization of regulations governing the qualities of the silks to be made and officials to enforce them. Wages were low and the economic regulations often in dispute, with an outright rebellion in 1744. It was against a background of almost continuous social unrest and internal dispute that Lyons produced some of its most astonishing dress silks.

During the last years of the 17th century the designs of silks were transformed from the formal pomegranate pattern inherited from the 15th century and the stylized sprigs that persisted throughout the first 70 years of the 17th. Abstract curling forms, often in gold and silver thread on a crimson damask ground, erupted into gigantic bizarre designs with a profusion of motifs of disproportionate scale juxtaposed. Fashions changed with the season, and by the second decade of the 18th century the bizarre forms had given way to luxuriant but formal designs based on the outline of the old pomegranate motif but enriched with lacy diapered fillings. There was an increasing desire in the 1730s to give a three-dimensional form to the designs: a designer named Courtois succeeded in large floral designs by using tones of colour; Jean Revel (1684–1751) introduced ***points** rentrés* by which the tones of colour were dovetailed. A reaction toward naturalistic life-size sprays of flowers came in the 1740s, a period in which some of the most successful English silks were woven. From the middle of the century designs with bunches of flowers and trailing ribbons dominated all others. Neoclassical influence can be detected in the later 18th-century silk designs as in other media, laurel wreaths and plain stripes occurring frequently. A period of very dark colours in the 1790s was succeeded by a fashion for light colours and light materials, especially silk gauzes and cotton muslins.

While such were characteristic dress materials, printed cottons often provided fashionable furnishings. In Lyons, however, Philippe de la Salle (1723–1803), designer and partner in a silk-weaving firm, designed a series of furnishings with lifelike birds, flowers, ears of wheat, etc., on a sumptuous scale.

The continuous change in fashion was perhaps stimulated by intense competition in the market for woven silks Genoa never lost its markets for heavy velvets and damasks, Lucca survived until the middle of the 18th century, but in the general climate of mercantilism every sovereign tried to restrict the import of luxuries and to foster native industries. Silk industries were revived in Spain and founded in Berlin and even in Russia. A large number of Chinese painted silks were also imported into Europe.

It was not, however, until the 19th and 20th centuries that Chinese *k'o-ssu,* silk tapestry-woven textiles, were appreciated in Europe. The dragon robes worn by the highest Chinese officials were not made known in the west,till after the sack of the Summer palace in Peking in 1860. A few fine 18th-century examples survive and can be seen in all major museum collections.

Very high-quality woolen. worsted and mixed textiles were made in the 18th century for everyday clothing, linings and upholstery; they were still very expensive, however, and secondhand clothing was much worn by the poor in all countries. Although all cotton goods were prohibited, substitutes with a linen warp and a cotton weft were made both in England and on the continent of Europe, and in England were virtually indistinguishable from pure cottons. While these goods possibly reached unprecedented technical perfection. far-reaching technical changes began to appear in the cotton districts of Lancashire and the heavy woolen industry of Yorkshire.

5. The Industrial Revolution. — Kay's flying shuttle (invented in 1733) speeded up and therefore cheapened the production of plain textile goods. Quicker weaving increased the pressure upon the spinners to produce more thread than they could by the spinning wheel, virtually unchanged since the 15th century. It was, however, nearly half a century before Richard Arkwright's water frame (1769) and Samuel Crompton's mule (1775) began to replace the hand spinners with machines. These inventions and their perfection gave an incentive to mechanize the preparatory processes of carding and combing. The period from 1780 to 1820 produced a multitude of devices to mechanize each of the processes formerly performed by hand. The first power loom was improved upon soon after the turn of the century. Primarily these inventions made possible the mass production of cheap cottons, but nearly all could be adapted to wool.

The greatest technical problem in silk pattern weaving was the cumbersome and expensive drawloom. The elimination of the drawboy and the automatic weaving of the pattern were finally achieved by Joseph Marie Jacquard (1752–1834), who built upon the ideas of his predecessors. The Jacquard loom was widely used in France by the end of the first decade of the 19th century and elsewhere by 1820. For the first time it was possible to lessen the cost of textiles with a woven pattern. Although Jacquard was a silk weaver his loom was quickly adapted in the cotton and linen industries and by the weavers of shawls, an important new industry in Scotland and at Norwich, Eng.

6. 19th and 20th Centuries. — The break in the normal stylistic evolution of the patterns of woven textiles is not clearly evident before the 1830s. The eclecticism of the taste of the next half-century reflected a total change in outlook. Techniques and new materials were of paramount importance. Using new machinery it was possible for the first time to reclaim rag wool for shoddy, thus lowering the cost of woolen goods and providing good warm clothing for the new poor of the rapidly growing industrial towns.

Except in the extreme luxury trades (in which Lyons silks and St. Étienne ribbons in France led the other nations), the textile centres of Europe and the United States competed with one another to produce large quantities of ever-cheaper power-loom-woven materials. The manufacturers' pride in these goods — each patented variation was acclaimed as a new material — was shown in the great international exhibitions of 1851 and 1862 (London), 1867 (Paris), 1876 (Philadelphia), 1878 (Paris) and others hardly less important. The overloaded Victorian interiors of the newly prosperous made extensive use of every kind of furnishing textile, creating an ever-increasing demand. The multiplicity of uncoordinated patterns was especially marked in textiles and provoked a natural reaction. On the one hand, there were official attempts to found trade schools and schools of design; on the other, William Morris and his associates rebelled against the domination of the machine (see ARTS AND CRAFTS MOVEMENT). Morris himself founded a firm to make high-quality furnishing fabrics using traditional dyes, the best materials and artists' designs. Although its influence was not limited to England, the movement hardly affected the styles of commercially produced textiles until the end of the century. (See also Printed Textiles, below.)

The scientific advances of the 19th century, particularly in chemistry, produced not only new dyes but, toward the end of the century, new fibres. The disease and virtual extinction of the European silkworm left the silk weavers of Europe almost entirely dependent upon the far east for their raw material; hence the incentives to find a substitute were strong. The first textile filaments were made in France from nitrocellulose; in Germany the cuprammonium process developed; in 1892 British scientists invented viscose rayon. But none of these proved wholly satisfactory.

After World War I cellulose acetate was exploited commercially, and in 1938 the first of a new series of fibres no longer based upon the structure of cellulose was developed in the United States. This was nylon, the first of the polyamide fibres, greatly improved after World War II. The polyester fibres were first used in the 1950s. The best of the new man-made fibres produced textiles that were tough, washable, crease-resisting, hard-wearing and less likely than natural fibres to shrink, fade or felt. Drawing on reliable supplies of raw materials they supplemented the four natural fibres very usefully, but the warmth of wool, the coolness of cotton and the elegance of silk were not easy to imitate. (See also SYNTHETIC FIBRES.) From the 1920s textile designs for the higher-quality materials have been once more the work of artists and reflect the general taste of their period.

7. Other Textiles. — Certain textiles fall outside the main historical developments. Japanese silks, though technically similar to Chinese, represent a different idiom in design hardly known in the west until it suddenly became fashionable in the 1870s. The coverlets woven by hand in parts of the United States preserved their traditional patterns throughout the 19th century. In some peasant communities of eastern and northern Europe, in north Africa and among the Indians of North and South America textiles were hand woven until the 20th century. Such textiles retained their intrinsic qualities until the use of aniline dyes destroyed their coherence by introducing alien, harsh and gaudy colour schemes which quickly faded to a lifeless and unpleasant monochrome. (N. K. A. R.)

II. PRINTED TEXTILES

The term printed textiles covers all textiles patterned by the application of pigments, whether by printing, painting or dyeing or by a combination of these methods. The pattern may be produced by painting on the cloth with a brush, by stenciling, by printing from wood blocks, engraved copperplates or metal rollers, or by screen printing, either with surface pigments or with dyes that penetrate the fibres of the cloth. The pattern may also be produced by "resist" or by mordant dyeing. In resist dyeing, the resist paste or wax, which is impervious to the dye, is painted or printed onto the material, covering the parts that are to remain uncoloured. In mordant dyeing, the parts that are to receive the colour are painted or printed with chemical substances known as mordants; when the fabric is immersed in the dye the colour is fixed on these parts, while washing removes it from the unmordanted areas. (These techniques are described at greater length in TEXTILE PRINTING.)

Printed textiles are believed to have been produced in the Caucasus as early as 2000 B.C. and there is no doubt that the art of ornamenting fabrics by painting or printing is of great antiquity. Painting was among the earliest methods of decorating textiles; among the oldest surviving examples of this are some Greek fabrics, dating from the 4th century B.C., found in tombs in the Crimea, and also the well-known painted Egyptian mummy cloths. In these early painted fabrics surface pigments were used, but at least as early as the 1st century A.D. the process of mordant dyeing was known to the Egyptians and is described by Pliny the Elder (d. 79 A.D.) although no mordant-dyed Egyptian fabrics of this date appear to have survived. Before the Christian era India had a reputation for its resist-dyed and painted cottons. In China the art of resist dyeing was certainly known as early as the 7th or 8th century A.D., while indigo resist-dyed linens, several with elaborate figure patterns of religious subjects, have been found in burial grounds at Akhmim, upper Egypt, and are thought to date from the 9th–10th century A.D.

In Europe, however, the art of textile printing does not appear to have begun much before the 12th century A.D., and the few pieces of printed fabrics of an earlier date that have been found in Europe appear to be of eastern origin. One of these, a piece of linen with a resist-dyed pattern of white circles on a blue ground, was found in the tomb of Caesarius of Arles (c. 470–542) and is preserved in the Nürnberg museum. A fragment of amber silk printed in gold leaf with a design of a falconer on horseback was found in the grave of St. Cuthbert in Durham cathedral (A.D. 1104), but it is assumed also to be of eastern origin.

1. Block-Printed Textiles.— The earliest extant examples of European printed fabrics, dating from the late 12th century, are of Rhenish origin. The fabrics, of silk or linen, were printed from wood blocks with surface pigments, usually in black, gold or silver. A few of the oldest pieces are printed in more than one colour, usually black and red, and occasionally a third colour. The patterns appear to have been copied from the Byzantine and near-eastern woven silks of the period. Although such fabrics seem to have been produced in considerable quantity and extant examples are numerous, there is reason to doubt the authenticity of many of the surviving pieces.

Early Development.—In the 14th century the patterns of Rhenish printed fabrics were based on the woven silks from Venice and Lucca. In one instance printed linen with a design of birds, lions and stylized floral motifs (fragments of which are in the Victoria and Albert museum, London, and at Berlin) survives together with the woven silk from which it was copied, a chasuble in the Stralsund museum in Germany. In the 15th century, patterns copied from Italian velvets, with ogival compartments containing stylized flowers or lobed pomegranate patterns, seem to have predominated.

Italian printed fabrics dating from the 14th century have also been found and examples such as the famous tapestry of Sion, with elaborate scenes of dancers and horsemen (in the Historisches Museum, Basel. Switz.). dating from the middle of the 14th century, show a high standard of technical excellence both in the cutting of the wood blocks and the actual printing.

Records of the Painter-Stainers' company show that painting on cloth was a recognized trade in England as early as the 13th century. but probably the earliest surviving example, dating from the early 15th century, is a burse from the parish church of Hessett, Suffolk, painted with the head of Christ and the symbols of the four evangelists.

By the 16th century simple block-printed fabrics appear to have been produced in most European countries. A number of English examples of the Elizabethan period, copying the popular "black work" embroidery or derived from contemporary lace-pattern books, have survived. Others, printed from engraved copperplates in ordinary printer's ink. were obviously intended as embroidery patterns. The 17th century saw considerable advances: in Germany, for instance, the patterns consisted on the one hand of floral designs not derived from woven sources but characterized by the detailed and elaborate cutting of the wood blocks, and on the other hand indigo resist-dyed linens, often with pictorial and religious subjects, which were copied from the contemporary linen damasks.

2. Origins of the European Calico-Printing Industry.— The chief advances in textile printing were the result of an attempt by European textile printers to imitate the fast-dyed, hand-painted Indian cottons that began to be imported into Europe during the early 17th century. It was not until the 1670s, however, that the European calico printers appear to have been successful (more or less simultaneously in France, Holland and England) in mastering the complex problems of mordant dyeing with madder, the basis of the imported Indian chintzes. Since "calico," the general term for cotton cloth of all kinds imported from the east, was also soon used to describe various cotton fabrics of European manufacture (including those with linen warps), textile printers came to be described as calico printers rather than, as in earlier times, linen or stuff printers. Calico printing was to an extent continued in most European countries during the 18th and 19th centuries but England, France, Holland, Switzerland and Germany were the only countries where the industry achieved any real importance.

The English calico-printing industry appears to have been founded by William Sherwin, an engraver, who in 1676 was granted a patent for a "new way of printing broad callicoe" and set up a printworks at West Ham, east of London on the river Lea. Other printers followed and by the end of the century the industry was well established. Indeed by 1696 the industry had already grown sufficiently strong to arouse the established silk and wool interests against it. A law of 1700 prohibiting the import of Indian chintzes was followed by laws of 1712 and 1714 which placed heavy excise duties on home-printed chintzes. Finally, in 1720, a law was passed that prohibited printing on all cotton cloth, but the calico printers were able to evade the intention of the law by printing on a mixed cloth with a linen warp and cotton weft. It was not until 1774 that the ban on printing was raised from all cotton cloth and not until 1831 that the heavy excise duties were finally removed. In spite of these restrictions the English calico-printing industry continued to expand and flourish.

In France the calico-printing industry was even more hampered by restrictive legislation than in England. An edict of 1686 forbade not only the wearing of imported Indian chintzes but their imitation and, although it was widely evaded, the industry made little real progress until the final removal of all restrictions on textile printing in 1759. Even before the lifting of the ban, however, a number of calico printworks had come into operation, including those of Koechlin Schmaltzer and Dollfuss at Mulhouse (1746), the Danton brothers at Angers (1753) and John Rudolph Wetter at Orange (1758). Wetter, a rich Swiss merchant, had previously established a printworks at the free port of Marseilles in 1744.

Although simple block-printed textiles had been produced earlier in Holland, the first successful attempts at imitating the imported Indian chintzes were made at a printworks at Amersfoort set up in 1678 by two Amsterdam merchants and a Turk living in Holland. Other factories followed and by the middle of the 18th century about 100 printworks were in operation, mainly in Amsterdam and the surrounding districts. The number of printworks, however, gradually declined, largely as a result of increasing French and English competition, and by 1800 only four were in operation. In the following years Belgian printworks supplied most of the exports to the Dutch colonies in the East Indies, but after the separation of Belgium and Holland in 1830, new printworks were established in Holland, forming the nucleus of the modern textile-printing industry in that country.

In Germany during the late 17th and 18th centuries Augsburg was the chief centre of textile printing. Resist-dyed linens and block-printed linens, printed in black or red, are found but, in order to protect the linen industry, printing on cotton was prohibited until about the middle of the 18th century. Among the most important German printworks was that of the brothers Neuhofer at Augsburg, which operated in the early 18th century, and that of Johann Heinrich Schiile, who is said to have introduced copperplate printing into Germany in 1766.

Switzerland was an important textile-printing centre throughout the 18th and 19th centuries. Block printing by the "application" method, which involved the use of watered colours (dye and fixing agent mixed together), had been practised in Switzerland since the 16th century, and although this method continued into the 19th century the resulting prints were not fast to light or soap and water. The *indiennes* industry of Switzerland, however, developed from the processes of indigo and turkey red dyeing rather than from block printing as such, and was introduced by Swiss printers who had worked in Holland and by French Huguenot refugees. The first printworks in Geneva was founded in 1687 by a group of local merchants and a Frenchman named Matthieu Marin. Other printworks followed and by about 1720 Geneva was an important calico-printing centre. During the latter half of the 18th century, however, the industry declined and by 1815 only two printworks remained in operation; by 1830 the Geneva industry was virtually extinct.

The calico-printing industry of Zurich was founded by David Esslinger in 1720, while that of Basel was founded in 1716 by Samuel Ryhiner, who had learned his trade in Holland. The most important centres of calico printing in Switzerland, however, were the cantons of Neuchbtel and Glarus. The first Neuchbtel calico printer was Jean Labran, who opened a printworks at Pré-Royer in 1715. By 1750 several others had come into operation.

One of the largest was that of Du Pasquier and Portales at Cortaillod, established in 1750 and by the beginning of the 19th century the largest in Switzerland, comprising more than 300 printing tables and a considerable number of roller-printing machines. The first calico printworks at Glarus was established in 1740 by Johann Heinrich Streiff, and the Glarus industry reached its peak in the 1840s.

Little is known of the Italian printworks apart from those in the Genoa area which specialized in the production of *mezzari,* large decorative panels copied from Indian models, the so-called "tree of life" being the commonest design. The most important factory was set up at Sampierdarena in 1787 by Michael Speich, a Swiss from Glarus, together with his cousin Luigi Testori, who succeeded to the business about 1830.

The earliest reference to calico printing in America is an advertisement in the Boston Newsletter of April 23, 1712, stating that a certain George Leason from England, together with a Boston clothier named Thomas Webber, had set up a printworks near the bowling green. Although similar advertisements are found with increasing frequency, it was not until the last quarter of the 18th century that textile printing can be said to have become an industry in the United States. One of the most important figures was John Hewson, an Englishman who, encouraged by Benjamin Franklin, set up a calico printworks in Philadelphia in 1774. His work was interrupted by the American Revolution, but he was able to resume his activities in 1789 with the assistance of a loan from the government. Although his output was considerable, and comprised both dress and furnishing fabrics and printed handkerchiefs, practically nothing has survived that can be attributed to him, although he is said to have printed a fine coverlet now in the Philadelphia Museum of Art. His factory lasted until sometime in the 1820s, the business being carried on by his sons. Among other 18th-century American printworks was that set up about 1790 at East Greenwich, R.I., by Herman Vandausan, a textile printer from Mulhouse. Other Rhode Island printworks included that of Schaub, Tissot and Dubosque (1794), and by 1840 there were 17 dyeing and printing establishments in that state.

Calico printing was also carried on in Massachusetts and New York. The first roller-printing machines in America were introduced in 1810 at the factory of Thorp, Siddall and Co. near Philadelphia, Pa.

Designs.—Although certain factories specialized in particular classes of goods, the general development of design in printed textiles was much the same throughout Europe and the United States, with the English and French printers taking the lead. Since surviving English and French textiles are far better documented than those of other countries, the general trend of design can best be studied by those examples.

The earliest surviving European examples were mostly printed in the limited palette of black, reds, purples and brown obtainable from madder dye, and the designs were often free adaptations of Indian floral patterns. Most of the earliest examples survive as linings to late-17th-century leather trunks or as linings to silk coats, stomachers and embroidered bags or purses. An important collection of impressions from early 18th-century textile printers' wood blocks survives in the Berch collection at the Nordiska Museet, Stockholm, which are mostly single- or two-colour prints mainly of floral designs, characterized by fairly elaborate cutting of the wood blocks. Though knowledge of these early European fabrics block printed in the madder style is fragmentary and uncertain, it is clear that by the middle of the 18th century at the latest the European printers were able to add indigo blues and weld yellows to the basic madder colours, either printed by block or painted or "penciled" with a brush, and that by this time the printed fabrics had achieved a status that enabled them to exist in their own right, not merely as cheaper substitutes for woven fabrics.

A folio volume in the library of the Musée des Arts Décoratifs, Paris, contains 13 samples of English chintz, collected by John Holker in Lancashire in 1750 and presented to M. De Montigny of the French Royal Academy of Sciences. These samples, which are quite unfaded and fully annotated, show that by this time the English calico printers were able to produce well-drawn floral designs using the full range of colours obtainable from madder dye, together with indigo and weld yellow. Supplementary evidence of the skill of the English calico printers at this time is found in a series of original designs and impressions from wood blocks (in the Victoria and Albert museum) by John Baptist Jackson, who worked as a calico printer for a few years before he set up as a wallpaper manufacturer in 1752.

3. Copperplate-Printed and Later Block-Printed Textiles.—In the middle of the 18th century, the introduction of copperplate printing radically transformed the appearance of European printed textiles by allowing a fineness of detail and delicacy of drawing that had not been possible with the comparatively coarse technique of wood-block cutting. Copperplate printing on textiles was invented in 1752 at the Drumcondra printworks, near Dublin, by Francis Nixon, who introduced the technique into England within the next four years. For the next two decades—apart from the short-lived factory of Gayet and Montgirod at Sèvres, France, which survived for only 18 months in 1760–61—Ireland and England retained a virtual monopoly of the new technique. From the beginning the technique of copperplate printing was admirably suited to the production of large-scale pictorial designs, with a repeat of about a yard square, covering a wide range of subjects including pastoral, mythological and theatrical scenes, chinoiseries and subjects commemorating important military and political events. It was also widely used for finely engraved floral designs for both dress and furnishing fabrics. Few documented Irish examples have survived but pattern books (in the Musée de l'Impression sur Étoffes, Mulhouse, and the Victoria and Albert museum) containing over 400 different impressions from English calico printers' copperplates, as well as a vast quantity of extant plate-printed textiles, testify to the excellence of the English productions. Although a number of the English pictorial designs have certain affinities with the French toiles de jouy (see below), a particularly striking group of designs with large flowers and birds seems to be especially characteristic of the English printers.

The copperplate designs were almost invariably monochrome, being printed either in blue, red, purple or sepia. One English factory, that of the Wares at Crayford, is known to have printed in copperplate in two colours. In a few instances, such as the textile printed by Robert Jones at Old Ford in 1769 (Victoria and Albert museum) and the "volunteer furniture" printed by Edward Clarke at Palmerstown, Ire., in 1783 (National museum, Dublin) additional colours were added to the basic copperplate design by printing from wood blocks or by hand painting.

Although evidence has shown that generally speaking the English surpassed the French in copperplate printing, the credit for its development previously was given to Christophe Philippe Oberkampf and his factory at Jouy. Oberkampf, the son of a cloth printer and dyer, was born in Germany but moved with his father to Aarau and acquired Swiss nationality. After working first at the Cour de Lorraine factory at Mulhouse and then at the Arsenal at Paris he set up a small factory at Jouy-en-Josas, near Versailles, where his first print was produced on March 1, 1760. Four years later, in 1764, new buildings were begun and, owing to Oberkampf's unrivaled technical skill combined with his flair for singling out the best French designers, Jouy became the foremost printworks in France. The productions ranged from small, block-printed designs for dress fabrics to large-scale pictorial prints for furnishings.

According to the biography of Oberkampf, the secrets of copperplate printing were brought to Jouy in 1770 by his brother Frédéric, who had seen it in use at Morat, near Neuchâtel in Switzerland. However, no surviving Jouy copperplate prints can be positively dated earlier than 1783, the date of the famous Travaux de la Manufacture. This design was the work of Jean Baptiste Huet, who became the factory's chief designer. Most of Huet's early designs were of pastoral scenes, such as "Offrande à l'amour," "La Fête de la fédération" and "Les Plaisirs de la ferme." After the Revolution Huet followed the general trend toward classicism and produced a series of designs in the Directoire style including the "Scènes Pompéiennes" and "Le Loup et l'agneau." Examples of his work can be seen in the Musée des Arts Décoratifs, Paris. Other prominent designers who worked for Oberkampf were Hippolyte le Bas. who specialized in architectural subjects such as "Les Monuments de Paris," and Horace Vernet, who specialized in hunting scenes. Although Oberkampf's reputation was such that the term toile de jouy became a generic description for all copperplate textiles, other French factories produced designs of equal distinction. among them the firm of Favre. Petitpierre et Compagnie (founded 1760) at Nantes and that of J. P. Meillier at Beautiran, near Bordeaux (founded 1792).

The introduction of copperplate printing did not, however. eclipse wood-block printing, and the two techniques developed side by side. The most popular wood-block designs continued to be floral, including designs based on the successive fashions in 18th-century woven silks. There is little basic difference between the wood-block-printed chintzes of the 1760s and 1770s, but in the 1780s several different styles emerge, including coiling floral designs with broken stems based on Indian models and large-scale arborescent designs often incorporating birds. Two parallel styles are especially characteristic of the last decade of the 18th century: first, designs on an almost black madder ground with delicately drawn mossy trails, which in England were popular for both dress and furnishing fabrics though in France they seem to have been limited to dress fabrics; second, designs of alternate vertical stripes, one on a white ground, the other on a dark, which were equally popular. This second type was virtually limited to England, while France favoured designs of detached sprigs of flowers, ears of wheat and insects, characterized by fine and precise cutting of the wood block.

Although finely engraved copperplate prints continued to be produced in France until the early 19th century. copperplate printing was in decline in England by that time. Most of the English factories that had specialized in copperplate prints were in London or the home counties. Among the most important were Robert Jones (c. 1760–80), Old Ford; Nixon and Co. (c. 1752–89), Phippsbridge. near Merton, Surrey; Bromley hall (c. 1740–1823), Middlesex: John Munns (*c.* 1769–84), Crayford, Kent; and Joseph and Mary Ware (c. 1760–81), Crayford.

Calico printing in Lancashire was established about the middle of the 18th century with an important offshoot in Carlisle, and from the onset the Lancashire and Carlisle printers concentrated on the production of wood-block-printed chintzes. By the beginning of the 19th century, most of the London copperplate printworks had closed down and with the shift of emphasis to Lancashire wood-block prints predominated. The leading factory in the production of high-class wood-block "furniture" prints was that at Bannister hall (founded c. 1798). near Preston. Lancashire, which. under successive changes of ownership, remained in operation until 1893.

The Bannister hall records dating from 1799 to 1840 include a continuous series of about 3.800 documented samples of printed cottons supplemented in most cases by the original designs, which provide an invaluable and accurate guide to the prevailing styles throughout those years, particularly since Bannister hall set the fashion for the other factories.

By 1800 the dark-ground style had given way to the so-called drab style, printed in yellow, olive, brown and buff, and the meticulous drawing of the 1790s was replaced by a broader technique with coarser cutting. The French copperplate Directoire prints were paralleled in England by a brief fashion in the years 1804–06 for "classical" and "Egyptian" designs, printed in hot "Pompeian" colours, and for *chinoiserie* designs incorporating figures. buildings and vases; "Indian" designs on bright-red grounds were also popular. Among the other wood-block styles popular in the early 19th century were designs incorporating game birds and architectural features. Panels printed for incorporation into patchwork quilts were produced in considerable quantity in the years around 1815.

4. Roller-Printed Textiles. — Although roller printing was invented by Thomas Bell as early as 1783 and was certainly used in the production of small-scale dress patterns by the beginning of the 19th century, it had little general effect on the design of printed textiles until about 1815. Thereafter in England the technique was used for pictorial prints, often of scenes of hunting and other sports and pastimes, but the designs were generally cruder than those of the 18th-century copperplate prints. In France the technique was widely used for a vast range of pictorial designs, often with diagonally hatched or finely diapered grounds.

From the 1820s onward the development of roller printing led to a vast increase in the output of printed textiles, although high-class furniture prints continued to be printed by wood block in the traditional madder style. In the 1820s the standard of engraving on the metal rollers was often extremely high. The actual engraving of the rollers was generally done not by the printers themselves but by special firms. One of the leading firms of engravers was Joseph Lockett of Manchester (later Lockett, Crossland), which supplied engraved rollers not only to the English calico printers but to printworks throughout Europe. This firm was largely responsible for the "fancy machine grounds" or "cover rollers" in which the whole background of the fabric was covered with elaborately engraved diaper patterns.

These enjoyed a considerable vogue in the 1830s and were often used as a background to the traditional, wood-block-printed floral chintzes.

5. Decline and Revival of Textile Design. — Until about 1810 all printing, with the exception of low-grade fabrics printed in fugitive colours, was based on the use of vegetable dyes, which in practice meant madder, indigo and quercitron. From then on, however, the competitive efforts of the French. German and English chemists resulted in a series of new chemical resists and discharges for transforming the appearance of the old vegetable dyes, and new methods for the use of colours such as prussian blue, cochineal pink and catechu brown. In addition, a completely new range of mineral dyes, including manganese brown, chrome yellow and antimony orange, and a "solid green" were placed at the disposal of the textile printers. These new discharges, resists and mineral dyestuffs had brought about a radical change in the appearance of printed textiles more than 20 years before W. H. Perkin's discovery of the aniline dyestuffs in 1856.

The combination of the indiscriminate use of these new colours, which were eminently suitable for roller printing, and a lower standard of engraving and design led to a gradual deterioration in printed textiles that was increasingly apparent from 1835 onward. A vast amount of cheap, roller-printed fabric was turned out by the English and European printers in a great variety of styles, ranging from floral designs and elaborate pictorial prints of romantic and sentimental subjects to various exotic styles intended for overseas markets. The eclecticism of the designers knew no bounds, and the 19th-century "battle of styles" was reflected in printed textiles that combined rococo, Gothic and classical elements with paisley motifs. tartan ribbons and a host of miscellaneous ornament. Even so, throughout the 1840s and 1850s, both the English and French and particularly the Alsatian printers continued to produce well-drawn floral chintzes, printed by wood block in the madder style, for the high-class furniture trade. Many of these were printed on challet, a fine worsted wool, instead of on cotton, which gave an added richness and depth to the colours Although the Alsatian printers maintained a high standard of technical excellence, little of distinction was produced throughout the 1860s and 1870s.

The revival of textile printing as a fine art and the revival of the decorative arts generally that came about in the later 19th century must largely be credited to William Morris. Morris produced his first design for a printed textile in 1873, the first of 44 different designs for chintz. all of which were printed by hand with wood blocks and, with one or two exceptions, with vegetable dyes. Several of his finest chintzes, including the well-known "Strawberry Thief" (1883), were printed by the laborious and obsolete method of indigo-discharge printing. There is little doubt that the Morris chintzes printed first by Sir Thomas Wardle at Leek, and later at Morris' own workshops at Merton abbey, are among the finest printed textiles of all time.

The 1870s also saw the production of printed textiles influenced by Japanese art, with highly stylized flowers whose flat symmetrical petals were set against fretted backgrounds. In the 1880s a heavily textured cotton known as cretonne and velveteen were much used for printed furnishing fabrics, while some of the finest dress fabrics were printed on silk. From 1880 onward there was an increasing tendency for textile printers to commission designs from leading architects, artists and professional designers, which did much to raise the general standard of production. Throughout the latter part of the 19th century and the 20th century, the styles in printed textiles have closely followed the general development of the decorative arts. In the years around 1900 the influence of Art Nouveau (*q.v.*) was apparent. and outstanding printed textiles in this style were produced by firms such as Liberty of London.

In the 20th century modern movements in painting and the influence of the Ballets Russes and the Bauhaus in Germany led to the development of geometrical and abstract designs, usually printed in strong, vivid colours, often emphasized by black outlines. In England the move toward abstract design was fostered by the Omega workshops. founded by Roger Fry and a group of artists, for whom in 1913 the Maromme printworks of Rouen produced a series of printed textiles. A leading firm that did much to popularize the new styles was that of William Foxton, who from 1917 commissioned designs from leading artists including Charles Rennie Mackintosh and Claude Lovat Fraser. In France outstanding printed textiles were produced by the firm of Bianchini Ferier to the designs of Raoul Dufy and other painters. The later 1920s and early 1930s saw a return to more subdued, pastel colours and floral designs. characterized by overlapping segments and highly stylized flowers. This style achieved widespread currency at the Paris exhibition of 1925.

6. Screen-Printed Textiles.—In the 1930s the development of screen printing finally removed all restrictions from the designer and allowed enterprising manufacturers to try out short runs of experimental designs without incurring the heavy expense of engraved rollers or resorting to the laborious process of hand-block printing. This has resulted in an ever-increasing variety of design in printed textiles and at the same time extended the practice of commissioning designs from artists rather than professional designers.

Between World Wars I and II there was an important revival of hand-block printing in England on the part of a number of artist-craftsmen who produced both dress and furnishing fabrics, designing, cutting and printing the blocks themselves. Most of these fabrics had simple patterns produced in dark low tones, often with vegetable dyes, no doubt as a reaction against the garish colours and elaborate designs of the mass of commercial production.

In most countries there was little advance in the design of printed fabrics during World War II but after the war the development of mechanical screen printing brought an even greater variety of printed textiles. In the postwar years Scandinavia achieved a considerable reputation for printed textiles. Danish manufacturers mere pre-eminent in the development of floral design, while Sweden and Finland tended to concentrate on crisp, geometrical patterns. With modern printing techniques the translation of any type of design onto cloth is possible. In contemporary screen-printed fabrics the designs range from abstract patterns imitating the work of Tachist and Action painters to elaborate florals, often with huge-scale repeats.

7. Oriental Textiles.—Persia.—The block printing of textiles in Persia may be traced back certainly to the 17th century. The journal of Jean de Thévenot (1633–77). *Relation d'un* voyage *au* levant, describes fabrics in which "the flowers and other paints are stamped upon them with a mould besmeared with colours" The French traveler Jean Chardin. in his *Voyages* en Perse (published in 1686), describes not only the painted cloths, similar to those from India. but also taffetas and satin, block printed with gold and silver with calligraphic. floral or pictorial designs Painted and printed textiles produced in Persia were exported to Europe to the East India company in the late 17th and 18th centuries, and although records describe the textiles as "perses" it seems that little distinction was made between those of Indian and Persian origin.

Persian textiles of the 18th and 19th centuries with patterns produced by a combination of block printing and hand painting survive in considerable quantity in the form of wall hangings, prayer mats, curtains for doors or niches, bed coverings and shrouds. Most of the designs are floral but incorporate pine cone and other decorative motifs.

China.—Chinese resist-dyed silks, dating from the 7th or 8th century A.D., are preserved in the Shōsō-in, the imperial treasure house at Nara in Japan, and similar fragments were discovered by Sir Aurel Stein in eastern Turkestan. From the 18th century onward floral patterns painted in body colour on silk were made for export to Europe to be made up as dresses or hangings. A number of ecclesiastical vestments of Chinese painted silk dating from the 18th century also survive.

Japan.—It is probable that the Japanese learned the art of resist dyeing from the Chinese. A fragment of Japanese silk stenciled with the Buddhist sacred wheel is believed to date from the 8th century, and stenciled patterns are generally characteristic of Japanese work. Block printing was also practised in Japan and included a method known as negative block printing in which the hollowed-out parts of the block. not the relief portions, are charged with colour. The form of resist dyeing known as tie-and-dye work was extensively practised in Japan, as well as in India. China and other parts of Asia, and in Africa. In Japan this method was known as the *shibori* process, and in the 18th- and 19th-century examples the process is often combined with embroidery.

(B. J. Mo.)

Javanese Batik.—Batik is a Javanese word applied to the wax-resist technique of pattern dyeing on cloth, as practised there. Those parts of the cloth not required to take the dye are covered with hot wax, after which the whole fabric is dipped in the dye vat, an operation repeated according to the number of colours in the pattern.

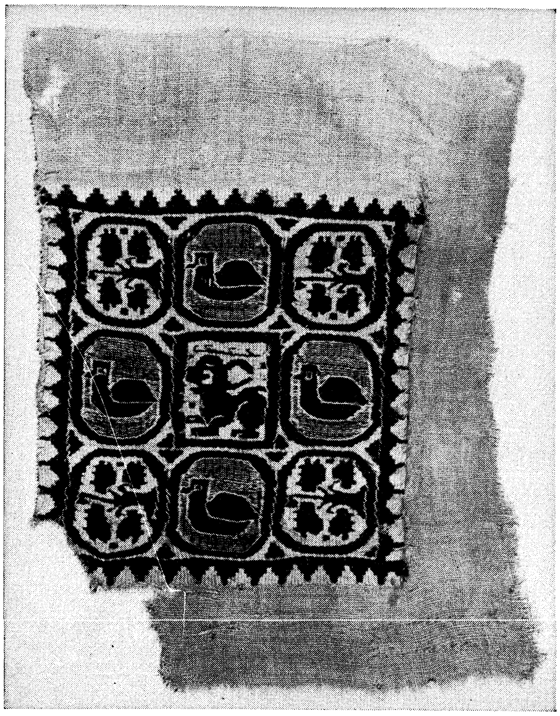
It is doubtful if any batiks preserved in museum collections date from before the 1750s, and therefore little is known about the origins of this technique in Java. However, there is evidence that a simplified batik technique (possibly copied from India) was widely practised independently in southeast Asia: the Toradjas of Celebes (Sulawesi), for instance, until the second half of the 20th century produced simple batiks, applying the hot wax by means of a narrow, flattened strip of bamboo. The decisive advances in Java, probably in the 18th century, seem to have resulted from the invention of the *tjanting*, a small copper crucible with a projecting spout and a bamboo handle. It is filled with wax and the pattern is drawn on the cloth with the molten wax which runs out of the spout. The cloth is elaborately washed and soaked to secure the right texture and surface and is then hung over a frame. the artist, usually a woman. sitting cross-legged before it. The design is sometimes first sketched in charcoal, but the best artists use only their *tjantings*, relying on visual memory. They outline the area that is to be dyed and cover the rest of the surface with wax The cloth is turned over and the operation repeated on the other side.

The cloth is then immersed in cold water till the wax hardens and is afterward dipped in the dye vat. The wax is removed, leaving exposed other parts of the cloth to be dyed different colours by the same process. The traditional colours are indigo blue, madder red and brown; secondary colours are produced by dyeing one colour over another.

In the 19th century copper-mounted wood blocks for applying the wax to the cloth were introduced. This. known as *tjap* printing, has almost entirely superseded the more laborious and highly skilled *tjanting* process. Batik was traditionally used almost entirely for clothing.

III. INDIAN TEXTILES

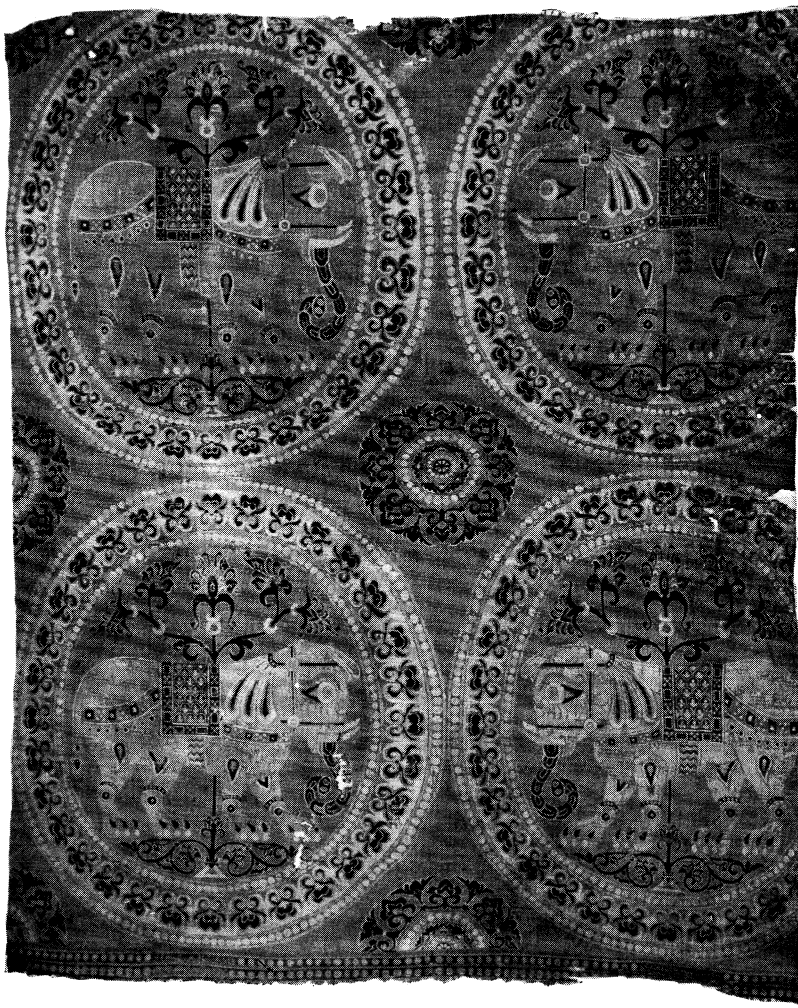
From early historic times India was famed for its textiles. This is known from literary and archaeological evidence, although very few fabrics of a date earlier than the late 16th century survive.



Near eastern silk with half-bird, half-dog design, thought to have come from a reliquary in the church of St. Leu, Paris; about A.D. 700–900

Panel tapestry woven of tan wool and purple linen; probably Egyptian or Mesopotamian, dating from the 5th or 6th century

Patterned cotton, woven in double cloth, with cat motif; relic of the pre-Columbian civilization of Peru



Byzantine elephant silk from the tomb of Charlemagne at Aachen, Germany; 10th century

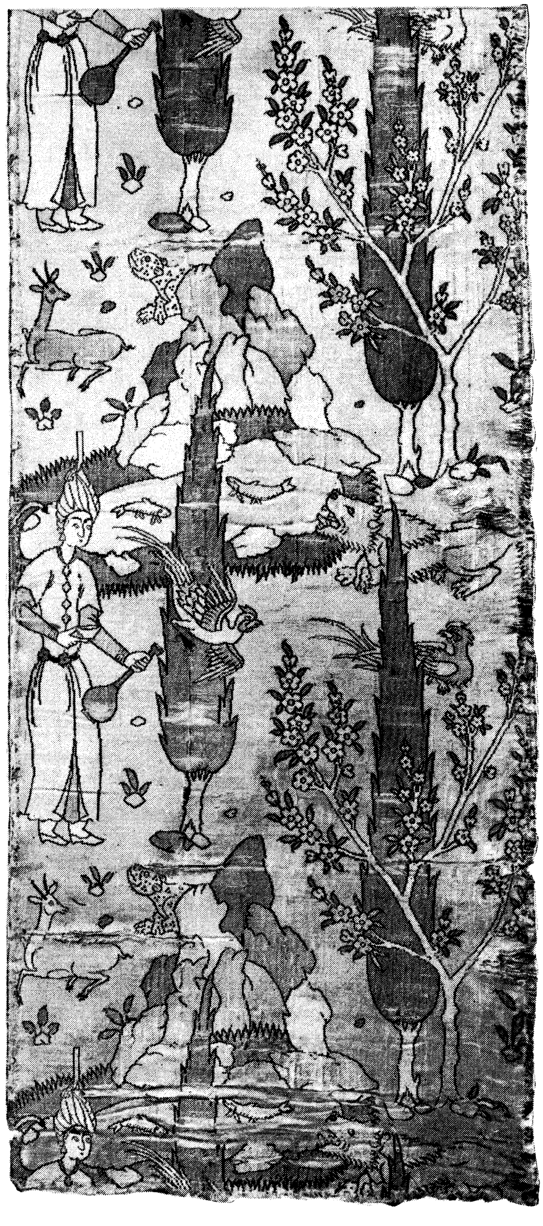
WOVEN TEXTILES: AMERICAN AND NEAR EASTERN

BY COURTESY OF (TOP LEFT) VICTORIA AND ALBERT MUSEUM, (BOTTOM LEFT) "CIBA REVIEW," CIBA LIMITED, BASLE, SWITZERLAND, FROM THE FRITZ IKLÉ COLLECTION, BASLE MUSEUM OF ETHNOLOGY, (BOTTOM RIGHT) THE CATHEDRAL OF AACHEN, PHOTO BY A. BREDOL-LEPPER; PHOTOGRAPH, (TOP RIGHT) JACK SKEEL FOR ENCYCLOPÆDIA BRITANNICA, INC

TEXTILES

Northern Italian silk woven with gilt membrane. The design, composed of stags, hounds, lions and phoenixes, shows the influence of Chinese decoration which prevailed in Italy during the last half of the 14th century

Persian fabric woven with a cup-bearer motif in the tradition of Persian illuminated manuscript design; 16th century

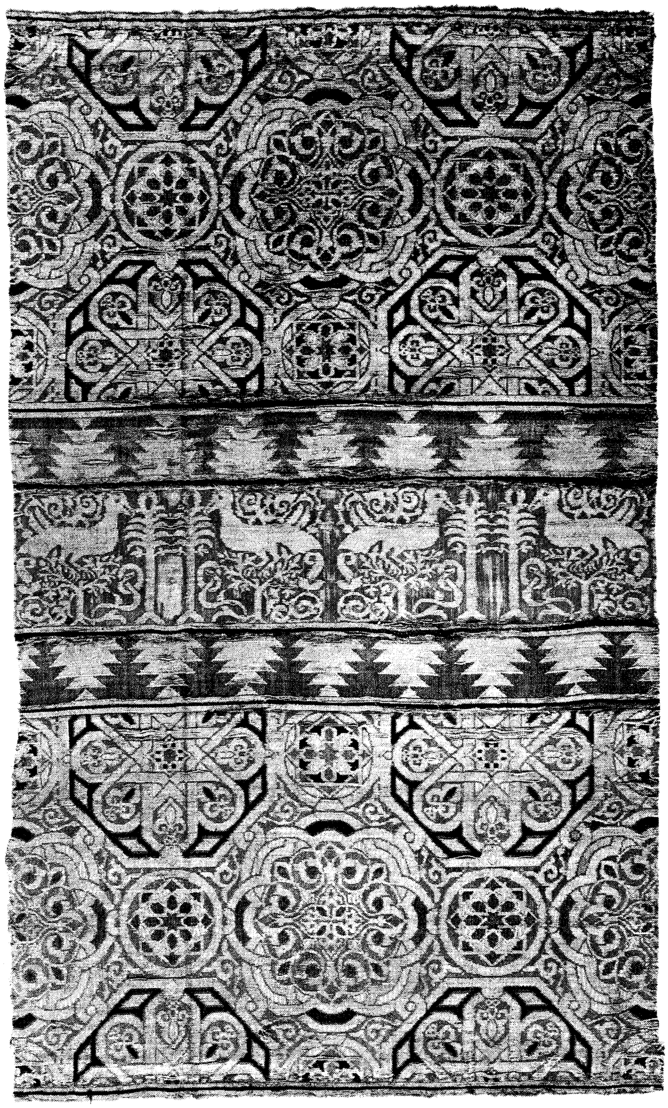


WOVEN TEXTILES: 14TH- AND 16TH-CENTURY NORTHERN ITALIAN AND PERSIAN

WOVEN TEXTILES:
SILK DAMASK,
SILK AND VELVET BROCADES

K'o-ssu, Chinese woven silk damask; early 18th century. Textiles of this quality were not introduced in Europe until the 19th and 20th centuries

Italian cut velvet brocaded with gold loops in a curving pomegranate design characteristic of late 15th- and early 16th-century textile fashion in Italy

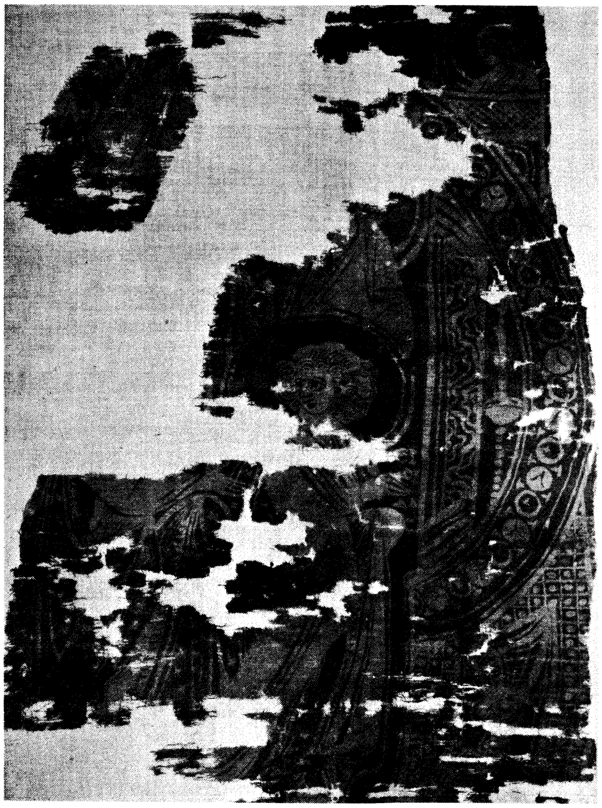


Hispano-Moresque silk brocaded in gold. The design is a blending of near-eastern ornamentation and Spanish-style decoration

BY COURTESY OF MUSÉE HISTORIQUE DES TISSUS; PHOTOGRAPH BY RENÉ BASSET

WOVEN TEXTILES: LATE 18TH-CENTURY FRENCH

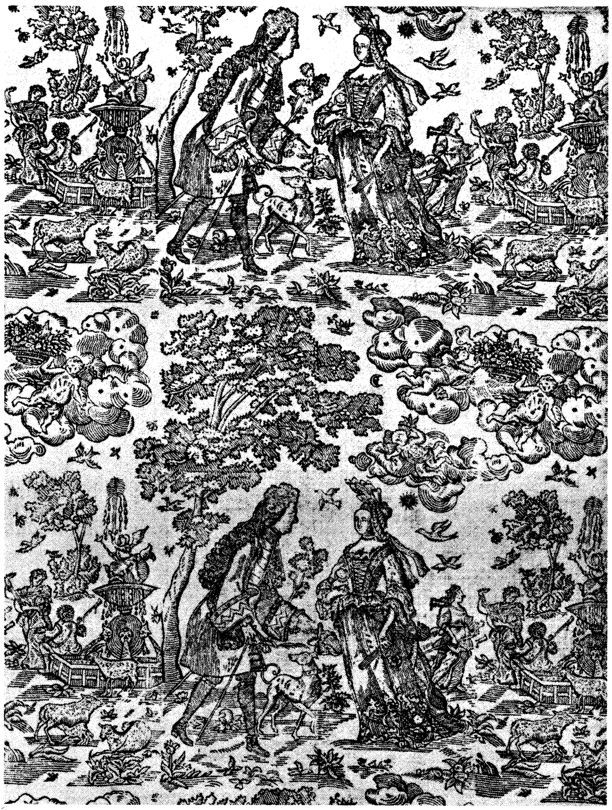
Woven silk textile hanging from the queen's chamber at Fontainebleau by Philippe de la Salle of Lyons, who designed a series of furnishings adorned with lifelike birds and flowers



Fragment of indigo resist-dyed linen found in the burial grounds at Akhmim, upper Egypt; believed to date from the 9th–10th century A.D.

Linen chasuble, wood-block printed in black with a design of stylized flowers and birds; Italian, dating from the end of the 15th century

Resist-dyed linen with a design showing Joshua and Caleb returning from the Promised Land; German (Rhenish), late 17th century



Diapered linen, block printed in black with a design said to represent Louis XIV and Madame de Fontanges; French, late 17th century

PRINTED TEXTILES: BLOCK-PRINTED AND RESIST-DYED LINENS

BY COURTESY OF (TOP LEFT AND RIGHT) VICTORIA AND ALBERT MUSEUM; PHOTOGRAPHS, (BOTTOM LEFT AND RIGHT) JACK SKEEL FOR ENCYCLOPÆDIA BRITANNICA, INC.

TEXTILES

Cotton and linen, copperplate printed in purple. Other colours were added to the design by printing from wood blocks and by penciling. By Robert Jones at Old Ford. 1769

Wood-block-printed cotton in madder colours. Blue added by hand penciling. Printed at Fordingbridge, Hampshire, about 1790

PRINTED TEXTILES: 18TH-CENTURY ENGLISH

Block-printed cotton from the factory of Christophe Philippe Oberkampf at Jouy, leading printworks in France during the 18th century. This piece, *c.* 1780

English cotton with pillar design, block printed on dark ground in madder colours, principally brown, tan and red; dating from about 1800

"L'Offrande à l'amour," copperplate-printed cotton by Jean Baptiste Huet, chief designer for Oberkampf, whose early designs were pastoral scenes, such as this one printed at Jouy about 1804

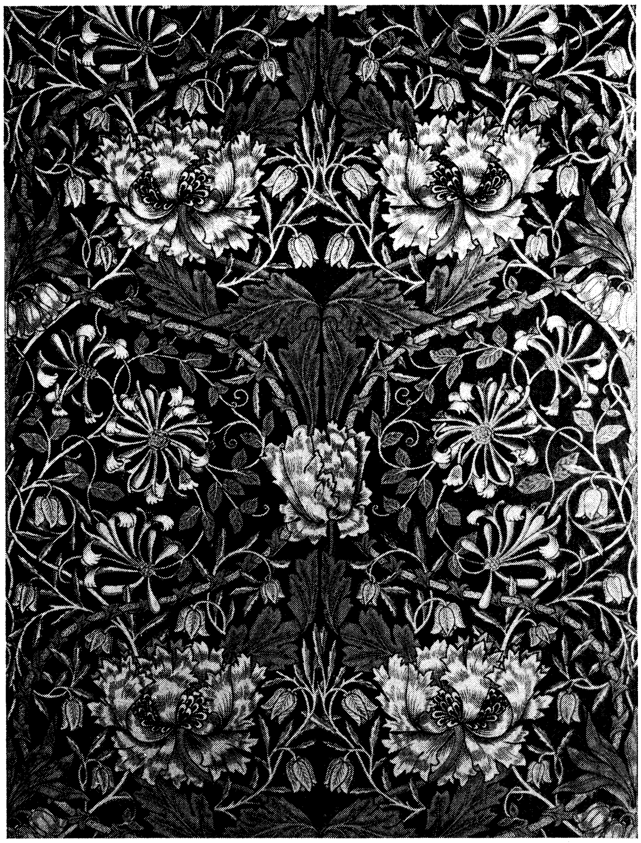
English cotton, plate printed in red: by Nixon and Co., Phippsbridge, Surrey, one of the leading English copperplate-printing factories. This piece dates from about 1770

PRINTED TEXTILES: FRENCH AND ENGLISH BLOCK PRINTS

TEXTILES

Above: English roller-printed cotton by Samuel Matley, Hodge, Cheshire: 1824. Roller printing greatly accelerated the output of printed textiles during the early 1800s

Left: English block-printed cotton in madder colours from Bannister hall, Lancashire; 1836. Founded *c.* 1798, Bannister hall designs set the style for other textile factories



"Honeysuckle," English block-printed chintz designed (1876) by William Morris, who revived textile printing as afins art during the 19th century

"L'Afrique," French block print on cotton and linen designed by Raoul Dufy lor Bianchini Ferier of Paris; dating from about 1924

PRINTED TEXTILES: ENGLISH AND FRENCH BLOCK AND ROLLER PRINTS

BY COURTESY OF (BOTTOM LEFT AND RIGHT) VICTORIA AND ALBERT MUSEUM; PHOTOGRAPHS. (TOP LEFT) JACK SKEEL AND (TOP RIGHT) C. H. CANNINGS FOR ENCYCLOPEDIA BRITANNICA, INC.

The decorative techniques traditional from early times are embroidery, resist dyeing, hand painting (with mordants) and brocading. A wide variety of materials have been employed for weaving, but the one most commonly used was cotton. Excavations at Mohenjo-Daro have shown that cotton was woven at least as early as the 3rd millennium B.C. The few minute fragments discovered owed their chance survival to impregnation with silver salts, absorbed from the walls of the silver vase in which they had remained for at least 4,000 years. Traces of purple dye, thought to be madder and therefore suggesting an early knowledge of dye chemistry, add to the significance of the discovery, while the numerous spindle whorls found at the same site—some of crude pottery and others of more expensive faïence—suggest that spinning was practised extensively and by all classes. Contemporary sculptures and terra-cottas show that at least two articles of costume for which India became famous, the girdle and the shawl, were already worn at this period.

Evidence is lacking for the thousand years following the collapse of the ancient city-states of the Indus valley; but the Greek physician Ctesias, writing in the early 5th century B.C., mentions the popularity of brightly coloured Indian textiles among the Persians, an indication that Indian fabrics were being made for export at least as early as this period. It is not known when they first reached Europe, but the use of the oriental word *carbasina* (Sanskrit *karpasa)* for cotton in the *Pausimachus* of Statius Caecilius suggests that it was before 200 B.C. Strabo, on the authority of Megasthenes *(c.* 300 B.C.), recorded the Indian love of finery and ornament, and added, "Their robes are worked in gold, and ornamented with precious stones, and they also wear flowered garments of the finest muslin."

During the 1st century A.D. Indian muslins became famous in Rome under such names as *nebula, gangetika* and *venti* textiles ("woven winds"), the latter exactly translating the technical name of a special type of Dacca muslin still being made in Bengal in the 19th century. Silk was also an important export to Rome, both as yarn and as finished cloth, but the author of the *Periplus (Circumnavigation of the Erythraean Sea),* written sometime between A.D. 50 and 130, makes it clear that the raw material was imported into India from China. Wild silks had been woven in India before this, but there is no proof that the domesticated silkworm was introduced into India from China before the medieval period.

Although there is no specific mention of dyed cottons in the *Periplus,* excavations at the site of the Indo-Roman trading station at Arikamedu, near Pondicherry, have revealed that large-scale dyeing operations were undertaken in the immediate vicinity of the port. Further proof that the Indian dyer was already famous in the Roman world for his skill is indicated by a reference in St. Jerome's 4th-century Latin translation of the Bible, Job being made to say that wisdom is so enduring that it "may not be compared with the dyed colours of India." There is also evidence that by the 8th century A.D. Indian dyed cottons were known in England, for Bede records in his *Life of St. Cuthbert* that the Synod of Clovesho forbade priests to wear clothes *tinctae Indiae coloribus* ("dyed with Indian colours").

Indian textiles of the medieval period can be studied in some detail from the Ajanta wall paintings (particularly those attributed to the 6th century A.D.). Apart from embroidery, at least four distinct techniques can be identified: *bandhana,* or ordinary tie-and-dye work; double tied-resist dyeing *(ikat);* brocading; and fine muslin weaving.

From the 12th century onward Indian dyed cottons were exported in bulk to Egypt, and many such pieces have been recovered from the sites of old urban rubbish dumps, especially at Al Fustat (Misr al Qadimah), the exceptionally dry climate accounting for their preservation. 'These are the oldest Indian patterned fabrics surviving

From earliest times there have been two distinct weaving traditions in India. The first was the domestic one, practised in every village into the 20th century and mainly concerned with meeting local needs. The second was the more specialized tradition of commodity production, mainly concentrated in or near market towns and characterized by guild organization. Whereas in the oldest literary records (such as the Rigveda) the weaver is feminine, the development of commodity production in the 1st millennium B.C. seems to have established professional weaving as an exclusively male occupation. During the 2.000 years between the Roman period and the decline of the handloom industry in the 20th century the main areas of commodity production remained the same. They are described in the *Periplus* in much the same terms as they were described by travelers of the 17th and 18th centuries. These main areas were: the west of the subcontinent with Gujarat, Sind and Rajasthan as the focus; south India, comprising the Coromandel coast as it used to be known, stretching from the Kistna delta to Point Calimere; and the lower Ganges valley, between Varanasi (Benares) and the Delta. The main reason for this disposition of the industry was of course geographical. Each of the three areas could offer ports suitable for foreign shipping, and also comparative ease of inland communication.

From the 16th century onward Indian pattern and design were much influenced by Persia. This influence reached India in the first place through Islamic court fashion; but by the 17th century it had spread to the villages. Many of the sprigged patterns and floral diapers so characteristic of the Indian block printer's art of later centuries were derived from Safawid Persia. The history of mordant printing with blocks (as opposed to the application of mordants by brush) is complicated, and it is not possible to establish with certainty that the former technique was practised in India before the period of Islamic influence. The balance of available evidence suggests that the technique of mordant printing with blocks reached India about the 17th century from Turkey.

One of the oldest traditional techniques of textile decoration and one that has been very widely practised in India is *bandhana.* Portions of a silk or cotton cloth are tied tightly with wax thread before the whole cloth is dipped in a dye vat; the threads are afterward untied. the parts so protected being left uncoloured.

The technique of *ikat* or double-resist dyeing, in which warp and woof are dyed separately by the tie-and-dye process before weaving. was practised in Orissa and the Deccan as well as in Gujarat. At Patan, in Gujarat, which produced the finest work of this kind in silk, such fabrics, known as *patolas,* were used especially as marriage saris. They were also extensively exported to southeast Asia from the 12th century onward. giving rise to many imitations in those countries.

The main centres of brocade weaving were Varanasi, Ahmedabad and the Deccan. The brocades for which India has been especially famed are woven silks in which part of the pattern is distinct from or supplementary to the wefts. Those woven in pure silk are called *amrus,* those with gold or silver thread in addition to silk, *kimkhabs* (Anglo-Indian, kincob).

Another form of brocading for which India was especially famous is the cashmere shawl. In this the technique corresponds to what in Europe would be called the twill-tapestry method. Coloured wefts are inserted by means of floating wooden bobbins on a simple loom. The weft threads alone form the pattern and do not run the full width of the cloth. being woven back and forth round the warp threads only where each particular colour is needed. The finest cashmere shawls were made of *asli tus,* the fleece frorn the underbelly of a particular species of wild mountain goat; the majority of shawls, however, were woven with the fleece of domestic goats, usually mixed with wool. The origins of the cashmere industry are obscure but can be traced back at least to the 15th century. Cashmere shawls were extremely fashionable in Europe between 1780 and 1880, during which period many European imitations were made on both drawlooms and Jacquard looms, especially at Norwich (Eng.) and Paisley (Scot.) and at various centres in France. The European imitation is always distinguishable from a cashmere original by the fact that in the latter the weft threads are inserted in the tapestry method and only for that portion of the required colour. not for the full width of the cloth.

Between 1600 and 1800 silk and cotton textiles were exported in large quantities from India to Europe mainly through the agency of the Dutch, English and French East India companies. The three classes of piece goods most in demand for this trade were plain-woven cottons (sold in competition with European linen), hand-painted cottons or chintzes (much coveted in Europe because of the brightness and permanence of their colours) and silk or mixed silk and cotton fabrics mainly used as dress materials. These goods were usually commissioned according to patterns sent out from Europe in the first place, but in the process of copying or adaptation the Indian craftsmen often infused an exotic spirit into the design's that actually increased their appeal in Europe. The importance of this trade is testified by the number of Indian textile terms assimilated into the English language: chintz, palampore, pajama, seersucker, dungaree, shawl and so on.

See also references under "Textiles" in the Index volume.

(J. C. I.)

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TEXTILES, HOUSEHOLD. This article describes the kinds of fibres and fabrics used in table linen. bed linen, tonels and kitchen cloths; offerssuggestions for selecting and buying such articles; and makes recommendations for their care, including laundering. For their manufacture see WEAVING and articles on the different fabrics. such as DAMASK and LINEN AND LINEN MANUFACTURES. See also EMBROIDERY; LACE and TEXTILES.

TABLE LINEN

Types of Fibre. — Linen is traditionally the most desirable of fibres for table coverings. Until the early part of the 20th century, in fact, they were almost invariably made from it. thus giving rise to the generic term table linen. Linen is very hard-wearing and is unaffected by the correct use of reagents for the removal of food stains and normal high-temperature laundering. If fully bleached during manufacture, it retains its whiteness during years of usage without recourse to an oxidizing bleach. and, if stiffened and well ironed. it has a crispness and sheen which contributes much to the attractiveness of a well-appointed table. Linens represent beauty and luxury. and so well do they wear that they are often passed from one generation to the next as cherished heirlooms. Cotton also is suitable for use in table-cloths. as it can be laundered at high temperatures and is not harmed by the correct use of the normal stain-removing agents, but it does not have quite the crispness or sheen of linen. The mercerization process does, however: increase the sheen. Cotton will readily take bright dyes which are fast to washing, so that gay-coloured patterned tablecloths can be manufactured.

Viscose rayon is a versatile fibre that can be finished to simulate linen or cotton and is less expensive than either. It can be treated to withstand normal washing but it is not so resistant to stain-removal agents as linen or cotton. It has a soft handle and therefore drapes easily, and it can be dyed to give lasting. pleasing pastel shades for coloured or patterned cloths. The chief virtues of such man-made fibres as nylon, Orlon and Dacron (Terylene) for table coverings are their ease of laundering and low moisture absorption. Cloths made from them require only washing and drying. without further finishing. and food stains can usually be removed very readily since they are not absorbed. Like rayon, these man-made fibres can be treated during manufacture so that the finished product may have the appearance of either cotton or linen. Oilcloths, pyroxylin covers and those manufactured from plastics of the polyethylene and polyvinyl types offer at low cost table coverings that are resistant to moisture and to soiling (but not to heat) and can be cleaned by wiping. Paper tablecloths are also on the market.

Types of Fabric. — Damasks remain the aristocrat of table linens and are usually made from linen fibres, but cotton, rayon. man-made fibres and blends or mixtures of these with each other or with linen are sometimes used. Damask is a single-structure fabric woven on a Jacquard loom. The designs. which may be geometrical or floral, are obtained by the use of long floats on a satin or twill background. Damask may be single or double. Only high-quality long fibres are used for spinning the thread from which double damask is made and this, together with the long floats, leads to a closely woven fabric with a high sheen, having more yarns per square inch than single damask. In single damask, the proportion of weft to warp threads is roughly equal, but in double there are more weft than warp, often in the proportion of three weft to two warp. Single damask usually has less than 160 threads per square inch whereas double has more than 170 per square inch.

Ginghams are medium- and lightweight cotton fabrics woven with dyed yarns to produce striped or checked effects. Cloths made of seersucker. a crinkled cotton fabric that does not require ironing, are usually in brightly coloured stripes or checks.

Small cloths or cloths for special occasions may be embroidered either by hand or by machine. Hand-embroidered cloths from many countries. including China. Italy. Puerto Rico, Spain and Switzerland, are on the market. The embroidery may be in either cotton or linen thread to match the fibre of the cloth or may be in coloured threads, as is often the case with Chinese embroidered cloths. Special cloths may also be made from lace or have lace insertion. Originally lace was handmade but is now mostly machine-made. The thread used for making it may be either linen or cotton and many of the designs are traditional.

Oilcloths for table use consist of a lightweight cotton material which has a waterproof coating on one side and a backing of a plain loosely woven cotton cloth. This is then coated with several layers of a vegetable oil mixed with colour pigments and fillers. Afterward the surface may be finished to give either a dull or shiny appearance and may be printed or embossed. To give a soft undersurface. the backing is often napped or brushed. Pyroxylin covers are similar to oilcloths, but the cellulose coating produces a more flexible and durable surface and there is little tendency for pyroxylin to become brittle and crack, as does oilcloth.

Plastics are nonwoven materials made without yarns. Sheets are formed by molding, extruding and calendering. Decoration of the surfaces may be accomplished by printing, embossing: embroidery and chemical treatment; these modifications make interesting and attractive textures with patterns that simulate woven fabrics. Additional strength and increased versatility can be obtained by the use of fabric backings bonded to the plastic. Paper fabrics for use as tablecloths are usually made by a bonding process in which a cross-laid web of thermoplastic fibres is laminated on either side with high wet-strength cellulose webbing.

Table napkins are manufactured from the same fibres and woven into fabrics similar to those used for tablecloths. Materials suitable for place mats include, in addition to the fabrics named, terry cloth. cork and straw.

Selection of Table Linen. — Use or purpose is of primary importance in selecting table linen. It is customary to use white linen damask tablecloths for formal dinners and banquets, while pastel-shade damasks are suitable for luncheons, suppers and informal entertaining in the home. Lace. embroidered and other fancy linen cloths are suitable for afternoon tea. Breakfast cloths and those used for informal supper parties are usually bright in colour, often of gingham or seersucker. Oilcloths, pyroxylin and plastic are popular for table covers in kitchens and summer cottages. Clear, lightweight plastic may be placed over plain woven cotton or rayon cloths to serve as a protective cover. Decorated plastic and plastic-coated materials are often used as table covers for informal service.

For most occasions table napkins are chosen to match the cloth, in fibre content. weave and colour. For informal parties, contrasting napkins in gay colours are often used.

In selecting place mats, colours should be chosen to complement the wood of the table surface and the fabric or other material should suit the degree of formality of the occasion.

Size. — The size of the cloth for a particular table is determined by measuring the width and length of the table and adding on 20–36 in. to each figure to allow for an overhang (with an additional allowance if the material is not preshrunk). Tablecloths and napkins are made in a number of standard sizes. Table mats should be of a convenient size and shape to fit the table and. if place mats are chosen, they should be sufficiently large to hold a complete well-spaced place setting.

Quality and Durability. — The staple or average length of the fibres from which yarn has been spun is of fundamental importance, for the longer the staple. the better the wearing qualities of the fabric. The best-quality linen cloths are made from the long flax fibres called line. for the yarns will be uniform throughout their length and have a high lustre. The presence of short flax fibres called tow is indicated by the appearance of thick uneven yarns in the fabric. which will give a fuzzy surface when rubbed. The staple length of different kinds of cotton varies considerably. but for damask cloths only the longest, strongest and finest fibres can be used satisfactorily.

When comparing quality, yarn number or size and fabric count or number of yarns per square inch should be the leading basis for selection. Generally, fabrics containing the larger-sized yarns have a lower count. The relationship of yarn number and fabric count can be readily seen when one visualizes that the finer the yarns the closer they may be woven. All other factors being equal, the greater the number of warp or lengthwise yarns and weft or filling yarns, the stronger the fabric. Compactness of construction is especially important in damasks: the long floats formed as a result of the production of intricate patterns on the Jacquard loom may adversely affect the wearing quality of the fabric, if not closely battened during weaving. A good single damask is more durable than, and therefore preferable to, a medium- or low-grade double damask. A poor-quality cloth is sometimes treated with an excess of size to give the appearance of a compact and closely woven fabric. This may be determined by rubbing two surfaces of the fabric together; if too much filler has been used. a white. powdery substance will be apparent, In good quality fabrics only a minimum amount of sizing need be added to produce a smooth appearance, and therefore little powdery residue should be deposited.

Finishing techniques are also important. The durability of cotton damask is greatly enhanced when the yarns have been treated with a permanent antilint finish which enables the cotton to retain the smooth handle, characteristic of damask, through the many launderings which the cloth must of necessity withstand. If the item is coloured or printed, the kind of dyestuff and its method of application are of major importance. As a class, vat dyestuffs are considered to ha e the highest degree of colour fastness when properly applied. The dyes used on table linen must, of course, be those that are fast to washing. and fastness to light and to dry cleaning are also extremely desirable. Hems should be even and sewn with short, regularly spaced stitches. A plain hem is more serviceable than one hemstitched either by hand or machine.

How well household textiles wear depends to a large extent on how well they launder, and this in turn depends on the fibre, type of construction, colour fastness and presence of special finishes. Linen and cotton are outstanding in this respect: the fibres are stronger wet than dry and tlferefore resist satisfactorily any wearing action in the washing; they can withstand high-temperature washing and are unaffected by the correct use of heavy-duty or built detergents, so that it is possible to thoroughly remove soil from them. The man-made fibres such as rayon have properties similar to the raw materials from which they were manufactured. but. as the fibrous polymers are partly degraded in their reformation during manufacture: the man-made fibres show increased sensitivity to laundering conditions. The synthetic fibres such as nylon are hydrophobic (water-repellent) by nature; therefore soil does not penetrate easily into the fibres and food stains are easily removed by laundering. Construction is also important; in general, the smoother, firmer and closer the weave, the more stable the fabric. Some fabrics in fancy or loose weaves cannot be laundered satisfactorily when made from natural fibres because the material tends to lose its shape, but with the use of man-made fibres this difficulty is overcome. Special finishes, such as those to minimize shrinkage, reduce static effects and increase resilience. may necessitate slight modifications in washing methods.

Cost. — This varies with fibre content, quality of fabric, intricacy of design, special decorations and size. The most expensive cloths are made of linen. In damasks, the more intricate the design, the higher the cost. and damask table napkins and mats with an all-over design are cheaper than those with a central pattern. Hand-made lace and hand-embroidered cloths are often the most expensive; hand work such as appliqué and lace insertions also adds to the price oi the finished item. It may be assumed that cost increases with the size of the cloth. Though the initial cost of linen table coverings and napkins is generally greater than that for other fibres. the service to be expected from such fabrics when properly constructed and woven makes them an economically wise choice. Cotton, rayon and the man-made fibres alone or in blends are attractive and less expensive materials.

Cave *and* Storage. — Table linen well-laundered and carefully stored will have a long life and remain in good condition. If the cloth or napkin becomes stained or spotted during use, it is advisable, when possible, to remove these stains before they have had time to dry into the fabric. The stains normally should be treated with the appropriate reagent but where dealt with immediately water is ofteh all that is necessary. Table linen is laundered by the method suitable for the fabric from which the article is made. White linen damask cloths can be washed at high temperatures up to 160" F. with a fair degree of friction, whereas rayon cloths should not be washed at temperatures exceeding 120° F. with a minimum amount of friction; *i.e.,* shortest washing time. All table linen should be rinsed until the rinsing water is clear, and cotton and linen damasks should be stiffened either by the use of starch or by the use of a synthetic resin. White cloths should be ironed on the right side to give as high a gloss as possible; any appliqué or embroidery should then be raised after ironing by pressing on the wrong side on a padded surface. It is customary to fold table linen in screen folds. large cloths in four and table napkins in three each way, small cloths in whatever way is most suitable for use and storage. It is desirable to have as few folds as is consistent with ease of storage and handling, as the fewer the folds the neater the appearance of the cloth on the table. Table linen should be stored on shelves in cupboards or closets. The storage place should be dark, cool and airy to prevent yellowing and deterioration of the fabric. A place that is warm, such as the top shelf of an airing cupboard, is not suitable for storing linen for any length of time. It is better to have several shelves narrowly spaced rather than few with wide spacings, as shallow piles of linen make for a minimum amount of creasing. Though it is most usual to store table linen in piles folded and flat. fewer creases will occur if cloths are folded only one way and then lightly rolled around cardboard or paper tubes and stored in rolls. Tray and teacart cloths and table runners also can be stored satisfactorily in this way. If linens are to be stored for a long time all starch and sizing should be washed out carefully and the articles thoroughly dried before being put away, to minimize the danger of damage by mildew.

Table Pads. — Used underneath a large cloth. table pads protect the polished wooden surface of the table. help make for quieter serving and often add to the draping qualities of the cloth. The pad may be made of felt alone or of felt with a waterproof top surface. The pad may be of the exact size of the table or. if sufficiently soft to drape, may have an overhang. If the table is large it may be more convenient to have pads that fold in sections, as these are easier both to handle and to store.

BED LINEN AND COVERINGS

Bedspreads or Covers. — These should be chosen to complement the style and colour of the room furnishings. There are two main kinds. (1) those that are merely a rectangular piece of material large enough to cover the bed and hang down to nearly floor level at the sides (and foot, if there is no end board), usually called bedspreads: and (2) those that are tailored, known as fitted bedcovers Spreads and covers should be colour-fast not only to washing and dry cleaning but also to light; lint-free; and crease-resistant.

Spreads may be made from all types of fibres and fabrics and may be woven or tufted. The two major divisions of woven bedspreads are known as Jacquard woven and non-Jacquard woven. Jacquard designs are generally more elaborate as they are produced on the versatile Jacquard loom: patterns include the quilted, raised, stitched and flat types. Plain and crimped constructions are included in the non-Jacquard woven category. All types of fibres and yarns can be used but in every case the weave should be firm and compact.

Tufted fabrics used for spreads, designated by such terms as chenille. candlewick and hobnail. are made by inserting yarn into a plain-woven ground material and slipping the loops to form tufts of short fluffy yarns. Tufts may be spaced intermittently or arranged in uninterrupted rows. A good-quality tufted fabric has a closely woven background and firmly secured pile. In buying a tufted spread it is important to see that the pile is lint-free.

Fitted covers may also be made from all types of fibres and weaves. but they are rarely tufted. The material is usually either plain in colour or bears an allover design which will lend itself to cutting and joining with little waste for pattern matching. These covers can be bought ready-made in standard sizes or made to fit a particular bed.

Blankets. — Made from soft yarns which can be heavily teased or brushed up so that a layer of air is entrapped on either side of the fabric, blankets provide maximum warmth with minimum weight. Wool is the traditional fibre and has many properties that make it highly satisfactory for this use. Though usually the highest in initial cost, a good blanket, *i.e.,* one made with long, strong fibres,. a high tensile strength, a compact weave and a strong nap. will give years of service. A high-quality all-wool blanket is soft to handle. fluffy in texture and light in weight.

Fibres other than wool may be used alone. or in blends with each other. or with wool. each giving special qualities designed for a specific purpose. Cotton is desirable for summer coverings, as it is cooler, easier to wash, less expensive and not attacked by moths. A wool content of 25% or more gives slightly more warmth than an all-cotton blanket. Orlon blanketing is lightweight. insect-resistant, retains heat and is machine-washable (as are wool and Orlon blends). Acrilan produces a very warm material that has exceedingly good shrinkage control and is naturally moth- and mildew-resistant. Proper construction has reduced the shedding problem and with adequate care piling and wrinkling may be kept to a minimum. Dynel received some use in bedding but is not highly satisfactory as it tends to shed and is very heat-sensitive. Rayon may be found alone or in blends in low-priced blankets, but care is necessary in laundering because rayon tends to lose some of its strength when wet. Some luxury blankets contain cashmere, camel's hair and Kashmir or goat hair.

Electric blankets provide uniform. controlled warmth without much weight, a single covering taking the place of two or three conventional blankets. In some, dual controls permit adjustment of temperatures to individual preference in the double-bed size. While performance is not affected by wool content, the presence of wool results in a more luxurious nap, better appearance and increased durability. Safety is assured if the wiring carries Underwriters' Laboratories Inc. approval or other specifications. Electric sheets are lighter and are used over the regular top sheet. Comforters or quilts that are electrically controlled are also available. Instructions as to the care of the electric blanket are given at the time of purchase and should be followed.

Comforters, Eider Downs and Quilts. — These may be chosen for their attractiveness but they are also very practical, adding greatly to warmth with very little weight increase. Often they serve as bedspreads or coverlets by day. They are made in a wide range of fabrics, which should be closely woven to keep in the filling. Coverings of comforters or eider downs may be of cotton, acetate or rayon satin, taffeta, brocade and *matelassé*. Even quilting assures even distribution of the filling, which may be of down, feathers, wool: cotton, acetate or of nylon, Dacron and Acrilan. The beauty of the covers may be enhanced by scroll stitching. A cap end at the foot of fitted satin comforters or eider downs helps to hold them in place, as also do drapes at the side which can be tucked in. Backings of cotton flannelette or other cotton fabrics reduce the tendency for them to slip off during sleep. In the care of these articles the outer covers as well as the inner fillings should be considered. Down. feather and wool fillings are usually dry-cleaned while the man-made fabrics have the advantage of being washable. Washable coverings must be resistant to fading from laundering and light. Quilts are generally of solid colour or printed cotton fabrics and are employed when less warmth than that provided by a comforter or eider down is desired.

Pillowcases and Sheets. — To determine quality when buying cotton or linen sheets, one should hold them up to the light: in a good-quality sheet the light shows through evenly. indicating that the yarn is of even thickness throughout; a poor-quality sheet will show light and dark patches. Sheets should be tested for excess sizing in the same way as table linen. Some sheets are manufactured with more threads to the inch down the centre strip. the area of greatest wear. than at the sides. The selvages should be strong and woven with extra yarns to give a tapelike effect. The size and finish of the hems should also be examined. The sheets should have been torn to size and not cut, so that they are on the straight of the thread and have square corners. (This can be determined by a close look at the hems.) Nylon blended with cotton will give increased wearing qualities as it increases the resistance to abrasion. Fibre and cotton blends. on the other hand. while increasing the comfort value of the sheets, reduce the wearing qualities. Drip-dry finishes applied to cotton sheets reduce the need for ironing but tend to reduce abrasion resistance and to increase both the protein-stain retention and the chlorine retention.

Sheets made entirely of nylon or Dacron (Terylene) are easy to launder. but the slipperiness of these fibres and their low moisture absorption are disadvantages that should be recognized. Some knitted nylon sheets are brushed on one side to give a raised pile and are therefore more comfortable.

The width of the sheet should be equal to the width of the bed plus 30 in.. to give a satisfactory tuck. A standard length is 108 in. before hemming. Fitted styles (with shaped corners'i are easy to launder, and the bottom sheet in particular requires no ironing. To ensure proper fit. the precise mattress measurements are necessary. Pilloncases should be at least one inch wider than the pillow. and are usually chosen to match the sheets in fibre content, colour and weave.

TOWELS

Terry Cloth Towels.—This type of material is most commonly used in bath towels and face cloths because of its softness and high degree of moisture absorption. It is made from a looped warp pile fabric. the loops being formed on one or on both sides by means of a special system of interlacing the yarns. Two sets of warp yarns are used, one of which is held tight and the other loose to form loops which are left uncut. The number of loops varies from 204 to 366 per square inch.

Most terry towels are made from cotton because of its durability and ability to absorb and hold moisture. The grade of cotton fibre and the way the yarn is twisted and spun are basic factors in satisfactory service. The uniformity of the underweave and its compactness determine the resistance of the towel to wear and are an accurate measure of its strength. This property is easily distinguished by holding the towel to the light: small, evenly distributed pinpoints of light are indicative of a regularly woven fabric; a close, tight weave has the ability to hold more of the absorbent loops and to hold them more securely. An indication of the nature of the foundation fabric can be seen from looking at the areas without loops near the hems or borders. Plain or basket weaves are less durable than a twill weave. A compact construction with a balanced count is essential for good wear.

The absorbency depends on the number of loops in the pile. their length and quality. The thicker the pile, the greater the surface; thus the higher the absorption value of the towel. A really good cloth is said to soak up approximately five times its weight of water. For maximum absorbency yarns should be loosely twisted and the loops formed from them of reasonable length. Texture ranges irom soft to hard, but whatever the texture a durable towel will feel firm and resilient to the touch. Selvages should be finished to give a firm edge and the weave should be very close. Hems should be sewn with small, even stitches and on the straight of the thread.

Terry towels are made in a variety of sizes to suit personal taste and purpose. Surfaces may be plain or sculptured, but elaborate designs reduce absorbency by limiting the number of loops in the pile. Embroidered effects in colour, dobby or Jacquard woven borders and the use of metalized yarns give high style characteristics to these articles. Colours in toweling range from pastel to dark shades.

Other Fabrics.—Textured fabrics, which as a group are less absorbent than terry cloth, serve specific purposes as personal and household toweling materials. Huckaback, generally known as huck. is a durable fabric with a rough-textured surface and a pattern produced by long warp yarn floats. Usually made of linen. it is an absorbenf material and is used for hand, face and guest towels. Crash is a coarse fabric with a rough, irregular surface obtained by weaving thick, uneven yarns. It is manufactured in different weights, the heavier type being used for dish towels and the lighter weight for glass, face and guest towels. Glass toweling, a plain weave linen fabric. is similar to crash but of light weight and construction. The fine yarns prevent linting, but the smoothness essential for polishing glassware reduces the rate of moisture absorption. The Jacquard woven or damask fabrics are used in face and guest towels. The quality of the linen yarns is similar to that found in tablecloths and the same qualifications apply. Fibres such as cotton or rayon map also be present. to lower the cost and to increase lustre. Bird's-eye. woven on a dobby loom with a small diamond pattern and a dot or eye in the centre, has heavy, loosely twisted filling yarns to make it more absorbent. It is used for dish towels. Honeycomb. also called waffle cloth, is similar to bird's-eye. the rough surface resembling the cells of a honeycomb, and is highly absorbent.

LAUNDERING OF FABRICS

Most fabrics can be laundered satisfactorily, but in doubtful cases some warm water should be tried on a small area of the material in the least conspicuous place. The material should then be inspected to see if there is any shrinkage, alteration in colour or general appearance. both in the wet state and after complete drying out. before immersing the whole article in water. Washable fabrics should be laundered frequently so that the dirt can be removed from them with the minimum amount of friction. The actual method of laundering an article depends more on the nature of the fibres and fabric construction, and on any finish given to the fabric after weaving, than on the type of article. For example, a blanket and a cardigan both made of wool should receive similar treatment during laundering. whereas the method of laundering a drip-dry cotton sheet should be different from that of a cotton sheet that has not been so finished.

Processes.—*Preliminary Treatment.*—Articles should be shaken or brushed to remove any loose dust or fluff before they are put into water. This is particularly important in the case of such articles as curtains, blankets and bedspreads, which are not washed every week. Double articles such as pillowcases and cushion covers should be turned inside out and the seams and corners brushed, as should pockets, trouser turnups and the inside folds of pleats. Any known stains which are not likely to be removed by washing should be treated and removed at this stage.

Soaking or Steeping.—Articles that are going to be hand-washed are often first steeped for one or two hours. This process does remove some water-soluble dirt and loosens the rest, so that the washing process is less arduous. All white and fast-coloured linens and cottons and some of the man-made fibres such as nylon and Terylene can be put to steep to facilitate dirt removal. If there are no protein stains present in the fabrics. warm water should be used, and the addition of a detergent will increase the amount of dirt removed by soaking. The articles should be opened out and there should be sufficient water to allow free movement. After steeping and before washing. as much water as possible should be removed from the articles.

Washing.—This may be done by hand or by machine. The temperature of the water and the degree of friction employed (the length of time allowed in the machine) depends on the nature of the fabric. For white cottons and linens. high temperatures and maximum wash time can be allowed, for white nylon and Terylene, moderately high temperatures and a fair degree of friction; for woolens the temperature should not exceed 104° F. and the amount of friction should be reduced to a minimum. For fugitive colours salt added to the wash water may reduce bleeding, but a synthetic detergent must then be used since soap is not soluble in salt solutions. Collars and cuffs and other parts of articles where there is a high degree of local soiling should be treated by rubbing or scrubbing with detergent before starting the general wash.

Rinsing.—Efficient rinsing is as important as adequate washing to ensure that there is no dirt left in the fabric. During the rinsing process the water should be changed frequently and the process continued until the water is clear.

Wringing.—Water can be removed from fabrics by hand wringing, hand squeezing. rolling in a dry cloth, passing between rubber rollers or by centrifugal force in a spin dryer. The degree of force used, or the length of time allowed in the spin dryer, depends on the nature of the fabric. Cotton and linen, unless specially finished. can be passed through a wringer most satisfactorily, but knitted woolen goods should be urapped in a cloth before being put through rollers to avoid stretching and undue strain on the wet wool Articles made from many of the man-made fibres are best rolled in a dry terry towel to remove surface water, so that they will not drip when hung up to dry. Passing them through a wringer may cause creases which are difficult to remove. If they are put in a spin dryer only the minimum time should be alloned. Drip-dry articles should not of course be squeezed in any way and neither should articles made from fabrics that retain creases made in the wet state, such as some forms of rayon taffeta.

Boiling.—If articles are boiled, the process should come after washing and rinsing, and best results are obtained if they are put into the boiler when the water is at a low temperature, allowed to come up to boil and held at boiling point for 5–20 minutes.

Stiffening.—Some household linen and personal articles may require stiffening after washing to give satisfaction in use and wear. The most usual stiffening agent used in laundrywork is rice starch. The degree of stiffness obtained after ironing depends on the thickness of the yarn and the closeness of the weave of the fabric, as well as on the strength of the starch solution used. This treatment has to be applied every time the article is washed. There are some commercial preparations on the market based on thermoplastic resins which give a stiffness lasting through several washes and which are usually highly satisfactory. For silk and many types of man-made fibres, starch is not a satisfactory method of stiffening and gum solution should be used.

When using any of the stiffening agents, the article to be stiffened should be damp and should be opened out, completely immersed in the solution and squeezed in it to ensure even distribution. The article should then be wrung to remove as much water as possible before being put to dry.

Drying.—All articles should be dried evenly and in such a way as to give as few creases as possible. If they are to be finished afterward by ironing, they should not be allowed to become completely dry but the process should be stopped when they are at the correct moisture content for finishing for the fabric from which they are made.

Finishing.—When ironing is necessary, the temperature depends on the fabric; for linen the sole plate of the iron should be about 450° F., for nylon 250° F. Dark fabrics are usually ironed on the wrong side to prevent shiny patches on the right side. Embroidery should be raised by firm pressing from the wrong side over a soft pad. For looped or napped surfaces, brushing up against the pile may give the best result, but velvet pile should be raised by steaming.

Airing.—All articles should be thoroughly aired before storing. Household linens are aired folded, but garments are usually placed on hangers.

Garments Not Suitable for Washing.—Some garments that cannot be washed satisfactorily may be sponged and pressed at home in-between commercial dry cleanings. Any loose dust or fluff should be removed by brushing. Grease spots can be removed by the careful application of any of the solvents on the market: care must be taken not to cause ring marks and best results are usually obtained by wiping a large area of the garment with a cloth moistened with the solvent before treating localized spots. When pressing, shiny marks on the right side can be avoided by pressing on the wrong side, using a damp cloth between the sole plate of the iron and the garment or, in some cases, by the use of a steam iron.

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TEXTUAL CRITICISM, a general term for the application of logical method to analyzing the relationship between preserved and inferential forms of a text, followed by the application of various techniques, including critical judgment, designed to establish what will ordinarily be the single definitive form of the text.

This article is concerned with general principles of textual criticism, particularly as they apply to the study of literature. For a related discussion, *see* BIBLIOGRAPHY: *Textual Bibliography.* For a detailed consideration of the critical problems posed by variant manuscript texts of the Bible and variant codices of the Old and New Testaments, *see* BIBLE and BIBLE, TRANSLATIONS OF.

CLASSIFICATION OF TEXTS

By "text" is meant a series of word forms inscribed in a language known, more or less, to the inquirer, and assumed to have a meaning that has been or can be ascertained. Thus, decipherment or recovery of meaning from inscriptions in lost tongues is not textual criticism. Texts may be preserved in autograph or in transmitted form. Transmission may be as close as the immediate copy of an autograph, or as distant as copies of copies to any degree; moreover, texts may be transmitted in written or in printed form (each generally defined) or in both. "Transmitted" texts share only one characteristic: their preserved forms are not written out by the author in any manner. When there is mixture, the transmitted and autograph parts are to be distinguished. In some few cases the problem of oral transmission will arise to complicate the usual written or printed line of transmission.

Autograph v. Transmitted Texts.—In its purest sense, "autograph" has traditionally been applied only to a document in the writing of the author. Some critics have argued that whatever has been attested or revised by the author, though in the writing of another, may also be included under autograph; but this position is impractical. If a copy made by an intermediary could be assumed always to be absolutely exact, or the review of the author that of a strict and accurate collator so that his attestation or revision carried the guarantee that in no respect did the whole derived document vary from its original in his own writing, the broader definition might be acceptable. But common experience shows that neither requirement is ordinarily met, and hence appro~ by an author of a nonautograph copy can under no circumstances bestow on that copy the authority inherent in a true autograph original; nor can authorial revision extend specific autograph authority further than the autograph revisions themselves.

In fact, textual criticism is accustomed to treat questions of authority with considerable literalness, and does not confuse what is authoritative with what is necessarily right. Most autograph is likely to contain slips and errors that are wrong by any absolute standard and would be acknowledged as wrong by the author if they were pointed out to him. On the other hand, lacking such specific acknowledgment, a critic has no option but to view autograph errors as authoritative, since no higher authority can be envisaged than the author; but this concept does not prevent their critical correction. Correspondingly, when autograph is not preserved, the form of the text that lies nearest in genetic relationship to the lost original becomes the paramount authority; and its errors must be esteemed as part of the only authority that can be recognized, even though the critic should quite naturally correct them. The act of correction applied to the most authoritative document that is preserved must always in a sense controvert authority. There is no harm in this principle once it is recognized that authority and correctness are not necessarily synonymous. Under these circumstances, correction, but never revision, can be made to a more authoritative from a less authoritative state of the text, or independently by an editor.

Before the invention of the typewriter no difficulty was experienced in demonstrating that a document was autograph, provided that a sufficient number of undoubted specimens of the author's handwriting were preserved for comparison. However, if writing were to be defined narrowly as handwriting, an author composing directly on the typewriter would produce no document that could be admitted as autograph. This situation is anomalous, for whether an author manipulates a stylus of some variety or taps marked keys (or, indeed, records his words electronically on magnetized tape), he has himself produced his original, and no human intermediary has entered until a person other than the writer makes a copy. Autograph, therefore, must be interpreted to include documents produced in the originator's own handwriting, typewriting, engraving or recorded voice—or any of the usual variations of these mechanical processes. The difficulty created in demonstrating actual production by the originator does not affect a case for autograph; indeed, the unevenness with which typewriter keys are struck may offer evidence to the scientific investigator as demonstrable as letter formations in script.

Determination of Original Copy or copies.—For all practical purposes the designation of a text as transmitted defines it as a nonauthorial copy; its degree of distance from the autograph original does not come in question. However, "original" must be taken only as a general term, for a preserved autograph may not represent the originally composed document but a transcript by the author, either as part of an act of further composition (which could include revision) or else as an act of producing a fair copy of the original document. Under few circumstances may a critic assume that the act of revision is absent from the production of an authorial fair copy, although it would be stretching the term to imply major rewriting rather than relatively minor polishing during what is generally a mechanical process. However. until an author has a fair copy (either autograph or transmitted) which satisfies him, the act of composition scarcely can be concluded. Thus several originals of varying form and date may be preserved in autograph, and variant transmitted texts may contain true authorial revisions.

The slippery nature of an original document must be emphasized, for critical writing has vastly oversimplified the problem. For example, a standard definition asserts that the aim of the textual critic is the restoration of a text, as far as possible, to its original form, if by "original form" is understood "the form intended by the author." This ignores the fact that at different times or for different purposes an author may intend a composition to take various forms, each of which will necessarily have its original. Even final intention, supposing it could always be determined when more than revision for literary excellence is present, may be an insufficient criterion. If the version of a play as cut and rewritten during rehearsals is printed, the author will have approved it as printed in its acted form, but if he had had an option he might have preferred to print the initial, more literary form. Revisions may be undertaken for various motives that do not meet with universal approbation. Such authors as William Wordsworth and Walt Whitman may in later years so alter their earliest printed originals as to achieve forms of their poems that call for parallel-text editions rather than the rejection (as the authors intended) of the earlier original in favour of the one that certainly represented their final intentions. All alterations are not necessarily connected with a desire for literary perfection; changes in political beliefs or a desire to moderate too frank autobiographical details may operate. Moreover, it does not necessarily follow that critics will always agree that an author's purely literary revisions are superior to his earlier version.

At any distance authorial intention is usually quite impossible to determine for the details of a text, and cannot be used as part of any scientific definition. If the literary and then the stage versions of an Elizabethan play are both preserved, as with John Fletcher and Philip Massinger's *Bloody Brother,* no later critic in the absence of collateral evidence can estimate the author's intention concerning his relative approval or disapproval of the two different texts. If this is so, it is clear that a critic would be greatly misguided to estimate intention or presumed original form if only one of the two variant forms had been preserved, and the original existence of the other was either not known or merely to be inferred. with no opportunity to reconstruct its forever lost details. Thus a critic must use the term "original" form always with a recognition that the word is loose in substance; and a definition of textual criticism must hedge on its characteristics.

For example, all that can be known, in any strictly authoritative sense, about a lost original must ultimately derive from extant transcripts. As a result. the original can have no recoverable characteristics not found in the preserved transcripts deriving from it. The technical original must be thought of only as the last version of the text produced before the transcription of the extant manuscripts or prints. and their ancestors, began. In a textual-critical sense, therefore, this original may not be, and often is not the author's original, but instead some transmitted copy of that other original which is forever out of reach. Any number of lost versions may have intervened between the textual original and the author's lost original. Thus it is quite false to believe that the critic's purpose in determining the ancestor of the earliest preserved forms of the text is "to recover the author's original." Moreover. it is false thinking if what is called the archetype in Lachmannian textual criticism (see LACHMANN. KARL KONRAD FRIEDRICH WILHELM) is confused with the author's lost original instead of being identified neutrally as the manuscript (or print), inferential or extant, and presumed to be single unless proved otherwise, from which all other extant and inferential copies are derived. In some cases this technical original may be the author's original; in most, however, it will be some intermediate transcript of an author's forever lost autograph.

The aim of the textual critic, then, may be defined (1) as the methodical establishment of a text in its purest and most correct form or forms as limited by the evidence of preserved documents; and (2) as the application of further techniques, including critical judgment. to clear a text insofar as possible of errors still present in the methodically established, or documentary form. The end of this second process is to approximate at least that substantive correctness that would have appeared in an authorial fair copy of a text as represented by preserved documents.

Accidental v. Substantive Variations.—In this definition, the "purest and most correct form or forms" of a text refers not only to an original and its possible revision or modification, but also to a distinction often made in printed texts; *i.e.,* between (1) the significant, or "substantive" readings of a text, namely, those afiecting the author's meaning or the essence of his expression; and (2) others—such as spelling, capitalization, punctuation, word division—affecting mainly its formal presentation, which may be regarded as the accidents and therefore as constituting the "accidentals" of a text. It may be that one form of a text preserves with considerable fidelity the accidentals of an author while at the same time containing substantive readings that he has seen fit to reject on a later occasion. The first edition of John Dryden's *Indian Emperour* (1667) is manifestly closer to his autograph than any other printed edition, since the slightly revised second edition (1668) was set from the first: and the considerably revised third edition (1670) was set from the second. However, this third edition, which on the whole contains the most authoritative range of Dryden's substantive readings, is manifestly inferior to the first in the authority of the accidentals. since in this respect it is a mere copy of a copy of the first edition; and Dryden's general approval of the text of this play for its revised substantives marked in a copy of the second edition can under no circumstances be taken as applying also to the variable compositorial characteristics. which in many cases have altered the third-edition forms of the accidentals from their generally more authoritative versions in the first edition. (It is most unlikely that Dryden ever saw the 1670 accidentals before publication.) In such a case the duty of the textual critic is clear. He must establish the facts that lead to the assignment of the third edition as the last revised substantive form of this text; and then establish the facts as between the rival claims (of the first printed edition and a scribal manuscript of an earlier version of this particular text) to be the most authoritative form of the accidentals on the whole. An editor would then place the most authoritative form of the substantives within the framework of the most authoritative form of the accidentals.

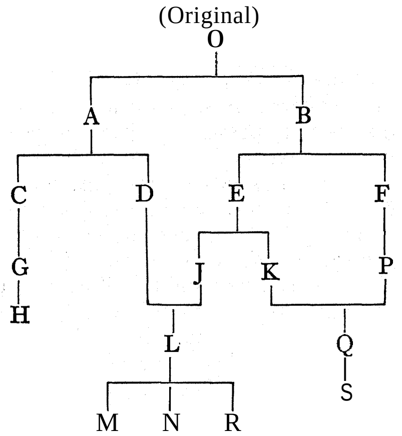
Much confusion has been caused in critical writing by failure to observe the two stages of procedure in the establishment of a text as remarked in the definition finally offered: (1) the fixing from documentary evidence by logical methods of the most authoritative form or forms; and (2) the emendation of this initially established text to approximate as nearly as possible an inferential authorial fair copy, chiefly in respect to its substantives. (In a completely modernized form of any old text, as is customary with the classics, the substantives constitute the sole problem, of course.) This final action achieves on a superior level the establishment of a critically definitive text. At one time only the first operation was called "textual" criticism, the second being known as "higher" criticism; but this distinction lapsed following the recognition that the second stage of purification involves more than simple critical judgment and may include bibliographical, paleographical and linguistic, as well as historical considerations.

The second stage of establishing a text does not differ essentially between manuscripts and printed books. However, the methods of utilizing preserved documents to establish the first, or documentary stage of the text often differ so widely between manuscripts and prints as to call for separate consideration.

THE GENEALOGY OF MANUSCRIPTS

The majority of manuscript texts requiring methodical textual criticism date from ancient or from medieval days before the invention of printing. although the custom of manuscript circulation may lead to problems even in such late Renaissance authors as John Donne.

Types of Genetic Relationship. — The analysis of the relationship of preserved forms of a text. as a whole, ends in the drawing up of a genealogical chart, such as the following, appropriate for a text wholly or chiefly preserved in manuscripts:



The genealogical tree always diverges in its lines of descent from a preserved or inferential original, the strict definition of which has been given above as that latest immediate ancestor, preserved or inferential, to all the manuscripts highest on the family tree; *i.e.,* to the heads of all families. The process of transcription by which the various copies stemming ultimately from this single great ancestor are formed is characterized by variation. If we exclude authorial or editorial alterations, variant readings arise only from the transmission of documents. Such variation, in the words of Sir Walter Greg, is postulated as universal; that is, every act of transcription introduces some variants. Variation is either "spontaneous" or "determined." Spontaneous variation is unconscious variation; it may range from a mere slip of the pen to addition, omission or substitution of readings through misreading or lapse of memory. Determined variation is conscious. and hence usually an attempt at emendation (correct or not) of fancied or of real faults in the copy being transcribed. Spontaneous variation is the more frequent. Of the variants introduced into any transcript, some will persist through subsequent transcription, whereas others will undergo further change and thus illustrate the rule of universal variation. In this way features peculiar to any manuscript are transmitted to its descendants but not in an invariable form. (Variation, one must recognize, is a neutral word and applies only to a difference between two readings, *without* respect to the order of derivation or to correctness.) Variation in a descendant may lead farther and farther away from the original reading; on the other hand, a descendant in varying from its immediate ancestor may actually restore by independent correction the reading of a more remote ancestor.

Variants may be vertical (*i.e.,* within a direct genetic line of descent) as when H, transcribed from G (or more likely from some lost intermediary), varies from G; or variation may be horizontal, as when A differs from B, both being manuscripts transcribed independently from O or from one or more lost intermediaries. (A and B are "collaterals" in that neither is an ancestor nor a descendant of the other.) It is horizontal variation that gives rise among collaterals to "grouping," or the arrangement of the manuscripts into family and subfamily groups according to whether they agree or differ in respect to particular readings.

Unless there is "conflation" (one manuscript affecting the readings of another by contamination), each family group shares an exclusive common ancestor deriving ultimately from the first independent descendants of the inferred or preserved great common ancestor O. In the tree above, the family groups are separated into A and B and their respective descendants, except that L joins both families by conflation and passes on this mixed inheritance to its descendants. A subfamily is a family whose ancestor is derivable from a manuscript which is the ancestor of still other manuscripts. For example, K and P are in separate subfamilies deriving from their ancestors E and F, which are collaterals deriving from B. In reading a genealogical table of texts, no inference can be drawn that a manuscript shown as deriving directly from another manuscript mas in fact copied from the exact manuscript shown on the tree as a parent. Between G and H or between B and F any number of now lost manuscripts very likely existed. Hence all variants in H from G, or in F from B need not have arisen in the act of copying the actual manuscripts of H and F, though for economy of assumption the textual critic must so take it. All that is shown by the table is that the line of descent from G to H and from B to F is a direct ancestor-descendant one. and that H has no other known ancestor than G, or F than B. In other words, no manuscripts deriving from any ancestor other than G were used in the transmission of the text from G to H, whatever the distance between them.

The case is quite different with L. Here the scribe (or a previous editor) had in his possession two exemplars of manuscripts, one in the direct line of descent from D, and the other similarly derived from J. These two manuscripts were conflated when in cases of variation between them the scribe chose readings now from one and then the other (or else merely copied a manuscript that had been editorially revised and annotated by selected readings from another). In this case conflation joined two manuscripts of different genetic, or family relationship, for neither D nor J shared any common ancestor except the ultimate ancestor O. On the other hand, lesser conflation took place in Q, but here the contamination served only to unite the members K and P of two collateral subfamilies. In the first instance, readings may appear together in L that had been used as genetic distinctions to separate the A and B families; *i.e.,* readings in which A and B and their descendants varied from each other. In the second. though variants may be reunited, the conflation, except fortuitously, includes no variant not characteristic of the B family as opposed to the **A** family.

Inferential manuscripts may appear in any family tree, although the recent tendency of textual criticism is to excise them wherever possible, as by Archibald A. Hill's theory of simplicity. An inferential (or hypothetical) manuscript marks a point at which some line of descent branches; it is a manuscript that must be posited to explain similarities between two or more other manuscripts, extant or inferred, when study shows that these are in a collateral and not in an ancestor-descendant relationship. In the sample tree, according to one school of thought, if A did not exist it would need to be posited provided one could show that C did not derive from D. or D from C, or C and D independently from O.

The process of determining the relationship of the manuscripts consists of isolating the major different family groups and then inferring the genetic grouping of the individual texts within these large groups. The process starts with a collation, or comparison of all known texts and a systematic recording of their variants, usually confined to substantive differences. According to Dom Henri Quentin. three major kinds of variants will develop: (1) variants shown by a single manuscript; (2) variants shown simultaneously by a few manuscripts; and (3) variants shown simultaneously by numerous manuscripts. The first are useless and must be disregarded. The second are valuable in determining families and subfamilies, for if the same few manuscripts repeatedly give a common reading different from all other manuscripts. it may be assumed that these few are clearly related and form a family or subfamily of their own. One of the first tasks, therefore, is to delimit the families hy means of such variants as are found repeatedly to be peculiar to certain constant groups of manuscripts. The families thus determined, the groupings within each may be filled in. The precise way in which a textual critic operates to determine the relationship of all forms of his text can scarcely be summarized. because of the complexity of the evidence and the differences in the weight given to various kinds of evidence. In general, the critic aims first at establishing the facts of genetic relationship and then at determining the direction of the relationship between ancestor and descendant.

Distributional **Evidence.**—What Hill calls "distributional" evidence is chiefly of service in determining the basic facts of relationship or nonrelationship. In distributional analysis the arrangement of differences in the texts is utilized as evidence without attention to the nature of the differences. This method rests on the postulate that unity in readings in manuscripts is more probably referable to unity in their source than to coincidence. The facts of variance are enough If the point of difference is, for example. the appearance or nonappearance of a particular word, distributional study does not attempt to inquire whether the nonappearance is an omission, or the appearance is an addition. It merely divides the manuscripts into groups depending upon the appearance or nonappearance of this word.

Distributional evidence may be used to assign the nature of groupings by indicating whether the relationship is direct (as in the vertical ancestor-descendant line) or collateral. For example, direct relationship can be shown in the following illustration. Suppose manuscript L shares readings with all other manuscripts in its family and has no unique readings. Manuscript M shares readings only with L and has no shared readings with other manuscripts not shared with L, but it also has some unique readings. This state of affairs is not compatible with a supposition that L is copied from M, since (because of the unique variants in M) the greater number of times that L agrees with the other manuscripts than does M is unexplained. On the other hand. this state of affairs is compatible with the hypothesis that M was transcribed from L.

One apparent fallacy in this reasoning is usually not of consequence. The larger share of L than of M in readings with other manuscripts could be explained, in isolation, as derivation of L from M if M were the earliest of all manuscripts and all derived from it as the common ancestor. However, a tree branches as it develops, not converges; and no rational genealogical chart can be reversed. Moreover. other evidence, which may be called genetic, provides a check on the direction of change.

The facts of the distribution of variant readings among manuscripts, therefore, may be utilized to show direct relationship. as above. or collateral relationship. For the latter. if in a group of more than two manuscripts having a common ancestor (like M, N and R), all manuscripts have unique readings, and all manuscripts shared readings in no constant arrangement, these facts are compatible only with independent derivation of the type known as radiation. On the other hand if the relationship is always constant, so that the shared readings of M are aluays shared only uith N or aith R the facts can be taken to be incompatible with radiation and hence derivation must be postulated.

Genetic Evidence. — Distributional evidence is frequently enough to settle a case, but it has its limitations when revision is present and especially (as exemplified in the texts of Donne or Robert Herrick) when copies are made from a poem in different stages of reworking. Hence the critic may call on a second order of evidence, which may be called genetic, or the comparison of individual differences with each other in the hope of discovering the direction of change. At its most scientific this inquiry still attempts to emulate distributional study by ignoring the critical considerations of meaning. at least in any strict sense of right and wrong. Instead, genetic study rests on the assumption that certain differences are more likely to have been produced by a given direction of change than by another. For example, if C omitted a passage present in both A and B, the direct sequence CBA, or ACB or any other scheme that set up C ahead of B would be disqualified, for where would A or B secure the passage if they were descended from C, no conflation from another source being proved?

Common errors of other sorts may also profitably be used but always with caution, for the process of correction reverses the direction of change toward error that would be expected from the process of copying. The critic attempts to separate reversible changes from variants that by their nature appear to be nonreversible. Moreover. Greg's postulate that spontaneous variation occurs oftener than directed variation would indicate that in a direct sequence the number of errors will ordinarily exceed the number of corrections, and hence that the most faulty will likely be the descendant, not the ancestor; but this line of argument is to be used with caution.

Similarly, the direction of change may sometimes be postulated by explaining one form as the result of a known type of mechanical error such as eyeskip or haplography. Unless distributional evidence indicates otherwise, an existent word is presumed to be earlier than a nonexistent word created by a familiar type of error. Even when two existent words comprise the variant, a known type of error may best explain the direction of change. Hill points to E. K. Rand's correction of Quentin in the following: *sub umbra culminis mei* (9 manuscripts); *sub umbraculum culminis mei* (2 manuscripts); *sub umbraculum tegminis mei* (5 manuscripts). Quentin had regarded *umbra culminis* as derived from *umbraculum tegminis* by the omission of *-um teg-*, whereas Rand properly derived *umbra culminis* from *umbraculum culminis* by omission of *-um cul-*. Rand's logic rests on true eyeskip fostered by the repetition of *cul-*, whereas Quentin's suggested omission cannot be correlated with such a type of known error.

Suggestive as genetic evidence may be, assumptions from individual readings may often prove to be untrustworthy; and hence the genetic method is usefully employed only when distributional evidence has been completely exhausted.

Physical and Stylistic Evidence. — Physical evidence is ordinarily of little use in dealing with classical or medieval manuscripts, since no correlation need exist between the date of inscription and the state of the text. It is of no pertinence to argue, for example, that because the paper of manuscript Y may be dated in 1640 and that of manuscript Z in 1240, the text of Z must represent an earlier state than that of Y; instead, Y might well have been transcribed from a manuscript that was representative of a form of the text nearer to the common ancestor than the ancestor of Z. However, modern manuscripts (and especially autograph) may yield extraordinary results when external evidence is applied. The manuscripts behind the 1860 edition of Whitman's *Leaves of Grass* neatly divide into groups that can be dated 1857 and 1859 respectively on the basis of the paper and inks. A brilliant recovery of the order of Emily Dickinson's manuscripts resulted from a minute external study of the paper and the handwriting characteristics.

Finally, in this preliminary stage, which consists only of the establishment of one form of a genealogical chart rather than any other, purely literary study based on assumed stylistic respects, superior sense, freedom from mistakes of fact, etc., is almost completely untrust orthy and should not be employed until the preceding three ranges of evidence have been completely exhausted, individually and collectively.

Determining the Most Authoritative Variant. — Once a genealogical chart has been drawn up by the critic's most rigid use of methodical evidence, it is proper to consider the authority of variants in the texts in the light of the facts of derivation as shown by the tree. In the sample chart it is obvious that if O is preserved no other known manuscript can contain a reading that possesses any authority, although some may own readings that are more correct. The textual critic will have arrived at the only preserved manuscript that — as the single common ancestor — is nearest to a lost autograph. Further treatment of this manuscript can involve only emendation.

On the other hand, if O is only inferential, and A and B represent the ultimate heads of only two families, the critic's position is less happy True, no preserved manuscript other than A and B can own authority; true, shared readings between A and B must be presumed to derive from inferential O, and therefore common readings possess the authority they would have if derived from a preserved O. (But notice that in either case O is not necessarily the real archetype or first original, but instead merely the one manuscript it is possible to infer as a common ancestor of A and B, even though through different lost intermediaries.) However, where A and B vary, only critical judgment can decide, on the evidence of each individual variant, which one is superior and therefore — by another assumption not always warranted—authorial.

The school of textual critics stemming from Karl Lachmann favoured the acceptance of one "best" manuscript and the rigid adherence to its readings in all possible circumstances as the only "scientific" attitude for an editor. This school tacitly considered that textual criticism ended with the establishment of the family tree and the consequent decision in favour of some one preserved manuscript as the '(best"; whereas, at least in the above chart, the tree does not favour either **A** or B. The illogic of the Lachmann position, in its abrogation of the critical second stage in preparing a definitive text, was exploded by **A.** E. Housman (Preface, *The Astronomicon of Manilius,* Cambridge University Press) : "To believe that wherever a best MS. gives possible readings it gives true readings, and that only where it gives impossible readings does it give false readings, is to believe that an incompetent editor is the darling of Providence. . . . Chance and the common course of nature will not bring it to pass that the readings of a MS. are right wherever they are possible and impossible wherever they are wrong: that needs divine intervention. . . . In books like Manilius and Lucan, preserved in various copies of equal merit, the editor cloaks his frailty by feigning that their merit is not equal: in books like Juvenal and Ovid's Heroides, where one MS. far excels the rest, h e feigns that it excels them further. and tries hard to treat it not merely as the best but as the sole authority."

Heeding Housman's excoriation, the most advanced textual critic no longer stops short with what the evidence of the genealogical chart may indicate about the authority of the readings; nor, when the chart is indifferent, does he rest content with fidelity to a chosen best manuscript. In every case of nonautograph he will accept only as comparative the authority of the earliest ancestors that can be established; and as the final stage of his establishment of a text he will treat it critically according to bibliographical, paleographical, linguistic or whatever other techniques are pertinent, and over all impose his literary judgment based on his knowledge of the qualities of the author treated. At this point. where methodical techniques largely desert a textual-critic editor, the resulting text will be good or bad depending upon the individual's own capacities. The acceptance of Housman's attitude and its extension, about the middle of the 20th century, to editing from printed texts constitutes one of the most interesting of modern developments in editorial theory. It places the responsibility for a text where it belongs, squarely on the shoulders of the editor. Yet confidence in critical ability to solve all problems may lead to a newer kind of laziness as acute as that Housman found in the "scientific" textual critic, if all the ancillary techniques for examining a text are not exhausted before reliance is placed on judgment rooted in subjectivity and intuition and in the cultural intelligence of an editor.

THE GENEALOGY OF PRINTED BOOKS

Transmission of a text in printed books differs so radically from transmission of an ancient or medieval manuscript text as to call for quite different basic postulates. The chief difference is that a manuscript that is a direct descendant of its most immediate ancestor is ordinarily not copied directly from the ancestor but from some one of a lost series descending from the ancestor. On the other hand, any edition of a book other than the first is ordinarily copied directly from some other known edition. Editions of books, therefore, are assumed to be contiguous in their relationship, and variants between them can be assigned to the agents producing the derived edition, or else to the author, within a given space and time. Secondly, under most circumstances editions of books are dated with reasonably correct dates, which show the relationship between editions. Both assumptions, although sometimes violated, permit the development of physical evidence that is the special province of analytical bibliography, a discipline that studies the effects of the printing process on the transmission of text (*see* BIBLIOGRAPHY).

' For example, the ninth edition (1694) of Dryden's *Indian Emperour* appears to conflate distinctive readings of the seventh edition of 1686 and the eighth of 1692. In manuscript study or in nonbibliographical criticism of printed texts, an editor would inevitably postulate either consultation and contamination or else derivation from a lost edition located between the seventh and eighth. However, the bibliographer trained to observe physical evidence will notice that the distinctive variants of the two editions never appear together on any page of the 1694 print; and starting with this fact he will develop other physical evidence to demonstrate that two different compositors alternated in setting the type for the 1694 edition, one of whom used the 1686 and the other the 1692 edition as printer's copy.

Determining the True First **Edition.**—One of the most difficult problems facing a textual critic of printed books is to determine which is the true first edition, and thus the authoritative text, in case two editions in the same year are issued without external or collateral evidence of priority. Dryden's play *The Wild Gallant* had two editions printed in 1669, the year of publication. On literary grounds Dryden's editor G. Saintsbury rejected what turned out to be the true first edition, and chose for his text the variant readings of the unauthoritative second edition. When the case was scrupulously examined, one piece of physical evidence was enough to demonstrate the true order. In what was proved to be the first edition the word "tells" was printed with a defective type for the second letter "l"; the type inked chiefly at the top and in many copies produced only a short mark that looked like an apostrophe. In the second edition the compositor faithfully copied what he thought he saw and set the corresponding word as "tel's," an impossible form. That this evidence must be accepted may be seen if one tries to reverse it and explain the defective type as deriving irom the apostrophe.

The chiei textual critic oi *Hamlet* between World Wars I and II, J. Dover Wilson, had pronounced the important second edition of 1604–5, the first of the good texts, as set throughout by only one compositor, who was an incompetent novice at the trade. But in 1953–54 one bibliographer showed that, on physical evidence that could be demonstrated from the printing of the sheets of the book, two presses had been employed in an alternation that would require the services of two compositors; Another scholar, J. R. Brown, by an examination of distinctive characteristic spellings, identified the sheets set by each compositor as those indicated by the presswork study and established the fact that these two now identifiable compositors had worked for the printer for several years as his regular men and, indeed, had set the second edition of Titus Andronicus and the first edition of The Merchant *of* Venice, both in 1600. Since these two texts have been much admired for their accuracy, the effect of this inquiry was to establish that deiects in the second edition of Hamlet are chiefly to be derived irom its manuscript rather than from the printer's incompetency. The difference is important for a textual critic.

One of the most brilliant bibliographical discoveries of the 20th century disclosed the false dating of the so-called Pavier Quartos of various Shakespeare plays. It was established that Pavier editions of some plays dated 1619 and editions of others dated a decade or more earlier shared identical standing type in their title pages. This physical impossibility revealed that some texts previously preferred on literary grounds by editors, such as that of ***King*** Lear, were actually unauthoritative second editions of no textual value. Whether Hamlet's flesh was "too too sallied" (*i.e.,* "sullied"), as in the First and Second Quarto editions or "too too solid," as in the Folio, had usually been decided in favour of the Folio. However in 1956 it was pointed out that the unusual form "sallied" in the second edition could not have derived unauthoritatively by contamination from the same reading in the imperfect first edition, since the second appearance in this play of the word "sally" meaning "sully" (Polonius to Reynaldo, Act II, sc. i) came in a section typeset by a different compositor, who would be unaware of the previous occurrence and must have copied his word from the manuscript, the first edition being wanting there. These examples suggest various typical ways in which bibliographical techniques that have been developed in the 20th century have revolutionized the study of printed texts by emphasizing the need to exhaust the physical evidence of analytical bibliography before attempting critical judgment.

The approach to textual criticism made by the analytical bibliographer emphasizes two primary requirements: (1) the careful examination of all preserved forms of a text, not only (a) to assure oneself that the external evidence of printed dates and the like is correct and that one has recovered the earliest edition (that text set from manuscript) but also (b) to guarantee that every other edition in which iresh authority might have entered has been placed in its correct relationship and the authority of its variants analyzed; (2) the careiul examination of the details of any edition possessing authority, whether the first or a revised print, to determine the nature of the copy used by the printer and its authority.

Determining the Nature of Printer's Copy.—The usefulness of this inquiry is by no means limited to early handprinted books but may be applied as profitably to the texts of James Joyce, T. S. Eliot and W. B. Yeats as to the text of Shakespeare. The common practice of dilettante editors to reprint as their text the last edition of a book printed in the author's lifetime is as serious a defect for modern as for older authors. (The theory was that the author might have revised the edition; such editors felt no requirement to look into the evidence for or against this theory.)

To take a small but significant example, the proofreading of F. Scott Fitzgerald's This Side of Paradise was careless in the first printing, and changes in the plates were made partly by the author and partly by the publisher in the fourth and seventh impressions. A few of these alterations, presumably made by the publisher, mistook the sense and created errors from correct readings, An editor would need to reject these in favour of the correct first-printing readings, to accept the corrected and revised readings by the author and publisher from the later printings, and then to make a variety of further corrections himself heiore arriving at a definitive text. In more complex form, no one edition of Joyce's *Ulysses* contains all of his desired readings; on the occasion when he went over the text in correction he unfortunately chose a corrupt edition and did not alter all its unauthoritative changes from the first-edition readings or notice all the first-edition errors that had been perpetuated. Any editor of Eliot or of Yeats would need to disentangle the author's corrections and alterations in revised editions irom errors developed in the course of various printings, which were overlooked. Fidelity to one printing or edition, early or late, cannot serve to establish a modern author's text.

In the 17th century Dryden partly revised the second edition (1668) of *The Indian Emperour* and more rigorously the third edition (1670). The fourth and fifth editions of 1670 derived in order irom the corrected third, but the sixth edition (1681) reverted to the second (1668); thereafter all texts of Dryden followed this family and ignored the corrected third edition, whose line terminated with the fifth edition. Since no Dryden editor beiore the 1950s undertook to collate all the early texts, the authoritative revisions of the third edition remained unknown, and the edited texts, based on the 1701 folio, not only retained most of the corruptions found in this 13th edition but also revealed only the intermediate revised state of the text as transmitted in the second-edition family line.

A typical example of failure to observe the primary rules of textual criticism in the analysis of all editions occurred in the text of Percy Bysshe Shelley's *Posthumous Poems*. In the first edition of 1824, edited by Shelley's wife Mary, an errata leaf containing 24 alterations, including a missing line, was added to the last copies to be bound up. This leaf, being uncommon, was overlooked by all Shelley's editors, although utilized to a greater or lesser extent in the various pirated editions that followed soon after the publication oi the volume. When Mrs. Shelley came to edit the revised collected edition of 1839, by bad luck she chose one of the pirated texts into which various corruptions had entered. Thus, although she collated her proofs against her manuscripts, not only did she overlook three of the errata-leaf corrections omitted in the pirated edition but she also passed some of the piracy's corruptions, notably the reading from "Stanzas Written in Dejection, near Naples," "The breath of the moist air is light" for the errata-leaf version oi this missing line, "The breath of the moist earth is light." The variant "air" appears first in the unauthoritative Galignani text of 1834, to be transmitted thence to Mrs. Shelley's 1839 edition. All Shelley editors, who sheeplike followed the supposedly authoritative 1839 text in the belief that Mrs. Shelley's attestation had been given to it and hence there was no need to inquire into its copy and method of printing, have reproduced as authentic a considerable number of errors that can be demonstrated to have arisen in the pirated texts oi Galignani and of Ascham used by Mrs. Shelley as the basic printer's copy.

The nearer machine printing approaches modern times and routine publishing procedures, the less need is there to inquire into the authority of the manuscript originally used as printer's copy, although the copy for any subsequent revised edition must always be identified and its relation to the earliest authoritative text as well as to the revised edition scrupulously analyzed. For books of the 16th, 17th and 18th centuries, however, when the personal characteristics of the compositor (though with diminishing force as time goes on) are likely to interfere in an important manner with the reproduction in faithful detail oi the underlying manuscript, the distinction of printer's from author's characteristics is of real moment. Two considerations operate. First, in texts dating from the time when authors frequently did not read proof and the printing-house proofreading was casual about variation from the author's wording, a study of the printer may reveal whether difficulties in the text are to be emended in one direction or another in accord with what has been determined about the capabilities of the identified compositor concerned. It is known that Jaggard's compositor A of the Shakespeare First Folio of 1623 was more faithful to his copy, generally speaking, than compositor B. Hence an emendation must pass sterner tests to be accepted in an A section of the Folio than in a B section, or in the pages set by what seems to be a very inaccurate apprentice, compositor E, first identified by C. J. K. Hinman in 1956.

Second, if the veil of print can be pierced, the critic may be able to make various important assumptions about the authority of a text, in whole or in part, according as he can estimate the nature of the lost manuscript underlying the earliest print or any later revision. Once it could be determined that a particular scribe, Ralph Crane, transcribed the manuscript used by the Folio printer for *The Merry Wives of Windsor*, certain very puzzling characteristics of that text were no longer obscure. What texts of Shakespeare were set from his autograph papers, and what irom scribal transcripts, is an inquiry that was scientifically tackled, from the strict bibliographical point of view, only after World War II.

The question of the copy underlying a print is often as acute in the case oi a revision as in the original edition. For example, if the Folio text of *Hamlet* was set from an independent manuscript, common readings between the Second Quarto and the Folio are presumptively authorial, given the collateral theory that the Second Quarto was set irom autograph papers. On the other hand, if, as has been argued, the Folio printer's copy was a Second Quarto that had been annotated by a scribe comparing it with the manuscript in the theatrical company's possession, a shared reading like "pious bonds" (assumed manuscript reading: "bands") for "pious bauds" ("bawds") could have perpetuated in the Folio an error of the Second Quarto, provided the scribe overlooked it. Hence the authority possessed by any Folio reading is much affected by what can be established about the nature of the printer's copy for the Folio text, a subject still in dispute.

Such a determination would not automatically settle in any given case whether the Folio or the Second Quarto variant reading was the authoritative one. But a critic who comes to the final stage in the establishment of a text—the synthesis of readings if there is more than one text possessing authority (as is frequent in manuscript and occasional in printed texts), followed in any case by independent emendation—is in a better position if he has thoroughly worked out the detailed history oi the text as a guide and limitation to the exercise of his critical or literary judgment than if he relies almost exclusively on his sympathetic acquaintance with the characteristics of an author and his period.

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(F. T. B.)

THACKERAY, WILLIAM MAKEPEACE (1811–1863), English novelist whose social satires are classics of English literature, was born at Calcutta. India, on July 18, 1811. His father and grandfather had been Indian civil servants. His mother was left a widow in 1816 and married Maj. Henry Carmichael Smyth in 1818. Young Thackeray was brought to England from India as a child and sent to private schools, first in Hampshire and later in Chiswick. In 1822 he was transferred to Charterhouse, at that time still on its ancient site near Smithfield.

Anthony Trollope noted that Thackeray's "change of retrospective feeling about his schooldays was very characteristic. In his earlier books he always spoke of the Charterhouse as Slaughter House and Smithfield. As he became famous and prosperous his memory softened, and Slaughter House was changed into Grey Friars, where Colonel Newcome ended his life."

In "Mr. and Mrs. Frank Berry" *(Men's Wives)*, for example, there is a description of a fight at "Slaughter House" following an incident almost identical with that used in *Vanity Fair* for the fight between Dobbin and Cuff. Although in both cases the brutality of school life, as it then was, is fully described, Thackeray also recognized the chivalry which may go alongside it. In the first chapter of "Mr. and Mrs. Frank Berry," Berry himself and old Hawkins both have a touch of the heroic, and in that story the bully whom Berry gallantly challenges is completely defeated, and one hears no more of him. In *Vanity* Fair Cuff, the swaggerer, is defeated as completely as is Berry's opponent, but he regains his popularity by one well-timed stroke of magnanimity, and afterward shows the truest kindness to his conqueror.

In 1828 Thackeray left Charterhouse to join his mother and her husband at Larkbeare in Devon, near Ottery St. Mary, which is the "Clavering St. Mary." as Exeter and Sidmouth are the "Chatteris" and "Baymouth" of *Pendennis*.

In Feb. 1829 Thackeray went to Trinity college, Cambridge, and contributed lines on "Timbuctoo," the subject for the prize poem (the prize for which was won by Tennyson), to a little paper called *The Snob*. James Spedding, Monckton Milnes (Lord Houghton), Edward FitzGerald and W. H. Thompson (afterward master of Trinity) were among his friends. In 1830 he left Cambridge without taking a degree. A visit to Weimar bore fruit in the sketches of life at a small German court which appear in *FitzBoodle's Confessions* and in *Vanity Fair*. In G. H. Lewes's *Life of Goethe* is a letter containing Thackeray's impressions of the German poet.

On his return to England in 1831 he entered the Middle Temple, and found material for some capital scenes in *Pendennis*. In 1832 he inherited a sum which, according to Trollope, amounted to "about five hundred a year." The money was soon lost—some in an Indian bank, some at play and some in two newspapers. *The National Standard* and *The Constitutional.* In *Lovel the Widower* these two papers are indicated under one name as *The Museum,* in connection with which Honeyman and Sherrick of *The Newcomes* are briefly brought in. Thackeray's adventures at play were utilized on three occasions, in "A Caution to Travellers" *(The Paris Sketch-Bookj.* in the first of the Deuceace narrations *(The Memoirs of Mr. C. J. Yellowplush*), and in *Pendennis,* vol. ii, ch. v, in a story told to Captain Strong by "Colonel Altamont."

About *1834* Thackeray settled in Paris to study art seriously. He had, like Clive in *The Newcomes,* shown early talent as a caricaturist. His pencil was at its best technically in such fantastic work as is found in the initial letters of chapters and in those drawings made for the amusement of child friends which were the origin of *The Rose and the Ring.*

In *1836* Thackeray married Isabella, daughter of Col. Matthew Shawe. There were three daughters barn of the marriage: one dying in infancy. The eldest, Anne Isabella, married in *1877* (Sir) Richmond Ritchie of the India office. She wrote several charming works of fiction: notably *Miss Angel* (1875), and subsequently edited Thackeray's works and published some volumes of criticism and reminiscences. The younger daughter, Harriet Marian, married (Sir) Leslie Stephen in 1867 and died in 1875. Mrs. Thackeray, to quote Trollope, "became ill and her mind failed her," in *1840.* and he "became as it were a widower to the end of his days"; she did not die till 1894.

In 1837 Thackeray went to London, and became a regular contributor to *Fraser's Magazine.* In this in 1841 appeared *The History of Mr. Samuel Titmarsh and the Great Hoggnrty Diamond,* a work filled with the wit, humour, satire and pathos. which found a more ordered if not a fresher expression in his later works. The characters are full of life; the book is crammed with honest fun; and for pure pathos, the death of the child stands in the company of very few such scenes in English fiction; but *The Great Hoggarty Diamond* had to be cut short at the bidding of the editor.

In *1840* came out *The Paris Sketch-Book,* much of which had been written and published at an earlier date. In *1838* Thackeray had begun, in *Fraser, The Yellowplush Papers,* with their strange touches of humour, satire and tragedy and their fantastic spelling; and this was followed by *Catherine,* a strong story, founded closely on the career of a criminal named Catherine Hayes and intended to counteract the then growing practice of making ruffians and harlots prominent characters in fiction. When *Pendennis* was coming out in serial form (1850) another Catherine Hayes, an Irish singer and famous prima donna. was much before the public. Thackeray, thinking of the former and oblivious of the latter Catherine Hayes, caused a great outcry in the Irish press by coupling the name with that of a recently notorious murderer. He afterward suppressed the passage but the incident is of interest because it explains the initial letter drawn by Thackeray for chap. xv, vol. ii, of *Pendennis.* The drawing is in itself highly comic, but must seem quite meaningless without the key. There soon followed *Fitz-Boodle's Confessions and Professions,* and the *Shabby Genteel Story,* a work interrupted by Thackeray's domestic affliction and afterward republished as an introduction to *The Adventures of Philip,* which took up the course of the original story many years after the supposed date of its catastrophe. In *1843* also came out the *Irish Sketch-Book,* and in 1844 the account of the journey *From Cornhill to Grand Cairo,* in which was included the excellent poem of "The White Squall." In 1844 there began in *Fraser* the *Memoirs of Barry Lyndon,* called in the magazine "The Luck of Barry Lyndon, a Romance of the Last Century." "Barry Lyndon" has. with a great difference in treatment, some resemblance to Tobias Smollett's *Ferdinand, Count Fathom* —the hero, that is to say, is or becomes an intolerable scoundrel who is magnificently unconscious of his own iniquity. The form and pressure of the time depicted are caught with striking verisimilitude, and in the boyish career of Barry Lyndon there are fine touches of a wild chivalry, simplicity and generosity. which mingle naturally with those worse qualities that, under the influence of abominable training, afterward corrupt his whole mind and career. The man is so infatuated with and so blind to his own roguery, he has so much dash and daring and is on occasions so infamously treated. that it is not easy to look upon him as an entirely detestable villain until, toward the end of his course, he becomes wholly lost in brutish debauchery and cruelty.

Thackeray became a contributor to *Punch* within the first year of its existence. John Leech, who was one of the earliest contributors, had been at Charterhouse with Thackeray and the two men were friends through life. Thackeray made his first hit with *Jeames's Diary,* begun in Nov. 1845, and may be said to have established his reputation by the *Snob Papers* (1846), now known as *The Book of Snobs.*

"Punch's Prize Novelists," another series which Thackeray contributed to the paper. contains some brilliant parodies of Edward Bulwer-Lytton, Lever. Disraeli and others. Because of differences in political opinion, his connection with *Punch* ended in 1851.

Minor but admirable works of the same period are *Legend of the Rhine* (a burlesque of Dumas's *Othon l'Archer*), in George Cruikshank's *Table Book,* edited by Gilbert À Beckett. *Cox's Diary* (on which was founded a well-known Dutch comedy, *Janus Tulp*), and *The Fatal Boots. Rebecca and Rowena* towers over every other burlesque of the kind. Its taste, its wit, its pathos. its humour, are unmatchable; and it contains some fine songs of a particular sort. In *1846* was published, by Bradbury and Evans. the first of *24* numbers of *Vanity Fair,* the work which placed Thackeray as a novelist of the first rank. It was completed in 1848, in which year it was also published as a book. The charge of cynicism Thackeray has himself met at the end of the eighth chapter, in a passage which is the best commentary on the author's method. He explained how he wished to describe men and women as they actually are. good. bad and indifferent: "Occasionally to step down from the platform. and talk about them; if they are good and kindly, to love and shake them by the hand; if they are silly. to laugh at them confidentially in the reader's sleeve; if they are wicked and heartless, to abuse them in the strongest terms politeness admits of. Otherwise you might fancy it was I who was sneering at the practice of devotion, which Miss Sharp finds so ridiculous: that it was I who laughed good-humouredly at the railing old Silenus of a baronet—whereas the laughter comes from one who has no reverence except for prosperity, and no eye for anything beyond success. Such people there are living and flourishing in the world—Faithless, Hopeless, Charityless: let us have at them, dear friends, with might and main. Some there are, and very successful too, mere quacks and fools; and it was to combat and expose such as those, no doubt, that laughter was made:"

Another accusation brought against the book was that the colours were laid on too thick, in the sense that the villains were too villainous, the good people too goody-goody. The best answer to that can be found by reading the work itself with care. Osborne is meant to be a poor enough creature, and one whose poorness of character is developed as he allows bad influences to tell upon his vanity and folly. The good in him comes out in the beautiful passage describing his farewell to Amelia on the eve of Waterloo, in which passage may be also found a sufficient answer to the statement that Amelia is insipid and uninteresting. So with the companion picture of Rawdon Crawley's farewell to Becky Sharp. Who that reads it can resist sympathy, in spite of Rawdon's vices and shady shifts for a living, with his simple bravery and devotion to his wife? As for Becky. there is certainly not much to be said in her defense. The reader learns that she thought she would have found it easy to be good if she had been rich, and also knows what happened when Rawdon surprised her alone with and singing to Lord Steyne in the house in Mayfair. After a gross insult from Steyne, "Rawdon Crawley, springing out, seized him by the neckcloth, until Steyne, almost strangled. writhed and bent under his arm. 'You lie. you dog,' said Rawdon; 'you lie, you coward and villain!' And he struck the peer twice over the face with his open hand. and flung him bleeding to the ground. It was all done before Rebecca could interpose. She stood there trembling before him. She admired her husband. strong, brave, and victorious." This admiration is the capital touch in a scene as powerful as any Thackeray ever wrote. The supreme art in the treatment of the character of the brilliant adventuress that Becky was makes the reader feel her attractiveness, though he knows her evil qualities.

Vanity Fair was followed by *Pendennis, Esmond* and *The Newcomes,* which appeared respectively in 1850, 1852 and 1854. *Esmond* is perhaps Thackeray's capital work. It is undoubtedly one of the greatest of English historical novels. The romance *Esmond* reproduced with accuracy the figures. manners and phrases of a past time. The character Beatrix is an insolent beauty who captivated men; "Esmond," according to Thackeray. "was a prig."

Beatrix reappears in the *Virginians* as the jaded. worldly and not altogether unkindly Baroness. The reader is left with the impression that it was just what Beatrix must have come to.

In 1851 Thackeray had written *The English Humourists of the Eighteenth Century,* delivered as a series of lectures at Willis' Rooms in the same year, and redelivered in the United States in 1852 and 1853, as was afterward the series called *The Four Georges.*

In 1854 was published that delightful burlesque, *The Rose and the Ring.* In 1857 Thackeray stood unsuccessfully as a parliamentary candidate for Oxford and in the same year appeared the first number of *The Virginians,* a sequel to *Esmond.* The last number came out in 1859, and in the same year Thackeray undertook the editorship of the *Cornhill Magazine.* This was a task which, as readers of his *Roundabout Paper* "Thorns in the Cushion" will remember, the kindliness and sensitiveness of his disposition made irksome to him. and he resigned the editorship in April 1862, though he continued to write for the magazine until he died. In the *Cornhill* appeared *Lovel the Widower,* previously written, with different names for some of the personages, in dramatic form; *The Adventures of Philip* (1861–62); the *Roundabout Papers,* some of his best essays; and (1860–63) the story, unhappily never finished. called *Denis Duval.* Among the *Roundabout Papers* is one differing in form from the rest, called "The Notch on the Axe—a Story a la Mode," an almost perfect specimen of the author's genius for burlesque storytelling. *The Adventures of Philip* is in the nature of a sequel to *A Shabby Genteel Story,* contains scenes which rank with Thackeray's best work; there are fine sketches of journalistic, artistic and diplomatic life, but Philip himself is impossible; the character is not drawn at all. *Denis Duval,* which reached only three numbers, promised to be a first-rate work in the *Esmond* manner. The author died while it was in progress, on Dec. 24, 1863. He was buried in Kensal Green, and a bust by Marochetti was put up to his memory in Westminster abbey.

The grace and the apparent spontaneity of Thackeray's verses are beyond question. Some of the more serious efforts, such as "The Chronicle of the Drum" (1841), are full of power and instinct with true poetic feeling. Both the half-humorous, half-pathetic ballads and the wholly extravagant ones must be classed with the best work of that kind; and the translations from Béranger are as good as verse translations can be, for Thackeray had the true poetic instinct.

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THADDAEUS: see APOSTLE.

THAILAND: see SIAM.

THAÏS, a Greek courtesan who lived during the time of Alexander the Great. She accompanied him on his Asiatic campaign, and is chiefly known from the story which represents her as having persuaded the emperor to set fire to the city of Persepolis. This anecdote forms the subject of Dryden's *Ode to Saint Cecilia's Day,* but its authenticity is doubtful, since it is based upon the authority of Cleitarchus, one of the least trustworthy of the historians of Alexander.

Thais subsequently became the wife of Ptolemy Lagus, king of Egypt.

Numerous anecdotes and witticisms attributed to Thai's will be found in Athenaeus.

See Diod. Sic., xvii, 72; Plutarch, *Alexander,* 38; Athenaeus, xiii, 576, 585; Quintus Curtius, v, 7.

THALAMUS, a globular congeries of nerve cells and fibres in the middle of the brain, divided into nuclei, and somewhat larger than a walnut. There all sensory impulses except those of smell are relayed on their way to the cerebral cortex.

In submammalian vertebrate animals the thalamus is chiefly olfactory and does not relay specific sensation, for there is no somatic cortex. With the development of the cortex in the mammals, and the projection of the sensations upon it, the sensory relay nuclei of the thalamus expand proportionately. Thus, the thalamus shows a large lateral geniculate body behind and laterally, for relay of visual impulses; a round medial geniculate body adjacent, for hearing; and a large somesthetic nucleus in its lower central part for bodily sensations. These three are the fundamental and best understood of its nuclei.

The thalamus may be divided into about 30 nuclei, each with differing connections and, therefore, differing functions. Most of them project to one or another of the numerous areal units of the cerebral cortex, so their function is indicated by that of the corresponding cortical area, where this is known. A few do not; they are the most ancient and conservative. Ignorance of the incoming connections of most of the nuclei is chiefly responsible for ignorance of their function. It is known, however, that the thalamus is not directly responsible for motor control.

The thalamus is rarely directly injured or the primary seat of disease, but it may be involved in more generalized disturbances. See also BRAIN; HYPOTHALAMUS; FEELING, PSYCHOLOGY OF.

(W. J. S. K.)

THALER, a silver coin formerly circulating in north Germany. See MONEY, MEDIAEVAL.

THALES, one of the Seven Wise Men of ancient Greek philosophy who was also universally held to have introduced geometry into Greece, was the son of the Carian Examyas of Miletus and of Cleobuline. The story of his Phoenician descent is unlikely. His date is fixed by the statement of Herodotus that he foretold an eclipse now generally agreed to be that of May 28, 585 B.C. Apollodorus' date for his birth, 624 B.C., was doubtless based on this as a *floruit.* According to Diogenes Laërtius he died in the 58th Olympiad (548–545 B.C.), aged 78.

His inclusion in the canon of the Seven Wise Men gave him an ideal character, and his name attracted many acts and sayings popularly associated with wisdom. Consequently his real achievement is hard to assess, especially since no contemporary sources exist. He was a practical statesman who, according to Herodotus, offered the wise advice that the Ionian cities should federate; and Diogenes states that he dissuaded Miletus from making an alliance with Croesus of Lydia. Practical interests are also indicated by the story told (but not believed) by Herodotus that he diverted the river Halys for Croesus, and by the tradition mentioned by Callimachus that he advised navigators to steer by the Little Bear rather than the Great. He is also said to have used his knowledge of geometry to measure the pyramids (Hieronymus of Rhodes cited by Diogenes) and to calculate the distance from shore of ships at sea (Eudemus cited by Proclus).

Such stories of little historical worth may yet serve to characterize his reputation. They could however be invented or selected according to a writer's predilections. Two in particular provide amusing examples of mutually canceling propaganda. According to Aristotle. Thales, foreseeing by his meteorological skill a glut of olives, hired all the olive presses in advance and, when the season came. was able to charge his own price for reletting them. The moral drawn was that philosophers can be as worldly wise as other men if they so choose. To demonstrate the contrary, that philosophy's chief glory is its abstraction from the world, Plato tells how Thales fell into a well while stargazing and was laughed at for studying the heavens to the neglect of what was at his own feet.

The best attested fact is his prediction of the eclipse which stopped the battle between the Lydian Alyattes and the Mede Cyaxares. The date 585 B.C. suits the chronology now that Herodotus has been shown to have erred slightly in implying that Astyages succeeded Cyaxares in 594. Thales could not have had the knowledge to predict accurately the locality or character of an eclipse. Hence the feat was isolated and apparently only approximate; Herodotus speaks of his foretelling the year only. The use of the Babylonian saros for this purpose has been convincingly denied by O. Neugebauer *(Exact Sciences in Antiquity* [1951]). All that his Babylonian contemporaries could say was that an eclipse was either excluded or possible, and this sufficed for their astrological aims. From their records, Thales could well have said that an eclipse was possible in the year which ended during 585. The coincidence that it occurred during a crucial battle and was nearly total would give him in retrospect an exaggerated reputation as an astronomer.

Thales was specifically credited with five geometric theorems, as follows: (1) that a circle is bisected by its diameter; (2) that angles at the base of an isosceles triangle are equal; (3) that opposite angles of intersecting straight lines are equal; (4) that the angle in a semicircle is a right angle; and (5) that a triangle is determined if base and angles relative to base are given. The real extent of his mathematical achievement is almost impossible to assess in view of the ancient habit of crediting particular discoveries to individuals with a general reputation for wisdom. The fifth theorem is associated with the feat of measuring the distance of ships from shore, for which an empirical rule would have sufficed.

Moreover the requirements of "proof" vary according to period; of the third theorem Eudemus himself said that, although it was discovered by Thales, Euclid provided the scientific proof. Yet we may well believe that the first Greek philosopher improved on Egyptian techniques of land measurement in the way described by Proclus, who after saying that Thales introduced geometry from Egypt adds that "he made many discoveries himself and laid the foundation for his successors, attacking some problems in a more universal way and others more empirically."

The claim that Thales was the founder of European philosophy rests primarily on Aristotle, who says that he was the first to suggest a single material substratum for the universe, namely water, or moisture. The reason, Aristotle suggests, was that moisture is pre-eminently the origin and sustainer of life: vital heat is generated by moisture; semen and all nourishment must contain it. Aristotle frankly admits that he writes from hearsay; whatever Thales may have written had long been lost. Nevertheless both the statement and Aristotle's conjectural reasons are probably true in substance. The origin of all things from water was a commonplace of Babylonian and Egyptian mythology (the tradition of Thales' sojourn in Egypt is strong) and can be traced among the Greeks as far back as Homer's description of Ocean as the genesis of all things. Thales had consciously renounced myth, but its legacy remained.

We need not doubt that he was in method and intention rational. The dualism of matter and life was in the future, and what he seems to have sought was a single principle, both origin of the world and permanent ground of its being, to explain the mutability and multiplicity of phenomena. It must therefore be not only material but also author of change, that is to say, something self-changing; for, as the more mature Aristotle complained, these early Milesians did not distinguish matter from active cause. But. in Greek eyes, what changed or moved itself was alive, had psyche ("soul"). Hence, we may guess, Thales' choice of the substance which seemed to have the closest connection with life, as moisture did in Greek thought both then and later. The whole universe was a living organism, nourished by exhalations from water.

Consonant with this are other statements which Aristotle found traditionally attributed to Thales, that "the magnet has soul because it attracts iron" and that "all things are full of gods." The latter Aristotle connects with the belief that "soul is mingled in the whole." Diogenes Laërtius quotes Aristotle as saying also that Thales attributed life even to the inanimate, arguing from the behaviour of the magnet and of amber.

Of Thales' cosmology nothing is known but the statement quoted by Aristotle that the earth floats on water. To the historian of science, his significance lies not so much in the primacy of water (though some, like Sir Charles Sherrington in *Man on His Nature* [1940], have shown that this is by no means an absurd idea) as in the attempt to explain nature by the simplification of phenomena and the search for causes within nature itself rather than in the caprices of anthropomorphic gods. For cosmic unity as such, mythical precedents may again be quoted. That "all things come from one" was an early belief in Greece as in other lands; the original unity of earth and sky is crudely reflected in Hesiod's *Theogony*. Through the mists of later anecdotal tradition the true stature of Thales emerges only dimly, but as far as can be judged both he and his successors Anaximander and Anaximenes are important as constituting a bridge between the worlds of myth and reason. The ideas of these philosophers appear to some historians as remarkable anticipations of modern science, to others as transparent rationalizations of myth. They could not free themselves entirely from the inherited cosmic framework, but in their approach to it, in their critical spirit and in their determination to produce a simple, rational scheme employing only natural causes, they took a step whose future importance can scarcely be overrated. *See* also references under "Thales" in the Index volume.

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THALLIUM, a metallic chemical element, discovered in 1861 by Sir William Crookes. During a spectroscopic examination of the flue dust produced in the roasting of seleniferous pyrites, Crookes observed a green line foreign to all then known spectra. He concluded that the mineral contained a new element, to which he gave the name of thallium, from the Greek for "a green twig."

Crookes presumed that his thallium was something of the order of sulfur, selenium or tellurium; but A. Lamy, who anticipated him in isolating the new element, found it to be a metal. (Symbol Tl, atomic number 81, atomic weight 204.39, stable isotopes 203 and 205.)

Thallium occurs in the rare minerals, crookesite. $(CuTlAg)_2Se$; lorandite, $TlAsS_2$; vrbaite, $TlAs_2SbS_5$; and hutchinsonite, $(TlAgCu)_2S.As_2S_3 + PbS.As_2S_3$. It is also found in minute quantities in various pyrites, some of which are processed for other purposes, as, for example, the manufacture of sulfuric acid. In such cases, thallium is often concentrated, as in the flue dusts which arise in roasting various pyrites and in the chamber muds arising from sulfuric-acid production; these by-product concentrates are the usual raw-material sources of thallium.

For the extraction of the metal from chamber mud, the latter is boiled with water, which extracts thallium as sulfate. From the filtered solution the thallium is precipitated as chloride by addition of hydrochloric acid, along with more or less of lead chloride.

TABLE I.—Physical Properties of Thallium

Density at 20° C., g. per c.c.	11.85
Melting point ° C.	303.5
Boiling point ° C.	1,457.
Radius of ion, Tl^+, Å.	1.15
Radius of ion, Tl^{+++}, Å.	0.95
Coefficient of linear expansion at 40" C., per ° C.	30.2×10^{-6}
Ionization potential of gas atom, volts	
1st electron	6.07
2nd electron	20.32
3rd electron	29.7
Resistivity at 20° C., ohm-cm.	18.1×10^{-6}
Potential at 25° C. tor $Tl \rightleftarrows Tl^+ + e$, volts	0.336
$Tl \rightleftarrows Tl^{+++} + 3e$, volts	−0.719

The mixed chlorides are boiled down to dryness with sulfuric acid to convert them into sulfates, ahich are then separated by boiling water, which dissolves only the thallium salt. From the filtered solution the thallium is recovered, as such, by pure metallic zinc, or by electrolysis. The (approximately pure) metallic sponge obtained is mashed, made compact by compression, fused in a porcelain crucible in an atmosphere of hydrogen and then cast into sticks.

Physical Properties.—Thallium is a bluish-white metal that is very soft, malleable and of low tensile strength. Two crystalline forms are known with a transition temperature of 226° C. Some of the common physical properties are given in Table I.

Chemical Character.—The elements gallium, indium and thallium comprise Subgroup III in the periodic table (see PERIODIC LAW). Thallium has the following electron arrangement in the incomplete orbits (O and P): $5s^2$, $5p^6$, $5d^{10}$, $6s^2$, $6p^1$. It readily loses one of its valence electrons to form thallous, the +1 oxidation state, or all three electrons to form thallic, the +3 state. In the chemistry of gallium and indium (*qq.v.*), which have the same outer electron arrangement, the +1 state is of little importance. Thallium metal resembles lead in most of its physical properties. Thallous ion resembles divalent lead in the formation of insoluble chlorides and iodides; it is also quite similar in many of its properties to the alkalies since it is a +1 ion of similar size. Thallic ion resembles aluminum and gold but with less pronounced acid-forming properties since it is a larger +3 ion.

Metallic Thallium.—As shown by the potential in the above table of physical properties thallium is easily oxidized to the thallous state. It tarnishes in air, forming an oxide film which readily dissolves in water; upon prolonged contact with air and water the metal dissolves to form a thallous-hydroxide solution. At red heat, water reacts to liberate hydrogen with the formation of thallous oxide, Tl_2O. Thallium dissolves in nitric acid and sulfuric acid; it dissolves less readily in hydrochloric acid, which precipitates the insoluble chloride. It unites directly with all the halogens.

Salts.—Thallium forms two series of salts: thallous, in which the metal is univalent; and thallic, in which it is trivalent. The thallic salts are, however, much less stable than the thallous.

Thallium salts are used in the manufacture of certain optical glasses because of the high refractive index conferred on the glass. They are all poisonous, having an action somewhat resembling that of lead salts, and are said to have a pronounced depilatory action, but this has also been denied.

Thallous hydroxide, TlOH, is most conveniently prepared by decomposing a solution of the sulfate with barium hydroxide. It crystallizes from its solution in long yellow needles, TlOH or $TlOH + H_2O$, which dissolve readily in water, forming an intensely alkaline solution which acts as a caustic and greedily absorbs carbonic acid from the atmosphere. Unlike the alkalies, it readily loses its water at 100° C. and even at the ordinary temperature to form the oxide Tl_2O, which is black or black-violet. Thallic oxide, Tl_2O_3, is formed when the metal is heated in air or oxygen at 500°–700° C., by the action of hydrogen peroxide upon alkaline solutions of thallous salts, or by heating thallous nitrate. It decomposes into thallous oxide and oxygen above 800°. The corresponding hydroxide, TlO OH, is very unstable. A thallothallic oxide, $Tl_2O.Tl_2O_3$ or TlO, is also known.

Thallous chloride, TlCl, is readily obtained from the solution of any thallous salt, by the addition of hydrochloric acid, as a white precipitate similar in appearance to silver chloride, like which it turns violet in the light and fuses below redness into a (yellow) liquid which freezes into a hornlike flexible mass. It is also formed when the metal is burned in chlorine. One part of the precipitated chloride dissolves at 0° C. in 500 parts of water, and in 40 parts at 100° C. It is less soluble in dilute hydrochloric acid. Thallous iodide, TlI, similarly obtained as a yellow precipitate, requires 16,000 parts of cold water for its solution. The yellow crystals melt at 190°, and when cooled assume a red colour, which changes to the original yellow on standing.

Thallous bromide, TlBr, is a light yellow crystalline powder; it is formed analogously to the chloride. Mixed bromide-iodide crystals have a high infrared transmission; lenses, windows and prisms ground from the crystals are used in instruments for the detection and measurement of infrared radiation.

Thallous perchlorate, $TlClO_4$, and periodate, $TlIO_4$, are interesting inasmuch as they, together with several other thallous salts, are isomorphous with the corresponding potassium salts.

Thallous carbonate, Tl_2CO_3, more nearly resembles the lithium compound than any other ordinary carbonate. It is produced by the exposure of thallous hydrate to carbon dioxide and therefore is obtained when the moist metal is exposed to the air. It forms resplendent monoclinic prisms, soluble in water. The bicarbonate is not known.

Thallous sulfate, Tl_2SO_4, forms rhombic prisms soluble in water, which melt at a red heat with decomposition, sulfur dioxide being evolved. It unites with aluminum, chromium and iron sulfates to form alums (*q.v.*). It also forms double salts of the type $Tl_2SO_4(Mg, Fe \text{ or } Zn)SO_4.6H_2O$. Thallous sulfide, Tl_2S, is obtained as a black precipitate by passing hydrogen sulfide gas into a thallous solution. It is insoluble in water and in the alkalies, but readily dissolves in the mineral acids.

Thallous nitrate, $TlNO_3$, is obtained as white, rhombic prisms by crystallizing a solution of the metal, oxide, carbonate, etc., in nitric acid. Various thallous phosphates are known, *e.g.*, $Tl_2HPO_4.H_2O$, TlH_2PO_4, Tl_3PO_4, $Tl_4P_2O_7$, etc.; they bear a close resemblance to the corresponding phosphates of the alkali metals.

Thallic chloride, $TlCl_3$, is obtained by heating the monochloride with chlorine under pressure, or by saturating a suspension of the monochloride in water with chlorine; when anhydrous it is a crystalline mass which melts at 24°. It forms several double salts; *e.g.*, with hydrochloric acid and the alkaline chlorides. The chlorine is not completely precipitated by silver nitrate in nitric acid solution, the ionization apparently not proceeding to all the chlorine atoms. The mixed chlorides $TlCl.TlCl_3$ and $3TlCl.TlCl_3$ are also produced by the regulated action of chlorine on the monochloride.

Thallic iodide, TlI_3, is interesting because of its isomorphism with rubidium and cesium tri-iodides, a resemblance which suggests the formula $TlI(I_2)$ for the salt, but T. M. Lowry and A. J. Berry (1928) showed that it does not give the reactions of a thallous salt, and when dissolved in methyl alcohol, it behaves as a binary electrolyte; *i.e.*, as $(TlI_2)I$ or as $Tl[TlI_6]$.

Thallic sulfate, $Tl_2(SO_4)_3.7H_2O$, and thallic nitrate, $Tl(NO_3)_3.3H_2O$, are obtained as colourless crystals on the evaporation of a solution of the oxide in the corresponding acid. The sulfate decomposes into sulfuric acid and the trioxide on warming with water, and differs from aluminum sulfate in not forming alums.

Thallous acetylacetone, $C_4H_7O_2Tl$, prepared from an alcoholic solution of acetylacetone and the hydroxide, is of interest.

Analysis.—All thallium compounds volatile or liable to dissociation at the temperature of the flame of a Bunsen lamp impart to such flame an intense green colour. The spectrum contains a bright green of wave length j.351 A. From solutions containing it as thallous salt the metal is easily precipitated as chloride, iodide or chloroplatinate by the corresponding reagents. Hydrogen sulfide, in the presence of free mineral acid, gives no precipitate; ammonium sulfide precipitates Tl_2S from neutral solutions as a dark-brown or black precipitate insoluble in excess of reagent. Thallic salts are easily reduced to thallous by means of solution of sulfurous acid, and thus rendered amenable to the above reactions. Thallous chloride can be titrated by potassium iodate in moderately concentrated hydrochloric acid solution.

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THAMES, a river of England, rising in several small streams among the Cotswold hills in Gloucestershire. Its source is generally held to be at Thames Head, in the parish of Coates, 3 mi. W. of Cirencester; but claims have also been advanced on behalf of the Seven Springs, the headwaters of the Churn river, 5 mi. S. of Cheltenham. The length of the river from Thames Head bridge to London bridge is 161¼ mi. and from London bridge to the Nore, 47¾ mi., a total of 209 mi. The width at Oxford is about 150 ft., at Teddington 250 ft., at London bridge 750 ft., at Gravesend 2,100 ft., and between Sheerness and Shoeburyness, immediately above the Nore, $5\frac{1}{2}$ mi. The height of Thames Head above sea level is 356 ft., Seven Springs 700 ft., and Lechlade 237 ft. and the average fall below Lechlade is 20 in, per mile. In the following paragraph the bracketed figures indicate the distance in miles above London bridge.

The upper course lies through a broad valley. The scenery is rural and pleasant; the course of the river winding. Before reaching Oxford the stream swings north, east and south to encircle the wooded hills at Wytham and Cumnor, which overlook the city from the west. The Windrush joins from the north (left) at New Bridge ($126\frac{3}{4}$), the Evenlode near Eynsham (119), and the Cherwell at Oxford (112). Between Lechlade and Oxford the main channel sends off many narrow branches; the waters of the Windrush are similarly distributed. and the branches in the neighbourhood of Oxford form the picturesque "backwaters." The river then passes the woods of Nuneham, and at Abingdon ($103\frac{1}{2}$) receives the Ock from the Vale of White Horse, at Dorchester ($95\frac{1}{4}$) the Thame (left), and it then passes Wallingford ($90\frac{3}{4}$) and Goring (85). The river now bends eastward, and breaches the chalk hills, dividing the Chilterns from the downs of Berkshire. From this point as far as Taplow the southern slopes of the Chilterns descend closely upon the river; they are finely wooded, and the scenery is peculiarly beautiful. At Pangbourne ($80\frac{3}{4}$) the Thames receives the Pang (right), and at Reading (744) the Kennet (right). After passing Reading it bends northward to Henley (65), east ard past Great Marlow (57) to Bourne End (54), and southuard to Taplow and Maidenhead ($49\frac{3}{4}$), receiving the Loddon (right) near Shiplake above Henley. Winding in a southeasterly direction. it passes Eton and Windsor ($43\frac{1}{4}$), Datchet ($41\frac{1}{2}$), Staines (36), Chertsey (32), Shepperton (30) and Sunbury ($26\frac{1}{2}$), receiving the Coln (left) at Staines, and the Wey (right) near Shepperton. Flowing past Hampton Court, opposite to which it receives the Mole (right), and past Kingston ($20\frac{1}{2}$), it reaches Teddington ($18\frac{3}{4}$). Passing Richmond (16) and Kew the river flows through London and its suburbs for a distance of about 25 mi., till it has passed Woolwich. Gravesend, the principal town below Woolwich, is $26\frac{1}{2}$ mi. from London bridge. The estuary may be taken to extend to the North Foreland of Kent. In the tideway the principal affluents of the Thames are the Brent at Brentford, the Wandle at Wandsworth, the Ravensbourne at Deptford, the Lea at Blackwall, the Darent just below Erith, and the Ingrebourne at Rainham, besides the Medway.

The basin of the Thames is of a composite character. Thus, the upper portion of the system, above the gap at Goring, is a basin in itself, defined on the west and south by the Cotswold and White Horse hills and on the east and north by the Chilterns and the uplands of Northamptonshire. But there are several points at which its division from other river basins is only marked by a very low parting. Thus a well-marked depression in the Cotswolds brings the head of the (Gloucestershire) Coln, one of the headstreams of the Thames, very close to that of the Isborne, a tributary of the Warwickshire Avon; the parting between the headstreams of the Thames and the Bristol Avon sinks at one point, near Malmesbury, below 300 ft.; and headstreams of the Great Ouse rise little more than two miles from, and only some 300 ft. above, the middle valley of the Cherwell. The White Horse hills and the Chilterns strike right across the Thames basin, but almost their entire drainage from either flank lies within it, and similarly a great part of the low-lying Weald, though marked off from the rest of the basin by the North Downs, drains into it through these hills. Further, the Kennet continues upward the line of the main valley below the Goring gap, and the Cherwell that of the main valley above it. The basin thus presents interesting problems. Its main features originated on a land surface high above the present level at a time when a thick cover of Mesozoic rocks extended far to the west of their present outcrop. The Thames developed its main stream along the synclinal axis of the London basin, roughly on the line of the present Kennet, at least by mid-Tertiary times. Much of the drainage of the area south of a divide running from Market Harborough through Birmingham to Plynlimon was carried southeastward toward this axis, as is evidenced by the wide valleys of the Cotswold headwaters and by the dry valleys across the Chilterns. When the supposedly Cretaceous cover was removed from the western areas, subsequent streams quickly developed along the outcrops of the clayey Jurassic beds. thus diverting many of these tributary streams to the northeast or southwest. The Goring gap across the chalk escarpment, developed as a deep valley in the ancient surface. was maintained and deepened by the waters collected by the upper Thames from the beheaded Cotsmold streams and by the Cherwell from the north. The lower Thames appears to have followed the Kennet direction northeastward near the line of the present St. Albans vale until the Ice Age when the accumulation of drift deposits blocked that outlet and forced the river south toward its present position. The intricate terraces of the Thames gravels are of great interest to Pleistocene geologists and archaeologists; in the Middle Gravels of the "100-foot" terrace of the Thames, at Swanscombe, Kent, were found fragments of the Swanscombe skull associated with Acheulean hand axes.

Tamesis and Isis.—The Thames about Oxford is often called the Isis, a name recorded in the 14th century. Caesar (De Bell. Gall. v, II) says that at the time of his invasion of Britain it was called Tamesis. E. Ekwall says it is a British river name cognate with the Sanskrit name *Tamasā,* a tributary of the Ganges; the name is taken to mean "dark river." In the first statute passed for improving the navigation of the river near Oxford (21 Jac. I) it is called the river of Thames, while in a statute of George II (1751) the word Isis appears.

River Regulation.— The flow of the Thames varies greatiy, according to the season. In very dry summers the flow at Teddington has been known to fall as low as 200,000,000 gal. per day and as high as 20,000,000,000 gal. in a rainy season. Flooding of the surrounding country is not uncommon, and it becomes a serious menace to the low-lying parts of London, where the river is tidal, when flooding coincides with high spring tides. The importance of storage reservoirs is manifest under such conditions of flow, especially bearing in mind the ever increasing needs of the London district. The water supply of London is considered under that heading; it may be noted here that the Thames forms its chief source of supply, but apart from this the corporation of Oxford and two companies in the Staines district have powers to draw water from the river.

Throughout the whole of the Thames watershed, and especially in the 3,800 sq.mi. above the intakes of the water companies (at Hampton or in the vicinity), the Thames Conservancy has enforced the requirements of parliament that no sewage or other pollution shall be allowed to pass into the Thames, or any water communicating with it.

In 1771 an act of parliament was passed authorizing the construction of pound locks on the Thames above Maidenhead bridge. In pursuance of the powers thus granted, the Thames commissioners of that day caused locks to be built at various points above Maidenhead, and between 1810 and 181j the corporation of London carried out river works on the same lines as far down the river as Teddington. The works as subsequently maintained by the Thames Conservancy board ensure an efficient head of water during the drier seasons of the year, and facilitate the escape of winter floods. The Thames is connected with neighbouring rivers by canals, but nearly all these are now abandoned or used only for pleasure boating or a little local trade. The Grand Union canal carries local London traffic and long distance traffic from London to Birmingham, Nottingham and Leicester. The Lea navigation takes goods to and from the London docks 26 mi. up the Lea valley. The vast traffic on the lower river and the estuary is controlled by the Port of London authority whose administration covers the waterway from Teddington to the Nore. Only pleasure craft and a little barge traffic use the river above Teddington.

In 1857 the Thames Conservancy board was established. Its powers were increased and its constitution varied in 1864, 1866 and 1894, but the creation of the Port of London authority limited its jurisdiction. Fish are fairly abundant, especially coarse fish such as roach, dace and bleak. The salmon was caught as late as 1833, but subsequent pollution killed many fish. The right of the public to take fish freely from the river has been frequently under dispute and fisheries came under the regulation of bylaws made by the Thames Conservancy.

THAMES, BATTLE OF THE, was fought on Oct. 5, 1813, during the War of 1812. During the first year of the war the British captured Detroit and gained control of much of the U.S. northwest. Capt. Oliver H. Perry's naval victory over the British in Lake Erie on Sept. 10, 1813, reversed the course of the northwest campaign. Brig. Gen. Henry A. Procter, the British commander, abandoned Detroit and began a hasty retreat across Upper Canada (Ontario) toward Lake Ontario. He was pursued by about 3,500 U.S. troops under the command of Maj. Gen. William Henry Harrison: who had the aid of Perry's fleet. The battle mas fought at Moraviantown on the Thames river, a few miles east of present-day Thamesville. The British with about 600 regulars and 1,000 Indian allies under Tecumseh were greatly outnumbered and were quickly defeated. Tecumseh was killed and many of the British were captured, but Procter escaped. The United States regained control of the northwest and most of the Indian tribes abandoned their alliance with the British. After the battle the U.S. troops returned to Detroit after destroying Moraviantown. a village of Christian Indians. In Canada the engagement is called the battle of Moraviantown.

THANA, a town and district in India, in the Bombay Konkan division. Bombay state. The town is 21 mi. from Bombay city, of which it is now practically a suburb. Pop. (1961) 101,103.

The DISTRICT OF THANA has an area of 3,683 sq.mi. It extends along the coast and is confined between the. Western Ghats on the east and the sea on the west, while on the north it is bounded by the Portuguese territory of Damaun and by Surat district, and on the south by Bombay suburban district. The district is well watered and wooded, and, except in the northeast, is a low-lying rice tract broken by hills.

Most of the hills were once fortified, but the forts built on them are now dilapidated and useless. The only rivers of any importance are the Vaitarna and the Ulhas. the former being navigable for a distance of about 20 mi. from its mouth. There are no lakes; but the Vehar and the Tulsi, formed artificially, supply Bombay city with water. In 1961 the population was 1,653.327. The staple crop is rice. Fishing supports many of the people. and the forests yield timber and other produce. Salt is manufactured by evaporation along the coast.

The territory comprised in the district of Thana (apart from Salsette island. which was acquired in 1782) formed part of the dominions of the peshwa, and was annexed by the British in 1818 on the overthrow of Baji Rao.

THANE: see THEGN OR THANE.

THANESAR, an ancient town of India, in Karnal district of the Punjab, on the Saraswati river. Pop. (1951) 11,273. As the centre of the tract called Kurukshetra in the Mahabharata, it is a holy place. The bathing fair held here on the occasion of a solar eclipse is said to be attended by 500,000 pilgrims.

THANET, ISLE OF, forms the northeast corner of Kent, Eng., and its name is derived either from a Celtic base meaning "bright" or "fire island," referring to beacons, or from the Old English. verb "to protrude." It is composed of a chalk ridge culminating in the North foreland and is separated from the mainland by two branches of the Stour river, one with the ancient name of Wantsum.

This former sea channel was guarded north and south by the Roman forts of Regulbium (Reculver) and Rutupiae (Richborough), and despite medieval reclamation and the silting up of Sandwich harbour! remained open for small boats until the 16th century. Anciently a ferry crossed the Wantsum at Sarre, but in the reign of Henry VII a bridge mas constructed with causeways across the marshes. The southern end of the channel was at Ebbsfleet, the reputed landing place of Hengest c. A.D. 449, and evidence of Jutish settlement has been found at Ozengell near Ramsgate and elsewhere. Thanet suffered later from Danish raids during which Minster abbey was destroyed.

Its location made Thanet of maritime importance and much of the island was associated with Dover or Sandwich and lay within the liberty of the Cinque Ports. During the 18th century Richard "Beau" Nash helped to develop Margate and Ramsgate as watering places. Modern Thanet forms one of the parliamentary divisions of Kent. It contains the municipalities of Margate and Ramsgate and the urban district of Broadstairs, and has a population of (1951) 98,695. (Fx. H.)

THANKSGIVING DAY, a national holiday celebrated throughout the United States, is a day of religious observance, set apart to give thanks for the blessings of the past year, as well as an occasion for family reunions, bountiful dinners and festivities in the home.

Though the origin of the holiday has been attributed to a thanksgiving festival held by Plymouth colony in Dec. 1621, such celebrations date from ancient times (see below). In the United States it became a particularly popular holiday in New England, and native fruits and vegetables, wild turkeys and pumpkin pies became traditional foods for the day.

From early colonial times the various American colonies celebrated thanksgiving days in recognition of such happy events as good harvests and victories over the Indians. Pres. George Washington in 1789 issued the first presidential thanksgiving proclamation in honour of the new constitution. During the 19th century an increasing number of states observed the day annually, each appointing its own date. That Pres. Abraham Lincoln, Oct. 3, 1863, by presidential proclamation appointed the last Thursday of November as Thanksgiving Day was due to the unremitting efforts of Mrs. Sarah J. Hale, editor of Godey's Lady's Book. Each succeeding president made similar proclamations, until Pres. Franklin D. Roosevelt in 1939 appointed the third Thursday of November. In Dec. 1941, however, congress by joint resolution approved by the president set the fourth Thursday of November as Thanksgiving Day, a national public holiday. Though Thanksgiving Day in the United States is rooted in native tradition, the idea of a day set apart to celebrate the completion of the harvest and to render homage to the spirit who caused the fruits and crops to grow is ancient and universal. Similarly, the practice of designating a day of thanksgiving for specific spiritual or secular benefits has been followed in many countries.

In the United States Thanksgiving, despite its religious association, often had a distinctly secular flavour. The Yankee country Thanksgiving in the middle of the 19th century traditionally featured a raffle of fowls on Thanksgiving Eve and a shooting match in the morning. In New York city the day was celebrated by companies of fantastically costumed persons who paraded noisily through the streets. Children dressed in the clothes of their elders went about their neighbourhoods begging for money or for contributions of fruits and vegetables.

Canada has long celebrated a Thanksgiving Day, the date varying from year to year, but finally generally placed on the second Monday in October. Pan-American Thanksgiving Day, observed annually by representatives of the Latin-American countries in Washington, D.C., was first celebrated in 1909.

See F. B Hough, *Proclamations for Thanksgiving (1858)*; W. D. Love, *The Fast and Thanksgiving Days of New England* (1895).

(J. K. So.)

THANT, U (1909–), Burmese educator. writer and UN official who was elected acting secretary-general of the Gnited Nations on Nov 3. 1961, to serve until April 10, 1963. G Thant's election marked the first time that anyone other than a native of Europe had held this position. He filled the unexpired term of his predecessor, Dag Hammarskjold, who was killed in a plane crash in Africa on Sept 18, 1961.

U Thant was born Jan. 22, 1909, in Pantanaw, Maubin district, not far from Rangoon, Burma. (Strictly speaking, "U" is not part of his name but is an honorific title comparable to "Mr." or "Honoured Sir," though the literal meaning is "uncle." The Burmese do not use surnames at all.) He was educated at the National high school, Pantanaw, and at the University of Rangoon, but had to leave the university to help support his family At the university U Thant became acquainted with Thakin Nu (later U Nu), who was to become prime minister when Burma gaintd its independence.

After dropping out of the university, U Thant returned to the National high school in his home town as a senior teacher and later as headmaster. During the Japanese occupation of Burma, in World War II, he was a member of various educational committees, and in Aug. 1943 he returned to Pantanaw to rebuild the high school, which had been damaged during the war.

After World War II, U Thant was persuaded by U Nu and by Gen. Aung San, then leader of Burma, to enter government service. In Sept. 1947 he went to the information department and in 1939 became secretary, ministry of information and broadcasting. He was in 1952–53 a member of the Burmese delegation to the United Nations and, after serving his government in various capacities back in Rangoon, in 1957 he became Burma's permanent representative to the UN. Throughout these years he traveled widely, accompanying Prime Minister U Nu on various good-will missions and to international conferences.

Devoutly Buddhist, U Thant sought to apply the personal disciplines of detachment and concentration to get to the heart of problems at the UN. Neutralist by practice as well as inclination, he castigated the U.S.S.R. for its actions in Hungary, criticized the French over Algeria and rebuked the United States for the situation regarding Cuba. When the U.S. snd the U.S.S.R. could not agree on a secretary-general after Hammarskjold's death. U Thant was the one person on whom they could compromise. The U.S.S.R. had earlier demanded a three-man secretaryship (the so-called "troika"). U Thant continued the Hammarskjold tradition by exercising extreme discretion, keeping himself available to all national representatives and forestalling problems before they became insurmountable. Like his predecessor, he considered the UN to be first and last a world instrument for sustained negotiation.
(G. C. Li.; P. M. A. L)

THAPSUS, a low peninsula, now known as Magnisi, joined by a narrow isthmus to the mainland of Sicily, about 7 mi. N.N.W. of Syracuse. The Athenians used it as a naval station in their attack on Syracuse early in 414 B.C. A number of tombs contained objects helonging to a transitional stage between the second and third Sicel period, attributable roughly to 1000–900 B.C., with a proportion of Mycenaean importations.

See Orsi *in Monumenti dei Lincei* (1897), vi, 89–150.

THAPSUS, BATTLE OF (47 B.C.). After his victor:: at Pharsalus Julius Caesar followed Pompey to Egypt, where the Pompeians accumulated a large army and were joined by Juba, king of Numidia. A battle was fought at Ruspina in which Caesar was almost overwhelmed, after which he moved to Veita and besieged it, withdrew on account of lack of supplies, and, in order to compel Scipio to battle, marched on Thapsus, an ancient city of North Africa in the province of Byzacium (the modern province of Tunis), on the coast more than 100 mi. N. of Carthage. Thapsus contained large military stores, was strongly garrisoned and blockaded by Caesar's fleet. On Feb. 4, 47 B.C., he arrived before the city, and immediately besieged it. This drove Scipio into action, for he at once advanced on Thapsus and threw up two entrenched camps, one for his own men and the other for Juha's eight miles south of the city.

The maneuvers which now followed were controlled by a salt water lake, the modern Sehka di Moknine, which lies to the southwest of Thapsus. Caesar had entirely surrounded the town, but Scipio considered that it was still possible to relieve it from the south. Caesar had foreseen the likelihood of this move, and had built a strong fort in the centre of the strip of land which separates the eastern margin of the lake from the sea. When Scipio advanced he struck this fort, and being unable to take it turned back and decided to march round the lake and force the northern approach to the city. This he did, and constructed two camps north of the lake. Though Caesar would have preferred to defer battle until he had taken Thapsus, he now determined to attack Scipio before he had finished his entrenchments. Leaving Asprenas, the proconsul and two legions to carry on the siege, with the rest of his force he marched against Scipio. One-half of his fleet he left to continue the blockade, and the other he ordered to sail down the coast and make a demonstration against Scipio's rear. Placing his left on the coast, Scipio drew up his army in three lines with his elephants and light troops in front of his right and left wings, his Numidian cavalry on the left, and the rest of his cavalry and light troops on the right. Advancing on him, Caesar also extended his army into three lines with the II. and X. legions on the right, the VIII. and IS. on the left, and five legions in the centre. His flanks he covered by five chosen cohorts supported by archers, slingers and cavalry.

As Scipio's camp was but half dug, Caesar's men wished to advance at once. Caesar, however, was not over anxious to precipitate the battle because he was largely outnumbered by the Numidian cavalry. Whilst he hesitated, the X. legion suddenly sounded the charge which was repeated all down the line. The archers and slingers soon overwhelmed Scipio's elephants with their arrows and stones, driving them back on their own line, where they not only demoralized the infantry but scattered the left wing horse. The infantry lines then clinched, fighting each other until sunset, when Scipio's right wing became demoralized. This affected the centre, and soon the entire line broke and sought refuge in the half-completed camp, which was speedily captured by a double envelopment of Caesar's wings. Scipio's force was annihilated in an awful slaughter of which Mommsen writes. "If the hydra with which they fought always put forth new energies, if the army was hurried from Italy to Spain, from Spain to Macedonia, from Macedonia to Africa, and if the repose ever more eagerly longed for never came, the soldier sought, and not wholly without cause, the reason of this state of things in the unseasonable clemency of Caesar." Fifty thousand corpses were strewn over the battlefield of Thapsus, and among them were several Caesarian officers known as opponents to the new monarchy.

In this battle neither strategy nor tactics are remarkable, but what is so is the insubordination of the men, and their growing sense of mastership in the new order which Caesar was creating. He wished to found an Empire, and aimed at a complete victory, constantly taking tremendous risks and ignoring the units. The soldiers wanted peace, so that they could return to their homes and families. At Thapsus a battle was begun between the will of Caesar and the desires of his men, it was slow and progressive, and did not end until Alaric had sacked Rome. *See* PHARSALUS, BATTLE OF: *Bibliography.* (J. F. C. F.)

THARAUD, JEROME (1874–1953), French man of letters, was born on March 18, 1874, at Saint-Junien, Haute Vienne, and educated at the college Sainte-Barbe and the *Ecole normale supérieure.* He became a lecturer at the University of Budapest. In collaboration with his brother Jean (1877–1952), he gained the Prix Goncourt in 1908, and the *grand prix* de *littérature* at the French academy in 1920. The brothers are joint authors (J.-J. Tharaudj of all their works. Jerome was elected to the French academy in 1938. He died Jan. 28, 1953.

Their works *include, Dingley, l'illustre écrivain* (1902); *Bar-Cochebas* (1907); *La Maîtresse Servante* (1910); *La Bataille à Scutari d'Albanie* (6th ed., 1913); *La Tragédie de Ravaillac* (1913); *La Vie et la Mort de Dtrouli.de* (1914); *L'Ombre dr la Croix* (1917); *Un Royaume de Dieu* (1920); *Quand Israel est roi* (1921); *Rendezvous espagnols* (1925); *La Rose de Saron* (1927). *See* J. Bonnerot, *Jérôme et Jean Tharaud, leur oeuvre* (1927).

THARGELIA. A Greek festival bearing signs of very high antiquity; in historical times part of the cult of Apollo, but quite possibly, indeed probably, older than its arrival in Greece. The name is derived from θάργηλος, which signifies an offering of some sort (exact nature and etymology quite uncertain) used at the festival. In Attica, it was held on the 6th and 7th of the month Thargelion, to which it gave its name; the latter date (toward the end of May) was supposed to be Apollo's birthday. On the 6th, certainly at Athens and probably elsewhere, two persons known as *pharmakoi* (magical people, "medicine men"), who had been chosen for their ugliness, were beaten with plants of a magically purifying value, including squills; being thus filled with good magic, they were led through the city, presents of food being made to them. In classical times they seem to have been regarded chiefly as scapegoats, and some pretense was made of stoning or burning them to death; it is, however, fairly clear that this was not their only significance. In Attica they were called σύβακχοι; their connection with Apollo is simply that he is the great god of purification. They occur elsewhere in Ionian ritual.

On the 7th, sundry holy things, very likely including an εἰρεσιώνα (see PYANOPSIA), were carried in procession, and an important musical festival, with prizes for the best chorus, was held in honour of Apollo; this is the only rite which definitely can be said is Apolline and not taken from some still earlier ceremony. It is noteworthy that on the 6th an offering of a ram was made to Demeter Chole.

The principal part of the festival was, therefore, agricultural, as already suggested, Apollo perhaps took it over because it was in part purificatory; it certainly had no intimate relation to his worship.

BIBLIOGRAPHY.—A. Mommsen, ***Feste der Stadt Athen,*** p. **468** *et seq.* **(1898)**; M. **P.** Nilsson, ***Griechische Feste,*** p. 105 (1906); L. **R.** Farnell, ***Cults of the Greek States,*** vol. iv, p. 267 *et seq.* (1907). For the pharmakoi *see* V. Gebhard, ***Die Pharmakoi in Ionien und die Sybakchoi in Athen*** (Amberg, **1926**; bibl.).

THARPARKAR, a former district of Sind, Pakistan; divided in 1955 into Mirpurkhas and Sanghar districts. Area 13.435 sq.mi. Pop. (1961) 728.300 The western part of the former district. the Pat, is watered by the East Nara canals and the Jamrao canal, and the presence of water created jungle and marsh; the eastern part, called Thar. is a tract of rolling sand hills, running northeast and southwest, composed of a fine but slightly coherent sand and forming part of the much larger Thar, or Indian desert (see INDIAN DESERT).

To the southeast of Thar is Parkar. where there are ranges of rocky hills rising to 350 ft, above the surrounding level and open plains of stiff clay. This area contains the ruins of several old temples. The principal crops are millets, rice, wheat, oilseeds and cotton.

Mirpurkhas (pop., 1961, 60,861) was the administrative headquarters of the district. The town is on the metre-gauge line running from Hyderabad to the India-Pakistan frontier. A metre-gauge feeder line runs north from Mirpurkhas to join, at Nawabshah, the main line from Hyderabad to Lahore, and another goes south to Jhudo.

THARRAWADDY, a town and district in the Pegu division of Burma. The town has a station on the railway, 68 mi. N.W. of Rangoon. Pop. (1953) 8,977. The district has an area of 2.815 sq.mi. The Pegu Yoma range separates it from Toungoo district and forms the water parting between the Irrawaddy and Sittang rivers; there are also many small elevations. The Irrawaddy is the principal navigable river. Teak forests and fuel reserves cover more than a quarter of the whole area. Among the wild animals found in the mountains are elephant, bison and various kinds of feathered game. The rainfal! ranges from about 60 to 90 in. Pop. (1941) 593,909, showing an increase of 15,880 in the decade. The railway runs through the centre of the district. with ten stations.

The chief towns (pop. 1953) of Tharrawaddy are Letpadan (15,896); Gyobingauk (9,922); Zigôn (7,652); Thonzè (14,443); Nattalin (8,927); and Minhla (6,470). The staple crop is rice. The history of the district is identical with that of Henzada (*q.v.*). Tharrawaddy was formed in 1878 out of that portion of Henzada lying east of the Irrawaddy.

THARROS, an ancient town of Sardinia, situated on the west coast, on the narrow sandy isthmus of a peninsula at the north extremity of the Gulf of Oristano, now marked by the tower of S. Giovanni di Sinis.

Tharros was 12 mi. W. of Othoca (Oristano) by the coast road, which went on northward to Cornus and from there to Turris Libisonis. The town was of Phoenician origin but continued to exist in Roman times. It was destroyed by the Saracens in the 11th century.

In the necropolis to the south of Tharros many Phoenician tombs have been excavated; they are rectangular or square chambers cut in the rock, measuring from 6 to 9 ft. each way. About 3 mi. to the north is the church of S. Salvatore, with underground rock-cut chambers below it with walls decorated with pre-Christian paintings.

THASOS, Greek island in the north of the Aegean sea, off the coast of Thrace and the plain of the Nestos river (Turk. *Kara-Su*).

Herodotus (ii, 44; vi, 44–48) tells of an early Phoenician settlement, of gold mines and of a temple of Heracles; Thasus, son of Phoenix, gave his name to the island. In 720 or 708 B.C. Thasos received a Greek colony from Paros. In a war between the Parian colonists and the Saians, a Thracian tribe, the poet Archilochus threw away his shield.

The Greeks also owned gold mines on the mainland. From these sources the Thasians drew annual revenues of from 200 to 300 talents. The Athenians, after a siege of two years, compelled the Thasians in 463 to destroy their walls, surrender their ships, pay an indemnity and an annual contribution (in 449 this was 23 talents, from 445 about 30 talents) and resign their mainland possessions. After the battle of Aegospotami (405 B.C.), Thasos again fell into the hands of the Lacedaemonians under Lysander who formed a decarchy there. In the dispute between Philip V and the Romans, Thasos submitted to Philip, but received its freedom after Cynoscephalae (197 B.C.).

After a period of Latin occupation in the 13th century it was captured by the Turks in 1462. After the close of the first Balkan War it was, by the terms of the treaty of London, May 30, 1913, ceded by Turkey to Greece. The capital stood on the north coast and had two harbours. The highest mountain, Ipsario, is 3,947 ft.

Besides gold, Thasos produces wine, nuts and marble. Germany occupied it in 1941.

The population (1961) 15.916, is distributed in ten villages, mostly at some distance from the sea; for the island suffered from pirates. The people are Greek Christians and do not differ in appearance from the inhabitants of the other Greek islands.

BIBLIOGRAPHY.—For a description of the island and its remains of antiquity *see* A. Conze, ***Reise auf den Inseln des thrakischen Meeres*** (Hanover, 1860); for inscriptions see ***Inscr. Gr.*** xii, **8;** the island is fully described in ***Journal Hell. Stud.*** xxix (1909).

THATÔN, a town and district in the Tenasserim division of Burma. The town is situated below a hill range, ro mi. from the sea.

Thatôn was formerly the capital of the Talaing kingdom and a seaport. Pop. (1953) 38,047. The district has an area of 4,870 sq.mi ; pop. (1941) 592,638.

THAXTER, ROLAND (1858–1932), U.S. botanist and mycologist, was born at Newton, Mass., on Aug. 28, 1858. He received the Ph.D. degree from Harvard in 1888, and in that year was appointed mycologist at the Connecticut agricultural experiment station. Three years later he returned to Harvard as assistant professor of cryptogamic botany. He succeeded William Gilson Farlow (*q.v.*) as professor in 1901, retired in 1919 and died at Cambridge, Mass., on April 22, 1932.

Thaxter's earliest paper on fungi (1887) was on the *Gymnosporangium* rusts and their Roestelia stages. He was among the first to study the slime bacteria (1892). His most famous work was done with the Laboulbeniaceae, a group of fungi that externally and apparently harmlessly parasitize insects. In his monograph (five parts published, 1896–1931) of this previously little-known family he described over roo new genera and 800 new species. In 1909 he served as president of the Botanical Society of America and in 1912 was elected member of the National Academy of Sciences. Farlow and Thaxter were successful in building an outstanding school and herbarium of cryptogamic botany at Harvard.

See account of Thaxter, with a list of his publications, in ***Biogr. Mern. Nat. Acad. Sci.,*** vol. xvii, pp. 55–68 (1937); notice in ***Proc. Linn. Soc. Lond.,*** vol. cxliv, pp. 190–192 (1932). **(J. W. TT.)**

THAYER, ABBOTT HANDERSON (1849–1921), U.S. painter, whose etherealized feminine figures were characteristic of U.S. art in the late 19th century, was born at Boston, Mass., Aug. 12, 1849. He at first specialized in animal painting, but after study in Paris with Jean Léon Gérôme, he returned to the United States (1879) with loftier aims. He was elected president of the Society of American Artists in 1884 and became a member of the National Academy of Design in 1901. He died at Dublin, N.H., on May 29, 1921.

Thayer painted delicate still life, imaginative landscapes and vital portraits. In figure pieces he often idealized young women with the obvious symbolism of wings or halos, but the real quality of these, as also of his youthful male subjects, is in character interpretation. He is best represented in Washington, D.C., at the Freer Gallery of Art and in the Gellatly collection, National Collection of Fine Arts. His long study of wild animals produced a theory of concealing coloration that was useful in developing camouflage in World War I. *See* ANIMAL COLORATION.

See Nelson C. White, *Abbott H. Thayer* (1952). (VL. B.; X.)

THAYER, WILLIAM ROSCOE (1859–1923). U.S. writer, was born in Boston, Mass., on Jan. 16, 1859. After travel abroad with a private tutor. he graduated at Harvard in 1881. In 1918 he was elected president of the American Historical association and was awarded numerous other scholarly honours.

Thayer died at Cambridge, Mass., on Sept. 7, 1923. He was best known for his works on Italian history, especially *The Dawn of Italian Independence* (1893); *A Short History of Venice* (1905); and *The Life and Times of Cavour* (1911). His *Letters* (1926) were edited by C. D. Hazen.

THAYETMYQ, a town and district in the Magwe division of the Union of Burma. The town is situated on the right bank of the Irrawaddy, opposite Allanmyo. Pop. (1953) 11,649. The cantonment is no longer used, and the population and importance of Thayetmyo have tended to decrease with the rise of Allanmyo (15.580 in 1953). There is a special industry of silverwork.

The district has an area of 4,642 sq.mi.; pop. (1941) 297,434. The rainfall ranges between 30 and 50 in. On the west is the Arakan Yoma range, and on the east the Pegu Yomas; and the face of the country, where it does not rise into mountains, is everywhere broken by low ranges of hills, many of which are somewhat barren. The chief river is the Irrawaddy, which traverses Thayetmyo from north to south.

Products are rice, cotton, peanuts, oilseeds, tobacco and cutch; the manufacture of the dyestuff is carried on extensively.

THEACEAE, the tea family, an important group of dicotyledonous shrubs or trees, with 16–18 genera and more than 200 species, chiefly tropical and subtropical, in both hemispheres. An important genus is *Canzellia,* wholly Asiatic, with 50 or more species, among them tea, *C. sinensis;* the cultivated camellia, *C. japonica;* and the Chinese tea oil plant, *C. drzrpifera.*

Stewartia, Franklinia and *Gordonia* species, all native to Asia, are often cultivated for ornamental purposes. The family is represented in the southern U.S. by two species each of *Stewartia* and *Gordonia,* sometimes called camellias, and franklinia *(Franklinia alatamaha),* a beautiful fall-blooming tree. *Ternstroemia,* with 90 or more species. and Eurya, with 100 or more species, occur in both hemispheres. *See* TEA: *Botany;* CAMELLIA.

THEAL, GEORGE McCALL (1837–1919), British historiographer, was born in Canada in 1837 and became a schoolmaster in Cape Colony in 1858.

Theal developed an interest in the natives and in the history of the country and, after settling a dispute with the Gaika Kafirs on behalf of the government (1877), joined the Cape civil service, in the native department. He was also appointed keeper of the archives, and in 1891 was made colonial historiographer, a position which he held until 1905. He died at Wynberg, Cape Province, on April 17, 1919. He published a *History of South Africa (1486–1872)*, 5 vol. (1888–93); official *Records* of *South East Africa,* 9 vol. (1898, etc.); *Records of Cape Colony,* 1793–1827, 36 vol. (1897, etc.); *The Beginning of South African History* (1902); and many other works, some in Dutch.

THEATRE (ARTICLES ON). The article DRAMA discusses the origins of the dramatic arts and gives a historical review of dramatic literature and institutions, from ancient Greece, Rome and India to the Broadway and West End of today. THEATRE is concerned with the dynamics of drama—the evolution of the various forms of stage presentation, and the ideas and methods that animate the modern stage.

The activities involved in bringing a script to life before an audience are treated in ACTING, DIRECTION AKD PRODUCTION. The changing standards by which theatrical values have been judged are discussed in DRAMATIC CRITICISM. The contributions of dramatists to national literatures are evaluated in such articles as AMERICAN LITERATURE; ENGLISH LITERATURE; FRENCH LITERATURE; SPANISH LITERATURE; etc.

Various forms of dramatic art discussed in the surveys mentioned above are represented also by individual articles—for example: BALLET; COMXEDIA DELL'ARTE; KABUKI THEATRE; MASQUE; MUSICAL COXEDY; NŌ DRAMA; OPERA; OPERETTA; PAGEANT; PANTOMIME; SHADOW PLAY.

Additional articles on forms of theatrical presentation include MIKSTREL SHOW; MUSIC HALL AND VARIETY; PUPPETS AND MARIONETTES; VAUDEVILLE.

Articles dealing with technical aspects of the theatre include COSTUME DESIGK, THEATRICAL; MAKE-UP (STAGE. MOTION PICTURE AND TELEVISION); MASK; STAGE LIGHTING; THEATRES (STRUCTURES).

MOTION PICTURES gives a comprehensive survey of motion-picture writing, directing and technology. Sections on animated cartoons and educational films are included, as well as discussions of methods of distribution. Other mechanical media for drama are treated in BROADCASTING and TELEVISION.

A series of articles deals with individual theatrical organizations—for example, COMÉDIE FRANÇAISE; FEDERAL THEATRE PROJECT; FOLIES-BERGERE; GROUP THEATRE; MOSCOW ART THEATRE; OBERAMMERGAU; THEATRE GUILD.

Among the articles on theatrical lore and activities are CONJURING; FOOL (JESTER); FORTUNE TELLING; PUNCH; and VENTRILOQUISM.

Many biographical articles—for example, those on Shakespeare and Garrick—review the work of the great playwrights and actors in the perspective of the societies to which they belonged. The article on Shakespeare outlines his life and work, the sources on which he drew and his place in Elizabethan London. A separate section of this article analyzes the various types of conjecture on which the anti-Shakespearean theories have been based, and balances these against the body of established facts.

The Index. in addition to listing complete articles on theatiical topics, guides the reader to subjects covered in individual sections and passages.

The following articles are suggested as a minimal reading program for an introduction to the history and basic methods of the dramatic arts: ACTING, DIRECTION AND PRODUCTION; DRAMA; DRAMATIC CRITICISM; MOTION PICTURES; TELEVISION: *Television Broadcasting;* and THEATRE.

THEATRE, the place in which dramatic entertainments are presented (from the Greek *theatron)* and, by extension, the activity comprising both the dramatic performances themselves and the work of all who are responsible for presenting them to audiences. This article is arranged as follows:

I. GENERAL

1. Introduction.—When the word theatre is employed in the extended modern sense, descriptive epithets like Greek, Chinese, Elizabethan and Restoration. used in conjunction with it, serve to characterize not only the style of acting, building, costume and setting used in the theatre of the nation or period of history specified but even the style of written texts, together with the complex structure of commercial organization, government regulation and social relations. Theatre is, then, a style of dramatic art individual enough in its theory and practice to warrant description by a special label; "Indian theatre," "medieval theatre," "theatre in the round" define whole subjects either as homogeneous categories or periods of dramatic history, or as identifiable dramatic styles.

These styles are evolved through the cross-fertilization of national and historical artistic traditions in theatre practice, as exemplified in England or France by the adoption during the 17th century of Italian Renaissance landscape scenery, or in Germany by the 19th-century vogue for Shakespeare or during the present century by W. B. Yeats's interest in the Japanese nō play and the public enthusiasm for the Russian ballet presented by Sergei Diaghilev in Paris and London. The physical shape of stage and auditorium. too, in the course of about 2,000 years, has had a direct influence on the sort of play devised for performance: this is clearly seen when Sophocles' *Antigone, Electra* or *Oedipus Rex* are compared with modern versions of the same stories (*e.g.,* by Jean Anouilh. Hugo von Hofmannsthal. Jean Cocteau) where the large role played in the original by a numerous chorus is adapted or omitted to conform with the physical conditions of modern theatres, which are both smaller in size and more intimate in the actor-audience relationship provided.

2. Actor and Society.—In any concept of the word "theatre" larger than that restricted to timber, bricks and mortar, the centre is the actor. It is on him that the author must depend if his own scenario or text is to reach the audience as a living action. It is on him that the audience must depend as the instrument through nhom the author's ideas are fully manifested in word, gesture and deed. Theatre, in the sense of a building, only acquires a *raison d'être* as a place for actors to perform in front of spectators. This is as true of the inanimate puppet and marionette theatre, and of the filmed drama or of the mechanically projected radio and television play, as it is of the animate theatre where. in opera. ballet or play, human actors encounter their audiences in person at every performance. All dramatic art, therefore, regardless of national or period label, takes its essence from the mimetic talent of the actor and its quality from the use to which this talent is put by the society that develops and rewards it.

The quality of the individual theatre will be particular to the society and mill reflect that society's own level of development and standards of civilization. Great periods of achievement in the theatre have generally tended to coincide with or to follow immediately upon great national achievement, as the theatrical vitality of Periclean Athens, of Elizabethan England. of Louis XIV's France or of Scandinavia in the late 19th century illustrates. By contrast, a civilization with a marked addiction to ostentation and material values is likely to reflect this in a theatre dominated by spectacle and vulgarity, as may be seen in the decadence of Roman drama, of the English theatre during the 19th century or in the implications in the name of Hollywood in the latter half of the 20th century.

This relationship between the actor and the society of which he forms a part is itself responsible for the pattern of birth, growth, climax and decay repeated within every period of the theatre's history distinct enough to be identified by such special designations as "Greek tragedy" or *commedia dell'arte.* The creative initiative is invariably spontaneous and supplied by amateurs either directly as performers or indirectly as patrons. Any degree of popular success is then sought by professionals for reward until a point is reached where technical perfection or virtuosity can be admired in its own right. Exploitation of the commercial possibilities by the actors, their sponsors or both, in such a manner that financial gain outweighs care for art, quickly undermines professional integrity; artistic standards decline until that theatre loses first the respect. then the support of its patrons, and finally, its identity. Outstanding examples of the amateur initiative are the dance dramas of primitive peoples, the essays in perspective scenery and stage machinery of the 16th-century Italian *intermezzi* and of the Stuart masque in England, and the American arena theatre movement that began in Seattle. Wash., at the University of Washington and was later endowed on a professional basis in Washington, D.C.

Another cyclic feature often repeated in the theatre's evolution is the sacrifice of an initial reliance on emblematic conventions of presentation to the gradual but increasing requirements of verisimilitude and spectacle for its own sake. This change is characterized by proportionately mounting production costs and by the sacrifice on the part of the actor of much of his own liberty of action to the whims or exigencies of painters and technicians; and in motion pictures, radio and television to the mechanical restrictions of microphones, cameras and transmitters as well.

The actor's standing with society at large depends upon that of the theatre as a whole. In a primitive community he gained the approbation of his fellow men for contributing his own unusually developed human talent for mimicry to their service: in a more sophisticated society his translation to professional status may make him an object of envy to many and of censure to those others who claim that it is improper to esteem. let alone reward. any form of pretense. Acting and actors. when the activity is self-conscious enough to merit description under these terms. have thus always been a debatable asset to society; Plato thought them worthless hypocrites while in England between 1648 and 1660 they were termed "caterpillars of the Commonwealth." At other times they have been valued highly enough to be thought worth fostering, as Aristotle believed them to be, or to warrant receipt of training, salary and pension at the expense of government! as in Soviet Russia in the 1960s.

3. Origins.—This ambivalence in the actor's status and reputation in society derives directly from the way in which his mimetic talent is first harnessed to the needs of society. This talent is instinctive in every child and brings him from infantile to mature social behaviour. Linked with this instinct to explore by imitation and thus to enlarge experience is an egocentric concept of the individual's relationship to other people. The two in conjunction result in the self-assertion that distinguishes the personality of one individual from that of another. Once pretense by imitation has acquired this degree of self-consciousness. a distinction between "the performer" and "the beholder" becomes possible; each is only satisfied by the presence of the other. Theatre is born when this co-operative act of make-believe extends to cover consecutive imitated action. The attention of the beholder is arrested and held by the nature and accuracy of the imitation, while the ability of the imitator is enlarged by knowledge gained from the experience.

Theatre in this most elementary of forms is inarticulate. depending neither on a formal text nor on improvised speech; known as mime (*q.v.*), imitation through gesture and movement of the face and body is common in this state to all peoples and requires only an open space for its enactment.

Historical study has revealed that theatre in this natural form is quickly harnessed by all primitive peoples in seeking explanations for what is mysterious and unknown in their own environment. Attempts are made to establish contact with the sources of power in nature that appear most destructive and hurtful to a primitive people: excessive heat and accompanying drought. rain and floods, extreme cold and other violent phenomena occasioning acute emotional anxiety to tribe or individual. The form that these attempts take is usually mimetic imitation of the phenomenon feared, or imitation of objects observed to be related to that phenomenon in nature; the consuming power of fire is sought from contact with the ashes or the secret of fertility from contact with evergreens; the rhythms of nature as heard and seen in the movement of the wind or the sea are copied and simulated in dance. With such means as these an appeal is made to the spirits or deities deemed to govern the elements to assist or at least to refrain from harming the supplicants. Disguise of the person in the shapes of nature and projection of the person into dance patterns imitating its movements are thus among the earliest distinctive components of theatre; a third essential is an open space where the disguised dancers may undertake their ritual.

The obstacle between these preparations and direct communication with the hidden god is consciousness of pretense in the whole nature of the action; the disguises adopted, being no more than emblems of the nature of the god, cannot be expected to induce the power required to permit speech with the god. A state of heightened emotional awareness has to be stimulated to obliterate this restrictive consciousness. It is here that the performers are called upon to generate an emotional response of an extraordinary kind in the beholders by accentuating the rhythmic quality of the dance patterns. The union between mortals equipped with nothing better than the crude symbols of the god's nature and behaviour and the controlling mind of the god himself, which in everyday life appears impossible, then becomes possible in the frenzy or ecstasy of the dance rhythms; and in this union of the spirit, involving the submergence of the individual in the whole, fear is overcome and anxiety allayed. Famine and plague may recur, but given the means of further communication the god can always be consulted.

The fear that is common to all individuals is that of death; it is thus to be expected that in their dance rhythms primitive peoples have been most attracted to those aspects of nature in which rebirth noticeably grows out of death; that is, to the solstices and the seasons. These phenomena account for the most persistent of all early theatrical imitations—the slaying of the god and his subsequent resurrection. The ancient rites associated with Osiris in Egypt derived from this assumption, and traces of it may be seen in the sword dances and mummers' play of the folk in northwestern Europe.

These rituals were designed to propitiate the forces of nature for past misdemeanours or to seek their assistance in future struggles. but many rites of a similar kind were evolved to give thanks for assistance received. These expressions of joy, however, were not marked by any such clearly defined narrative pattern as that of the dying god; the most notable characteristic was simply excess as exemplified for the whole western world by the proverbial Saturnalian orgy of Roman times or, in the Christian era, by the licentious Feast of Fools. when what E. K. Chambers described as "the peasant beneath the cassock" revealed his nature.

The transition from these dance rituals (specimens of which may still be observed in New Guinea and in parts of Africa) to a species of pretended action that incorporates a long and formal narrative with accompanying dialogue is difficult to discuss since it was not within the means of persons making this transition to record its details. They could only transmit what they knew, verbally or by example, to those who followed them and who added to and embroidered what they inherited with spontaneous inventions of their own. It is, therefore, to anthropologists and experts in the primitive religions of the world that one must turn for information. Relics survived in regular drama in the continued use of masks; in the relationship between actor and chorus in the earliest Greek tragedy and the earliest liturgical plays of the Christian Church, which reflected that of priest and congregation; in the elaborate emblematic headdresses, costumes and gestures of the Indian and Chinese classical theatre; and in the presence of an altar as the focal centre of the earliest Greek and Christian dramatic action. Above all there may be discerned in the written texts of tragic drama a continuance of earlier efforts to explain the inexorable laws of nature to fearful mankind, and in all early comedy a deliberate release of high spirits, which, in mocking everything artificial, pompous or unnatural, extols the liberty and bounty of nature.

Tragedy and comedy are the two primary types of theatrical experience that dramatic art. however sophisticated the place or time. has continued to provide. The more serious kind has always preserved some affinities with its religious origins, while the more frivolous kind has always been liable to degenerate into forms offensive to a highly developed sense of public decency. It is the exploitation of the latter forms of simulated action by professional actors for commercial reward in return for the social recreation provided (in contrast to the spontaneous amateur theatre of worship) that has caused both actors and the theatre to be attacked from time to time as vicious. immoral and better suppressed.

II. THE EAST

The country with the earliest reliable record of a dramatic tradition more advanced than ritual dancing is India, its history being traceable to about A.D. 100. Java, Bali and Burma all possess a notable dance drama, but it is from China and Japan that the most highly formalized dramas have survived into current use, despite contact with the western world. Indian classical theatre (Sanskrit) was virtually extinguished as a result of the Muslim invasions of the 10th century and after; but enough information, in the form of play texts and treatises about their staging, survived for attempts at revival to be made during the 19th century. Sot enough is yet known in the west about the early history of the oriental theatre to ascertain the degree of interaction between the various dramas of distinct national origin; the Japanese theatre, however, owes as direct a debt to the Chinese theatre as the American theatre does to that of western Europe.

The transition from dance drama to regular plays in India, China and Japan was made in each instance through the Buddhist religion and aristocratic patronage, distinct genres with written texts being in existence in India by the 2nd century A.D., in China by the 6th and in Japan by the 14th. In all three countries actors have had a mixed reputation, some enjoying the friendship of princes and others being regarded as little better than beggars or criminals. In India, actors (nuta, "a dancer") formed an identifiable class or caste in society and female roles were played by men until the 20th century. In all three countries an actor's training started in early youth, and a high degree of skill was required not only in dancing but also in singing, mime and acrobatics.

Where theatre buildings and the stage conventions employed in them are concerned, common practice is again evident. Temples and palaces adapted to suit the actor's needs sufficed initially and, in India, probably continued to do so; at least there is no evidence of buildings constructed to accommodate dramatic representations alone. In China and Japan, however, actors acquired wealth and position enough to become independent of their patrons and to build regular theatres for popular audiences. The typical Chinese theatre is a rectangular building containing a large projecting stage (almost square) backed by a curtained or painted wall containing two doors. The nō stage in Japan (and the kabuki stage, which is adapted from it) also projects into the auditorium and is square (18 × 18 ft.). A penthouse roof (adapted from the Shinto temple of origin) projects over this stage and is supported by pillars. (See NŌ DRAMA: Staging; KABUKI THEATRE.)

Theatres of the east have no scenery in the western sense of the word. Place is identified by emblems, some being permanent fixtures like the four stylized pine trees (one large, three small) of the nō stage, others taking the form of large stage properties like the arched gate or painted flags of the Chinese theatre: change of place is identified by the mime of the actors, by special properties like the Chinese tasseled horsewhip and by the shifting of properties in the audience's view by stage assistants, who sit on the stage throughout the action. These architectural and scenic conventions bear a marked resemblance to those used in European theatres of the middle ages and early Renaissance (see below).

A similar reliance upon an emblematic manner of presentation is seen in the costuming and acting style of oriental plays. Masks are rare. Only the first actor (*shite,* slztay) wears one in nō. The painting of the skin. however, and particularly of the face, was regular in all three theatres and developed to a quite remarkable degree in China. where the hua-lien or painted face denotes character through both the particular lines and colours of the make-up. Many have been standardized, and the actor is trained to be competent in the style, colour and scale of beards, applied jewels, lines and spots appropriate to particular characters.

Headdresses and articles of clothing also serve to demonstrate character and temperament. In Indian drama gods and princes are immediately identifiable by their exceptionally elaborate headdresses, while in China and Japan animal headdresses (especially tiger heads) and plumes worn above the painted face are appropriate to warriors of high rank. Colour symbolism plays as important a part in costume as it does in make-up: robes of rich silks and satins are often 'so elaborate as to require long practice in the wearing of them if they are to be maneuvered with any semblance of agility or grace.

Contact with the west did not at first make any difference to these traditions except in India, where, under British rule, a growing European interest in Sanskrit literature led to a revival of classical plays in Bengali translation (1857 and after). This revival was possible because of the survival of both the play texts and the *Natyasastra* of the Brahman priest Bharata, a detailed treatise on the composition and production of plays written during the 3rd century A.D. and as important a document for the study of Eastern drama as the writings of Aristotle and Vitruvius on Greek and Roman drama have proved to be in the west. Other later commentaries embroidered on Bharata's work but added little that was new. Archaeological research has brought to light a few pictorial representations of early performances.

Music has always formed an important element in the oriental theatre. Instrumental music conjoined with religious ceremonies introduced the leading player, who sang or spoke an explanatory prologue. In Japan, this function is shared between the second actor (who enters first) and the first actor; in China, the protagonist of the drama undertakes this task; in India. it was done by the leader of the company (*Sutradhara*). The orchestra (dominated by flutes, drums. cymbals and gongs) not only accompanies chanted dialogue but also sets a tempo that is carefully followed by the actors in their movements.

Formal differentiation of genres exists in the eastern theatres. Japanese kabuki and nō are the most obviously distinct; but in China wu (the military play) and wen (plays with civilian subject matter) are traditionally as different. Distinctions in the Indian theatre, as between *nataka* ("heroic legend") and *prahasna* ("farcical stories"), are also real. Japanese nō is itself divided into categories. Nowhere, however, is there any close correspondence to western genres (with the possible exception of melodrama). and in India the happy ending was invariable. Act and scene divisions of the kind familiar to the west are normal to all oriental plays, but unity of place has never been a question of consequence in a drama where episodic narrative is the dominant characteristic of structural form and where the technical virtuosity of the actor in a familiar role has always counted for more than novelty of plot or formal compactness. Western motion pictures, when introduced into eastern countries, found substantial popular support because of their episodic treatment of narrative; such techniques were already familiar to audiences.

Photographic realism. however, while easily copied by film makers of eastern nationality, has struck a severe blow at the imaginative emblematic conventions of the oriental stage. which by the 1960s had lost popular support to films and television.

III. THE WEST

The history of theatre in the west differs from that of the east in two important respects. In the west there was the phoenixlike rebirth of organized drama in the middle ages after about 400 years of seeming death, and in the 20th century the quest for verisimilitude in dramatic imitation culminating in the mechanical reproduction of performances on film—a western invention subsequently exported to the east.

The most important single feature distinguishing the drama of the first phase. from the 5th century B.C. to the 6th century A.D., from that of the second phase, from the 10th century A.D. to the 20th. was the intervening influence of Christian philosophy and ritual. The theatre of the first phase was Greek in origin, spread to Italy and from there was transplanted east. west and south to the frontiers of the Roman empire; northward it penetrated into Austria, Germany and even Britain. The decline and fall of the theatre. already sapped from within by a growing dependence upon costly spectacle coinciding with objections to the nature of the spectacle raised by Christians on moral grounds, was one of the results of the barbarian invasions.

Although many theatres of the Hellenistic period are still standing in the 20th century, the new drama of Christian inspiration that began to take life and shape in the 10th century did not make use of these buildings; nor did it imitate the sophisticated forms of Greek and Roman regular drama since the new texts. acting and stage conventions mere supplied by amateurs. Not until the 15th century was any serious concession made to earlier practice. The full-scale revival of Greek and Roman play forms and architectural concepts that followed in the 16th and 17th centuries was consequently distorted from the start; difficulties arose because a Christian society was seeking to emulate a product of non-Christian inspiration and because this society lacked adequate knowledge of stage practice in anything but late Roman theatres. The imitation consciously pursued was thus unconsciously based on a phase of Greco-Roman theatre already decadent in its addiction to spectacle and in its relation to society. The result. in every European country that already possessed a theatre of Christian inspiration. was to create a divorce between the two; *i.e.*, between a religious stage commanding popular support and a *commedia erudita*, or academic theatre, of interest only to the aristocracies of intellect and courtly privilege. This divorce coincided in time with the wars of religion; and, since the popular theatre was religious, the divorce took a form in each European country that followed the pattern of ecclesiastical government. In Italy divorce between the two became total by the end of the 15th century; in Spain—because of close supervision and gradual modification by the Inquisition—it is scarcely discernible; in France, Germany, the Low Countries and England it was erratic. Censorship and suppression. however, are everywhere in evidence, the differences from one country to another being in timing and degree. In France the religious stage was dissolved by the edict of 1548; in England it had become impossible by 1590 for any play devoted to religious subject matter to he performed with impunity. To the revival of Roman theatre, the court amateurs of European countries contributed something of their own—a preoccupation with dance and song, which were developed respectively in succeeding centuries as ballet and opera.

Despite the immediate triumph of the academically inspired neoclassical theatre in the 17th and 18th centuries popular elements returned to it, the way being led by the *commedia dell'arte* (*q.v.*) in Italy and by sentimentalism in English drama of the late 17th century. The romantic revival championed by Diderot in France and Lessing in Germany restored some dignity to the popular theatre of earlier times but it did not recover for a theatre of situation, intrigue. manners and scenes the popular support previously accorded to the theatre of religious and heroic narrative with its emblematic conventions of presentation. The development of melodrama in the 19th century restored to narrative and action their earlier pre-eminence, but the theatre's ability to provide accompanying spectacle of a realistic kind was eclipsed by the potentialities of the motion picture, which came into existence by the beginning of the 20th century.

The commercial potentialities of film theatre were quickly realized. The technique of marrying sound to picture was perfected in the late 1920s, opening a national market for repeated showings of a single performance, which. with the additional accomplishment of providing subtitles and "dubbing" in foreign languages. was extended to include a world-wide market. Further wholesale changes in bringing plays to audiences, instead of obliging audiences to come to theatres, are similarly attributable to advances in scientific knowledge; the most notable being the invention of radio and television transmission and of processes for the recording of such transmissions.

A. Antiquity

1. Greece.—As well as creating great dramatic masterpieces, the classical Greek theatre has left a notable legacy to posterity in the (1) distinctness of the three dramatic genres—tragedy. comedy (old, middle and new) and satyr play; (2) the size and shape of the theatre buildings; (3) the division of function within the drama between actors in the roles of characters and those serving as choric commentators interpreting between the protagonists of the stage action and the audience; and (4) the strongly characterized masks worn by the actors.

A relationship between religious festivals and the three forms of regular drama (particularly in the rites associated with the nature god Dionysus) is generally acknowledged by historians but evidence is lacking with which to define this relationship in any detail. The outstanding survival from the earliest Greek tragedy is the relationship among single actor, chorus and audience (the whole community), which parallels that among priest, initiates and congregation in religious ritual. The parallel is reinforced by the themes and structure of the earliest surviving plays. Tragedy, being concerned with the moral government of the universe, was strictly serious and formal; Aeschylus' Oresteia, for example, concerns crime and its consequences in terms of mortal and divine retribution. Comedy (*i.e.*, old comedy), being contemptuous of all human attempts to behave as if mortals possessed the minds of gods, was joyous, robust and satirical; Aristophanes' Lysistrata, although deeply serious in its concern about war, still appears in the 20th century to be as uproariously funny as it is outspoken in the means suggestedto prevent war's recurrence.

As Greek drama developed, emphasis shifted from divine and cosmic themes to mortal and microcosmic problems. H. D. F. Kitto has written that tragedy was formed, ennobled itself and lost its vigour while Athens was passing through the same processes; during this period, he points out, tragedy moved from communal to individual themes. Comedy underwent a series of equally clear transitions from, broadly political (old comedy) to social satire (middle comedy) and then to a comedy of manners with stereotyped characters in plots dependent on intrigue and situation. Changes in theatre practice kept step with these thematic tendencies. Aeschylus (*q.v.*) called on the services of a second actor (both actors doubling in more than one part) and Sophocles (*q.v.*) on those of a third. Both authors tended to increase the number of characters in their plays, and their successor, Euripides, went farther still in this direction. The chorus lost ground to the actors in number and function. The original dithyrambic chorus of 50 that Aeschylus inherited had been reduced in Euripides' lifetime to less than half the number, with nothing more to do than interpolate decorative lyrical odes as interludes in the action. In comedy, whereas Aristophanes used his chorus as formally as Sophocles, the new comedy of Menander used it for induction or the interpolation of songs for their own sake. The pursuit of realism brought with it a corresponding change in the nature of both stage language and setting. The earliest plays are made up of sequences of choral odes interrupted by "episodes" of speech for actors (*e.g.*, Aeschylus' Agamemnon). Sophocles' plays were distinguished by the perfect balance achieved between choral and dialogue speech; the metrical rhythms are of the utmost importance and probably carry in them some reminder of the original choric movements.

The place of performance, initially a large dancing floor (orchestra), was elaborated first with a dressing room and then by extension and decoration of the skene thus created on a scale great enough to permit the use of revolving panels (periaktoi) bearing pictures designed to identify the place of action and other machines. Nevertheless, the Greek theatre was wholly emblematic, employing men to impersonate women, using masks to conceal the fact that one actor was playing more than one part, and identifying place by symbol. ,Moreover, in attempting any imaginative reappraisal of a Greek play in performance, it must be remembered that the auditorium seated 10.000–20,000 persons, all of whom looked down on the orchestra and thus saw at one time the geometrical patterns of the chorus dances and the magnificence of the landscape beyond the skene.

Aristotle's notes on dramatic composition in the Poetics and a list of prize-winning plays (Didascalia) written in the 4th century B.C. provide much knowledge of the historical development of drama in Greece and a careful appraisal of the theory of tragedy, its function and composition. as practised up till his own day. These notes were translated, summarized and commented upon in Latin in later centuries (see below) but did not circulate widely in the west in the Greek original until late in the 16th century.

2. Rome.—The only plays that survive as a basis of an appreciation of Roman theatrical tastes are the comedies of Plautus and Terence (2nd century B.c.), the tragedies of Seneca (probably written to be read, not acted) and a few fragments of pieces attributed to Ennius, Pacuvius and Accius of the 3rd and 2nd centuries B.C. There is the related evidence of a great many theatre buildings (most now in ruins) ranging from such small intimate edifices as may be seen at Verulamium (St. Albans) in England, at Taormina in Sicily or at Pompeii near Naples to such grandiose monuments as the well-preserved examples at Orange in Provence and Aspendus in Turkey (see THEATRES [STRUCTURES]). As it is Aristotle's writings that furnish most knowledge of the history and theory of drama in Greece, so it is Horace (epistle to the Pisos. better known as *Ars poetica*, or "The Art of Poetry") who gives some picture of what Romans expected of their theatre. Documentation of theatre architecture and machinery, however, is better than that surviving from Greece because of the preservation of Vitruvius' De *architectura* (1st century B.c.) and Pollux's *Onomasticon* (2nd century A.D.).

The affinities between Greek new comedy and that of Plautus, as well as those present in the two styles of theatre building, argue a marked continuity between Greek precedent and Roman practice. On the other hand, the lack of any corpus of tragic texts; the nomadic and comparatively professional quality of the Roman actor's status; the certainty of a raised stage in Roman theatres, which was of more importance than the orchestra; the use in theatres built during and after the 1st century A.D. of a drop curtain with the development of scenic effects that the curtain allowed; and the additional attention given to the comfort of the audience—all indicate a positive Roman attitude to theatre that was both mundane and commercially angled. This picture is reinforced by the knowledge that under imperial rule mime and pantomime based upon actors' improvisations and acrobatics came to dominate a theatre growing steadily more luxurious in its appearance and fittings at the expense of the dramatist. Mere theatricality, exploited for the sake of display and for commercial gain, was substituted for the former religious, moral and artistic concerns of actors and audiences. With this change responsible people came to regard the theatre as something unworthy of their attention.

In republican days. Roman comedy at least still possessed written texts and aimed at exposing vice and ridiculing folly in as amusing a manner as possible. A noisy crowd in holiday mood had to be silenced by the actors and its attention held against the competition of rival sports and festival attractions. The success of Plautus and Terence at least is demonstrated by the way in which their plays have held the stage in revivals, translations and remodelings up to the 20th century. Even radio and television have deemed them worth revival in translation, Plautus' *Mostellaria,* Miles *Gloriosus* and *Menaechmi* being among the most successful.

With the alienation of the writers, however, and the steady increase in purely spectacular extravagance and vulgarity it is easy to understand why early Christians should have been as contemptuous of theatrical performances and as hostile to the profession of acting as their writings and actions show that they were. The closing of the theatres in the 5th century A.D. after the triumph of Christianity within both eastern and western halves of the Roman empire did not result from any particular antipathy to regular drama; the early Christian Fathers within the empire were opposed to a form of dramatic art so debased through commercial exploitation as to have lost any relevance to the general good of society. Outside the empire they had to contend with dramatic rituals as yet too primitive to have acquired regular forms but the closer on that account to the primitive religions that Christianity was seeking to suppress. The theatre of the ancient world thus survived in fragments only like some river that has temporarily split itself into several channels: a selection of texts, a variety of disused buildings (useful as quarries), some theoretical treatises, and groups of itinerant mimics, singers and dancers exercising their talents illicitly wherever a patron or passer-by could be found to look and listen, The barbarian invaders from the north and east. possessing no regular drama of their own and speaking languages other than Greek and Latin, could not supply the initiative required to reunite these isolated components of former dramatic and theatrical traditions.

B. Christian Revival

1. International Drama of the Medieval Church.—The first steps toward reunification were taken spontaneously and unself-consciously in the christian liturgy; the festival of Easter and celebration of Christ's resurrection provided the occasion; the meeting of the three Marys with the angel at the empty tomb and the angel's announcement of the resurrection to them was the theme. This elementary dramatic performance involving mime, dialogue and emblematic representation of person and place was soon adapted and repeated in connection with the miraculous birth celebrated at Christmas at the time of the winter solstice. In the first instance both of these dramatic representations took place within the ritual of the Mass and were enacted by the choir. The initiative appears to have come from the duchy of Swabia in the 10th century, the text taking the form of a chanted Latin introit, *Quem quaeritis in sepulchro, O Christicolae?* The great religious houses of St. Gall (now in Switzerland). Limoges and Fleury quickly elaborated these texts both musically and in the extension of subject matter. though treatment of Christ's Passion is conspicuously absent. Dramatic representation spread to areas as remote from one another as Dublin and Augsburg or Winchester and Florence, and would seem to indicate that it was accepted as part of the church's missionary and instructional activities. It is not until the end of the 13th century that the Passion is treated fully or that the vernacular is preferred to Latin.

During 300 years of slow elaboration in these liturgical music plays, a code of symbols drawn from earlier liturgical practice and chant came to be applied to the performance of these plays; the code served as the basis for subsequent theatre practice in respect of acting. costumes and setting. St. Ethelwold, as bishop of Winchester. in his *Concordia Regularis* (*c.* 978) drew up a set of rules for the acting of the *Quem quaeritis* ceremony in his diocese governing gesture. vestments and means of suggesting locale. (*See* E. K. Chambers. *Mediaeval Stage,* vol. ii.)

Similar information may be gleaned from the rubrics of service books all over Europe, though a great many of these were destroyed in the course of the Reformation. One of the fullest to have survived is the French *Festum Praesentationis Beatae Mariae* of Philippe de Mézières (1372), from which the wholly ritualistic and emblematic nature of these performances may easily be reconstructed. This text along with all others of importance is printed in Karl Young's *The Drama of the Medieval Church.* The gradual extension of the subject matter treated in these religious playlets led to an episodic narrative style with small regard to formality in respect of time, place or action. Thus in every respect this drama performed by priests for the enlightenment of worshipers openly admitted the pretense implicit in the representation.

This very important characteristic, so different from the 20th-century theatre practice which often uses every conceivable scientific device to pass off the pretense as the actual, applied with equal force to the vernacular adaptations of scripture in dramatic form that began during the 14th century. Known in Italy as *sacre rappresentazioni,* in Spain as *autos sacramentales,* in France as *mystères* and in England as miracles or (*post* 1800) as mystery plays (*see* Drama: *Medieval*), these plays were centred on Christ's Passion and were designed to stress the humanity as much as the divinity of Christ. Thus. while preserving in field, market place or town hall the same emblematic quality in performance as the liturgical play of cathedral or church interior. the highly ritualistic style of performance was relaxed to accord better with the secular elements now preponderant in the narrative. Chant gave place to speech church vestments were supplemented by contemporary costume appropriate to peasant or secular official. and scenic elements, specially made for the performance. became more decorative. The high seriousness of purpose remained, but comic elements, particularly in association with devils and peasant characters (*e.g.* Mak of the Wakefield second *Shepherds' Play* or Mrs. Noah of the Chester *Deluge*), obtained a place in the plays, assisted no doubt by the use of vernacular speech. The initiative for these cyclic dramas, which grew long enough to occupy anything from a day's duration (in York) to a week's (in London and Mons), probably must be credited to mendicant friars. Plays of similarly didactic and devotional purpose concerning the lives of Christian saints and martyrs grew up simultaneously throughout Christendom but of a more markedly national character, as determined by the particular story. Additional room for topical and local subject matter was provided by the dramatic adaptation of sermons depicting mankind's struggle to arrive before the judgment seat at doomsday with an army of virtues rather than vices to plead his fate. This kind of play. religious in purpose but secular in virtually all externals, linked parable and symbol in dramatic narrative to the symbolic manner of presentation derived from the liturgical music plays.

Thus the way was opened in every European country for a theatre as secular as that of antiquity but now consistently Christian in its ethos. In France the result mas seen in *entremets* and *soties;* in Germany in the *Fastnachtsspiel* and (farther east) in the *Neidhartspiel;* in Spain the *sainete;* in England in the "disguising" (formerly mumming, latterly masque) and the interlude (*see* Interludes; Masque; Mummers). All of these genres are distinct. national, independent; yet at the same time each of them is only an aspect, coloured by racial temperament, geography and climate, of a spirit common to Christendom. These factors also governed the conditions of performance, common practice being more noticeable than particular variants. Performances were closely linked to festivals of the Christian calendar, themselves adapted from earlier folk festivals of the agricultural year—Christmas (winter solstice): Shrovetide, Easter and May day (advent of spring); Ascension, Whitsun and Corpus Christi (summer solstice); St Michael, and All Saints (harvest thanksgiving and autumn). Choice of a place of performance was governed by the mutual convenience of actors and audience. churches. where large enough; adjacent yards or cloisters where the churches were too small: market places, quarries, even playing fields; town halls, baronial halls. palace halls. The hierarchical stratification of medieval society was strictly observed in the provision of "standings" (and more rarely seats) and arrangements for the privacy and sight lines of spectators. Stages and auditoriums were as occasional as performances. with the notable exception of the "pageant waggon" stages used in the north of England that were carefully stored away for future use. Most religious plays were performed, as in Athens, by the local community for its own members. The actors received wages but were not professionals. Female parts were played by choirboys, though not invariably. The "wives of this town" presented the play of *The Assumption of the Virgin* in Chester. The cost was underwritten by both church and town: surviving expense accounts prove that the biggest single item was the cost of scenic units and winch machinery for flying angels and disappearing devils. Modern observers may be surprised at the endurance of audiences ready to sit or stand all day for several days watching these simple but dignified and profound plays; the plays then had a rarity value augmented by long months of corporate preparation and heightened by a sense of occasion, both of which have been lost.

2. Medieval Minstrelsy and Pageantry.— An equally occasional but more nearly professional theatre that aimed at social recreation rather than religious edification grew up during the late middle ages among minstrel troupes in princely courts and the households of the lords spiritual and temporal. The troupe consisted of *jongleurs* ("tregetoures") who entertained with mime, music and circus acts, and whose social status and way of life were probably descended from those of the nomadic mimes of the Roman theatre, it was led by the *trouvère* ("troubadour"), a probable descendant of the Teutonic *scôp,* who held the rank of esquire and sang or recited *chansons de geste.* This theatre gave expression to song dance and romance literature in mime for the pleasure implicit in these things rather than for any devotional purpose. During the 15th century the troupe split into separate groups of musicians and actors. While employed as household servants and expected to perform for their master at calendar festivals, they were allowed to travel, taking their costumes and stage properties with them, and to perform for reward wherever their leader could obtain entree. Weddings and other private celebrations provided the occasions for such performances. The plays. compared with those of the religious stage, were short and often the work of a poet of reputation. Masks were frequently used and doubling of parts was invariable.

This association with aristocratic traditions and requirements brought the nascent theatre of social recreation into close contact with the codes for identifying person, rank and place developed in heraldry. Royal progresses. coronations, tournaments and battle honours which were usually celebrated by elaborate civic pageantry, provided a meeting point where the emblematic conventions of heraldry and of Christian ritual could be fused to the advantage of the actors and the painters and engineers who embellished their stages. The characters of the pageant theatres of city streets, in their persons and their speeches, contributed to a similar amalgamation of scriptural, mythological and historical figures.

This was the theatre—religious in its inception. recreational in its later development—that in the 16th century joined hands with the theatrical traditions of Greece and Rome; this was the theatre that was destined by its associations with Roman Catholic faith and ritual to become a principal target for Protestant reformers.

3. Renaissance, Reformation and Counter Reformation.—The revival of interest in all things. Greek and Roman, hastened by the fall of Constantinople to the Turks (1453) and the invention of printing, affected every theatre in Europe either directly or indirectly through Italian example. At first there was the novelty of seeing in action plays that had not been performed for more than 1,000 years; then there was the attempt to recreate something of the conditions and atmosphere of the original performances in Roman or Greek times; finally there was the adaptation of both to fit changes in manners. language and technical skills: the appeal of "modern dress" performances. Plautus' *Menaechmi* was performed in Latin before Duke Ercole d'Este in 1486. and Terence's *Phormio* by St. Paul's choirboys before Cardinal Wolsey at Hampton court in 1528. The reliance of Latin comedy upon typed characters (master, parasite, young lovers, braggart-coward, etc.) and upon plots of intrigue and situation made it easy for 16th-century adapters to do much the same in both vernacular speech and contemporary idiom. Cardinal Bernardo da Bibbiena's *La Calandria* in Italy, Rodrigo Cota's *Celestznn* in Spain and Nicholas Udall's *Ralph Roister Doister* (*c*. 1553) in England are examples of this adaptation. In tragedy, a similar reliance upon Latin example (Senecan closet drama) and upon Latin adaptations of Aristotle (rather than the Greek original) provided Renaissance revivalists with a picture of ancient drama in which questions of form assumed a greater importance than those of either content or purpose. Dramatic entertainments of this kind, eagerly championed by pedantic scholars and deemed by their patrons to be a proper adornment of a civilized household, were accepted by the intelligentsia of Europe regardless of whether or not they were likely to enjoy any popular support.

Had the divorce between the religious stage and the theatre of pedagogic archaism been as complete in other European countries as it was in Italy (where the latter was largely pioneered). there would have been no "golden age" of Lope de Vega, Cervantes or Calderón in Spain and no .'Elizabethan theatre" in England, for both English and Spanish theatres depended for their existence on the triumph of popular common sense over academic rationalism and an extravagant addiction to spectacle for its own sake

In Italy, *commedia erudita,* comedy and tragedy imitating Roman example, was played out within 100 years and became subject to violent reactions in wholly unexpected directions: the beginning of *commedia dell'arte* and pastoral-lyric drama, or "opera." The former was a revulsion against a restricting form and a reassertion of the spirit of comedy stemming from that peasant stock whose religious stage had been so rudely spurned in the late 15th century. Some of the outward farcical qualities of the *commedia erudita* were taken over (*e.g.,* scenarios, type characters), but with the *commedia dell'arte* (*i.e.,* of the profession) the change is evident enough; improvisation was substituted for a fully scripted text, the personality and skill of the actor were now highlighted rather than the toil and erudition of the author, and the appeal to a popular audience was restored. Tragedy of the Senecan kind (*e.g.,* Gian Giorgio Trissino's *Sofonisba,* written about 1515 and first performed in 1562) was redeemed from suffocating boredom by the *intermezzi,* or interludes, between the five formal acts; these were devoted to songs and dances with decors designed by architect-painters of outstanding genius; *e.g.,* Mantegna. Baldassare Peruzzi. Raphael. Leonardo da Vinci. These *intermezzi* naturally grew in length and scale to a point where they came to eclipse the more serious episodes of the performance The "satyr" play of Greco-Roman drama provided a classical source for the *intermezzi,* with their songs. dances and scenic experiments, which were deemed. in the absence of evidence. to have developed along pastoral lines from them. Torquato Tasso's *Aminta* (1573) and Battista Guarini's *Pastor Fido* (1598) forged the link. In Italy itself the emphasis on song resulted in what is now called opera; in France, dance took precedence, thus opening the way to what was later known as ballet; in England, words, song, dance and spectacle were developed in the perfect equipoise of the Stuart masque; this genre. however, relied too greatly on the occasion celebrated to survive without an autocratically administered exchequer.

The scenic theatre. based on heavily subsidized study of Vitruvius and later on the commentaries on him (Sebastiano Serlio. Andrea Palladio. Vincenzo Scamozzi, and Lorenzin Sabbatini were the most influential), spread during the 17th century to France, Austria, Germany. Scandinavia and also to Spain at the hands of Italian exponents imported for the purpose. Inigo Jones's reputation in English theatrical history, however, rests on his independent development of ideas picked up during periods of study in Italy (1603–04 and 1611–13). The new Renaissance theatre modified the classical theatre construction; the built-in perspective, though still formal, made an attempt at versimilitude that led to a fundamental disharmony in the elements of presentation. The best seats in the theatre were now determined by their view of the scene. The *frons scaena* was remodeled to form a proscenium arch concealing the elaborate scenic devices behind it, though it was still regarded as part of the scenery backing the actors rather than as a barrier dividing them from their audience. It was symptomatic of this theatre that the architect-painter took precedence. at least in respect of production costs, over both dramatist and actor.

That this prototype of Italian origin was not followed either simultaneously in time or uniformly in pattern elsewhere in Christendom was because of a combination of individual national factors and the varying international pressures of the Reformation and Counter Reformation.

During the Reformation it was inevitable that hostility to Catholic Rome and what it stood for on the one hand and enthusiasm for imperial Rome and what that represented on the other should collide at many points, not least in the theatre. In Germany, England and parts of the Low Countries and of France, Rome was at once the throne of the muses and the seat of Antichrist, the viewpoint depending on religious persuasion and academic background. With religious drama already deeply entrenched in popular esteem the theatre in these countries, however involuntarily, could not avoid becoming a contentious issue in domestic politics. In Germany the stage was set to work early in the 16th century as an active instrument of propaganda for the Reformed church. This initiative passed quickly to England—Thomas Kirchmayer's *Pammachius* (1538) was dedicated to Archbishop Cranmer—while Thomas Cromwell employed John Bale (*q.v.*) and others to write polemical interludes mocking the traditions of the Roman Catholic religious stage: the pope, monks, friars, transubstantiation. The plays were adapted from the traditional miracles and moralities and quickly led to riots. Kett's rebellion of 1549 was deemed to have grown out of a disturbance at a play in the Norfolk village of Wymondham. Tudor governments, Protestant and Roman Catholic, from 1543 onward were forced into taking legislative action against the theatre. Actors were systematically placed under strict supervision and control; an increasingly vigorous censorship was imposed on play texts in manuscript and in print; places of performance were scrutinized and made subject to licence. Under Elizabeth I the amateur religious stage was systematically suppressed. the last miracle play to be performed being that at Coventry in 1584. Under James I all actors, plays and theatres were made subject to royal licence.

In 16th-century England neoclassical drama was not accepted unquestioningly, partly because of its association with Rome and with Latin. partly because topical debate proved far more acceptable than intrigue to audiences, and partly because the nation as a whole was thrown back on its own wits and resources in the face of the mounting threat of foreign invasion. Relaxation of tension followed swiftly upon the execution of Mary, queen of Scois (1587) and the defeat of the Spanish Armada (1588), and with it came a readmission of Italian ideas in art and education. By then, however, a distinctly English style of secular theatre had grown out of the ashes of the religious stage. It was distinguished by its reliance on the symbolism derived from liturgical plays and from heraldry; it owed its narrative to the miracle cycles and saint plays, its emphasis on debate and parable to the morality play and its professional character to the players of interludes. The shape and size of its stages and auditoriums were influenced by the animal-baiting arenas, the circular and rectangular tilting yards. the square or rectangular halls and (probably) yards of inns and by the rectangular town halls and guildhalls of provincial towns. Professionally organized and relying on the financial support of commercial speculators and the protection of sovereign and court officials. the theatre of Marlowe. Kyd, Shakespeare. Jonson. Dekker and Webster remained a popular theatre in touch with its medieval heritage and self-confident enough to draw what it wanted from neoclassical precept and no more. Public theatres (Globe, Swan. Fortune, Hope. Red Bull, etc.). private theatres (Blackfriars, Whitefriars, the Cockpit) and the court theatre of the masque represent accurately enough a box-office dependerice on plays and performances reflecting past traditions, present experiments and a prototype for the future.

Where the court masques mere largely the pride of amateur participants, the public and private theatres, in the hands of such shrewd and wealthy men of business as the Burbages (James 1530–97. Richard 1567–1619, Cuthbert 1566–1636), Philip Henslowe (*c.* 1550–1616) and his actor son-in-law Edward Alleyn (1566–1626), were in all respects professional. This distinction they achieved in the face of tough opposition from the more Calvinistically minded reformers and capitalist merchants who objected to the absenteeism created by the popularity of stage performances. These factions in society grew steadily more powerful in Jacobean and Caroline times. banning actors from one provincial city after another; the actors themselves. in concentrating upon a metropolitan business. position at,court, coterie audiences and extravagant spectacle, aided their enemies in cutting the bonds of popular support. The closing of the theatres in 1642 at the outbreak of the English Civil War represented as much a popular revulsion against actors and plays, considered to be little more than royal slaves and royal toys, as it did an act of puritan retribution against a relic of popery.

In Germany. France and Spain features of this pattern are repeated but with important differences of emphasis. In Germany the initiative that adapted the traditions of the religious stage for purposes of Protestant propaganda was strong enough to retard the development of the neoclassical theatre even longer than in England. Little direct Italiari influence is to be seen in German plays or stagecraft (beyond the arbitrary act and scene divisions) until late in the 16th century. The only outstanding theatrical figure was Hans Sachs (1494–1576), who adapted a disused Catholic church (the Marthakirche) in Niirnberg in 1550 as a theatre for his own and other plays acted by a company of which he was himself the leader. English traveling actors, by importing Elizabethan plays and stage conventions, gave the Germans a taste of theatre that was professionally organized for purposes of social recreation rather than for those of moral improvement and reinforced their native traditions. But this vitality was counterbalanced by the social upheaval of the Thirty Years' War, and the sterility of the polemical *commedia erudita* of the Jesuit Counter Reformation. Of attempts to combine popular Protestant drama with neoclassical precepts only the plays of Andreas Gryphius (1616--64) have attracted attention from posterity. Italian opera with accompanying scenery made heavy inroads in court circles, serving to establish a complete divorce between popular tradition and aristocratic taste by the middle of the 17th century.

In Spain, by marked contrast, the impact of the Reformation and Counter Reformation on the theatre was slight. The reason was that the Inquisition, as reorganized under Torquemada (*c.* 1486), had taken care to purge the religious stage of those elements that in other countries laid it open to ridicule. Neoclassical theatrical ideas thus developed alongside traditional popular plays and stage convention, since authors were able to write for either as inclination and occasion suggested. Since the feast of Corpus Christi continued to be observed (it was abolished in England) plays associated with the feast (*autos sacramentales*) continued to be presented throughout the 16th century and after. Courtly actor-playmakers similarly had opportunities of a far less inhibited kind than in England, although less highly organized than in Italy, to refine their craftsmanship by conscious imitation of Latin authors and to develop subject matter of an avowedly secular kind. The playwrights Juan del Encina (1468–c. 1537) and Gil Vicente (c. 1465–c. 1539) and the critic and theorist Bartolomé de Torres Naharro (c. 1480–*c.* 1530) provided between them the backbone of this alternative to the popular (and largely amateur) religious stage.

From this cult of *entremes*, *comedias* and tragedias the Spanish theatre acquired as recognizably professional an outlook and status as that of the English interludes, while from the popular religious stage it retained as distinctly rhetorical and emblematic techniques of performance and presentation as those of' the Elizabethan theatre. Market places and innyards on provincial circuits provided the actor-playwright Lope de Rueda (1510--65) with his theatre building and it was a member of his company, A. de Rojas, who in El *Viaje entretenido* gave a vivid picture of the actor's life. Under municipal control professional theatres were provided in *corrales* (courtyards) administered by religious and charitable institutions. These buildings slightly precede in date those in England, but whereas in England such buildings were limited to London, in Spain the practice spread quickly from Madrid (c. 1560) to all large provincial cities. As in England. the performers suggested improvements in the buildings they used and these found their way into subsequent designs. Performances took place in the afternoons and were accompanied by items of song and dance corresponding to the Elizabethan jig. 4 roof projected over a raised stage; the wall from which the stage jutted contained doors and windows; costume was contemporary dress adorned with heraldic or other emblems of identification; traps and flying machines were provided. This theatre was nearly akin in national temperament and professional need to that of Elizabethan and Jacobean England, and it produced dramatists of as outstanding a quality in Cervantes. Lope de Vega and Calderón, all of whom exploited the narrative possibilities of their stage to the full. Action, wide-ranging and fast-moving, was the hallmark of this theatre of the siglo de oro (see SPANISH LITERATURE: Castilian *Literature*) just as it was in the English theatre. It differed from English practice, however) in the continuing liberty allowed to plays based on biblical and theological subject matter; in the work of Calderón. for example, there is to be found a perfect blend of religious subject matter and symbolic presentation; the medieval theatrical tradition has been modernized in theology and literary style by the Counter Reformation and in stage convention by the adaptation of neoclassical settings and machinery that was wholly lacking in England. Where England contributed to the German theatre through the repertoire of strolling players, Spain contributed to France the vitality of its drama of character, situation and intrigue.

Spanish influence, however, was particularly marked in the Low Countries. governed by Spanish rulers through the first half of the 16th century and in revolt against them during the second half. The indigenous religious stage. with its notable morality play Elckerlyc (Everyman, c. 1470) and the festivals of the Rederijkers Kamers (chambers of rhetoric; see DCTCH LITERATURE), formed the basis of a theatre that might have been as influential throughout Europe as Flemish painting had not conditions of political and social unrest disrupted its development and made it subject in turn to the dominance of Spanish. Jewish and French influence. The Schouwburg theatre, built in Amsterdam by Jacob van Campen (1637), nevertheless provides the theatre historian with as interesting a building as the Teatro Olimpico at Vicenza (Palladio and Scamozzi. 1580–84).

Both illustrate the transition from medieval to classical styles of theatre architecture; the Olimpico, as markedly advanced toward the new style as was the Schouwburg (although built so much earlier in time), is noticeably dependent on the past. In these two theatres and in Johannes de Witt's drawing of the Swan theatre in London (built c. 1594) may be seen three manifestations of neoclassicism tempered by the pressures of the Reformation and Counter Reformation that conveniently epitomize a whole period of violent controversy and astonishingly varied achievement.

C. Classical, Baroque and Romantic Reaction

The French theatre followed Italian example in divorcing religious and popular drama from secular and recondite drama. Sacred drama was forbidden by decree in 1548 to prevent its being used by the Protestants to try to bring Roman Catholicism ınto contempt. Artists, unfortunately. cannot be created by decree and in consequence the great French heritage of religious plays and popular farces was followed by attempts to ape Italian academic example. but in a manner even more dogmatic than the model. The typical medieval mixture of joyous and sad, tragic and comic found no sequel in the rigid theorizing of the scholar poets, of whom Étienne Jodelle (1532–73), Robert Garnier (c. 1535–c. 1600) and Jacques Grévin (c. 1538–*c.* 1570) enjoyed a limited repute at the time. A taste for dancing and spectacle grew up among court amateurs in France centred on the ballet de cours, of mhich Le Bullet *comique* de la reine of Balthazar de Beaujoyeulx is the best-knonm example. Printed ın 1582 it provides illustrations of the scenic arrangements that were still traditional and include Circe's garden, a grove of trees and a large cloud. Early in the 17th century Pierre Corneille encountered bitter criticism in trying to bridge this gap between the unity of place demanded by the theorists and the *décor simultané* of theatre practice. a gap only made the wider by the conspicuous absence until 1595 of any professional acting company other than the crippled Confrérie de la Passion, who owned the Hôtel de Bourgogne.

Not until political stability returned to France under Cardinal Richelieu could a theatre as genuinely professional as that of Spain or England return to Paris. Two theatres. the Hôtel de Bourgogne and the Marais, then began to develop on professional lines and in keen competition, with tragedy, comedy and pastoral in the Italian manner established as the only recognized dramatic genres It was not until 1650, however, that Italian stage machinery was coupled to performances in public theatres' the occasion was Corneille's *Andromède* with settings by Giacamo Torelli It was left to Molikre and Racine to bring the French theatre, one in comedy the other in tragedy, to a pre-eminence sufficient to eclipse that of both England and Spain. and this despite perhaps the most vicious sequence of literary intrigues and personal attacks the theatre has ever known, or at any rate recorded Molière (1622–73), himself an actor. and Racine (1639–99), acquainted from youth with theatre practice and assisted by Molière. enjoyed that same protection of the sovereign and those near to him that had distinguished the careers of Shakespeare, Ben Jonson, Philip Massinger and others in England; together they brought to the theatre a degree of observation both of human foibles and of human passion and suffering that sufficed to give a genuine vitality to the revived classical forms not attained before or since. Aided by two remarkable musicians, Jean Baptiste Lully and Jean Philippe Rameau, the pastoral form was also vigorously developed in France in the directions both of opera and of ballet.

The influence of Molikre and Racine, together with that of Corneille. was felt everywhere in Europe and was synthesized for Europe in Boileau's Art *poétique* (1660). Nowhere else. however, was their genius matched; only in England, and there only in comedy, was anything written or staged that has maintained a hold on posterity in terms of frequent adaptation and revival. English tragedy modeled on the French, of which Sir William Davenant and John Dryden were the twin advocates, degenerated, as Italian tragedy had done, into operatic fantasy. Everywhere, however, from Sweden in the north to Austria in the east the real victor was the theatricality of the baroque spirit expressed in stage settings and their illumination. Classicism triumphed momentarily in France, but it was the spectacular rather than the literary quality of the revival that held Europe entranced throughout the 18th century. Everywhere it was the designers and the actors whose names counted with audiences rather than those of the writers. The costume designs of Lodovico Burnacini (1636–1707). the perspective settings of the Bibbiena family, which between 1680 and 1780 were unchallenged for originality and activity, and theatres like the opera house in Bayreuth define the baroque spirit and its rococo sequel that spread outward from dramatic representations to enhance the whole of aristocratic life. Theatre worthy of the name became a courtly or at least a metropolitan toy designed to kill time in a manner as costly as befitted its aristocratic patrons. Popular theatre dwindled into fairground improvisations and the meagre, eviscerated repertoires of strolling players At both levels there were extensive exchanges, Gustavus III of Sweden enjoying at Drottningholm in 1780 what Louis XIV had initiated at Versailles a century earlier. Pierre de Chamblaine de Marivaux in Paris enjoying closer affinities with Carlo Goldoni in Venice or Richard Brinsley Sheridan in London than with Molière, and booth theatres in provincial streets holding audiences with debased relics of Jonsonian "humour," German farce and Spanish intrigue grafted onto the improvised scenarios of *commedia dell'arte.*

Reaction and revolution came not from left or right but from the centre; *i.e.*, from the bourgeois public denied a theatre for so long by Puritan sentiment in England, by aristocratic privilege in France, by war and social unrest in the Low Countries and middle Europe. by stagnation in Spain and by feudalism in Russia and Scandinavia. A spirit of satire and sentimentality, long smoldering beneath the surface, began to make itself felt in England, particularly in the work of Henry Fielding and George Lillo; similar romantic yearnings in Germany mere made vocal by Lessing and, in the following century. these tendencies were further advanced by the nationalistic and democratic fervour of Italians, Norwegians and Russians. culminating in the work of Verdi, Ibsen and Chekhov. Moreover, the political revolution that, country by country. shattered the aristocratic façade of European theatre was accompanied by an industrial revolution of equal consequence to stage architecture and convention.

The pastoral fantasies, countertenors, literary controversies about the unities and restricted admission by privilege of birth were of little or no interest to the merchant *bourgeoisie* of Europe returning slowly to theatre or demanding theatres of their own. They wished for action and narrative of a kind not seen on the stage (outside Spain) for generations; an unwitting return was made to the genuine beginnings of theatre in ancient Athens or during the middle ages rather than to those beginnings mistakenly judged to be represented by the Roman stage on which the whole edifice of neoclassicism had been built. These yearnings, however, were not supported by any particular erudition and were in any case quickly coloured with political vested interest and spectacular possibilities of the new stage devices. Aristocratic opera and ballet were thus subjected in the early 19th century to popular sentimentalizing. comedy of character, manners and wit; to a taste for farce and tragedy; to an eagerness for violence and horror.

The cult of spectacle. however, so long a luxury for the few and the corrupter of their theatre. did not disappear; it increased and corrupted in turn the taste of the newcomers. The apotheosis of the changed theatrical style was melodrama. Melodrama is a difficult term to define since it embraced among writers such distinguished men as Goethe. Victor Hugo and Pushkin, reached its zenith in Germany and its nadir in England and the United States and, having quitted the animate theatre via grand opera and classical ballet, has perpetuated itself in motion picture and in television serial. In one sense it represents the last despairing heroic fling of the theatrical rhetoric inherited irom a pre-Christian past; in another sense it has come to stand for all that is most sentimentalized and hypocritical in a Christian-rooted theatre. What is clear is that melodrama represents a watershed in the history of European theatre; it was at once the last genuinely theatrical form with an appeal strong enough to dram its support from all ranks of society and the jumping-off point for that division between the actor and his stage that characterized the subsequent development of dramatic art in the west. Some actors, singers and dancers chose to exploit the more hedonistic and less educated element of the popular audience. With methods and organization resembling that of the medieval minstrel troupes or Roman mimes, they made what capital they could from their own personality and special "acts!' but with the important difference that on the financial success of performances in public houses it became possible to erect theatres for the purpose, thus giving a degree of urban regularity to what had hitherto been the largely rural and nomadic occupations of the fairground. From the "music room" annex to public bars sprang not only the professional circus but also the great provincial and metropolitan chains of theatres known in Britain as music hall and in the United States and parts of Europe as vaudeville and epitomized in England by the twice-nightly variety shows managed by Sir Edward Moss and Sir Oswald Stoll (see below).

Where stage plays were concerned, the popular section of the audience derived amusement from parodies of classical theatre forms ('burlesque [*q.v.*]; extravaganza; burletta) and from the spectacular sensations of shipwreck. forest fire and earthquake intermingled with violence and idealism supplied in the more elaborate melodramas, of which R. C. A. de Pixérécourt in France (1773–1844) was the pioneer and prime exponent. A similar cult of individual personality developed within the more orthodox dramatic genres of the traditional theatre, finding its prime expression in productions of Shakespeare's plays in England, in opera under German and Italian leadership and in Russian ballet. Shakespearean title roles gave the "star" actor his pre-eminence in his profession. while vocal virtuosity and powers of mimetic expression were similarly emphasized in opera and ballet respectively. Paradoxically, the narrative and spectacular elements of libretto and setting were also exploited for their own sake in a manner that made all actors other than the star the virtual prisoners of an army of technicians. The invention of gas lighting with the possibility of blacking out the auditorium (c. 1823). subsequently improved in both safety and flexibility by electric lighting. forced even the star actor off his commanding "forestage" and incorporated him within the stage picture as an adjustable item in the pictorial design. Because of the technical problems involved in manipulating these animated landscapes with narrative coherence. the star actor was gradually obliged to hand over his control of his fellow actors and the scenery; both actors and scenery were now subject to control by financial speculators and a neutral observer who. from the humble status of stage manager, came thus to be elevated to the dignity of producer, *régisseur* or director. Further dignity and power were added to his status as techniques of mechanical reproduction in motion pictures, radio and television increased the ratio of engineers and technicians to actors in any single dramatic performance, and as the star actors lost financial control to their managerial partners, (See ACTING. DIRECTION AND PRODUCTION : *Direction.*)

With the retirement of the actor off his forestage and into the scenic picture, realism of an almost photographic kind became a mnin object of production. Assisted by a developing interest in historical and archaeological accuracy that was initiated by the actor David Garrick (*q.v.*) in his costuming of Shakespeare's plays and brought to its highest point by Sir Henry Irving (1838–1905) (see IRVING) and Sir Herbert Beerbohm Tree (*q.v.*) in the costumes and settings used in their productions, this realism in externals demanded concessions from both dramatists and actors in the written and spoken text. Both had to be scaled down if the dichotomy between realistic sets and costumes and a rhetorical text and delivery were not to appear ludicrous. The language of poetry and a large measure of the virtuosity that had earlier distinguished the professional from the amateur actor were both victims of this sacrifice. Dramatists were forthcoming in France in Victorien Sardou and Eugène Scribe, in England in Thomas Robertson. in Germany in Gerhart Hauptmann. in Scandinavia in Bjørnstjerne Bjørnson, Strindberg and Ibsen and above all in Russia in Chekhov, capable of making stage action and dialogue look and sound as natural as everyday life. It was in Russia at the Moscow Art Theatre that the first serious steps were taken by the actor-producer Konstantin Stanislavski (*q.v.*) to codify a style of acting as appropriate or "natural" as the verisimilitude of the new plots. settings and dialogue demanded. The imitations that followed, under George Bernard Shaw and Harley Granville-Barker in England. under André Antoine and Jacques Copeau in France and under Eugene O'Neill (*q.v.*), Lee Simonson and others in the United States, together with the reaction against them, belong to the 20th century and to modern drama and theatre.

D. SUPPLEMENTARY ARTS

1. Opera. — Opera (*q.v.*) deserves consideration as a form of theatre in which song and instrumental accompaniment are predominant. Much eastern theatre is operatic in that the dialogue is musical; so too was the liturgical drama of the medieval church, as the recording of the Plays of *Daniel* made by the New York Pro Musica quickly demonstrates.

Opera of the sort. however, that is generally accepted under that name was introduced into Europe by the group of Florentine patricians known as the *Camerata* (*c.* 1597), whose object was to intone the dialogue of tragedy in the manner they imagined it had been recited in the theatres of ancient Greece. The result was what is known as recitative, which, when linked to aria (song), provided a text or libretto sung throughout to musical accompaniment. The story of *Orpheus and* Eurydice was provided with such settings by J. Peri. G. Caccini and C. Monteverdi in quick succession between 1600 and 1607. The latter did for music-tragedy what the painters of equal genius had done 50 years earlier for the tragic scene. Opera, thus firmly based on scenery, song and tragic or pastoral themes. swept northward through Venice, where the first public opera house was opened in 1637, to Vienna and Germany. Then it swung in two great arcs northeast to Warsaw, Stockholm and St. Petersburg and northwest to Copenhagen, Amsterdam. Brussels and London at the turn of the 17th century into the 18th century. Paris and London enjoyed a brief creative period of indigenous opera in the Italian manner between 1650 and 1700 dominated respectively by Jean Baptiste Lully and Henry Purcell.

Comic themes were introduced from Naples early in the 18th century, being developed irom between-the-acts of serious opera in the same way that tragic and pastoral opera had itself developed out of the *intermezzi* to neoclassical tragedy. While Handel arid Gluck dominated the serious operatic scene during the early and middle parts of the 18th century respectively. these developments reached their peak in Mozart's compositions for the theatre toward the close of the century.

The coincidence of political and industrial revolutions with the bourgeois sentimentalism evident in melodrama brought about a reaction toward romantic and historical plots; together with the development of the orchestra these factors led directly to the romantic opera of Verdi (1813–1901) and Wagner (1813–83). The outstanding theatrical features of all 19th-century operas are the emphasis placed on melodic line and the reliance upon the vocal range and power of the principal singers. These characteristics were quite out of line with development in the regular theatre. as signalized in the plays of Ibsen. who abandoned verse for prose. and in the acting style of the Moscow Art Theatre under Stanislavski.

Reaction to the primarily tragic and serious effusions of Verdi and Wagner (grand opera) found its outlet in light, or comic, opera. In England the light opera of W. S. Gilbert and Arthur Sullivan. in Austria the waltz opera of Johann Strauss and Franz Lehar and in France the *opéra-bouffe* of J. Offenbach (where recitative was reduced to the barest minimum and unaccompanied prose dialogue restored) opened the way to the operetta and musical comedy of the 20th century and perhaps the first distinctively transatlantic form. the American "musical."

2. Ballet. — A ballad, or ballet, in the 15th century formed an item in the repertoire of the minstrel troupe that came to be enacted in mime; to this were added the embellishments of songs and dances, the whole making up an evening's revels. During the 16th century the poem became little more than a prologue to establish the nature of the dances in masquerade. These developed as a series of "entries" of disguised courtiers who. after dancing with one another. took partners from among the spectators. Known in Italy as *maschera,* in England as masque and in France as *mascarade,* the element of dance became predominant in France during the 17th century. These ballets danced by amateurs reached their climax at Versailles at the hands of Lully and Molière. After being taken over by professional dancers they were integrated with Italian opera but could not develop further until fashion in dancers' costume allowed both greater freedom and precision of movement. This change. initiated by Marie Anne de Camargo (1710–70), was followed by attempts to link formal dances mith musically accompanied mime in the same way that one aria was linked to another by recitative in opera. The innovator was J. G. Soverre (*q.v.*), whose treatise *Lettres sur la dunse et sur les bullets* stimulated public interest and discussion of ballet as an art form all over Europe.

The objective was a re-creation of the sort of dancing deemed to have graced the classical theatre of antiquity; but, being pursued at a time when romantic forms were beginning to find public favour at the expense of classical ones, ballet derived little more from pseudoclassicism than the conventional ballerina's costume of skintights surmounted by a short skirt of tiered muslin and the so-called "classical" dance figures before being enveloped in the mystical miasmas of fantasy and spectacle derived from Gothic melodrama. Severtheless the combination of costume and dance figures sufficed to re-establish the bodily skill. grace and expressiveness of the actor with force enough to attract to it the unsophisticated folk dances of peasant communities who as yet had no other theatre. The imperial ballet of the Russian court was in the most advantageous position for this assimilation: for in Russia. as a comparatively undeveloped country of great geographical and climatic variety, a wider range of peasant dances existed for exploitation than anywhere else in Europe. A rapidly developing and strongly nationalistic school of music. itself largely indebted to the melodies and rhythms of folk music. provided Russian ballet with creative impetus enough not only to surmount any danger of the new art's dying as a result of suffocation from repetition and stereotyped convention but also to revivify dancing in the west (*see* BALLET).

3. Mime, Pantomime, Vaudeville and Music **Hall.**—Any concept of a theatre other than that restricted to timber, bricks and mortar depends for its existence on and develops around the person of the actor. Moreover. any society that has once advanced far enough to recognize the pleasure latent within the performer-beholder relationship has never been able to dispense with it. Thus although the peoples of the world have, from time to time and from place to place, and for various reasons, either refused to permit or failed to sustain an organized theatre, they have never lost touch mith the rnimer who is able to entertain with no properties other than his own voice and person. Recognizing the tenuous nature of his hold over his audience. the mimer has inevitably and invariably relied upon the easiest means of provoking laughter—verbal mockery and physical indignity.

Whatever society has prescribed to he sacred or illicit has tempted comment from him by virtue of the power that any shock possesses to attruct and hold attention. The barbed satire of social criticism and the appeal of pathos. both demanding a high degree of awareness and intelligence in their portrayal: augment the equipment of the more skilful and experienced mimer.

Throughout recorded history therefore the mimer, whether known under Greek, Latin or vernacular names, has enjoyed the abiding favour of the more oppressed sections of society and the constant disapproval of those in authority, except at rare times when that authority was too secure for any challenge to be regarded as a threat. hlarkets, fairgrounds, city streets at festival times. village green and taverns have provided their perennial auditoriums. At times they have organized membership, their finances and their patrons well enough to originate a distinctive style of theatrical performance warranting a label. The Xttelan fairs of Roman Italy, the medieval minstrel troupe. the Feast af Fools, the *commedia dell'arte* of Renaissance Europe, harlequinades. English pantomime and music hall, extravaganza, burlesque. revue, cabaret. American vaudeville and American burlesque (including strip tease) are among the most notable forms. All have been characterized by the lack of any regular script; the liberty permitted to the actors to improvise their actions and extemporize their dialogue as prompted by audience response; by the occasional interpolation of song and dance; by solo performances from individual artists; and by the exploitation of spectacle for its own sake in conjuring tricks. sexual allure. scenic machinery and. in the case of pantomime, music hall and vaudeville. in luxury and glitter of the auditorium. Blasphemy, obscenity and sensationalism, if not invariable characteristics. have been near enough neighbours to provoke constant reproof from councilors of church and state of actors engaged in these activities. Bourgeois opinion has generally aligned itself behind these dignitaries when faced with a choice between advancing its own status in society and forsaking the entertainments of the peasant, serf or manual labourer. While therefore it is on these entertainers that the theatre always relies in times of crisis for its very survival and the renewal of its energy (and must accordingly award them a place of honour and esteem), it is upon them too that responsibility must be laid for the theatre's reputation as a disreputable. frivolous, naughty. wicked or otherwise undesirable element in society. (G. W. G. W.)

IV. 20TH CENTURY

1. Asian Theatre. — The most flourishing theatre in Asia in the early 1960s was the Chinese. Every town of size had several theatres, and there were many hundreds of touring troupes. The traditional theatre prospered alongside the modern theatre. since the Communist government, although it suppressed much that was traditional in other forms of Chinese culture. allowed the immensely popular classical opera to survive: forbidding performance of only a few operas on political and moral grounds. The history of the modern theatre in China dates from 1907, when the first western plays were performed. "The talking drama," so called to distinguish it from the classical opera, was at first attacked by the universities opposed to the translation of plays into the vernacular. *paihua,* instead of the formal antique language of literature. In 1919 the "literary revolution" of the students won official recognition for *paihua* as the language for the translation of modern works, As western plays became more numerous. a number of theatres adopted western methods of staging and Chinese playwrights began to write plays in the realistic manner dealing with contemporary problems. Actresses. banned from the theatre in the 18th century, were allowed to return in 1912 after the establishment of the republic. but only in all-women troupes, in which the actresses played the male parts. In the 1920s they were admitted to the ordinary companies. By this time the status of the actor was very different from what it had been at the beginning of the century when he was regarded as belonging to the very lowest social class. The change was largely because of Mei Lan-fang, 20th-century China's greatest actor. and also a considerable scholar and a man of infinite grace and charm. The Chinese theatre in the early 1960s relied mainly on its own playwrights though a number of Russian plays were performed. Western plays were comparatively few as they were only allowed when they completely accorded with the views of the government.

In Japan the modern theatre movement began in 1924. when the Tsukiji Little theatre opened in Tokyo. This was the first Japanese theatre modeled on the realistic theatre of the west. Its founder, Hijikata Yoshi, had studied with the Moscow Art Theatre and had also become a convert to Communism. Four years later a kabuki actor, Ichiawa Chojuro, who had been playing in the U.S.S.R. with his troupe, left the kabuki to form the Progressive theatre, a community theatre on the Russian model. It included both kabuki and modern plays in its repertoire. In the middle 1930s the government decided that it could no longer tolerate the political propaganda of these two theatres. so the Little theatre was closed; Hijikata settled in Russia and the Progressive theatre confined itself to classical kabuki. But under the post-World War II occupation the Progressive theatre returned to its original policy, producing a number of Russian plays, and Hijikata came back to work in Japan. By the 1960s the Japanese theatre had long outgrown its Communist beginnings, but as a result of its origins a great many of its plays dealt with social problems. The variety of western plays given in the Japanese theatre was proof of its tolerance and interest in many conflicting ideas. Playwriting was increasing in the early 1960s, and with it Japan's theatrical importance in world drama.

The immense diversity of the 20th-century Indian theatre was exemplified by the annual drama festival in New Delhi, started in 1954, at which some 15 different languages and cultures were represented. The most influential theatre in India was the Prithvi because it played in Hindi, the national language of India. and thus reached a far larger audience than, for instance, the Bengal and Maharashtra theatres, which could be understood only in their own provinces. The Prithvi theatre was founded in 1943 by Prithviraj, famous throughout India as a film star. Its tours extended from Calcutta in the east to Saurashtra in the west, from Kashmir in the north to Dhanushkhuti Raneshwaram in the south. The plays in the repertoire mostly dealt with contemporary life and reflected Prithviraj's political and religious views. Most of the comparatively small amount of professional acting in India was concentrated in Calcutta. which had a number of modern theatre buildings as well as a prosperous motion-picture industry; as a consequence, actors were able to work in both mediums, In Bombay was India's most modern-minded theatre, called Theatre Cnit, founded in the middle 1940s by Alkazi, a young actor and director trained in London at the Royal Academy of Dramatic Art. The company performed in English but nevertheless was essentially an Indian theatre catering for an Indian public. An instance of the combining of the traditional folk and dance drama with modern theatre was Sundari's Gujerati theatre, which had its headquarters in Bombay. The plays dealt with political and social themes and particularly with the emancipation of women. In south India the first modern theatre was founded in the early 1930s by Rajamanickam. The choice of play was strongly influenced by the founder's deep religious convictions. Besides playing in its own theatre in Madras the company, more than a hundred strong in the 1960s. toured extensively, visiting other provinces to play to the Tamil communities. The Indian National theatre in Bombay. founded as a worker's theatre to take the drama to the farms and the factories, by the 1960s had branches in all the big Indian cities. The actors were mostly amateur! but more and more amateurs turned professional and it seemed likely that India would have a considerable number of professional companies when Hindi. compulsory in every school in India, became the common language.

Outside India. Japan and China, there was hardly any modern theatre in Asia. In countries such as Ceylon, Burma, Malaya and Indonesia, the highly developed forms of dance drama were so popular that there was little urge to found a modern theatre. Only in the Philippine Islands were there signs of a modern theatre developing from the efforts of enthusiastic amateur groups such as the Philippine National theatre and the Manila Theatre guild.

2. Great Britain: Direction *and* Development.—During the 19th century the English theatre was ruled by the actor-managers who directed their own productions with their permanent companies, invariably playing the leading parts themselves. At the beginning of the 20th century their authority began to be challenged by the new independent directors who rarely acted in their own productions. The first of these to establish himself firmly in the theatre was Dion Boucicault, who from 1901 to 1915, under the management of Charles Frohman, directed all the plays presented at the Duke of Tork's theatre. An autocratic director, he acted all the parts himself to the cast, who had to copy him down to the minutest detail. A director with an entirely different method was Harley Granville-Barker (*q.v.*), who from 1904 to 1907. in partnership with John E. Vedrenne, directed a series of plays for short runs at the Royal Court theatre. The venture was founded as a protest against the stagey artificial style of acting in the English theatre at that time. At first he was accused of teaching his actors "not to act" because he trained them to avoid over-exaggeration, to behave as normal human beings. He taught his actors to create a part by identifying themselves so completely with the character that gesture, movement and facial expression were the natural expression of the character's thoughts and feelings. At a time when actors had no hesitation in sacrificing character for the sake of a flamboyant theatrical effect. Granville-Barker laboured with endless patience to make the characters in a play "seem to live and move by the laws of their own being." He soon gathered round him a group of new writers hitherto uninterested in writing for the theatre because of its artificiality. Bernard Shaw alone among the authors whose plays Granville-Barker directed disliked his methods. Shaw disliked naturalism; he wanted the actors in his plays "to pull out all their stops and declaim"—which was precisely what Granville-Barker was teaching his actors to avoid. He was at his best as a director with the plays of Gerhart Hauptmann, Ibsen and John Galsworthy.

Granville-Barker did not limit himself to the direction of naturalistic plays; his three Shakespearean productions given at the Savoy (1912–14) revolutionized the Shakespearean theatre in England. As a young man he had acted in William Poel's productions for the Elizabethan Stage society. From Poel he had learned how much the full effect of a Shakespeare play depends on unbroken continuity from scene to scene, though contemporary actor-managers with their elaborately spectacular productions kept halting the play to give time for elaborate changes of scenery. Instead of realistic scenery Granville-Barker used stylized, decorative backgrounds. He speeded up the plays not only by avoiding waits for scene changes but also by teaching his actors to speak the verse swiftly though without gabbling. To audiences and critics accustomed to the slow and ponderous declamation of the Shakespearean actors at that time it seemed a breakneck speed.

In 1920 Granville-Barker retired from the theatre but the subtle and exact kind of realistic production, purged of all theatrical clichés, was continued and developed by both Gerald Du Maurier and Basil Dean. Before World War I Dean had worked under Annie Horniman at the Gaiety theatre. Manchester. where she had been insisting on the same sort of naturalism that was practised first at the Royal Court theatre; like Granville-Barker she too had gathered around her a new school of playwrights including St. John Ervine, Stanley Houghton and Harold Brighouse. At the St. Martin's theatre Dean trained a young company to give an exact interpretation of the external characteristics of their parts instead of encouraging them to use their imaginations as Granville-Barker did, but the result was acting that had extraordinary clarity, sharpness and precision. In his method of directing Dean continued the dictatorial methods of Boucicault. Du Maurier, on the other hand, directed with a deceptive casualness, which, like his own acting, concealed a very highly developed naturalistic technique. Both as an actor and as a director he had a bad influence on English acting because his imitators, lacking his technical skill, achieved only underplaying and inaudibility in their attempts to emulate the extraordinary quiet ease of Du Maurier's naturalness.

A foreign director who refreshed English acting and direction was Theodore Komisarjevsky. uho in 1919 went to England from Russia, where he had been director of the Imperial and State Theatres. Under his direction of a series of plays by Chekhov and other Russian authors the acting achieved a sensitiveness and an inner realism that set a new standard in the English theatre. His Shakespearean productions at Stratford-upon-Avon startled and often infuriated audiences accustomed to seeing there the conventional presentation of the plays. His productions were full of invention. sometimes brilliant. amusing and illuminating, sometimes merely wayward. He must be blamed for starting the "let's-be-different-at-all-costs" style of Shakespearean production that is still all too prevalent in the English theatre.

In the same tradition. Sir Tyrone Guthrie, a great director with a superb theatrical imagination, beginning in the 1930s. enforced the point of a line with a revealing stroke of "business" or brought small parts vividly to life by imaginative touches of detail, heightening the effect of everything that happened on the stage by his gift of pictorial composition and swirling movement. But sometimes his inventiveness was used merely to surprise and shock the audience or to satisfy his own sense of humour. Another fine Shakespearean producer in the English theatre at mid-20th century was Peter Brook with his superb productions of *Measure* for *Measure, Timon* of Athens and *The* Winter's Tale. His work also included brilliant interpretations of a number of French authors.

In the late 1950s the director who most powerfully influenced the English theatre was Joan Littlewood. For many years she had worked with her own company at Stratford East, on the outskirts of London, without causing any particular stir. When her productions were transferred to the West End, however. audiences responded immediately to her tremendously vigorous productions of "low-life" plays directed in the style that owed a great deal to Bertolt Brecht (*q v.*) and the traditions of the English music hall. The actors often addressed the audience direct, freeing themselves from the confines of the play. The productions were fast, noisy. broadly humorous and brimful of vitality and often. at the same time. managed to convey a considerable subtlety of characterization.

In the late 1950s and early 1960s the most experimental theatre was the Royal Court under George Devine. It gave opportunities to an extraordinary number of new writers, new directors and new designers. Rut lacking a permanent company, at the beginning of the 1960s, the young directors were not able to evolve a style of production sufficiently individual to influence the theatre as a whole In London there was no permanent company apart from the opera and ballet companies; even the Old Vic engaged its actors on comparatively short contracts. It was to remedy the lack of a permanent company with a recognizable style that Peter Hall, the director of the Royal Shakespeare theatre at Stratford-upon-Avon, in 1960 engaged a company on long-term contracts to play both at Stratford-upon-Avon and in London at the Aldwych theatre, presenting modern plays as well as plays by Shakespeare and other classics. In the provinces there were many repertory companies where the players remained comparatively unchanged for two or three years, but as most of them did a new play every week they had no time to experiment From the very few repertory companies that ran their plays longer and had longer to rehearse. an occasional production came to London; but probably the most experimental and influential was the Birmingham Repertory. which. under the direction of Sir Barry Jackson, between World Wars I and II brought many of its productions to London, including the first modern-dress *Hamlet* and the first production of Shaw's Back to *Methuselah* in its entirety.

Provincial and Repertory Theatre.—In the English provinces, the theatre divides into touring theatres and repertory theatres The touring theatres are visited by London companies either before or after they have played in London. and also by companies specially engaged to tour a London success in the provinces A play on tour seldom remains at any of these theatres for more than a week, but in the larger cities a big musical production sometimes stays up to six weeks. At Christmas nearly all these theatres stage an elaborate Christmas pantomime, a form of entertainment peculiar to England and so popular that the run often extends far past Christmas, sometimes lasting for three or four months In the early 1920s there were more than 250 touring theatres in England and Scotland. Many towns had several such theatres, besides at least one music hall. By 1960 the number of touring theatres housing straight plays had dwindled to less than 30. Many had been unable to survive the competition of motion pictures; others were destroyed during World War II; and after the war television proved the deadliest rival of all.

The provincial repertory theatres have withstood the competition of other forms of entertainment more successfully than the touring theatres. These so-called repertory theatres have no real right to the title, because they are not repertory theatres in the true sense of the word. Although they maintain permanent companies they do not keep a repertoire of plays ready for production as is the practice in the continental repertoire theatres, which give performances of several plays from their repertoire in the course of a week. The English repertory theatres put on a play for a short continuous run and then the production is scrapped. Most of these theatres run each production for only a week, some for a fortnight, while a few in the big cities perform their plays for three weeks or a month. Producing a play a week for the greater part of the year obviously means that these weekly repertory companies are always working against time; nevertheless the standard is often surprisingly good, especially when the company is so organized that the leading players can appear in minor roles for a week or two when they have a major part ahead of them.

Most of the players in the London theatre gained their early experience in the provincial repertory theatres, starting in "weekly rep" and graduating to the repertories that are able to give two or three weeks to rehearsals because their productions run for more than a week. The London theatre owes much to the repertory theatres not only because they supply it with actors who have been accustomed to playing a wide variety of roles but also because many London successes were first produced by the repertory theatres.

The first repertory theatre in Great Britain was founded by Annie Horniman (*q.v.*) at the Gaiety theatre, Manchester, in 1907. It introduced to England the work of a number of important continental dramatists and also gave opportunities to a number of promising local playwrights who became known as "the Manchester school." In 1921 it closed through lack of support and became a cinema. The oldest existing repertory theatre is the Playhouse at Liverpool, which opened in 1911. The one with the most distinguished record is the Birmingham Repertory, founded by Sir Barry Jackson in 1913. Among many other leading repertory theatres are those at Nottingham. Bristol, Sheffield, Glasgow, Windsor, Worthing, Salisbury, Oxford, Leatherhead, Coventry, Colchester and Richmond.

There are approximately 50 repertory theatres in Britain that play all the year round (except for a summer vacation of a few weeks), but there are nearly 30 more at the holiday resorts that open only during the summer months.

The *National* Theatre.—In 1949 the British parliament passed the National Theatre act empowering the treasury to make a grant of £1,000,000 to build a National theatre. Two years later the queen mother laid the foundation stone on a site on the south bank of the Thames overlooking the river, donated by the London County council. Successive governments continued to put off the building of the theatre on the grounds that there were many other buildings more urgently required. It was not until 1962 that the treasury at last agreed to release the £1,000,000.

3. U.S.S.R.—The history of modern theatre in Russia began with the founding of the Moscow Art Theatre (*q.v.*) in 1898 by Konstantin Stanislavski and Vladimir Nemirovich-Danchenko. For the previous 12 years Stanislavski had worked with a company of amateurs and it was the best of these, turned professional, who formed the nucleus of the Moscow Art Theatre company. When Stanislavski began his work the Russian theatre mas one of the most backward in Europe; acting consisted mainly in selecting from a stock of theatrical clichés whatever seemed most appropriate to the moment; little time was spent in rehearsal. The plays. mostly French comedies and farces, or Russian imitations of them, were so stereotyped that the same performances and the same sets could. with a few slight variations, be used time after time. The first three productions at the Moscow Art Theatre, which opened in 1898. caused no particular stir. It was the production of Chekhov's *The Seagull* that established the theatre and Stanislavski's reputation. The quietness, intimacy and complete naturalness of the playing was something entirely ne .

While Stanislavski continued in production after production to develop his infinitely detailed method of direction. the antirealist movement initiated by the Symbolists and Surrealists spread to Russia. where the Art Theatre was an obvious target. These criticisms came at a time when Stanislavski himself was beginning to feel that having perfected his realistic method of production he must seek new paths. In 1905 he founded a small studio theatre for experiment and research, appointing Vsevolod Meyerhold (*q.v.*) as its director. Meyerhold had been a member of the Moscow Art Theatre company but had left it three years previously when he became a convert to the Symbolist movement. When, after many months of preparation. Meyerhold staged two productions. Stanislavski disliked them so intensely that he closed the studio. He felt that the actors had been used merely as puppets to illustrate Meyerhold's theories. Yet these two productions had an important effect on him as a demonstration of the abject and slavish obedience to which the dictatorial producer could reduce his actors. He determined that henceforth the actor should be his collaborator instead of his subordinate and he began to develop the method of "inner realism" that came to be knomn as the Stanislavski method and was still the basis of the training of all the actors in the Russian theatre in the early 1960s.

After the 1917 Revolution Stanislavski refused to allow his theatre to become a platform for spreading propaganda. He believed that the mission of the Art Theatre was to maintain a standard of acting that actors in the other theatres might attempt to emulate when the first excesses of the Revolution had abated. The official edict decreed that everything—characterization. ideas. emotions—should be reduced to the simplest possible terms for the sake of the new audiences, many of them completely illiterate. This amounted to a command to the actors to overact, to abandon all subtleties of characterization and feeling. to return to the old, crude. melodramatic style of acting. 4s some of Stanislavski's own company were being influenced by the enthusiasm with which the new audience in the Soviet theatre acclaimed overacting, he decided to take his company out of Russia: so in 1922 he left on a tour of Europe and America that lasted for two years. On his return he decided that the Moscow Art Theatre must to some extent adapt itself to suit the mentality of the new audiences. He began to produce in bold, sweeping strokes, stressing whatever was dramatic in the play and enlivening the comic scenes with tricks borrowed from vaudeville. There were no half tones, no subtleties. but none of the crudities and exaggerations of the Soviet theatre of that time.

Meanwhile. hfeyerhold had become one of the most powerful influences in the Russian theatre. He declared that the principles of the propagandist theatre conform with those of Marxism because they attempt to underline "the elements which make prominent what is common to all men, the unindividual." The detailed and subtle portrayal of emotions was described as "worthless soul junk" and the actor was ordered to "forget his little rickety ego" and become "an instrument for social manifestos." There were many other producers who. educated to despise an individualistic society, exercised every kind of ingenuity to deprive the actors of their individuality. Aleksander Tairov made his actors wear fantastically exaggerated make-ups to ensure that they would not resemble anyone in real life and thus become individuals in the eyes of the audience. It was Tairov who invented the "constructivist" setting, a gaunt scaffolding supporting a few bare platforms on different levels, with every strut and bolt ostentatiously exposed to view. The aggressive functionalism of this kind of setting was regarded as having considerable propaganda value at a time when the Russians mere being taught to revere the machine as part of their training to become one of the great industrial nations of the world.

A more moderate director in the postrevolutionary theatre was Evgheny Vakhtangov, a pupil of Stanislavski. In 1914 he had been put in charge of one of the studios attached to the theatre and in 1920 he was appointed director of this subsidiary of the Art Theatre. renamed the Third Studio. But Yakhtangov was not altogether in accord with the quiet, everyday naturalness of the Art Theatre. His natural exuberance impelled him toward a style of production that. while avoiding the extreme stylization and unrealism of Meyerhold and Tairov. would. nevertheless. enlarge, heighten and sharpen character. emotion and gesture. He wanted to work in vivid colours instead of the half tones of the Art Theatre. In place of Stanislavski's inner realism he wanted what he called "outer-technique." He found the ideal actors for his purpose when Stanislavski put him in charge of a group of Jewish players who in 1917 had formed themselves into a company for the production of plays in Hebrew. Calling themselves the Habima Players they later became affiliated with the Art Theatre. Vakhtangov's masterpiece was his production of *The Dybbuk* in 1922. It was his last production; he died a few months later at the age of 39. but for many years afterward the Habima Players included his production of The *Dybbuk* in their tours of Europe and America so that it became, outside Russia, the best knomn of Soviet productions. In 1931 the Habima permanently settled in Palestine and in 1945 opened their own theatre in Tel Aviv (see HABIMA THEATRE).

The youngest of the postrevolutionary directors was Nikolai Okhlopkov, born in 1900. His earliest productions were entertainments given in World War I on an improvised platform set up in the middle of the square of his home town to entertain the troops, who encircled the stage on all sides. As a result of his experience of the open stage he found the proscenium theatre cramping and in Moscow experimented with ways of breaking down the barrier between actor and audience. In 1932 he became director of the Realistic theatre. where for his production of *The* Iron Flood he converted the whole auditorium into a rocky. mountainous terrain. seating the audience among the rocks so that the actors, playing scenes in every part of the auditorium, were mingled with the audience. He made many other experiments in other kinds of staging but in 1938 the Realistic theatre was closed on the grounds that his work appealed too exclusively to specialists and intellectuals. By this time, under Stalinism, the experimentalism that in the 1920s had made the Russian theatre the most exciting in the world had come to an end. Four years previously Meyerhold, officially censured for his "obsession with the vague abstractions of decadent art" and for being "the father of formalism," had been deprived of his position. Tairov. rebuked for being out of touch with his audiences. had been relieved of the direction of the Kamerny theatre. In the cases of Meyerhold and Tairov it is certainly true that their work was too cold and abstract to please audiences who wanted warmth and humanity and reality. But under Stalinism the theatre virtually ceased to progress since any sign of originality, any deviation from the normal, was at once condemned as decadent. The scenery became more and more laboriously realistic as any setting that was in any way impressionistic was apt to be condemned as belonging to abstract art. Only the magnificent standard of acting in the Russian theatres remained unchanged.

After Stalin's death the theatre was relieved of many of its shackles and there was a cautious return to experiment, particularly at the Satire theatre. Okhlopkov, the only survivor of the group of experimentalist producers who dominated the theatre in the 1920s. remained the most original and stimulating director, though there were times under the Stalinist regime when his originality displeased the authorities and he was criticized for having too unruly an imagination.

In the early 1960s the Russian theatre was perhaps seen at its best in its productions of the classic Russian authors, directed with meticulous care and exactitude and reproducing. with extraordinary verisimilitude and no longer with any satiric intention. the manners and customs and ways of life of the tsarist days. The unique feature of the Russian theatre was its gigantic scale—the vast number of theatres. the fact that there were companies playing in more than 50 different languages. the size of the companies (100 actors was not unusual). the size of the repertoire of every theatre. the huge and superbly equipped stages showing a succession of elaborate scenes. the size of the theatregoing audience and the vast sums of money spent on the theatres by the government so that they need make no attempt to pay their way and could keep their prices reasonably low. The professional theatre could not wholly satisfy the demand for dramatic entertainment and every encouragement was given to the amateur to supplement the work of the professional. Most theatres accepted responsibility for at least one amateur group, the members of the company giving much of their spare time to training and advising the group. Amateur companies of outstanding merit were given the title of "people's theatre." Most of these companies were based on the palaces of culture and toured the neighbouring towns as well as playing in the factories and the collective farms. The close relations between the professional and the amateur were mutually beneficial because the professionals found that contact with the everyday people who were the personnel of the amateur groups infused freshness and reality into their own performances.

4. Germany.— The character of the German theatre was entirely changed during the early years of the 20th century by the work of Max Reinhardt (*q.v.*). When in 1903 he gave up acting to concentrate upon direction, the German theatre was an educational institution rather than a place of entertainment; producers of the classics had to be scrupulously faithful to long-cherished traditions and conventions. The slightest deviation aroused the wrath of the critics. most of them university professors. Reinhardt, who lived his early life not in Germany but in Vienna, had a love of colour and gaiety, richness and display, and it was these qualities that he brought to his productions. He was fiercely attacked not only by the traditionalists but also by the new school of German realists. What they particularly disliked about his work was its unashamed theatricality, a quality that they scrupulously avoided in their own low-toned productions. One of Reinhardt's greatest services to the German theatre was that he restored to it its theatricality — but a theatricality purged of staginess. In doing so he revolutionized German acting. In his productions of modern plays he taught his actors a style that was realistic in feeling but avoided the drab, painstaking exactness of the realist school; it was warm, vivid and colourful. always a little larger than life. In his productions of the classics he demanded lively, supple speaking in place of the slow, ponderous delivery of the traditionalists. He made his actors think afresh about the characters instead of dutifully assuming ready-made characterizations. When in 1906 Reinhardt opened his Kleines Theater in Berlin. he initiated a movement that grew steadily throughout the 20th century. Its aim was to break down the separation of stage and auditorium and to restore the old intimacy between actor and audience Reinhardt. in his endeavours to rescue the players from their isolation behind the proscenium arch. often took them out of the theatre to play in places that in those days seemed odd and eccentric settings for a theatrical entertainment — a square in Venice. a palace ballroom in Vienna, the Boboli gardens in Florence and the Domplatz and inside the cathedral itself in Salzburg. He produced *Oedipus Rex* in a circus arena with one end used for gigantic architectural settings unframed by any kind of proscenium. For his production of *The* Miracle in London in 1911 he transformed the huge Olympia exhibition building into a cathedral so that the audience became part of the congregation. But although Reinhardt was a master of spectacle, his versatility was such that with equal skill he directed subtle and intimate plays in small theatres. From the early years of the century up to the outbreak of World War I his personality completely dominated the German stage; nearly all the young directors and actors had either worked in one of his companies or had been trained in one of his schools.

Immediately after World War I two of his disciples, Leopold Jessner and Erwin Piscator, became the dominant figures of the German theatre. Their Expressionist style of direction was partly evolved because of the desperate shortage in postwar Germany of material for building scenery. In their antirealistic productions. actors on the bare, darkened stage were picked out by shafts of light against a black background; if there was any scenery at ail, it mas limited to one or two small pieces, symbolic rather than realistic. Stylization in staging inevitably led to a stylized method of acting. which in turn demanded stylized writing, and it was thus that the short-lived German school of Expressionist drama was created. Characters in the plays became symbols instead of people. Their lines were stripped of all but the key words and phrases, so that the dialogue resembled the staccato wording of a telegram. Later, in the 1920s, when steel. timber and other material became more plentiful in Germany. Piscator directed a series of Expressionist productions in which he used elaborate and expensive machinery. The front of his stage was constructed on the principle of the conveyor belt; in the centre of the stage a cantilever bridge moved up and down; lantern slides and motion-picture films were projected onto the back wall; above the proscenium Communist slogans blazed in lights; the gigantic shadows of pulsating machines were thrown onto gauzes. Jessner, too. made exuberant use of the lifting of the restrictions on the use of building materials in theatres. His favourite form of setting was a vast flight of steps extending the entire width of the stage, rising steeply to a high platform at its back. He was greatly influenced by the work of the Russian directors of the immediate postrevolutionary period and copied them in oversimplifying characters and their motives, abandoning subtlety for elementary forms of symbolism. The Expressionist movement failed because when an actor is reduced to the level of a puppet he can only express a few emotions, and those only in the simplest form.

The postrevolutionary phase was followed by a period in which the German theatre reverted to conventional realism. When the Nazi party assumed power, their passion for vast meetings and immense processions was reflected in the theatre — or rather, in vast propaganda dramas presented in the open air in sports stadiums. parade grounds and huge natural sites. World War II destroyed most of the theatres in Germany but the desire for theatre and opera among the people was so intense that rebuilding started immediately after the war. A great opportunity presented itself for building theatres of new and revolutionary design but many were still based on the picture-frame stage, often elaborately mechanized for the handling of huge. realistic settings.

The most important influence in the post-World War II German theatre was Bertolt Brecht. When, in the early 1930s, Reinhardt and many other leading players and directors were driven into exile. the acting on the German stage lapsed into exhibitionism and splurgy emotionalism. Brecht was a disciple of Meyerhold and made constant use of the anti-illusionist devices that Meyerhold invented to enforce his dictum that "the actual world exists and is our subject; but this play and this stage are not it." For instance, as a means of destroying the illusion of actuality Brecht flooded his stage with white light throughout the performance, irrespective of whether the action took place at daybreak or sunset, at midnight or noon. In between the scenes, captions, slogans and comments were projected onto a gauze curtain. Points were emphasized by songs that had nothing to do with the action of the play but were what Brecht called "musical addresses to the audience" in which the actor stepped out of the story and commented on the play. Brecht's theory of acting was a reversal of Stanislavski's doctrine that the actor: must identify himself completely with the part he was playing. Brecht demanded an objective style of acting. It was to free the audience "from the spell cast upon them by the witchcraft of realistic producers who make a dream world of reality" that Brecht evolved what he called "the alienation effect." After Brecht's death in 1956, his company, the Berliner ensemble, continued to train actors according to his principles and toured in many countries with a repertoire of his plays.

In spite of the number of German theatres and the huge sums lavished upon them in the form of government and municipal grants, there were few signs in the early 1960s of any strongly progressive movement and no directors were dominant enough to impose any distinctive style. Much of the best creative work was done in the opera houses. The extreme shortage of contemporary playwrights was the main reason for the lack of any essentially Germanic style of acting and direction. As the majority of plays were imported from other countries the actors and directors were forced to compromise in their methods. leaving themselves too little time and opportunity to develop an indigenous style.

5. France. — The reaction against realism. which during the early years of the 20th century was a powerful influence in the

German and Russian theatres, was slower to reach France. It was the founding of the Théâtre du Vieux Colombier by Jacques Copeau (*q.v.*) in 1913 that initiated the reaction in that country. Copeau came from outside the theatre. He was a literary critic and editor of *La Nouvelle revue française.* Profoundly dissatisfied with contemporary plays, which were shallow because obsessed with photographic detail and classics "so tightly swathed in the trappings of tradition that they were unable to breathe," he became a producer and set up his own company. Like Reinhardt, Copeau sought to break down the barrier between actor and audience; at the Vieux Colombier the stage was left unframed. There were no wings and no definite line of demarcation between stage and auditorium (the actors simply made their entrances through doors from the adjoining rooms). Decor was used rarely and sparingly, seldom consisting of more than one or two painted screens, or a balustrade or a draped curtain. Only the barest minimum of furniture and properties was used. and nothing was put on the stage merely as an aid to realistic illusion. The atmosphere for each play was created almost entirely by lighting.

Before opening the Vieux Colombier Copeau took his little company of 11 actors away from Paris to his home at Le Limon. There they improvised scenes and practised exercises designed to make their bodies and voices flexible instruments. In their improvisations they learned much from Charles Dullin, who had been a reciter in the cafés of Montmartre and was an exponent of the traditional *comédie improvisée,* which was still popular in the cabarets of Paris and the fairs of provincial France. The acting at the Vieux Colombier was, in a modern play, at first sight completely realistic. although the detailed business of the ordinary realistic production was reduced to a minimum. But closer watching showed that gesture was being used sparingly and selectively, so that each gesture was given unusual significance. Copeau's productions of Molikre and Shakespeare were notable for their lightness, grace and gaiety. In 1923, he took a group of young actors to Burgundy. where, besides studying acting, they worked in the fields and in a carpenter's shop. They took part in the local wine festival, performing what they described as "diversions." The peasants called the group "Les Copiaux," and it was under this name that they first appeared before a town audience at Basel, Switz., in 1926. The most characteristic of their productions was *La Danse de la ville et des champs,* described as a *spectacle Bourgzcignon, joué, dansé, chanté, mimé par Les Copiaux.* It was written and produced by Michel Saint-Denis. In 1930 he took over the direction of the company. which was renamed the Compagnie des Quinze. It was disbanded in 1936 but during these few years it became internationally famous for its fine speaking and expressive miming, the imaginative simplicity of the settings and the pictorial beauty of the groupings. The company had its own author, André Obey, who wrote his plays to suit the methods and talents of the group.

Copeau's influence on the French theatre was greatly strengthened and extended through the productions of Louis Jouvet (*q.v.*) and Charles Dullin, who left his company in 1922 to start theatres of their own. Jouvet's productions of Molikre were his most important contribution to the French theatre. He freed the plays from the weight of tradition built up from literary criticism that was stifling them on the stage. His famous production of *L'École des Femmes* was hailed by the French critics as *le retour à l'art classique—le retour au véritable esprit de Molière et son sidcle.* While Jouvet was always scrupulously careful to subjugate himself to his author, Dullin's productions were strongly coloured by his own personality and tastes. He hated what he called *l'horrible naturel.* He loved brightness—bright colours. bright music, bright movements. Copeau's influence on him was apparent in his elaborate use of expressive gesture and mime. His productions of Aristophanes' *The Birds* was a good example of the mingling of the elements of carnival and social satire that he sought to find in nearly every play he produced. In complete contrast to the colourfulness of Dullin's productions was the asceticism of Georges Pitoeff, who believed that the primary aim of the director should be to focus attention on the central idea of the play and eliminate all external details of decor and acting that might tend to obscure it from view. His greatest contribution to the French theatre was the number of foreign dramatists whom he introduced to the Parisian public. These three directors, together with Gaston Baty, were known as "Les Quatre."

Baty served his apprenticeship in Germany under Reinhardt, from whom he learned how to handle crowds brilliantly and to use elaborate stage mechanism and lighting equipment with skill and showmanship. His pictorial sense was superb and his groupings and movement were beautifully composed, but they existed for themselves rather than for their contribution to the play. He was often accused by critics of overelaborating the classics in order to display his inventiveness, but on the other hand he directed the delicate plays of Jean Jacques Bernard with infinite subtlety. Dullin's use of mime was continued and elaborated in the productions of one of his pupils. Jean Louis Barrault. who left the Comédie Française in 1946 to form his own company at the Marigny theatre. Much of his work was symbolistic, both in decor and acting, a combination of pantomime, rhythmic movement and shadowgraphs. He has been accused, rather unfairly: of being "an enemy of speech," of regarding words simply as an accessory to visual means of expression. Another pupil of Dullin was Jean Vilar, who in 1951 became the head of the Théâtre Nationale Populaire (T.N.P.). His style of production was governed by the size of the Palais de Chaillot, the headquarters of the T.N.P., a theatre seating nearly 3,000 with a stage 70 ft. deep and a proscenium opening 80 ft. wide. Vilar made no attempt to fill the stage with scenery. He did no more than suggest the background of the play by the simplest possible means. Instead he filled his huge stage with big, swirling movement and because the size of the auditorium made subtlety impossible he trained his actors to use bold, simplified gestures and to delineate their characters in powerful outline rather than in detail. It is a style that is well suited to the great open-air theatre at Avignon, where the company appeared every summer. Until the 1950s theatrical activity in France was almost entirely concentrated in Paris, but with the help of the French government theatrical centres mere established at Strasbourg, Aix-en-Provence, St. Étienne, Toulouse and Reims, from where the companies go out to play in the surrounding districts.

6. British Commonwealth.— The arrival of the talking pictures practically annihilated the theatre in the countries of the British commonwealth but after World War II there were signs of a rebirth. Interest in the theatre was stimulated by visits to Canada and Australia by companies from England, including the company from the Shakespeare Memorial theatre (in 1961 renamed the Royal Shakespeare theatre) at Stratford-upon-Avon and the Old Vic headed by Sir Laurence Olivier and Vivien Leigh. In Australia in 1954, it was decided to commemorate the queen's visit by establishing an Elizabethan Theatre trust to encourage Australian drama and opera. Two-thirds of the sum raised was contributed by the public. the remaining third by the government; The Majestic theatre in Sydney. renamed the Elizabethan theatre, became the headquarters of the trust and Hugh Hunt, previously director of the Old Vic in London, became its first director. The company from Sydney had a considerable success in London in 1957. when it appeared in Ray Lawler's *The Summer of the Seventeenth Doll.*

In Canada the Festival theatre at Stratford, Ont., was opened in 1953 to give summer seasons of Shakespeare. At first it mas housed in a huge tent; in 1957 a permanent theatre was built. Sir Tyrone Guthrie frequently produced at thc theatre and a number of British stage stars: including Sir Alec Guinness, appeared with the company but the theatre became increasingly able to rely upon Canadian actors. A National Theatre school was founded in Montreal. Que., teaching in French as well as in English so that it could train players for the French-speaking companies. In Toronto, Ont.. the Davies theatre, directed by the two Davies brothers. gave a wide variety of plays; but it was symptomatic of the shortage of good Canadian playwrights that when the company appeared in London it was in a play by an English author. In Oct. 1960 the O'Keefe centre, a large well-equipped modern theatre, was opened in Toronto.

New Zealand is a difficult country for the professional because even in the largest cities the population is too small to support a permanent professional company and the distances between towns make touring expensive. In 1960 the only professional company, the New Zealand Players, who once toured the country, were forced to abandon their work through lack of sufficient financial support. However, in 1961 Richard Campion, who had formed the Players, helped to organize the New Zealand Theatre company; this new group planned to tour one production a year and was given a grant by the government arts advisory council.

Kenya has a National theatre in Nairobi, opened in 1956. At the beginning of the 1960s there was no professional company attached to the theatre, which was largely devoted to amateur companies, European, African and Asian, including some that drew their members from all three groups. Nairobi had also had for many years the only professional company in east Africa, the Donovan Maule Players, recruited mainly from the English theatre. In 1959 they moved into a finely designed new theatre. In Kampala, the capital of Uganda, a National theatre was opened in 1960 and was run much the same way as the Kenya National theatre. In both Uganda and Nairobi the annual drama festivals showed a continual rise in the quality and quantity of the plays by African authors dealing with life among their own people.

7. South Africa. — The theatre in South Africa relied mainly upon touring companies from other countries, but during the 1950s it became largely self-supporting. The National Theatre organization, founded in 1948 with a government subsidy, had permanent centres in Johannesburg and Pretoria and gave regular performances all over the country by the 1960s. Johannesburg continued to be the main theatrical centre with a number of permanent companies, such as the Brian Brooke Company and the Johannesburg Repertory Players. Cape Town had the Cockpit Players run by Leonard Shachs and the Hofmeyr Theatre with its own company, and throughout the country there were flourishing amateur organizations.

In the early 1960s Negro theatre in South Africa was as yet unorganized, depending for its strength on the vitality of township jazz concerts. Late in the 1950s the African Drama trust was founded to try to give it coherence. In 1961 an all-Negro cast scored a notable London success with *King Kong*. (N. M.)

8. United States. — The first theatre — actors, scenery and repertory — was imported to the American colonies from England about 1750. Early performances were given in existing halls or in hastily built quarters resembling the small English provincial theatres of the day. These provided a small stage with little wing or fly space, framed by a proscenium arch, in front of which extended a shallow apron with a proscenium door on either side. The first scenery consisted of the minimum of traditionally painted drops, wings and borders necessary to suggest the many settings required by a large repertory. When the first permanent theatres were erected, shutters running in grooves replaced drops to close in most settings at the rear. Illumination was provided by candles in chandeliers hanging from the ceiling of the auditorium, in a row of reflector holders placed as footlights and in holders fastened to the backs of the wings.

The first American plays were modeled on English drama. A native type, the shrewd, rural Yankee, first appeared in Royall Tyler's *The Contrast* (1787), which introduced also a favourite theme of early American drama: the triumph of native honesty and worth over foreign sham and affectation. In 1798. William Dunlap, America's first professional playwright, dramatized recent American history in his blank verse tragedy *André,* in which George Washington is a principal character. The heroic Indian was added in John Augustus Stone's *Metamora* (1829), the tough city lad in Benjamin Baker's *A Glance at New York* (1848) and the stout-hearted frontiersman in Frank Murdoch's *Davy Crockett* (1872). Native-born actors early performed in minor roles. and the native star, able to hold his own with the best on the London stage, appeared with Edwin Forrest in the 1820s and Charlotte Cushman in the 1830s. Forrest's "American" style was characterized by muscular strength and vocal power. Theatre, first confined to the eastern seaboard, in 1815 expanded into the Ohio and then to the Mississippi valleys. In 1850 it made the leap to San Francisco and the Pacific coast.

To begin with, settings, including all except a few pieces of furniture actually used by the actors, were painted on wings and shutters. The use of real instead of painted rugs and draperies and a full complement of furniture appeared in the production of Dion Boucicault's *London Assurance* (1841). Detailed historical accuracy in setting and costume first attracted attention in Charles Kean's production of *King John* (1846). In Edwin Booth's theatre in 1869, wings and shutters in grooves were abandoned, scenery was supported by stage braces and the box setting began to be used. In the next 30 years, the detailed realistic setting was perfected by such producer-directors as Augustin Daly, Steele MacKaye and David Belasco. Realistic production was stimulated by the introduction of gas lighting about 1825 and of electricity about 1885.

Realism in acting appeared in some of the characterizations of Yankee specialists like George H. Hill in the 1830s and '40s; in Francis F. Chanfrau's tough city lad in the '40s: in Matilda Heron's unconventional *Camille* in the '50s; in Edwin Booth's quieter acting of Shakespeare and Joseph Jefferson's "natural" Rip Van Winkle in the '60s; and was fully developed by William Gillette and Mr. and Mrs. James A. Herne in the '80s. James A. Herne's *Margaret Fleming* (1890) was the first realistic problem play in the manner of Ibsen. Herne could not secure production of this "new" drama in a regular theatre because of a radical change in theatre organization.

At the beginning of the 19th century, each major city had a resident repertory company. As population grew and spread westward, so did the number of resident companies, and a leading actor found it profitable to set himself up as a star. playing brief guest engagements with one resident company after another. The proliferation of such stars and the rise of the long run, which was necessitated by increasingly expensive staging, eventually destroyed the resident company. It was replaced in the 1860s and '70s, except in a few of the largest cities, by the traveling "combination." Originating usually in New York city, which since 1825 had been the leading theatre centre, hundreds of these combination companies, presenting either a small repertory or a single play, were providing entertainment the length and breadth of the land. Booking agencies were formed as liaison between companies and theatres. Several theatre owners; producers and agents, of whom Charles Frohrnan was the best known, formed the Theatrical Syndicate in 1896, which by controlling booking in key cities gained a virtual monopoly of theatre throughout the country. The Syndicate was not interested in the play with limited audience appeal. The theatre on all levels, from serious drama to burlesque, was the country's chief medium of entertainment. It was a big and prosperous business, and it was beginning to be attacked for "commercialism." The change from repertory to the single play and the rise of realistic production also shifted artistic control from the actor to the manager. who became the producer-director, or *régisseur*. In the last decades of the 19th century, Daly. MacKaye and Belasco not only selected and cast their plays, and directed the rehearsals, but also personally supervised all other aspects of production.

In the first decade of the 20th century, realism dominated: in the plays of Clyde Fitch, William Vaughn Moody and Edward Sheldon; in the acting of Mrs. Fiske, Richard Mansfield and Ethel Barrymore; and in the productions of Belasco and Harrison Grey Fiske. The pretty operettas of Victor Herbert and the brash musical comedies of George M. Cohan were popular. The first *Ziegfeld Follies* appeared in 1907. The New Theatre in New York city, with a resident company dedicated to art rather than business, was established in 1909 but collapsed after two seasons. Visits of the Abbey Theatre in 1911, Reinhardt's *Sumurun* in 1912. Granville-Barker's company in 1915 and Copeau's group from the Vieux Colombier in Paris in 1917 provided exciting glimpses of the work of Europe's art theatres and of the "new stagecraft.," thus adding to the growing dissatisfaction with the U.S. theatre.

The modern period on Broadway may be said to have begun in 1919 with the establishment of the Theatre Guild, the first commercially successful U.S. art theatre, for in the next decade occurred a flowering that placed U.S. theatre for the first time on a par nith the best theatre of Europe. Eugene O'Neill emerged from the Provincetown Players (*q.v.*) in 1920 with *Beyond* the *Horizon* to win world-wide fame. He was quickly followed by Sidney Howard, Robert Sherwood. Maxwell Anderson, George Kelly, Elmer Rice, S. N. Behrman, Philip Barry and others; their plays provided an expression of American life that was unprecedented in its richness and variety. Besides the Theatre Guild, such producers as Arthur Hopkins, Gilbert Miller. Winthrop Ames, George C Tyler and Kenneth Macgowan staged the new American drama, interesting new plays from abroad and some classics in the new style. Designers Robert Edmond Jones, Joseph Urban, Lee Simonson. Cleon Throckmorton. Norman Bel Geddes and Jo hlielziner provided distinguished settings that were realistic, symbolistic or expressionistic as required by the new drama The Moscow Art Theatre company visited New York in 1923 and impressed with the quality of its ensemble acting. which only a permanent organization could achieve. Some of its members remained in New York to practise and teach the Stanislavski system for actors (see also MOSCOW ART THEATRE). In 1926 Eva Le Gallienne established a permanent repertory company that presented classics old and new. Show Boat appeared in 1928 and became a classic of the musical stage. Outside New York city, competition from motion pictures reduced the number of theatres open to traveling companies from 1,500 in the early 1900s to 500 but on Broadway the number of productions grew from 150 in 1920–21 to 280 in 1927–28.

The stock market crash of 1929 heralded the end of unparalleled prosperity in the theatre and in the nation. The nation recovered from the ensuing economic depression, but the theatre, under increasing competition from motion pictures, radio and television, did not In the next 30 years traveling companies all but disappeared. and productions on Broadway shrank to 60 in 1949–50 and expanded only to an average of 70 in the following ten years. No new theatres were constructed. The Civic Repertory theatre succumbed in 1933.

Nevertheless, live theatre continued to attract talented writers: Clifford Odets. Sidney Kingsley, Lillian Hellman, Thornton Wilder and William Saroyan beginning in the 1930s; Tennessee Williams, Arthur Miller and William Inge starting in the 1940s. Rising costs encouraged simplification of setting and by 1950 the box setting mas seldom seen. Rising costs and shrinking audiences necessitated longer and longer runs. Enterprises outside the standard pattern, however, enjoyed some success. The Group Theatre (*q.v.*) for six years maintained a permanent company, developed new playwrights and evolved a new acting style based on the Stanislavski system. From 1935 to 1939 the Federal Theatre project (*q.v.*) presented hundreds of productions of all sorts and showed that a large untapped audience existed for live theatre at low prices. From 1937 to 1939 Orson Welles and John Houseman maintained a permanent company and limited runs in the Mercury theatre. From 1947 the Actors Studio cultivated the "method," derived from Stanislavski's system and practised by such actors as Marlon Brando, Geraldine Page and Julie Harris. In 1955 the first U.S. Shakespeare festival was held at Stratford. Conn.. and it became more popular each summer. The American National Theatre and Academy (ANTA), chartered by congress in 1935 and activated in 1946, encouraged theatre, professional and nonprofessional, throughout the country. As theatre activity decreased, the producer declined in importance and the stage director rose. Among the important directors in the 1940–60 period were Elia Kazan. Robert Lewis. Harold Clurman, Joshua Logan and Jose Quintero. The musical show after 1930 gained in polish and sophistication. Examples were: *The* Band *Wagon* and Of Thee I *Sing* (1931), Pal Joey (1940). Lady in *the* Dark (1941), *Oklahoma!* (1943). South *Pacific* (1949) and *My* Fair Lady (1956). In 1935 George and Ira Gershwin turned the play Porgy by DuBose and Dorothy Heyward into America's first successful folk opera. Porgy and Bess.

Off-Broadway Theatre.—Plays have always been produced in small theatres outside as well as in the main theatrical district in New York. In 1915–18 the Washington Square Players, in the 1920s the Provincetown Players and in the 1930s the New Playwrights drew audiences and critics off Broadway. A new era began in 1952 with the successful revival of Tennessee Williams' *Summer and Smoke* at the Circle in the Square and gained momentum with productions at the Phoenix. the Theatre de Lys and the Fourth Street theatre. In 1961–62, the *New* York *Times* counted 100 off-Broadway productions. 34 more than on Broadway. Revivals of classics and of recent plays that had failed on Broadway predominated at first, but the proportion of new plays increased, With a few exceptions, such as at the Phoenix, the single play and the long run predominated. Since production often took place in improvised quarters under makeshift conditions, it showed styles and forms seldom seen on Broadway. Many productions were staged without a proscenium arch and with the audience on two or three sides of the playing area. Actors, directors, designers and producers who achieved success off Broadway were soon active on Broadway. And those who had made their mark on Broadway began to appear in off-Broadway theatre, attracted by the greater freedom it offered. Some notable productions off-Broadway were Threepenny Opera at the Theatre de Lys, the revivals of Chekhov at the Fourth Street theatre and The *Iceman Cometh* at the Circle in the Square.

Summer Theatre.—Declining production on Broadway was accompanied by a growth of theatre in resort areas during the vacation season. In 1940, 80 summer theatres were open for a ten-week season, performing a different play or musical each week in tents. barns and sometimes in regular theatre buildings. More than 200 such "straw-hat" theatres were in operation in the early 1960s. Resident companies, frequently augmented by visiting stars: usually performed recent Broadway successes, and occasionally they tested a new play for possible Broadway production.

The *Negro* in the *U.S.* Theatre.—In native plays, the Negro appeared first as a plantation hand. a minor comic character, Later he was frequently seen as a comic domestic servant. In the 1830s Thomas Dartmouth Rice was extremely popular singing and dancing as the eccentric "Jim Crow" in an entertainment he called "Ethiopian Opera." Out of such white performances of Negro song and dance came Negro minstrelsy (see MINSTREL SHOW). Edward Harrigan introduced the city Negro in his comic Mulligan plays of the 1880s. The slavery plays like Uncle Tom's *Cabin* (1852) and the Civil War plays like The Reverend *Griffith Davenport* (1899) first treated the Negro seriously. Edward Sheldon's The *Nigger* (1910) was the first play to deal with Negro problems in modern society. After the Civil War, Negroes became popular performers in minstrel shows and later in all-Negro musicals. From 1910 on. individuals like Bert Williams were featured in musicals like the Ziegjeld Follies; the integrated musical appeared in the 1940s. Negroes gained recognition in serious drama somewhat later: Charles Gilpin in The *Emperor* Jones (1920), Richard Harrison in The *Green Pastures* (1930), Canada Lee in Native Son (1941) and Paul Robeson in *Othello* (1943). Playwrights who contributed to the drama of Negro life include Ridgely Torrence, DuBose and Dorothy Heyward and Paul Green. Negro playwrights had little success on Broadway until Lorraine Hansberry's *A* Raisin *in the* Sun became a hit in 1959.

Community Theatre.—Community theatre grew out of the little theatre movement and its art theatres that sprang up (c. 1900–25) in protest against the commercial theatre and under the inspiration of the free theatres of Europe. Among the leaders were Gilmor Brown in Pasadena. Calif.. Frederic McConnell in Cleveland, O., Samuel J. Hume in Detroit, Mich., and Maurice Browne in Chicago. The little theatres presented noncommercial plays, European and American, with the "new stagecraft." in small theatres for small audiences. As road companies disappeared, most of these organizations lost their "art" theatre aims and became substitutes for professional theatre, presenting popular plays in larger theatres to larger audiences with more paid personnel. By the early 1960s three types of community theatres existed: (1) a few with paid actors and staff. like the Arena theatre. Washington, D.C.; (2) a few more with paid staff and a few paid actors, like the Cleveland Playhouse; and (3) the great majority with some paid staff only.

University Theatre. — Dramatic performances by students go back to the colonial period, but instruction in theatre subjects did not enter the curriculum until about 1900, largely in colleges of liberal arts and as part of the reaction against commercial theatre. Early leaders in this movement included George Pierce Baker at Harvard. Thomas H. Dickinson and Gertrude Johnson at Wisconsin, and Frederick H. Koch first at North Dakota and later at North Carolina. In 1914 the first department offering training for the professional theatre was established at Carnegie Institute of Technology under Thomas Wood Stevens. After World War I, under the leadership of such men as A. M. Drummond at Cornell, E. C. Mabie at Iowa and Glenn Hughes at Washington, there was a tremendous expansion of courses, departments and degrees. The National Theatre Conference of leading university and community theatres was organized in 1932. The American Educational Theatre association was established in 1936 and after 1949 published the Educational Theatre Journal. By 1958–59 more than 500 college theatres were producing annually more than 1,000 plays for audiences of about 3,000,000. Much of this growth was because of the disappearance of professional theatre outside New York city. Although the aims of university theatre have been primarily cultural, it has affected the professional theatre, especially off-Broadway. Its unique contributions have been the development of theatre for children and the popularization of arena and other forms of open staging. (B. HT.)

9. Latin America. — The theatre in Latin America varies greatly from country to country. Its development is highest in Argentina, Mexico, Brazil, Uruguay and Cuba in that order, with the other countries trailing considerably behind. The advent of motion pictures around 1900 brought about a decline in the theatre throughout Latin America but a theatrical revival became noticeable after the 1930s when playwrights abandoned the late 19th-century Spanish dramatists as models and introduced techniques and styles from the best European and New York theatres.

Early in the 20th century a nationalistic theatre arose in Argentina depicting the conflicts between the *criollo* population (descendants of settlers from the old world) and the immigrants. This movement produced a legion of playwrights, the best known of whom was an Uruguayan, Florencio Sanchez. His plays, written between 1903 and 1909, were mostly dramatic but others cultivated a more festive theatre, such as the Argentine *sainete* ("farce"). Modern Buenos Aires, Arg., boasts scores of professional theatres, numerous experimental and art theatres and the Teatro Colón with its own opera company, symphony orchestra and ballet. The Argentine motion-picture industry developed steadily until it ranked second in America only to that of the United States.

Although the Mexican theatre is not comparable to that of Argentina, it grew through the efforts of enthusiastic art groups and many exceptional dramatists, such as Rodolfo Usigli (Corona de sombra, 1947) and Xavier Villaurrutia (Juego peligroso, 1950). Beginning in the 1950s numerous theatres were built or halls adapted as teatros de *bolsillo* ("pocket theatres"). Mexico's motion-picture industry was almost on a par with Argentina's. Mario Moreno (Cantinflas) became a world-famous motion-picture star.

In Brazil the theatre enjoyed generous official protection and a high level of theatrical culture resulted. The quality of Brazilian theatrical production was comparable to that of any country. Among the best-known modern Brazilian authors were Joracy Camargo (Deus *lhe pague,* 1932) and Guilherme Figueiredo (*A rapôsa* e as uvas, 1935). Procópio Ferreira came to be considered one of the world's greatest contemporary actors. The modern Brazilian motion-picture industry, though commercially smaller than those of Argentina and Mexico, was technically and artistically excellent.

Cuba, with a glorious theatrical past, witnessed a sharp decline at the beginning of the 20th century. The peculiar political satire known as the bufos *cubanos* flourished for a while but dwindled away in the 1920s. In that decade and in the 1930s composers and playwrights developed the *zarzuela* cubana, a type of musical comedy that was successful at home, in Spain and in Latin America. Among the composers of the *zarzuelas* were Ernesto Lecuona, Moisés Simons and Gonzalo Roig. Cuba also made important contributions to the theatre in the field of the ballet; the Cuban ballerina Alicia Alonso became internationally known.

Chile produced at least one outstanding playwright; Armando Moock (Rigoberto, 1935). (Lu. A. B.)

10. Drama Festivals. — During the height of the season there are so many drama festivals in Europe that it is difficult to keep count of them. The most comprehensive is the annual "Theatre of the Nations" festival in Paris. The festivals in the Netherlands, Stockholm, Berlin, Zürich, Munich and Vienna are, like the Paris festival, international in character. The Dublin festival is essentially national, although one or two companies are invited from other countries. The festival at Pitlochry in Scotland, which lasts throughout the summer months, always includes a proportion of Scottish plays in its program but is by no means exclusively national. At Epidaurus, Greece, the festival is devoted to the Greek classics. This is one of the many open-air festivals, among which the most important are those at Baalbek, Lebanon, Avignon, France, and Dubrovnik, Yugos. Besides these there are many smaller open-air festivals in France and Italy, most of which use surviving Roman theatres. The festivals at Salzburg and Edinburgh combine music and drama. The Edinburgh festival has given the first performances of a number of distinguished plays, including two by T. S. Eliot, but much of the most interesting drama at this festival is to be found among the "fringe," the name given to the small pioneering companies, mostly very youthful, that are not officially part of the festival. (N. M.)

Some of the best-known summer drama festivals in the United States are devoted to Shakespeare. At Ashland, Ore., Shakespeare's plays are presented outdoors in what resembles an Elizabethan public theatre. A similar repertory is presented in a reconstruction of the Globe theatre at San Diego, Calif. At Stratford, Conn., Shakespeare's plays are produced in a modern theatre. The New York Shakespeare festival is staged in the city's Central park. Opera has replaced the spoken drama in the 19th-century opera house at Central city, Colo. The Arts festival in the Public Garden, Boston, Mass., includes opera and ballet, as well as drama; so does the Richmond, Va., Festival of Arts.

Although Stratford, Ont., is best known for its productions of Shakespeare, its program includes new plays, operetta, films and music. Vancouver, B.C., stages an international festival of drama, opera and ballet. (B. HT.)

See also references under "Theatre" in the Index volume.

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THEATRES (STRUCTURES). A theatre is a building or place furnished with seats and provided with a stage upon which plays or dramatic spectacles are performed; a playhouse. The present article deals only with the physical aspects of the building and its equipment. For articles dealing with the theatre in the larger meaning of the term, see DRAMA; THEATRE; also ACTING, DIRECTION AND PRODUCTION; COSTUME DESIGN, THEATRICAL; STAGE DESIGN. (X.)

HISTORICAL DEVELOPMENT

In considering the form of the modern theatre building and its physical aspect, and in tracing the origins and development of that form from the earliest known theatres of Europe, it is well to keep in mind the basic meaning of the word "theatre." From the Greek θεασθαι, it means roughly "a place for seeing." In a short survey of the subject it is not necessary to mention pre-Greek theatres, beyond saying that there is no known connection between those of earlier civilizations and the theatre of Dionysus at Athens, with which the histories of drama in the western world traditionally start. In Egypt nothing approaching a constructed theatre in the place-for-seeing sense has been uncovered, although accounts and fragmentary texts of passion plays, resurrection plays and coronation plays are known, some of a date earlier than 3000 B.C. Egyptologists identify the performances as ritualistic and pageant-like, involving processional movement, so that it is likely that temple courts and terraces rather than planned auditoriums accommodated the devotional audiences.

Greek Theatre.—The first Greek theatres were little more than marked-out dancing circles, each around an altar, at the foot of hillsides on which spectators stood or sat. From this natural form the first built theatres took their main outlines: a circle or orchestra (ὀρχήστρα) for the chorus and actor or actors, and rising tiers of wooden seats, built against a hillside for the spectators. These seats extended usually around two-thirds or more of the orchestra, since at this time dancing or movement was more important than acting, and there was no stage for the spectators to face. The type of the first built theatres is shown in fig. 1. The one actual example that has survived (partly restored) is the magnificent theatre at Epidaurus, although archaeologists have uncovered foundations of theatres of this stageless type under several Greek-Roman or Roman theatres surviving in partial ruin. It should be kept in mind that in no period were any two Greek theatres exactly alike.

Returning to the theatre of Dionysus at Athens, one notes that the temple of Dionysus Eleuthereus appeared in relation to the theatre approximately as indicated in the diagram (all within the precinct sacred to Dionysus on the southeastern slope of the Acropolis). One conjecture is that the architectural form of this 6th-century temple helped determine the shape of the stage building, which was later to be added at the edge of the circle opposite the seats. But the more widely accepted theory is that out of necessity a hut or tent (σκήνη) was added at the edge of the orchestra as a retiring room for the actors, for changes of masks or costume, etc.; and that the stage building was in all later ages an elaboration of this shelter—dressed, in the later Greek period, with those beautiful architectural forms with which the Athenians adorned all their important structures.

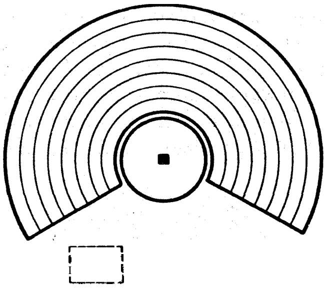


FIG. 1.—PLAN OF GREEK THEATRE OF EARLIEST TYPE

Just when the *skene* became truly a stage building with studied relationship to orchestra and auditorium is a matter of conjecture. As a step in the development of the larger theatre form, the three parts of the theatre may be thought of as developing gradually into a set arrangement as shown in fig. 2.

Here one sees the accretion of the three features that characterize theatre building through many succeeding centuries: (1) θέατρον or auditorium; (2) orchestra; and (3) scene; names which persist even today. But at this time players and chorus appeared only in the orchestra, the scene remaining an architectural background to the action and a practical retiring house for the actors, structurally separated from the auditorium by entrances or runways called παραδοί (Lat. parodi).

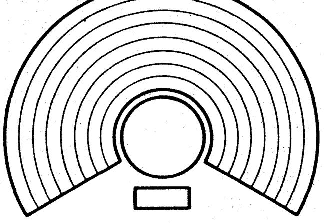


FIG. 2.—THE THREE-PART THEATRE ARRANGEMENT OF SEATS, ORCHESTRA AND SKENE

Such was the theatre form when the 5th century B.C. dawned, and such it remained, with only slight changes, in all probability, during the period of Aeschylus, Sophocles and Euripides. The architectural features and the height of the *skene* are still only to be conjectured, though excavated foundations at Athens indicate clearly the plan and limits of an early stage building, wider than the dancing circle and with ends projecting forward toward the auditorium.

Archaeologists have waged one of their bitterest battles over the question as to when the raised stage made its first appearance, but it is now almost unanimously agreed that in the "high" period of Greek drama there was no platform stage. The theatre at Athens had taken this general form, with possibly a portico at the front of the scene building, between the paraskenia or projecting skene ends (fig. 3); but the acting space in front of the skene was level with the orchestra floor. A platform would imply a separation of actors from chorus belied by the only evidence, the play texts.

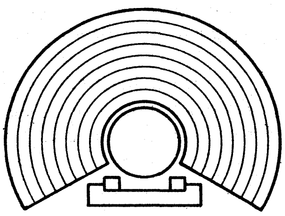


FIG. 3.—SKENE ENLARGED AND PROBABLY ADORNED WITH ARCHITECTURAL ORNAMENTS OR POSSIBLY A PORTICO

In Greece the theatres were regularly built in hillside hollows, thus avoiding any need to build supporting framework for the tiers of seats, xcept perhaps at the ends of the rings. The auditorium was broken by up-and-down aisles with steps into a number of wedge-shaped segments of seats, and sometimes by one or more lateral aisles (as in the theatre at Epidaurus).

The student of later forms may profitably transfer his attention to a point beyond the controversy about the introduction of the raised stage to that time when there was, without doubt. an auxiliary platform for acting. The next well-differentiated type of theatre is that in which the stage building is characterized by a high narrow platform on the audience side, called at times the proskenion (from which "proscenium" is derived), and at others the *logeion* or "place for speaking." As acting became more and more important, the skene developed into a combined architectural background and platform for lifting the actor into clearer view (fig. 4). It is to be noted here that the typical Greek separation of auditorium and scene building still exists, although acting now is divided between the orchestra and a stage in the later sense. Through the late Greek and the so-called Greek-Roman periods, the narrow *logeion* doubtless went through a gradual widening process. Also the stage building was soon a two-storied affair. When the actor appeared on a raised stage, the acoustics (generally excellent in open-air theatres) were improved. As acting on platforms became standard, the rings of seats doubtless came to be planned as less than the old two-thirds of a circle, moving toward the standard half-circle plan of the Romans. The Greek tragic drama retained a certain processional element, and the separation of the stage building by means of the παραδοι was then retained. There came to be three doorways in the stage wall for actors' entrances; the παραδοι afforded fourth and fifth entrances to the orchestra, especially for the chorus and, by a convention adopted at some unknown time, for actors understood to have arrived from a distant place. (Later the two side entrances became symbols for arrival from the country on the one hand and from the forum or the city on the other.)

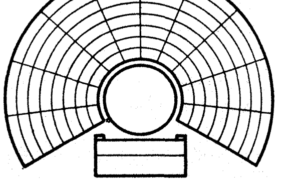
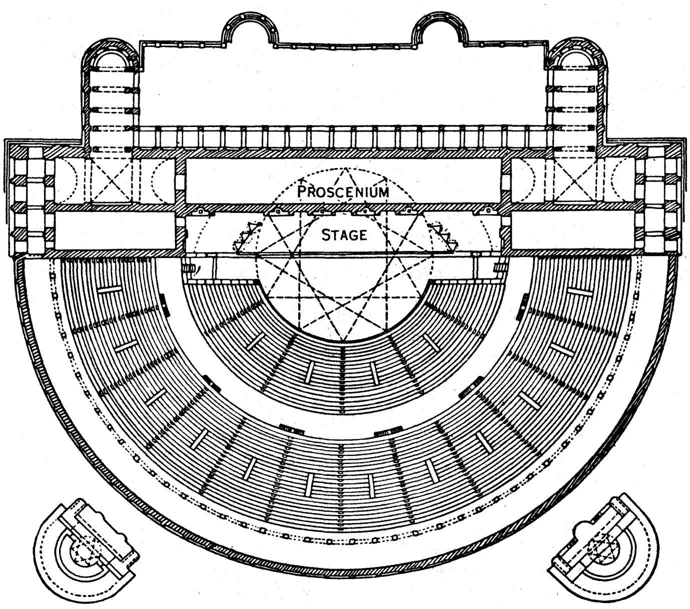


FIG. 4.—A PLATFORM ADDED AS PART OF THE SKENE

Roman Theatre.—Ruins of Roman theatres afford absolute evidence regarding the arrangement of the Roman stage and auditorium. The two heretofore separate buildings had now been pushed together to form one structure, not placed, as in Greek times: against a hillside hollow, but erected as a free-standing building supported'by arch construction. The orchestra had been contracted to a half circle and added to the seating space; and all the acting was done on a platform stage, behind which the greatly enlarged skene and paraskenia rose, with rich architectural ornamentation, to a considerable height. (See fig. 5.) There is shown in fig. 6 a drawing after A. N. Caristie's restoration of the stage of the Roman theatre at Orange, Fr., of which the stage wall still exists, though stripped of its ornamental features. In many Roman theatres, including this one, a colonnade above the highest tier of seats ended in junction with the left and right top extremities of the stage wall. This provided in the Roman theatres a sense of enclosure unknown to the Greek playhouses or to the transitional structures.



FROM A. STREIT, "DAS THEATER"

FIG. 5.—PLAN OF A TYPICAL ROMAN THEATRE AS SEEN IN THE RECONSTRUCTION OF THE THEATRE OF MARCELLUS, ROME

A special sort of theatre with wooden platform stage, for comedies, as shown in many extant vase paintings, is disregarded here as having little or no influence on the traditional or persisting form of theatre. These' simple stages existed in both Greece and Rome. Left aside too are such classic structures as the Odeum of Atticus Herodes on the Acropolis in Athens, built in the 2nd century A.D. as a recital hall; and similar odea and senate chambers and the like, characterized often by graceful auditoriums but lacking stages.

In the Roman theatres there were no built-in facilities for scene changing, and it may be assumed that in general there was no painted scenery, though elaborate stage machinery for trick effects, apparitions, etc., is described by contemporary writers. The *ekkyklema* seems to have been a sort of wagon stage, so pivoted beside the "palace doorway" of the skene that it could be wheeled onto the stage to disclose a set tableau. Efforts to localize the play scene visually may have been tried on lesser stages than those of the great surviving stone theatres. And there is a description (in Vitruvius) of a device, originally Greek, for indicating to the audience a change in the play's locale: a three-sided standard or signboard, on a pivot, with painted indications of a severe architectural scene for tragedy, a less monumental street scene for comedy and a forest scene for satyr plays. These boards or *periaktoi* were revolved at the interval for change of plays and possibly at some entrances (as of a god character) within a play performance. Nevertheless it must be inferred that, in general, the architecture of the stage wall *was* the "scene." This wall was regularly pierced by five doorways, three at the back and one in each of the *paraskenia*. The large centre door was the "palace entrance."

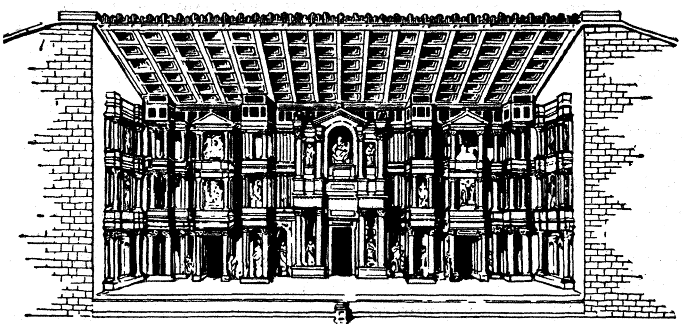
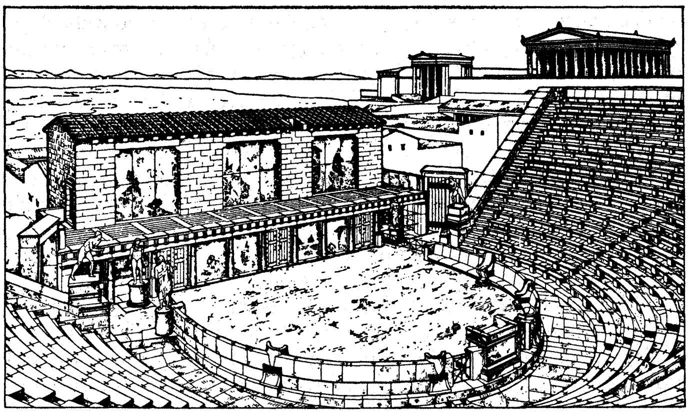


FIG. 6.— BACKGROUND OF ROMAN STAGE SHOWING NARROW CENTRAL "PALACE DOORWAY WHICH WAS MODIFIED IN THE RENAISSANCE THEATRE. AS SHOWN IN FIG. 11, TO PROVIDE A MORE EXTENDED VISTA

The main thesis (of a gradual evolution from dance circle to monumental late Roman playhouse) has here been baldly set down, with diagrams, in order that the reader may visualize a continual process of adaptation of the theatre to the needs of a changing drama and—in the case of degenerate Rome—of spectacular "shows." Without attempting a census of all surviving classic theatres, one may pause over the especially instructive examples.

Existing Classic Theatres and Restorations.—The pure type of Greek playhouse, with full-round orchestra, is to be seen only in the beautiful structure at Epidaurus. Otherwise there are the restorations on paper and museum models of such areas as the Acropolis at Athens or the sacred precincts of Delphi and Olympia. The early wooden playhouses would in any case have disappeared; but the savagery with which wars were conducted by the conquering Romans accounted for the ruination of the stone structures that adorned not only the cities of Greece proper but the provincial Greek cities of the Asian and African coasts and of Sicily and the Italian mainland.



FROM A. VON GERKAN, "DAS THEATER VON PRIENE"

FIG. 7.— THE THEATRE AS PART OF THE TEMPLE GROUP. A RECONSTRUCTION OF THE GREEK-ROMAN THEATRE AT PRIENE

After destruction came generally rebuilding, but on the transitional Greek-Roman or the straight Roman model. Thus the Greek theatre at Syracuse disappeared when the city was devastated and the inhabitants were massacred in 212 B.C. But later one of the largest of Roman theatres was constructed on the site. Considerable portions of the auditorium and of the foundations of the stage building remain.

Of the transitional type buildings, when a raised stage has been added and the orchestra has been cut down from the full round but the stage building has not yet been consolidated with the auditorium, sufficient ruins survive for archaeologists to present fairly accurate restorations. Fig. 7 shows the probable aspect of the Greek-Roman theatre at Priene in Ionia, as pictured by A. von Gerkan. The ground plan and arrangement of parts can be relied upon; though the windowlike spaces in the upper stage building have been criticized as wholly conjectural, as perpetuating the 19th-century belief that provision was commonly made for painted scenery.

A further step toward consolidation of the building's once separate parts is illustrated in the theatre of Dionysus at Athens, as the structure appears in its latest, partial restoration. Indeed there is evidence that the Greeks under their Roman masters remade this most holy of ancient theatres so that gladiatorial fights could be staged there. The orchestra, moreover, was sealed up in such a way as to improvise the playhouse into a naumachia or lake-theatre for the staging of mimic sea fights.

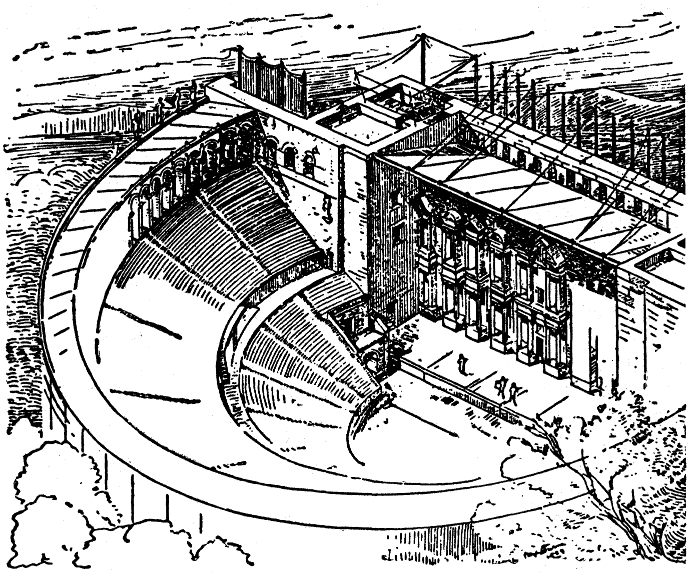
Of the large stone or concrete Roman theatres the one at Aspendus, in Asia Minor, is best preserved. The entire auditorium with its crowning colonnade may be seen (since Count Lanckoronski's restoration in 1884), together with the stage wall, including parts of the impressive ornamentation. The stage floor, being of wood, has disappeared. This magnificent structure, built in the reign of Marcus Aurelius, is estimated to have seated 7,500 spectators. It may be considered typical of the scores of playhouses erected in the far-flung cities of the Roman empire. A sketch, fig. 8, illustrates perfectly the relationship of parts. Examples more accessible to the ordinary traveller include the impressive ruins at Orange in France, the theatre at Taormina in Sicily, in which some of the columns adorning the stage are still intact, and the two theatres at Pompeii. The larger theatre at Pompeii, dating probably from the 1st century B.C., is said by Plutarch to have been modelled after that at Mytilene in Lesbos—which at so late a date would be a Greek-Roman type structure. The smaller theatre at Pompeii, aside from a certain feeling of grace and intimacy that pervades it, is of special interest as bolstering the theory that in Roman times small, roofed theatres were commonly built adjacent to the larger open-air playhouse for use in case of rain. It is a theory not easily proved; certainly the roofed Odeum in Athens, built during Hadrian's reign (A.D. 117–138), was not well suited for a typical Roman extravaganza, and the rare covered theatre-like structures elsewhere seem to have been designed as chambers for musical recitals, senate houses, etc.

In Rome itself the theatres wholly crumbled, except for parts of the theatre of Marcellus, after the stone facings had been stripped away by pillagers during the dark ages. But contemporary writers supply a record of some unusual, not to say amazing, examples of ingenuity in raising bigger and ever bigger playhouses. It is said that the first stone theatre in Rome was torn down before completion, in 154 B.C., as part of the republican campaign to halt the march of "Greek luxury" among the stern and practical Romans. This seems to have been one of the few times that morals had anything to do with the Roman theatre or drama. Roman drama had begun in humble and obscure types of ritual procession and farcical interlude, mostly Etruscan; but later there were Roman playwrights copying Greek plays. Nevertheless, the theatre was already divorced from religion—a basic difference between the two nations and an important factor in shaping the Roman playhouse form.

It was Pompey who erected the next celebrated stone theatre in Rome (begun in 55 B.C.). As a ruse he placed a shrine to Venus Venetrix at the top of the auditorium. Thus it could be said that the rows of stone seats served as steps to a temple; but the stage lacked nothing for the showing of such spectacles as the populace now demanded. Pliny wrote that Pompey's theatre accommodated 40,000 spectators—doubtless a gross exaggeration, though the stage wall was 300 ft. long. The place had architectural grandeur, and certainly it was big enough to permit gladiatorial contests. At its opening, it is said, 500 lions and 20 elephants were killed.

After the change-over to rule by emperors, Augustus Caesar boasted that he had rebuilt the "magnificent" Pompey's theatre, had erected the theatre of Marcellus and had been instrumental in getting Cornelius Balbus to build a third playhouse. In view of the known magnificence of adornment in the theatres of Roman provincial cities, one can only believe that the capital city of the empire would decorate its playhouses sumptuously, and every attempted restoration on paper has shown the stage wall as architecturally rich and showy. This is the very peak of palatial adorning of the stage wall with story on story of columns, pilasters and niches, with an abundance of statues and of gilding—the very elements destined to turn up in the stage-wall ornamentation of the academy theatres of the Italian Renaissance and to persist as standard ornamental features of the proscenium arch in theatres built in the 18th and 19th centuries throughout Europe and the Americas.

As a last word about the theatres in Rome it should be said that even greater claims of bigness and munificence were made for wooden theatres temporarily erected. Pliny writes that the aedile M. Aemilius Scaurus constructed in 58 B.C. a theatre seating 80,-



FROM DURM, "DIE BAUKUNST DER ROMER"

FIG. 8.—RECONSTRUCTION OF THE ROMAN THEATRE AT ASPENDUS. SHOWING ROMAN BOWLLIKE FORM

000 people and adorned with 3,000 statues among 360 columns; and that a few years later one G. Curio built two theatres so arranged that after use as separate playhouses in the morning one of the auditoriums could be swung around to face the other, thus forming an amphitheatre for performances in the afternoon—an architectural curiosity that taxes piesent-day credulity. Nevertheless the Romans accomplished well-nigh incredible feats of engineering in other types of building. And the final impression to be carried away from an examination of the surviving ruins should be one of wonder that so many small Roman cities should have owned theatres almost incredibly grand.

Mediaeval and Elizabethan Theatres.—In the history of theatre architecture there is, strictly speaking, no mediaeval chapter. The latest ancient mention of activity in a Roman theatre is dated A.D. 533; but it can be assumed that most of the classic playhouses had long before gone "dark" under the stress of the barbarian invasions. The drama was then, and for many centuries after, a tenant in castle halls, courtyards and town squares. Toward the end, important new sorts of stages and staging came in—the beginnings of modern illusory scene design. But no type theatre developed out of the acting of plays in the altar area of the Christian church, the first place in which a new tradition of playwriting and acting took form.

When the plays were pushed out onto the church porch, and then driven away to public squares, there still was no crystallization of a structure combining stage and "place for seeing." The strolling players of another sort, inheritors possibly from the suppressed miming tradition of fading Rome, from minstrels and from Teutonic *scop* and gleeman, no more had theatres. Indoors a castle hall would do. Outdoors a platform with simple curtains served the actors; the audiences stood.

One exception alone is sometimes claimed: the school theatres. But colleges, then universities, appeared (on the foundations of student guilds or student-scholar guilds, under church protection) only in the late 12th and the 13th centuries, and there is no record of their dramatic activities. There is an edition of Terence's plays, printed in 1493, illustrated with puzzling diagrammatic sketches of an "opened" auditorium and of scenes on a platform stage before curtains; and these illustrations teased some scholars into inferring a type theatre specially suited for revivals of classic comedy or for native plays after Roman models. This is in any case a revival activity, typically of the Renaissance in both substance and date.

The Jesuit theatres, moreover, overshadowed all other manifestations of the school theatre. They would be expected to have picked up and carried on any tendency toward crystallization of a type playhouse. As a matter of fact the instructional school plays of the Jesuit colleges—colleges numbering possibly 300 in Europe within 50 years of St. Ignatius of Loyola's death in 1556—were staged in every imaginable sort of improvised theatre: school hall, college courtyard, public square and, in exceptional cases, theatres especially constructed in imitation of contemporary models, from the classic theatre as reconstructed for the learned academies to the ballroom theatre with provision for the new changeable scenery. Bridging thus from the mediaeval era's incomplete theatre to the Renaissance time when two types of playhouse were being standardized, the Jesuit activity emphasized all tendencies toward a new playhouse without providing a lasting structure of its own. One sort of stage used by the Jesuits in Holland, that of the *Rederijker* societies, who had utilized it for the unveiling of *tableaux-vivants* in the then novel "scenery," is of interest historically as suggestive of the change from the stage of the Italian academy theatre to the typically modern proscenium-framed stage.

The theatre in Shakespeare's time, in England, is technically of the Renaissance era. But its utter difference of design from the types of Italian Renaissance theatres already developed, which were destined to determine the form of practically all the playhouses of Europe (including England) within the 18th century, mark it as unique. It was of immense importance for a few years, then thrown away.

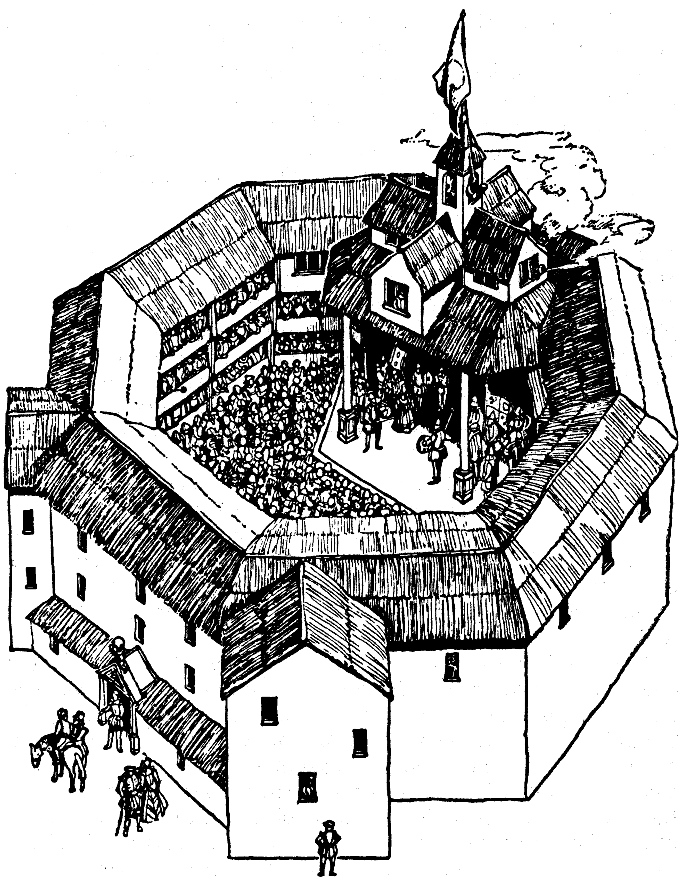
The sources go back to wide English activity in church plays (from the early 13th century); then mystery plays in town squares or market places, produced by the mediaeval guilds, most notably on wagon stages; and, as the guild productions began to lapse, secular drama offered by strolling players. Productions by the strolling bands of actors at town house or country castle had, eventually, a revolutionary effect upon the history of scene design, and that was destined to determine the form of the English theatre after the Restoration. But it was the production of plays in the inn courtyard that determined the general form of the Elizabethan playhouse.

The first theatre built in London was put up in 1576 by the actor James Burbage. After use by many of the court-protected acting companies, and for exhibitions of fencing, swordplay and other sorts of "sport," it was demolished and its timbers utilized in the construction of the Globe theatre. This is Shakespeare's playhouse, built in 1599, and its structure is known to modern students in practically every detail.

The auditorium is the old innyard; though yard and balcony rings have been rounded—or, like the exterior, made hexagonal. In any case, the whole is doughnut-shaped; or, as Shakespeare described it, a "woodden O." The shilling patrons sat on the stage, three-penny patrons had stools in the balconies, which were in three tiers, while the groundlings stood in the yard, at one penny. The stage platform jutted out into this yard and placed the actors amid an audience pressing round three sides of them. Some of the declamatory element in the verse drama of the time can be ascribed to this actors' intimacy with the audience and to a certain disorder that would be inevitable among standees. It is not to be missed that this was still a daylight theatre. Its capacity, at a stretch, was 2,000.

The stage is a jutting platform with a low railing, and it is roofed. It is of the architectural type—that is, without provision for change of scenery. But at the back are curtained recesses, in three stories, and angled at the sides are two permanent stage-level doorways.

There is a considerable amount of machinery, including trap doors and a cannon that can be fired from a window at the top of the tiring house. In general this is a very large stage for acting in



FROM WATKINS, "ON PRODUCING SHAKESPEARE," BY COURTESY OF MICHAEL JOSEPH. LTD. DRAWING BY MAURICE PERCIVAL

FIG. 9.— THE GLOBE THEATRE

the round, yet fitted at the back for diversified effects of grouping and with curtained openings for revealments, balcony scenes and the like.

The Globe theatre is typical and most popularly known (fig. 9); and all the others, the Theatre, the Swan, the Curtain, the Rose, the Fortune and a small number more, approximated its architectural features. The one contemporary picture of an Elizabethan theatre is a sketch by a Dutch visitor to London, one Johann de Witt, of about the date 1596. Allowing for possible inaccuracies in the rough drawing, one may note the general accordance with the Globe theatre plan, yet a considerable difference in the tiring house features (fig. 10).

In Spain there developed at this time a somewhat similar courtyardlike theatre. Where strolling players had earlier found sufficient a hastily erected platform, backed by a blanket hanging between poles, there now appeared the *corral* theatre. The "auditorium" provided galleries and balconied windows for important spectators, while the unroofed but sometimes canopied pit accommodated standees and some seated patrons.

The stage never approached the elaboration of the English Globe or Fortune type. It seems to have been merely a platform, unrailed. jutting well into the pit. Behind was the tiring room, at first no more than a curtained space, later developed for varied "reveal" effects—and finally making concessions to the vogue for illusory scenery.

The English theatres were closed immediately upon the Puritan triumph of 1642. When others opened, 20 years later, they were modelled, at least piecemeal, upon the Italian type. (And indeed London had known, before the closing, one indoor candlelit playhouse, the Blackfriars, where Shakespeare played in James Burbage's company in winter; and at some undetermined date the new foreign scenery was tried out there, as well as frequently in court masques.) The Spanish *corral* theatres lasted longer.

Renaissance Theatre.—At almost exactly the time when Shakespeare was entering the London theatre and Lope de Vega was writing for the Spanish *corral* stage, Italian scholars and patrons were coming to fullest activity in the revival of every aspect of classic culture. The Renaissance spirit demanded construction of theatres on the classic model. The earliest, that of the Este family at Ferrara. no longer exists; but the second, a perfect example, survives in the Teatro Olimpico at Vicenza. This was built by the Olympian academy between 1579 and 1584, and was designed by the famous architect Andrea Palladio. It is, in effect, a small Roman theatre roofed over and rendered more compact. Palladio, acting upon his knowledge of the laws of classic architecture as set down by Vitruvius (of the 1st century B.C.), saw to it that the stage was commodious, that the five stage doorways were in orthodox position and that the stage wall was covered with a rich architectural show of pilasters, niches, statues and assorted bric-a-brac (fig. 11). It was this decorated and encrusted stage wall that was to survive in later theatres even up to the 20th century, at first as partial background to the action (as in the plan of Inigo Jones, fig. 14), then solely as the ornamental proscenium frame when the stage for changeable scenery had gone behind a curtain.

While Italy had developed no type theatre to house the diverse elements surviving from mediaeval religious plays and the activities of strolling comedians, the ruling families had cultivated two tastes that influenced the next move in theatre architecture. The one was for strictly classical plays, the other for pageantlike settings and general scenic display.

Palladio had enlarged (beyond any known Roman model) the central or palace doorway in the Olimpico stage wall. In 1585 his pupil Vincenzo Scamozzi, yielding to the demand for scenic novelty, built within this doorway a street in diminishing perspective, and in each of the other four doorways lesser "perspectives." Thus unwittingly he, more than any other, ended the era of classic, permanent architectural backgrounds for acting and opened the way to the stage with illusory setting, a type which was destined to become universal. There would be no more serious talk of architectural stages and acting in the round until the early 20th century.

As a matter of fact Scamozzi had not provided a changeable make-believe setting. He had not even provided acting space within the perspective. But a glance at the plan of a theatre built by Scamozzi at Sabbioneta in 1588 (fig. 15), and at the plan by Inigo Jones for a theatre never constructed (fig. 14), shows the process by which the vista became the stage, the architectural stage wall being reduced in importance until it was finally no more than a proscenium frame. From one make-believe background (usually a street, as specified by Vitruvius for his *periaktos* machine, for tragedy and comedy, back in Roman times) the producers raced on to movable backgrounds and to changes of setting within a single play session or a session combining a classic play with the spectacular intermezzi, or introduced masquelike episodes between acts.

Localized stage setting had a long history behind it at this time, albeit mostly on temporary stages. (See STAGE DESIGN.) There had been the station stages of the mystery and miracle plays, with realistic scenes such as the famous "Hell mouth"; and picture scenes in the masques at courts or in classic play revivals there, including those perspectives based nominally upon Sebastiano Serlio's interpretations of Vitruvius; even localized place roughly painted on the curtain of platforms used by the popular outdoor comedians. But for the first time the architecture of the theatre is radically changed to accommodate scenery.

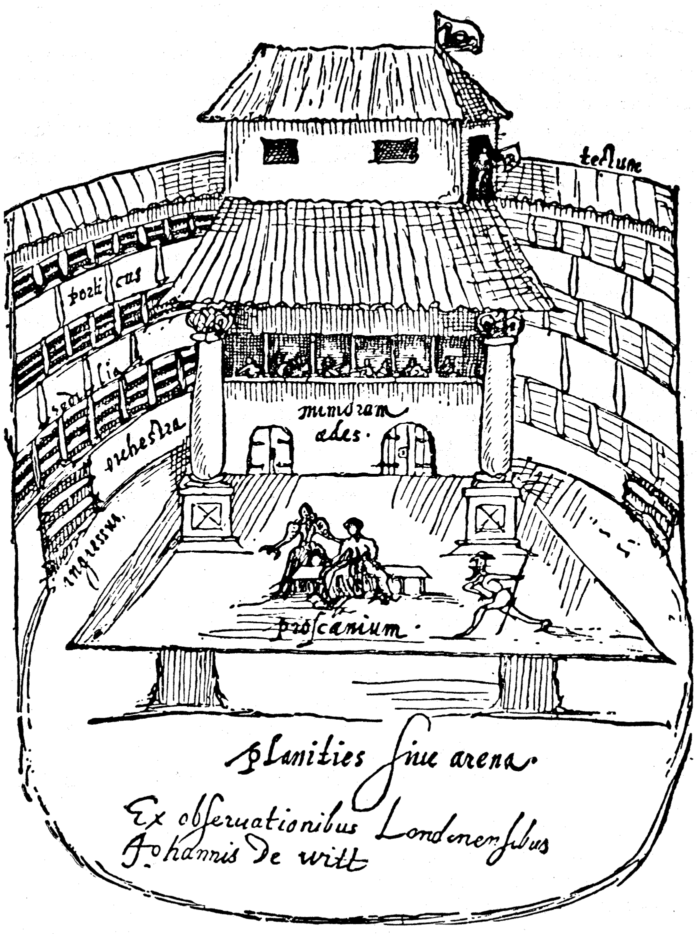


FIG. 10.—A DRAWING OF THE SWAN THEATRE BY JOHANN DE WITT ABOUT 1596, ONE OF THE FEW CONTEMPORARY SKETCHES OF THE ELIZABETHAN THEATRE

The final step is illustrated in the playhouse that is usually called the first modern theatre, the Teatro Farnese at Parma (1618 or 1619), shown in fig. 16. Here the entire stage may be said to have been pushed through the central doorway of the old stage wall, the ornamentation of the Roman skene remaining only as decoration of what is now the proscenium arch—and a very impressive display this residual element makes. The stage within is curtained from the auditorium and is thus adapted to changing pictorial settings. From this time on the curtained stage and proscenium arch are unfailing features of the theatre. The plan of the Farnese theatre is particularly interesting, too, as showing the entry of another influence into the shaping of the auditorium. Instead of a semicircular bank of seats, as illustrated in all the Roman and Renaissance diagrams so far, the auditorium is U-shaped. This influence entered because the masques and court plays had been produced largely in ballrooms or banquet halls, where one end of the hall had been reconstructed for an auxiliary stage and the main floor left free for dancing or as an arena for pageantry, etc. The spectators were ranged around the three sides away from the stage, perhaps in chairs on temporary platforms, perhaps in balconies. Architects combining this U-shaped auditorium with the curtained proscenium-frame stage, pushing the bank of seats forward, soon determined the theatre form that was basic thereafter—the horseshoe auditorium.

The Horseshoe House—17th to 19th Centuries.—It was this Italian plan that became the standard of theatre building throughout the western world, conquering successively the French courts, the courts of Austria, Bavaria and other countries to which the Italian and French Renaissance influence extended, then England and indirectly America. Scenery was soon standardized so that the wings and backdrop restricted the playing space to a wedge-shaped section of the stage floor; and the auditorium sidelines followed the lines formed by the edges of the wings. The picture scene persisted through two and a half centuries, with ever greater elaboration, demanding larger and larger stages; and the auditorium half of the building kept its many-galleried horseshoe plan. With variations toward rounder or squarer auditorium, the general form persisted until late in the 19th century, from smaller court playhouses to immense opera houses.

At first the arena portion of the auditorium was merely a flat floor and consequently the best seats were not there but at the front of the first balcony; and almost throughout the period of the horseshoe theatre the main floor sloped but slightly, thus allowing three, four or five superimposed balconies or galleries.

In the late decades of the 17th century there had occurred an amazing spread of "the Italian idea," and the public theatres everywhere came into line as soon as circumstances permitted. In some countries, nevertheless, especially those in which private theatres, *i.e.*, those of the court or nobles, constituted all the theatre there was, the new buildings incorporating the stage fitted for wing settings and the auditorium shaped like a horseshoe arrived laggingly.

In France there had been, in small number, tennis-court theatres, a sort of feeble analogue to the English Elizabethan stage and the Spanish *corral* theatre. France retained even after 1600 a type of multiple-station setting inherited from the outdoor religious plays. Its stage was hardly more than a "shelf for acting." But as far back as the mid-16th century there had been court occasions when Italian artists? stage machinists and settings had been imported by the French; and in the early 17th century the Italians were putting in full-rigged stages for the French kings, in palace-ballroom theatres.

A painting of King Louis XIII at a performance in Richelieu's ballroom theatre (later the Théâtre du Palais Royal) is typical of this sort of transitional playhouse. In France the Italian proscenium and the Italian operatic setting thereafter remained standard, and as the ballroom auditorium was given up, the horseshoe auditorium was to appear in both private court theatres and in the larger public houses.

The English theatres of the Restoration period were of similar kind. Inigo Jones, who had studied classic ruins in Italy, who had made copious notes on everything Palladian and especially the Teatro Olimpico, designed adaptations of the vista stage and the architectural proscenium, and he staged masques at court. The next step is illustrated in a famous set of engravings (dated 1673) of the stage and its "very elegant frontispiece" in the Duke's theatre in Lincoln's Inn fields (the second house of the name). It shows the typical "elegant" proscenium and a full set of Italian-style in-

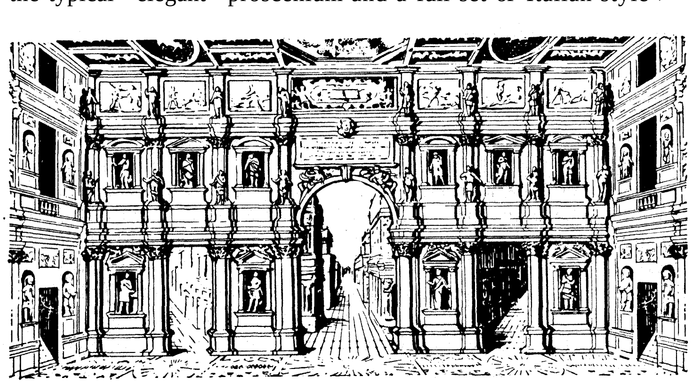


FIG. 11.—DRAWING OF THE STAGE WALL OF THE THEATRE OF THE OLYMPIAN ACADEMY, VICENZA, IT.; SOMETIMES CALLED THE PALLADIAN THEATRE AFTER ITS ARCHITECT, ANDREA PALLADIO (1518–80)

door and outdoor settings. In the transition to the horseshoe auditorium, however, the English were sloner to give up certain advantages of the pre-Restoration playhouses. An apron stage or forestage in front of the curtain, with a doorway or dooraays (up to three) for actors' entrances on either side, remained a feature until the late 19th century. The pit for standees or with benches remained too, the quality seats being all in boxes and galleries above.

Christopher Wren (1632–1723) drew what seems to be the earliest plan of an English theatre with a true horseshoe audito-

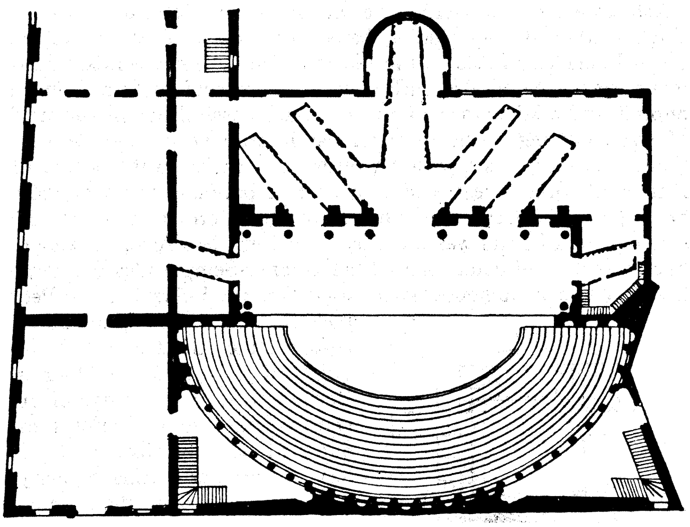


FIG. 12.— PLAN OF THE THEATRE OF THE OLYMPIAN ACADEMY

rium. This may have been a study for the Drury Lane theatre of 1674. With the opening of the equally famous Covent Garden theatre in 1732, the French-Italian type of theatre may be said to have become wholly acclimated in London. Pictures of the interior of Drury 'Lane in 1795 and again in 1842 (rebuilt) show how the progress ended. 4 well-known painting of the Park theatre in New York city in 1822 reveals how closely America followed the English type; though there the builders omitted an auditorium feature that had become standard in most European houses: a tier or tiers of boxes adjoining the proscenium frame at the ends of the balconies or galleries. In the English theatres these boxes looked down on the forestage or apron (as they had in one of the earliest Venetian opera houses in the early part of the 18th century; as they did occasionally in France when the stage jutted before the curtain line); but more often the boxes gave but an awkward and incomplete view of the action.

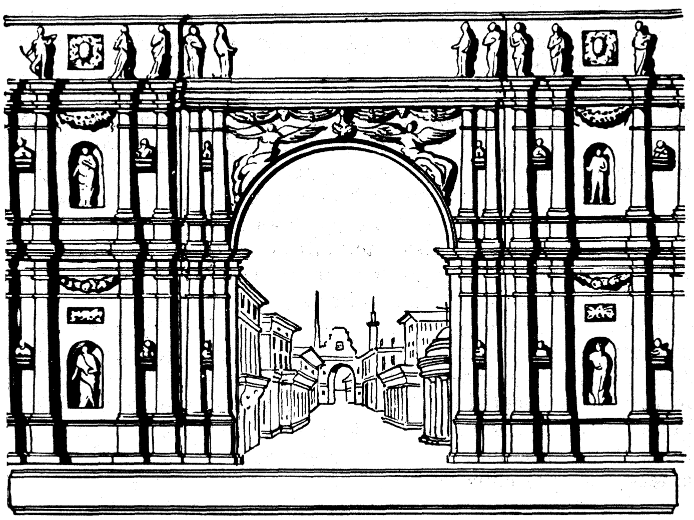


FIG. 13 — ELEVATION BY INIGO JONES OF A WIDENED CENTRAL VISTA. DESIGNED TO GIVE A PICTORIAL BACKGROUND AND PROVIDE ACTING SPACE WITHIN THE VISTA

One other transitional building must be mentioned: the famous Schouburgh in Amsterdam as shonn in an engraving dated 1638. In a rough semicircle backing the acting platform are apparently some relics of the simultaneous or station stage of the mediaeval mystery plays. centring in a construction not unlike the outdoor *Rederijker* stages, but with openings for vistas and, well forward, provision for a curtain to veil changes. But Holland was soon moving into the international current and the history of its theatres after 1750 is little different, architecturally, from that of other European countries.

These and many lesser exceptions aside, the horseshoe playhouse, arriving as a type in the late 17th century, dominated theatre building through the 18th century and the 19th. It is easy to visualize it in terms of the great and regally decorated monuments such as the San Carlo Opera house in Naples, La Scala in Milan, Drury Lane, the Théâtre Français, the Burgtheater (originally the Hofburgtheater) and the Opera in Vienna, the Paris Opéra and New York's Metropolitan Opera house.

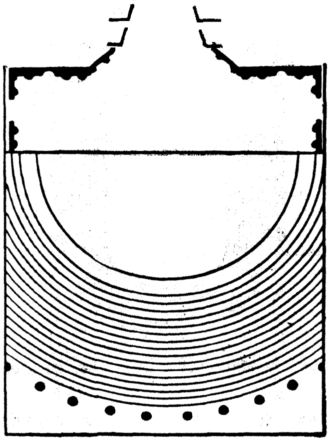


FIG. 14.— PLAN OF FIG. 13

With the great multiplication of commercial theatres in the 19th century, effort was sometimes made to equal the architectural showiness of these monuments, but more often to duplicate their plan on a smaller scale.

Practically all descriptions of Renaissance and later theatres begin with accounts of the stage arrangements and the plan and appointments of the auditorium interior. The exterior architecture is seldom mentioned. So many post-Roman theatres at first were constructed inside existing buildings that there was seldom a concern for façades. If at court, a ballroom or a courtyard was assigned. "Public" theatres were squeezed into. among other buildings, tennis courts (which were roofed in those days), innyards, even bear-baiting "gardens" and riding schools and warehouses. The grander continental theatres of the 18th and 19th centuries were, however, erected as independent entities, often dominating a small park or city square.

Palladio. Inigo Jones, Christopher Wren, Gottfried Semper and Karl Friedrich Schinkel were architects who came to be associated with theatre projects. But there emerged no theatre style, unless it was a species of Baroque as brought in by the scene designers and architects of the Galli da Bibiena family in the late 17th and the 18th centuries. They practised internationally. The style, debased into French Rococo, found new release in the Paris Opéra built about 1870 by (Jean Louis) Charles Garnier. Between 1700 and 1870 more sober architects had fitted their theatres with casings designed in whatever derivative style was in vogue at the moment. Italian Renaissance had come first, then Baroque, followed by the softer French Renaissance and Rococo, and through the cycles of Greek Revival and Roman Revival.

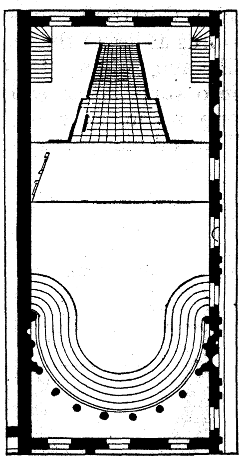


FIG. 15.— PLAN OF NARROWING VISTA. THEATRE AT SABBIONETA, IT., BUILT BY SCAMOZZI IN 1588

Unfortunately the capital cities of the world. and especially those of the royal and ducal courts in Europe, felt that the Garnier monument, the Paris Opéra, chef-d'oeuvre of lavish Rococo or showy Exposition architecture, was a model perfectly suited to house the art of the theatre and a regal achievement to be jealously copied. Official theatres from the Royal theatre at Wiesbaden (1894) and the National theatre in Prague (1883) to the National theatre in Mexico City (20th century) emulated this "style," at least so far as the sumptuous air and overdecoration a ere concerned.

It is a melancholy truth that pictures of theatres seldom appear in books illustrating the history of the art of architecture, so nondescript are the outward appointments. A few monuments consistently stylized are exceptions to the rule: Schinkel's Schauspielhaus in Berlin, severely classic; the somewhat stodgier Opera in Vienna, in controlled French Renaissance; and some would say the Haymarket theatre in London.

Theatres of 1900–30.—The main changes in the construction of early 20th-century theatres, when the builders of commercial houses became leaders, were the exclusion of all but one balcony and the steeper tilting of the main floor, thus throwing the best seats into the orchestra. It had been noted that the horseshoe form provided a considerable number of bad seats, in the proscenium boxes, at the gallery ends and even at the ends of the orchestra rows. The proscenium boxes were therefore generally abolished, then all the side galleries; and the auditorium, in relation to the proscenium frame, was narrowed and eventually was made fanlike.

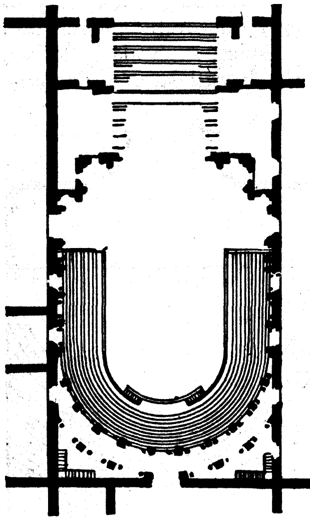
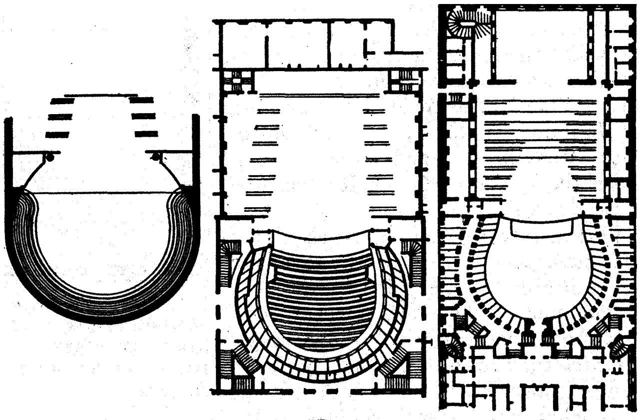


FIG. 16.—PLAN OF THE TEATRO FARNESE, PARMA, IT. (1618–19), CALLED THE FIRST MODERN THEATRE

With the coming of more realistic standards in stage setting, with the disappearance of the old-style painted wing settings and the appearance of the box set (for interiors at least), the old vista lines, marking the edges of the wings or flats, no longer needed to determine the auditorium sight lines.

The Germans were the first to reform the horseshoe auditorium, and the finer monuments of the simplified style are in Germany; but the American theatres built after 1900 were generally in the new idiom. In France and Italy the 18th–19th century tradition persisted more stubbornly. The contracted orchestra remained and the best seats (for seeing the play) were in slightly raised rings of loges and in the front of the first balcony just above.

A remarkable example of advanced thinking about theatre design had occurred in 1876, when the Wagnerian Festspielhaus at Bayreuth in Germany was constructed. The architect was ostensibly Gottfried Semper, but it was Wagner who sketched out (in words at least) the requirements that led to the revolutionary fanlike auditorium. He demanded that every spectator face directly into stage space and have sight into full stage depth—so that only a bank of seats, the rows slightly curved, could be utilized. The full plan of the revolutionary building is shown in fig. 18.



A B C

FIG. 17.—PLANS OF THEATRE DESIGNS USED FROM MIDDLE 17TH TO LATE 19TH CENTURY: (A) DRURY LANE, LONDON. (B) THÉÂTRE FRANÇAIS, PARIS (1790). (C) LA SCALA, MILAN (1778)

In Germany the impulse was taken up by Max Littmann and he became the outstanding theatre architect of the early 20th century. His Prince Regent theatre in Munich, his Schiller theatre in Charlottenburg, Berlin, and his Kiinstlertheater in Munich, all with simplified banks of seats, had influence throughout Europe and the United States. The Kiinstlertheater especially delighted the generation of young theatre artists who became disciples of Adolphe Appia and Edward Gordon Craig in the decade after 1915. Its chaste exterior in modern style and its simple interior, with the single, rather steeply sloping bank of seats, as seen in fig. 19, seemed perfectly fitted to the ideals of the new stagecraft. Littmann experimented also with adaptable proscenium frames in an effort to take advantage of the enlarged possibilities in the field of stage lighting, One of the most impressive of 20th-century theatre façades, this marking a return to classic motifs, is that of Littmann's State theatre in Stuttgart, a building group actually housing two theatres. In the hands of other German architects the simple bank of seats was modified to a form less severely wedgelike. Oskar Kaufmann adapted the Wagner-Semper idea to a large theatre (with an immense "space stage") in the Volksbiihne or People's theatre, a socially advanced co-operative theatre in Berlin (fig. 20B). His Kroll Oper in Berlin added to the wedge of orchestra seats some useful remnants of balcony boxes and gallery, for greater seating capacity, without impairing the atmosphere of spacious modern decoration or the utilitarian sight lines, and in the Volksbuhne he only modified the old-time three galleries. At Stratford-on-Avon in England the new Shakespeare Memorial theatre built in 1932 followed closelv the German reform models, especially those of Littmann.

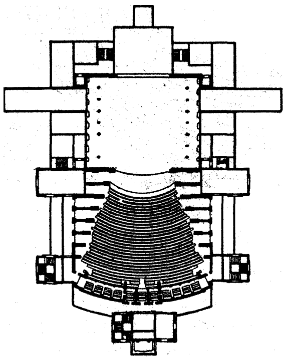


FIG. 18.—PLAN OF THE BAYREUTH FESTSPIELHAUS, GOTTFRIED SEMPER, ARCHITECT. THE FAN SHAPE WITH STRAIGHT SIDES AND A WIDE SPLAY WAS USED

In America the squeezing out of balcony, gallery and boxes was a slower process; at any rate there were fewer examples than in Germany of the total reform of the horseshoe-and-hencoop auditorium. But soon after 1900 the American commercial theatres had got well along toward a standard fan-shape plan. The orchestra, enlarged and scientifically tilted, contained the best seats. Above this at the back there was one balcony. Metal construction and modern engineering made it possible to dispense with the troublesome pillars and posts that had been all too conspicuous in many earlier examples.

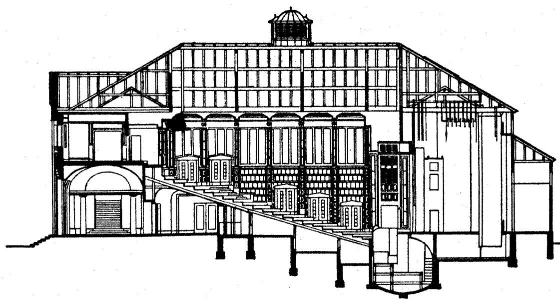
In large cities, especially New York, where ground value was an overwhelmingly important consideration, the commercial theatres were commonly built with shallow stages, wider proscenium openings and wider auditoriums. Ingenious solutions were found to the problem of fitting such a house to small and sometimes irregularly shaped sites. Standard fire laws imposing the necessity for a certain number of aisles and adjacent doorways and certain types of fire escape, laws not kept up to date in view of progress abroad, hampered American architects.

There were, however, theatres in New York early in the new century which approached the German "modern" standard. Three may be briefly described as typical. The Little theatre, opened in 1912, circumvented the laws that hampered neighbouring playhouses because its seating capacity (originally) was only 299. In basic plan and outline it approximated the most advanced houses abroad, as indicated in fig. 20A.

In 1927 there opened the Ziegfeld theatre, which was intended to be a model American theatre for large musical productions. One of its two architects, Joseph Urban, had been intimately connected with reform theatre and art movements in Austria and Germany before settling in America in 1911. He planned the Ziegfeld theatre technically on the latest continental models and decorated it gaily because it was particularly designed for musical shows of the "Follies" type. Joseph Urban also designed theatres for moving pictures—but these, with their different requirements, are part of another story.

The builders of the Guild theatre in New York, after assembling advice from a great number of modern stage designers and architects, provided a house undistinguished in its decorative features but logically adapted to modern methods of staging and affording a fair view from every seat. The longitudinal section and plan of the orchestra floor, fig. 21, indicate that at this time the last vestiges of the 19th-century horseshoe auditorium with boxes had been exorcised.

The one feature at first glance apparent in these three American theatres, as distinguished from the same type as developed in Germany, is the breaking-up of the orchestra with two aisles. In Europe theatre architects traditionally have allowed more space between rows of seats, and entry to each row is from the ends. Thus the modern orchestra was one solid bank of seats (fig. 20B). The less generous allowance of space to each seat in America, added to the very strict laws about access and exit (after disastrous fires), brought about the specifying of a certain number of aisles per length of seat row.



FROM LITTMANN, "DAS MÜNCHENER KÜNSTLER THEATER"

FIG. IS.— SECTION OF MUNICH KÜNSTLERTHEATER, SHOWING THE STEEPLY SLANTING FLOOR

Except for the breaking-up of the banks of seats, the American theatre of the early 20th century seemed simpler in plan than the German. There were smaller lobbies, fewer vestibules and social rooms and the dressing rooms for actors were relegated to positions above or below the orchestra level. This again was due to excessive ground cost in the large cities.

The great accumulation of machinery for changing scenery, which had grown and grown since the days of the Italian and French Renaissance ballroom theatres, reached a peak about 1900; and machinery for electric lighting had then become complicated and cumbrous. A building such as the Paris Opéra might have as many as eight floors (or the equivalent space) above and below stage to facilitate handling of scenery; and as late as 1901 Littmann built the Prince Regent theatre in Munich with extraordinary over-stage and under-stage space—contrasting strangely with the simplified single-bank auditorium. But when the ideals of Gordon Craig and Adolphe Appia found wide support, especially as to the de-emphasizing of scenery and the need for an artist-director as co-ordinator of all the elements of production, a new simplification of stage equipment was initiated. There was considerable experimenting with turntable or revolving stages, with wagon and elevator stages and with other devices calculated to effect changes of scene quickly and so to do away with the stage house in which painted flats were "flied" or hung (from, technically, the gridiron). This house above stage had been a bother to architects who wanted to afford a consistent period look to the exteriors of their theatres. But it must be said that the reform movement of 1910–30 failed to relieve the theatre of the high storage building for hanging flats and curtains, though it did bring in a great deal of simplification of stage machinery. In the same years lighting engineers developed equipment of almost miraculous variability, flexibility and delicacy, the whole controlled from a single switchboard.

The latest of the historic type theatres was, then, this house that took shape especially in Germany, a little later by reflection in America. In the end, hardly a country in the western world escaped the influence. France, England (where the new stagecraft was very slow in gaining converts), Scandinavia, Czechoslovakia and many another country might yield pictures of similar, if generally later houses. Most would show an exterior indicating the basic nature of the division of space within: auditorium lower than of old, with towering stage house at back; within, a bank of seats, on a floor uniformly sloping or slightly saucer-shaped, more tilted than during the horseshoe period, restricted at the sides along lines determined by the edges of the proscenium portal (which, of course, had lost most of its ornamentation). And there was one balcony—generally. This might be called the conformist theatre of, say, 1930.

***Nonconformist Theatres*, 1915–35.**—Between **1915** and 1935 there was an unprecedented ferment of ideas about "new" ways of staging plays. Revolutionary opinions, especially about bringing the actor clear of the old clutter of painted scenery, clear even of any contrived setting, were heard in many countries. Individualistic plans for new theatres, mostly starting from the premise that the proscenium-frame playhouse was due to be scrapped, were committed to paper—and sometimes became the basis of actual buildings. Since no type theatre was widely established, all this effort must be summarized very briefly.

First of all, there was agitation for a return to the architectural stage. The Elizabethan or Shakespearean theatre was most often thrust forward as a model, though this must be put down as far more than a revivalist activity. Probably the first attempt to recapture the intimacy and vividness of forestage acting before an unchanging architectural structure was that of Karl Immermann, who built his "Shakespeare Stage" at Diisseldorf in 1840. Similar projects were under discussion during the decades following; but only after 1910 were theatres with architectural stages built in any number—and then only by the little theatre groups. The most professional and by far the most fruitful artistically of the permanent-stage theatres was the Théâtre du Vieux Colombier in Paris. The animating genius there was Jacques Copeau, the wisest and most lovable of all the members of the group of idealists and reformers in Paris. Associated with him was Louis Jouvet. The Vieux Colombier stage was a very free adaptation of Elizabethan models. A number of interchangeable elements or units were added, in the nature of screens, sections of stairs, curtains, etc. Yet with all its possibilities of change of mood in setting, it had no provision for the picture scene. For a few years it was the world's foremost progressive stage.

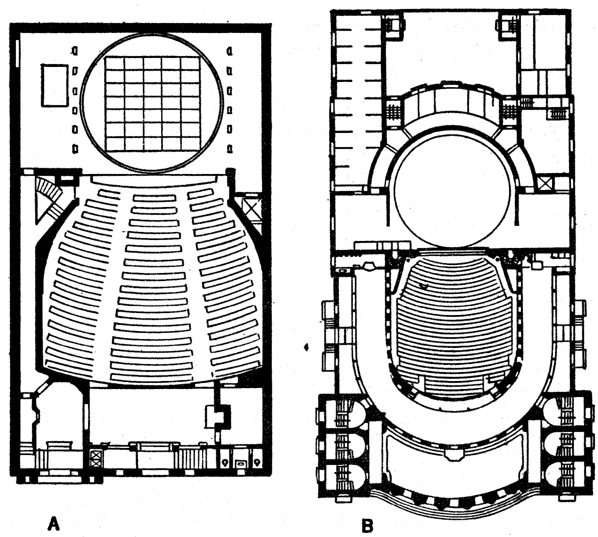
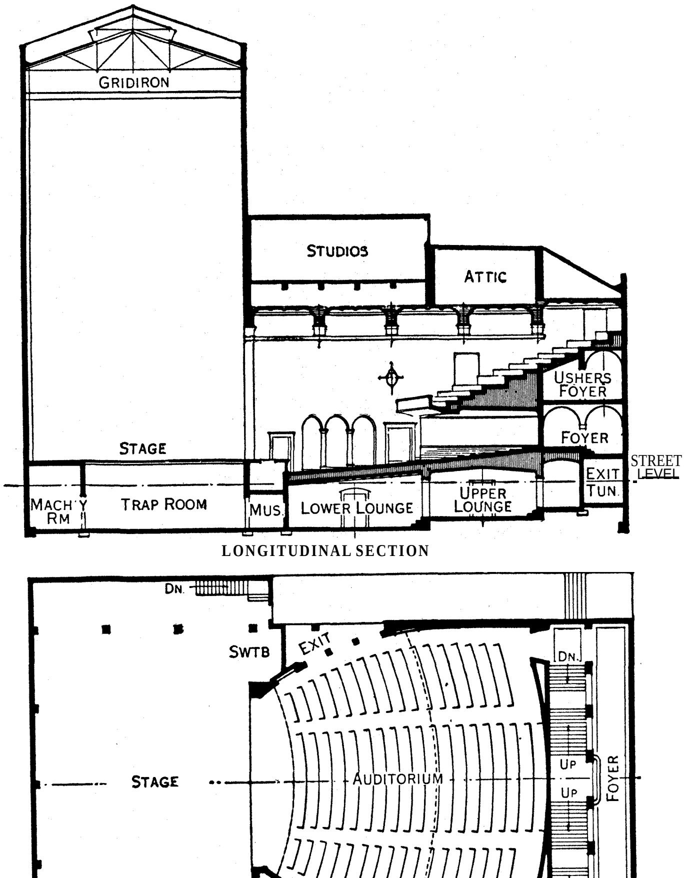


FIG. 20.— EXAMPLES OF FLOOR PLANS OF EARLY 20TH-CENTURY THEATRE BUILDINGS: (A) THE LITTLE THEATRE, NEW YORK CITY: HARRY C. INGALLS AND F. B. HOFFMAN. JR., ARCHITECTS. (B) VOLKSBÜHNE (PEOPLE'S THEATRE), BERLIN; OSKAR KAUFMANN, ARCHITECT

Adolphe Appia never had a theatre of his own, but his drawings of simplified and mood-creating stages cannot be overlooked as influences. So too, in America. Norman Bel Geddes published a considerable number of plans for "theatres of the future." He, too, failed to see any planned playhouse built, but his drawings of scenes as they would be in circular or circuslike theatres—that



GROUND FLOOR PLAN

FIG. 21.— PLAN OF GUILD THEATRE. NEW YORK CITY. DESIGNED BY C. HOWARD CRANE. FRANZHEIM AND BETTIS. ARCHITECTS

is, theatres in the round—encouraged the longest-lasting impetus carrying on from the 1915–35 period; *i.e.*, production in the round.

What is generally termed the space stage does not necessarily demand abolition of the proscenium arch. It is only that the space within which the actors appear is darkened and the figures are picked out by localized light. The settings, if any, are fragments of wall or possibly a hummock or a small platform with steps—never a full stage picture. Perhaps the finest staging of the sort was accomplished at the Volksbiihne in Berlin during the 1920s, on a proscenium-framed stage.

For production in the round, in the full sense, there were and are innumerable improvised theatres. In these the audience surrounds the acting platform on at least three sides, if not full circle. As a matter of fact, the one great exemplar of this type of theatre failed considerably of closing the circle; but in the Grosses Schauspielhaus in Berlin (constructed in a circus building) Max Reinhardt presented many extraordinarily vivid productions. He dramatically utilized the immense forestage to keep his actors in intimate contact with the spectators, but he took advantage of an inner regular stage too.

In the United States the testing of new ways of staging, in the face of a great decline in production at the commercial theatres, fell to the university and little theatres, or to the few community theatres. But the best of the community theatre houses, notably those at Pasadena, Calif., and Cleveland, O., were built within the proscenium-stage type. Certain of the university playhouses are perhaps the finest theatres in America—say those at the University of Iowa, Iowa City, the University of Wisconsin, Madison, and, a little older in type, Yale university. But these too have the proscenium frame.

Nowhere in America, indeed, has experimental staging led to the building of nonconformist houses as important as the Théâtre du Vieux Colombier or the Grosses Schauspielhaus. The Russian producers, who were the world's foremost adventurers in new ways of staging between 1920 and 1935, fitted some of their improvised theatres with forestages and some with banks of seats not unlike Greek theatre auditoriums; but there is no report of a standardized new type of house.

Most heralded was the Theatre of the Young Spectator, or more simply the Children's theatre, in Leningrad, which seated 600 spectators in a semicircular Roman-type auditorium, with an enlarged orchestra pit arena, a forestage and small inner stage. The constructivist type of setting, which is considered especially an invention of the Russians, demands no more than a stage with a decently wide proscenium portal, though it can be fitted upon a forestage or in an arena as well.

All these individualistic theatres, and the theories behind them—theories looking forward to the elimination of the proscenium-frame house (and the "peephole stage" that especially represented late 19th-century realism)—all these developed before 1935. They represent historic advanced thought about theatre architecture as it existed before World War II.

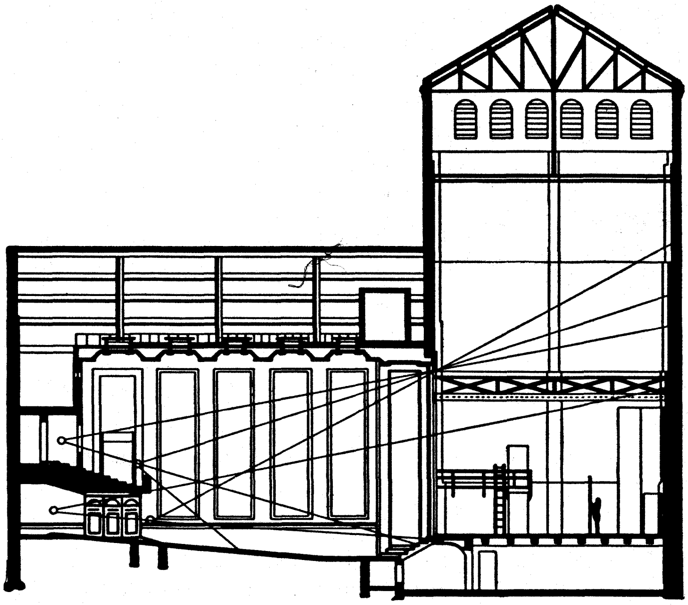
BIBLIOGRAPHY.—In English one book is outstanding as regards physical changes in the theatre's form: Allardyce Nicoll, *The Development of the Theatre*, 3rd ed. rev. and enl. (New York. London, 1948). It is profusely illustrated, particularly in the areas of Roman, Greek and English playhouses. *See* also George Altman, Ralph Freud, Kenneth Macgowan and William Melnitz, *Theater Pictorial: a History of World Theater as Recorded in Drawings, Paintings, Engravings, and Photographs* (Berkeley, Calif., 1953; Cambridge, 1954). This is primarily a collection of scenes and settings, but includes views of stages and auditoriums, with historical notes. Notable as offering, in a monumental work, views and plans of the theatre of one era is Edwin O. Sachs, *Modern Opera Houses and Theatres*, 3 vol. (London, 1896–98); it memorializes the regal-display, horseshoe houses and the beginnings of the German reform movement. Succinct and useful still is Martin Hammitzsch, *Der moderne Theaterbau* (Berlin, 1906). For further guidance the researcher should consult Nicoll's book, which includes extensive bibliographies. (S. CHE.)

DESIGN AND CONSTRUCTION OF MODERN THEATRES

Since the Renaissance the design and construction of theatres, their auditoriums and their stages, have been determined by three factors: (1) the relation of the actors to the stage and the stage setting; (2) the relation of the actors to their audience, as influenced by methods of acting and stage setting; and (3) the size and social status of audiences which patronize theatres and make them popular and potentially profitable.

As these factors change, the essential parts of a theatre change with them. namely the stage itself, including its apron or forestage, the dimensions of the stage house or backstage, the plan and seating arrangements of the auditorium. It is therefore necessary to summarize briefly the development of theatre architecture by way of understanding how the basic elements of theatre design function.

No innovation, modern in its own day, has ever been wholly original. Each in turn has revived and modified theatre structures of earlier epochs. The first Renaissance theatre, the Teatro Olim-



BY COURTESY OF "THEATRE ARTS" MAGAZINE

FIG. 22.---CLEVELAND PLAYHOUSE. 1927. SMALL AND ROWLEY. ARCHITECTS

pico at Vicenza (1584), used the steeply pitched, semicircular arena seating of the Roman theatre and simplified its elaborate architectural facade back of the platform on which the actors played, piercing it with three portals through which vistas of streets in perspective could be seen. In the Teatro Farnese at Parma (c. 1618)) the stage had a single wide curtain in an ornamental frame, the proscenium, which became a permanent part of theatre design for three centuries in every royal, state or commercial theatre in Europe and the United States and remains one prevalent type of stage familiar to every theatregoer.

The auditorium of Wagner's Festspielhaus at Bayreuth, a revolutionary innovation in 1876, reproduced almost exactly the seating arrangements of the Teatro Olimpico. Max Reinhardt, for his Grosses Schauspielhaus, Berlin, 1919, remodelled an existing circus arena, using it for much of the action of his spectacular pro-

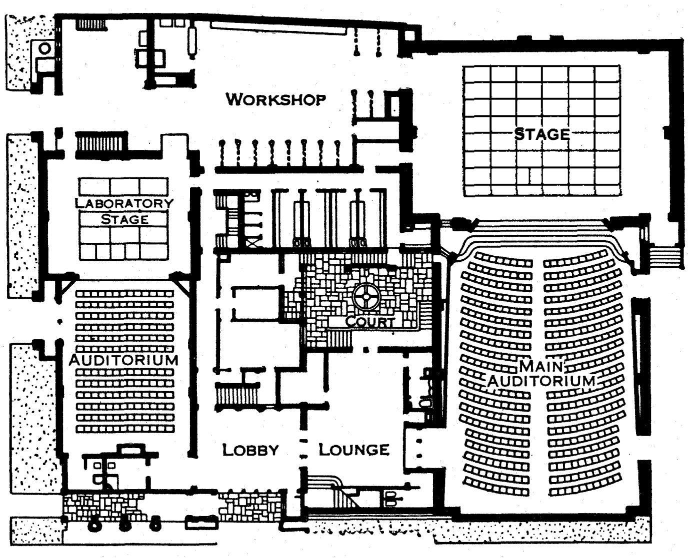


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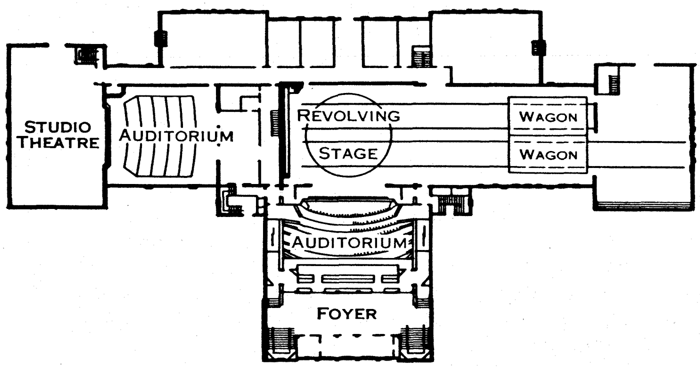
FIG. 29.— PLAN OF THE CLEVELAND PLAYHOUSE

ductions, and added a bare platform stage at one end—a combination of a Roman gladiatorial arena and a Roman theatre. The Volksbühne in Berlin adopted the same general scheme. Entrance doors or portals at either side of the proscenium opening, a standard feature of London theatres throughout the 18th century, were revived at the Provincetown playhouse, New York city (1923), Smith college, Northhampton, Mass. (1928), the University of Wisconsin theatre (1939) and at numerous other college theatres. Reproductions of the Shakespearean stage, either replicas or modifications of the basic structure of the Globe theatre or the Curtain theatre, were built at the Folger library, Washington, D.C., the Shakespeare Memorial theatre at Stratford-on-Avon, Eng., and at Stratford, Conn. The theatre designed for the Cologne exhibit of modern architecture, 1914, was permanently divided in three parts that could be used simultaneously or closed off by curtains in alternation; it revived the simultaneous settings of the Hôtel de Bourgogne, Paris, 1609, and the arrangement of the wagon stages on which allegorical tableaus were performed in the streets of Flemish and French cities during the 16th and 17th centuries for the festivities that greeted visiting royalty. The semicircular extended forestage of the Civic theatre, Malmo, Swed., 1944, is similar to forestages used for ballet interludes at the Drury Lane and the London Opera house, *c.* 1809. Modern directors who deride the proscenium stage as a mere peep show and have established theatres in the round, where actors are encircled by the audience, in turn revive the actor-audience relationship of the primitive ritualistic performances of Africa and Asia.

Influence of Popular and Literary Taste.—The popularity of the proscenium was originally due to another Renaissance innovation—architectural and landscape vistas, receding to a vanishing point within a picture frame, established by the masters of Renaissance painting. The first perspective stage settings were three di-



BY COURTESY OF "THEATRE ARTS" MAGAZINE

FIG. 24.— PLAN OF THE UNIVERSITY THEATRE, STATE UNIVERSITY OF IOWA, IOWA CITY. G. L. HORNER AND R. C. SANBERG. ARCHITECTS

mensional, but the illusion of vast distance in a limited space was soon heightened by painted perspectives of soaring vaults and colonnades, as in the designs of a great family of Baroque artists, the Calla da Bibienas.

At the same time, directors, playwrights and audience were eager to witness spectacular productions with many changes of scene. Molière, who supposedly declared that all he needed to stage a play was three boards and a passion, as a theatrical manager reconstructed the Palais Royal theatre, occupied by his company, in order to accommodate elaborate scene-shifting machinery. The royal theatre was known as the Hall of the Machines and a favourite effect was the gloire or apotheosis, in which as many as 30 or 40 actors, costumed as Olympian deities, were seated on platforms masked with tinsel rays and silhouettes of clouds; these were lowered and suspended in mid-air above the stage as a spectacular finale to a performance.

Where scene shifts were originally made by sliding flats on and off stage in a series of grooves or slots, the increasing weight and elaboration of stage settings required machinery for lowering scenery and hauling it out of sight. Before the middle of the 19th century the grooves became obsolete. Backdrops, platforms or flats were suspended overhead from beams, the flies. counterweighted with sandbags and lowered into place on hemp lines, tied off to a pinrail or fly gallery, similar to the system used for handling the rigging of sailing ships. With the substitution of a metal gridiron and a pinrail at stage level, this counterweight system remains a permanent part of stage equipment. For efficient use it requires a sufficiently high stage house and thus determines one important building cube in theatre construction.

The spectacle of a performance was not confined to the stage. The auditorium plan adopted was U-shaped with shallow tiers of balconies or boxes where, during the intermissions, the socially élite, plutocrats or the nobility, could display themselves and be seen by the commoners or bourgeoisie seated on the orchestra floor. This remained the prevalent plan for theatres and opera houses throughout the 19th century; the first tier of boxes at the Metropolitan Opera house in New York city was known as the "diamond horseshoe."

This basic plan was modified by three trends: the decline of the aristocratic or titled classes as a political and social influence; the rise of democracy; and the introduction of iron and steel in building construction. Deep cantilevered balconies increased the number of theatre seats and improved their sight lines. These, with a realignment of orchestra seats in a fan-shaped or flattened arc, became the basic elements of a theatre plan.

Two other developments, one technical and one literary, also modified theatre design. The first was the introduction of gas-lighting in the 1850s and of electricity in the late 1870s. Until then the principal source of illumination consisted of huge candle chandeliers, usually three, hung directly in front of the proscenium arch; by comparison the stage itself was dim. Actors came forward in order to be seen, and the prevalent rhetorical style of acting in classic and romantic drama reinforced this tendency, tirades and soliloquies being delivered directly to the audience as verbal arias. The second development was the growth of realistic play-writing. With this and the introduction of the box set, the proscenium opening became an invisible fourth wall; behind it the actors moved in factual reproductions of palace halls, living rooms, cafés, kitchens or hovels. The illusions of painted perspective seemed artificial, destroying the new illusion of reality which, both in theory and practice, became the artistic goal of directors and playwrights. As a result, stage settings became increasingly architectural with built columns: cornices, doorways, stairways and balconies and even mythical sites monumental in scale.

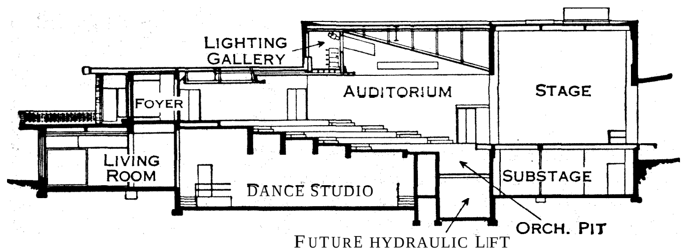
In consequence theatre technicians and architects of German and Austrian state and municipal theatres enlarged the stage house and equipped it with elaborate machinery for handling and shifting stage settings.

In the Dresden Royal theatre Max Littmann divided the entire acting area with three elevator stages that sank to cellar level where wagon stages (on rolling platforms), each containing an entire setting, were speedily slid into place and raised to stage level. Similar shifts could be made at stage level. Another technician, Karl Lautenschlager, introduced the revolving stage, used in the popular theatre of Japan, a turntable at stage level, and enlarged it to hold several settings which could be rotated into view. The depth of the stage was increased to house plaster domes that, under diffused lighting, replaced sky drops and heightened the illusion of atmospheric depth.

The Declining Professional Theatre.—No important contribution to theatre design was made in the theatres built in New York city between 1903 (the Lyceum) and 1927 (the Ethel Barrymore). The total number of such legitimate theatres in operation (*i.e.*, for the production of plays or musical comedies) dwindled steadily in and after the 1930s, many having been demolished or converted into motion-picture houses or television studios. These "Broadway" theatres, crowded into an area roughly half a mile square, with capacities ranging from 500 to slightly more than 1,700 seats, were built on expensive, centrally located real estate with costs of construction running from $500,000 to $1,000,000. As a result, plottage was reduced to a minimum, and with the exception of the Guild theatre and the Ziegfeld the stages were constricted in width, depth and height and lobby and promenade space was inadequate. Façades were a pastiche of some historic style such as Georgian or Hispano-Moresque or a hybrid combination of several.

In order to encourage theatre building, the New York city code was revised so that a theatre could be made part of a larger office or business building, thereby enabling it to carry only a portion of the real estate: maintenance and construction costs of any site.

The Resurgent Amateur Theatre.—The total number of professional theatres throughout the United States, housing either local stock companies or Broadway plays on tour. also dwindled during the same period to scarcely more than 200 by the 1960s.

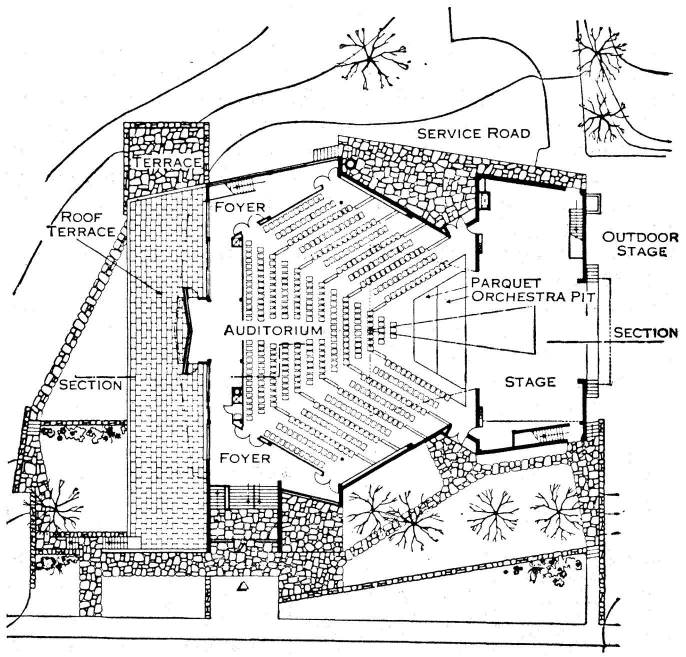


BY COURTESY OF "ARCHITECTURAL FORUM"

FIG. 25.—SARAH LAWRENCE COLLEGE THEATRE, BRONXVILLE, N.Y., MARCEL BREUER. ARCHITECT

(In 1885 there were more than 5,000 theatres in about 3,500 towns and cities.)

During approximately the same period, the number of college and university theatres increased to almost 2,000. It was in this field, including the allied one of civic centres, that modern theatre architecture had progressed by mid-century. Notable examples were the Pasadena Community playhouse (1925), the Yale University theatre (1926), the Cleveland playhouse (1927), the Kalamazoo (Mich.) Civic auditorium. (1931), the Avery Memorial, Hartford. Conn. (1934), the University of Iowa (1935), the University of Wisconsin (1939), Oberlin (O.) college (1953), Sarah Lawrence college, Bronxville, N.M. (1951), and the University of Arkansas, Fayetteville (1950).

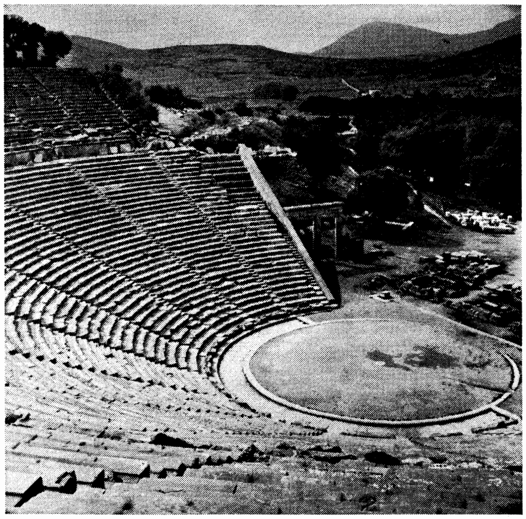


BY COURTESY OF "ARCHITECTURAL FORUM"

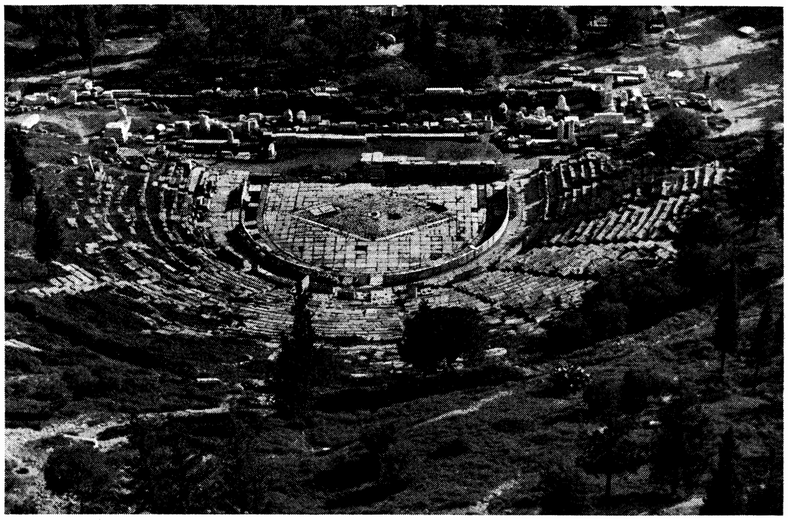
FIG. 26.— UPPERFLOOR PLAN. SARAH LAWRENCE COLLEGE THEATRE

Such theatres give an opportunity for integrated planning and functional design. The commercial theatre, crowded into a constricted plot between business buildings, was and is nothing more or less than a boarding house, rented to temporary tenants who have either to provide the excess profits of a "smash hit" or vacate the premises.

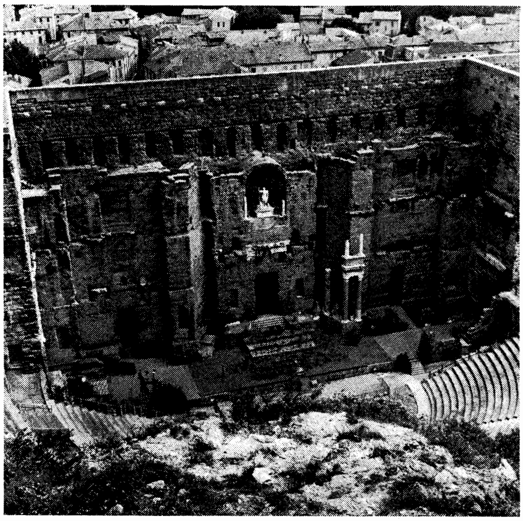
On the other hand, college and civic playhouses. like the municipal and state theatres of Europe, are considered of enough cultural importance to be endowed. Exterior design becomes not a mat-



Cavea (seating area), orchestra and (right) ruins of the stage buildings of the Greek theatre at Epidaurus by Polyclitus, *c.* 340 B.C.

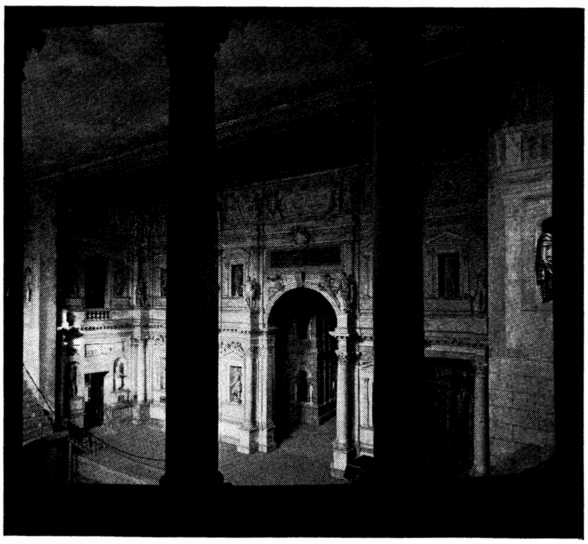


Theatre of Dionysus, Athens, showing the paved orchestra enclosed within a low wall, an addition which was made to the original Greek structure by the Romans about A.D. 54–68



Stage and *frons scaenae* (front wall of stage building) of the partially restored Roman theatre, Orange, France: *c.* A.D. 50

Remains of the Roman theatre on the shore of the Mediterranean sea near Tripoli, Libya, dating from the 3rd century A.D. The *cavea* seated 5,000 persons



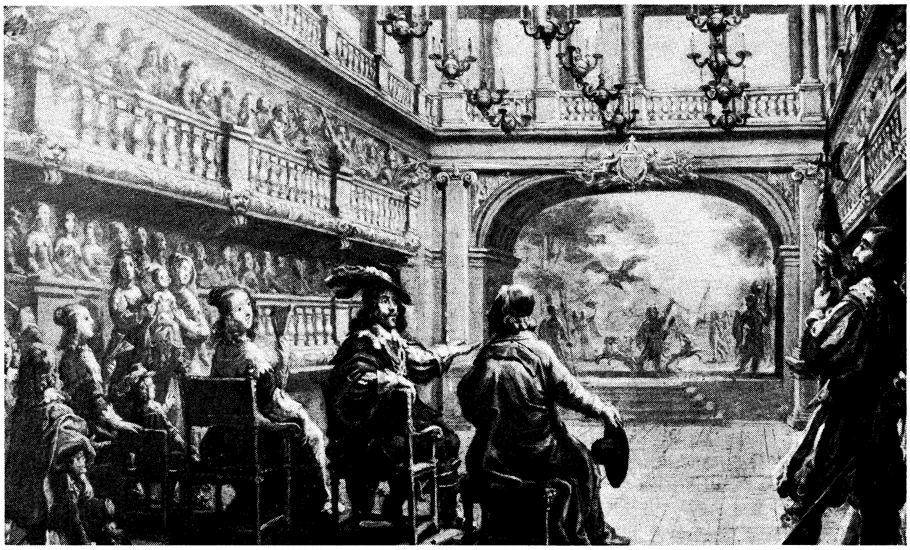
Teatro Olimpico, Vicenza, Italy, a theatre designed in the Roman manner by Andrea Palladio and Vincenzo Scamozzi, 1580–85

Permanent architectural frontispiece of the Farnese theatre, a Renaissance court theatre at Parma, Italy; designed by G. Aleotti, 1618

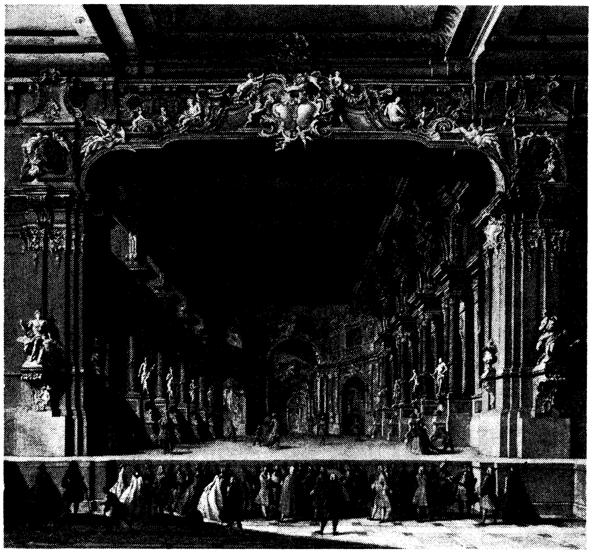
GREEK, ROMAN AND RENAISSANCE THEATRES

PHOTOGRAPHS. (TOP LEFT) N. HADJISTYLIANOS, (TOP RIGHT) ALISON FRANTZ, (CENTRE LEFT) PAUL ALMASY, (CENTRE RIGHT) UNITED PRESS INTERNATIONAL, (BOTTOM LEFT) G. E. KIDDER SMITH, (BOTTOM RIGHT) FOTOCELERE, TURIN

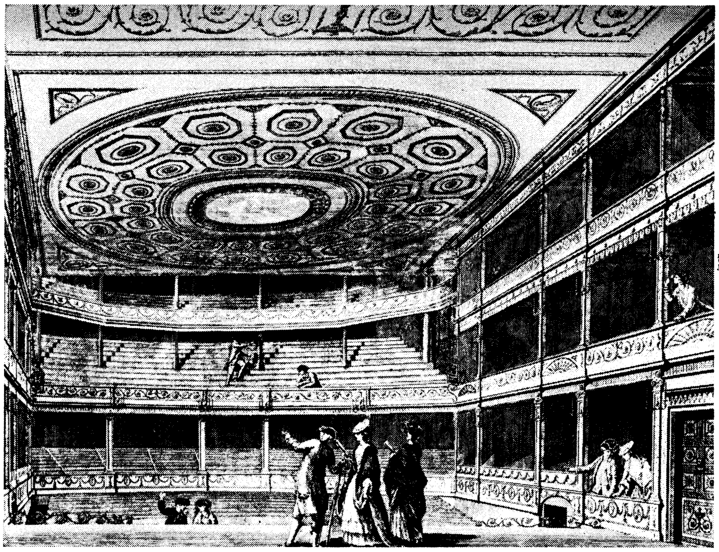
The Petit Bourbon, Paris, as illustrated in the frontispiece by J. Patin to Baltazarini's ***Balet comique* de *la Royne,*** 1582



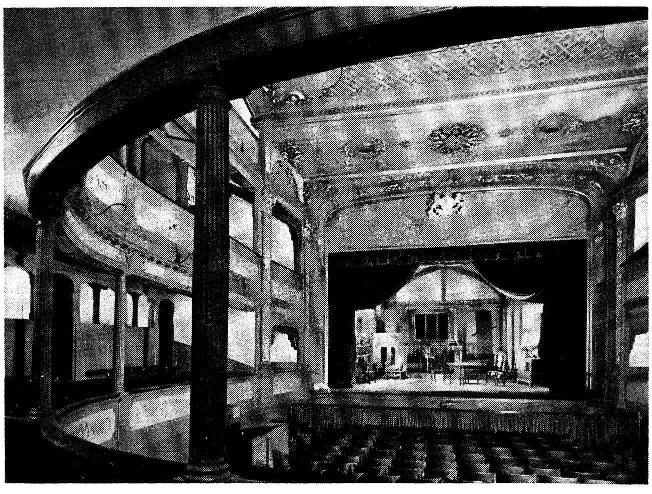
Anne of Austria, Louis XIII and Cardinal Richelieu at a performance in a 17th-century French theatre, probably the Théâtre du Palais Royal, Paris



Interior of a baroque theatre, from a painting ascribed to one of the Galli da Bibiena family, 17th-18th-century Italian artists



Theatre Royal, Drury Lane, London, adaptation by Robert Adam in 1775 of Christopher Wren's 1674 building. After an engraving by Adam, figures corrected in accordance with scale drawings in Soane collection



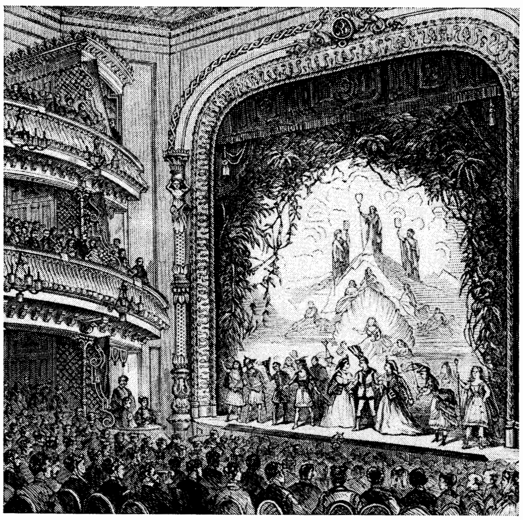
The Theatre Royal, Bristol; J. Paty, 1766. This building in its original form closely resembled Wren's Drury Lane

View of the six semicircular tiers of boxes (loges) in the La Scala opera house, Milan, Italy; 1778

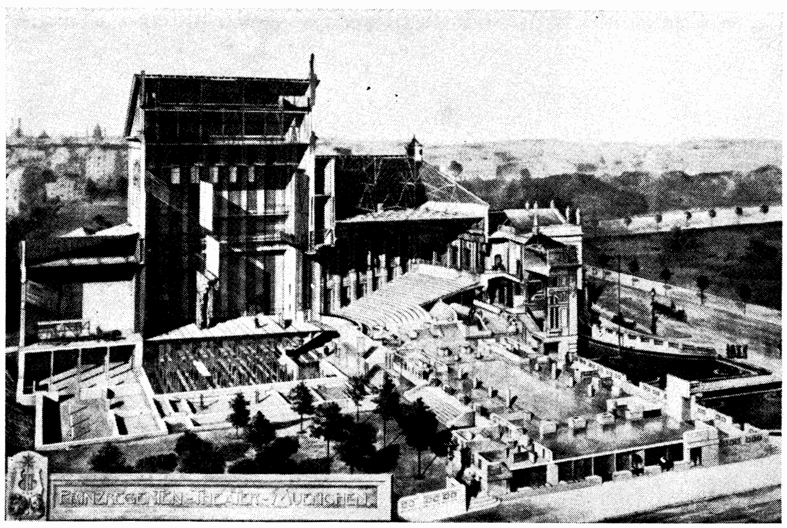
RENAISSANCE AND POST-RENAISSANCE THEATRES

BY COURTESY OF (TOP LEFT) THE TRUSTEES OF THE BRITISH MUSEUM (TOP RIGHT) CAISSE NATIONALE DES MONUMENTS HISTORIQUES PARIS, (CENTRE LEFT) THE TRUSTEES OF THE NATIONAL GALLERY LONDON; PHOTOGRAPHS, (CENTRE RIGHT) RICHARD LEACROFT, (BOTTOM LEFT) ARCHITECTURAL REVIEW, (BOTTOM RIGHT) ERIO PICCAGLIANI

The interior of the Theatre Royal, Drury Lane, London, as rebuilt by Henry Holland in 1794. From a water colour by Edward Dayes (1763– 1804)



Interior of John Brougham's Lyceum theatre, New York city; 1850. From an engraving by J. C. Taylor, 1863

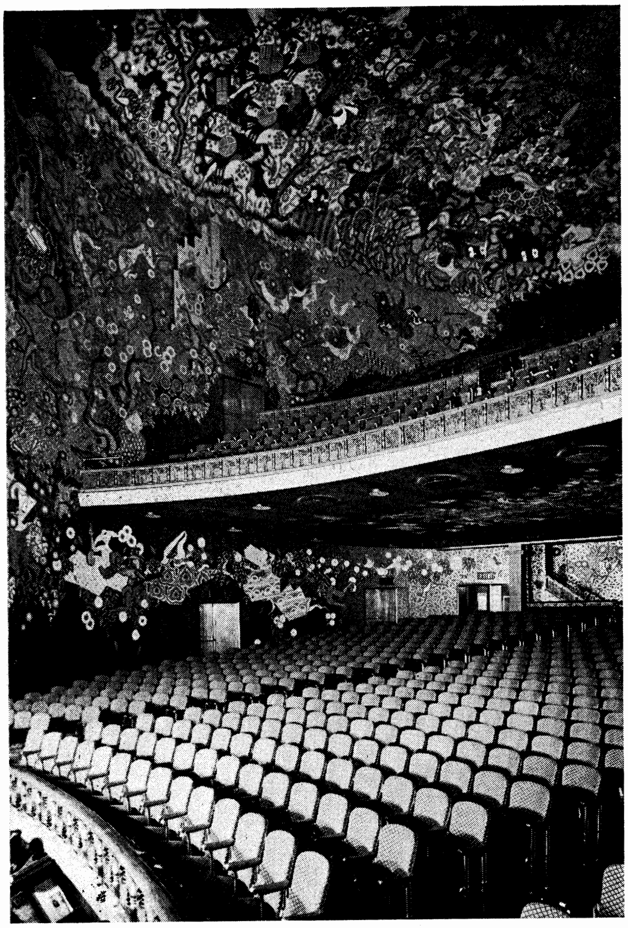


Cross-sectional drawing showing the interior of the Prince Regent theatre, Munich, designed by Max Littmann, 1901

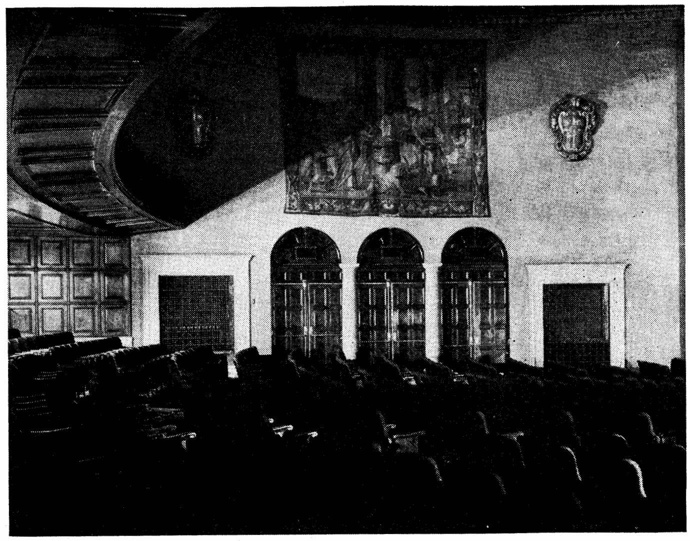
THEATRES OF THE 18TH, 19TH AND EARLY 20TH CENTURIES

BY COURTESY OF (TOP) GEOFFREY W. G. AGNEW; PHOTOGRAPHS, (BOTTOM LEFT) CULVER PICTURES INC., (BOTTOM RIGHT) FROM SHELDON CHENEY 'THE THEATRE, THREE THOUSAND YEARS OF DRAMA, ACTING AND STAGECRAFT'

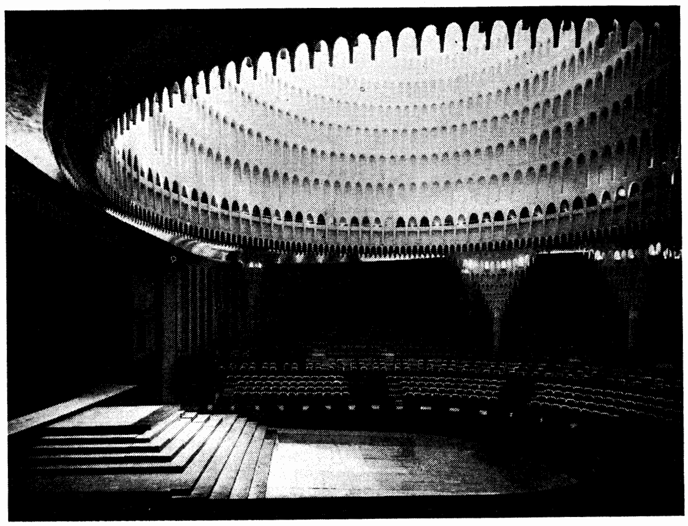
THEATRES (STRUCTURES)



The Ziegfeld theatre, New York city, showing the ornate décor in the auditorium. Architects, Joseph Urban and Thomas W. Lamb; 1927

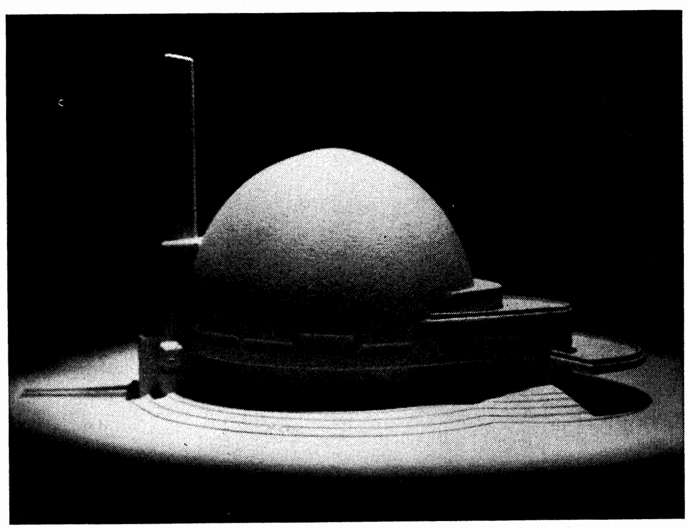


The Guild theatre, New York city, which illustrates the type plan that became standard for picture-frame theatres. Architect, C. Howard Crane; 1925



The Grosses Schauspielhaus, Berlin, a circus building converted into a theatre for Max Reinhardt. Architect, Hans Poelzig; 1919

The Künstlertheater, Munich, in which the seating was designed with a constant rise of steps from front to rear. Architect, Max Littmann; 1908

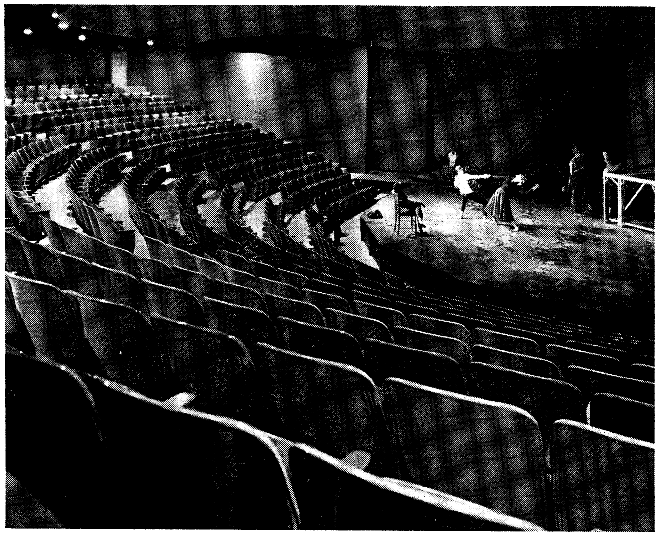


The project Theater #14 designed in 1922 by Norman Bel Geddes for a theatre proposed for the Century of Progress exposition, Chicago (1933–34)

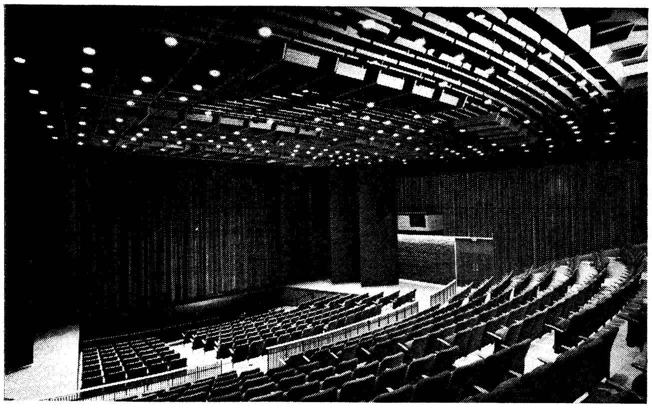
EARLY 20TH-CENTURY THEATRES

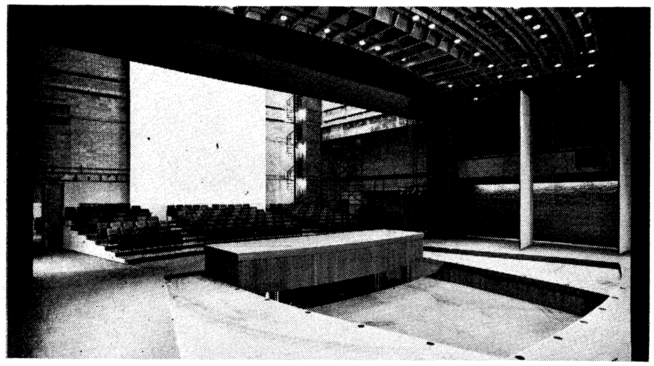
BY COURTESY OF (TOP LEFT) DRIX DURYEA (CENTRE RIGHT) MORRIS GEST, (BOTTOM LEFT) MAX LITTMANN, (BOTTOM RIGHT) NORMAN BEL GEDDES

The Penthouse theatre, University of Washington, Seattle, an example of theatre-in-the-round. Architect, Carl F. Gould; 1940

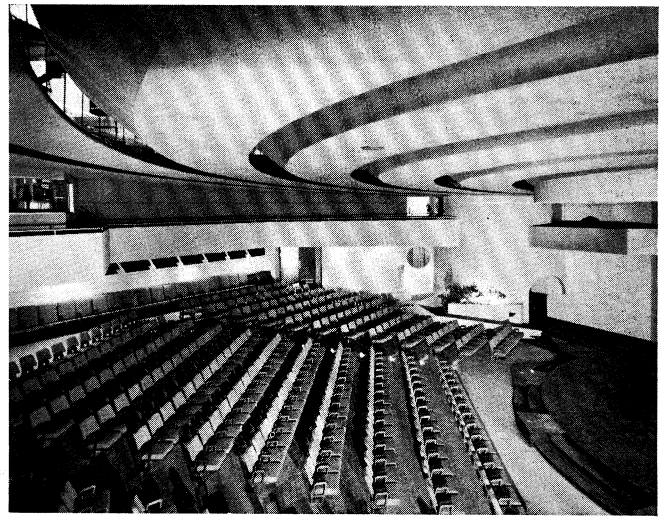


The Community theatre, Western Springs, Ill., showing the open stage within the auditorium. Architect, G. Orth, Design Consultant, J. H. Miller: 1960–61

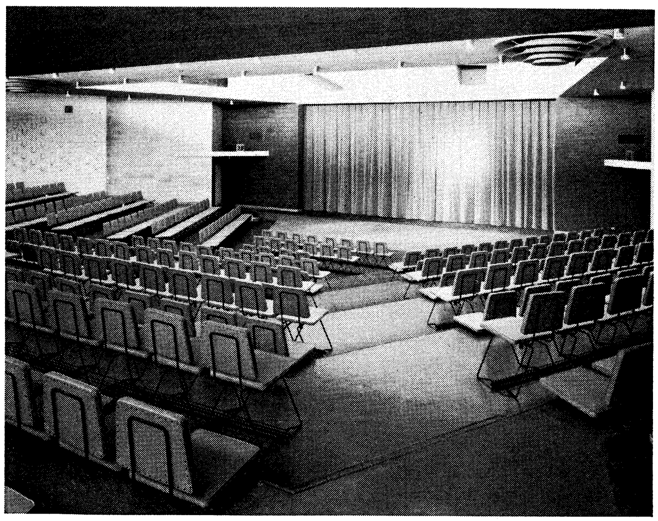




Coeb Drama centre, Harvard university, showing the interior rearranged for three stage-audience relationships: top, conventional auditorium of the proscenium (picture-frame) type; ***centre,*** modified theatre-in-the-round: bottom, three-sided platform theatre. Architect, Hugh Stubbins: 1959–60



Interior view of the auditorium and revolving stage of the Kalita Humphreys theatre, Dallas, Tex. Architect, Frank Lloyd Wright; 1959

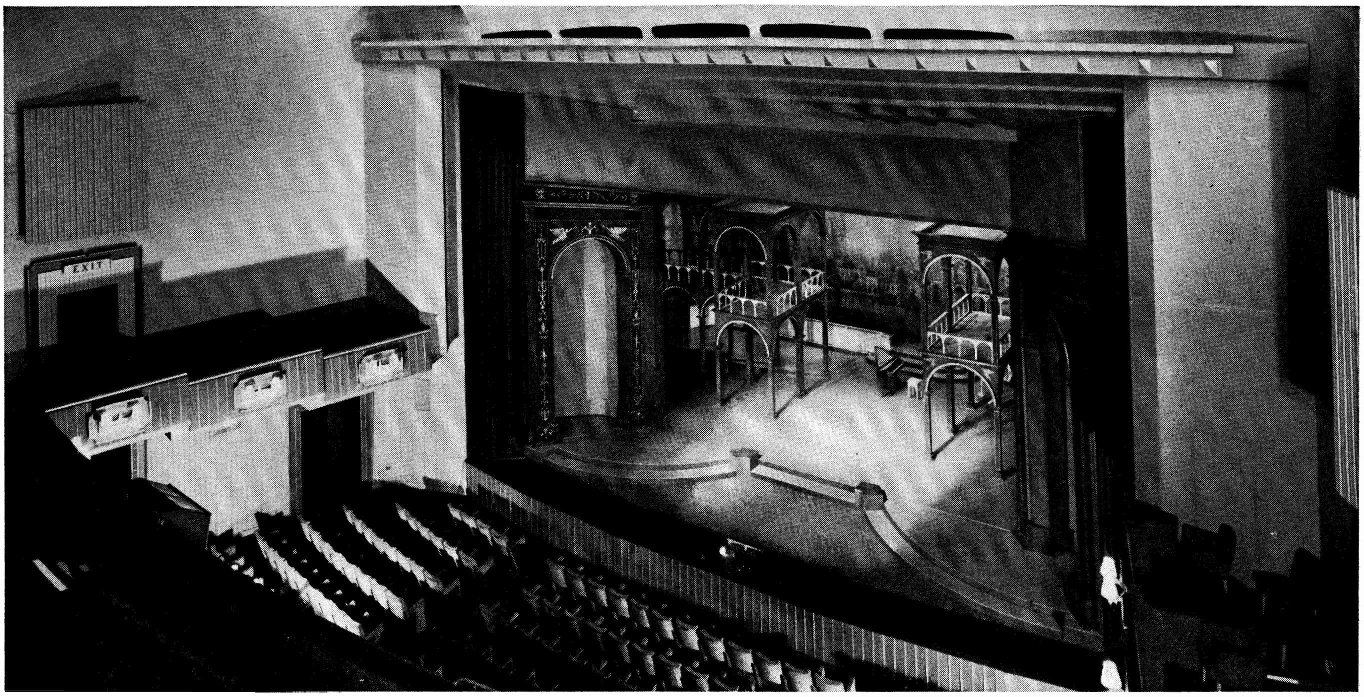


Interior of the auditorium of the Sarah Lawrence college theatre. Bronxville, **N.Y.,** an example of functional theatre design. The 500-seat theatre can be adapted for open stage productions, plays within a proscenium or open-air performances. Architect, Marcel Breuer; 1952

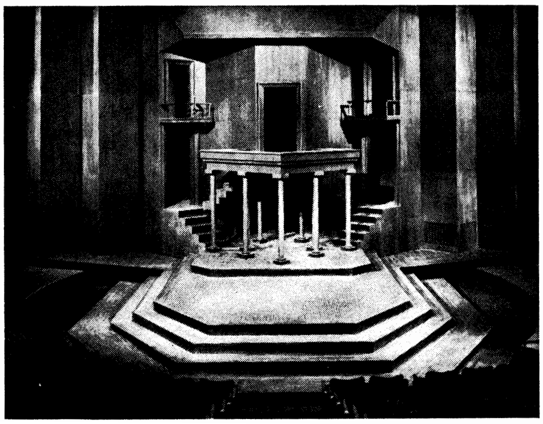
UNIVERSITY AND COMMUNITY THEATRES

BY COURTESY OF (TOP LEFT) PENTHOUSE THEATRE (TOP RIGHT) THE TPEATRE AND ARTS CENTER, WESTERN SPRINGS, ILL , (CENTRE RIGHT) THEATER CENTER; PHOTOGRAPHS, (LEFT, TOP, CENTRE AND BOTTOM) CLEMENS KALISCHER. (BOTTOM RIGHT) BEN SCHNALL

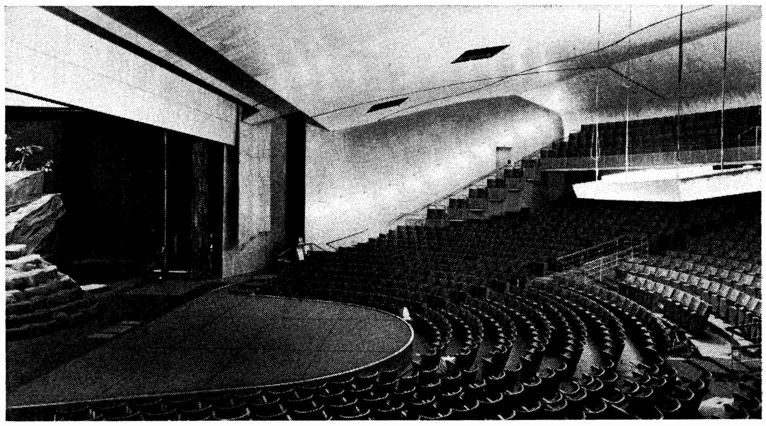
THEATRES (STRUCTURES)



View of the stage of the Royal Shakespeare theatre, Stratford-upon-Avon, Eng., as altered by Brian O'Rorke in 1951. The original stage, built in 1932, was designed with a deep proscenium frame that contained a removable forestage, with steps to the auditorium

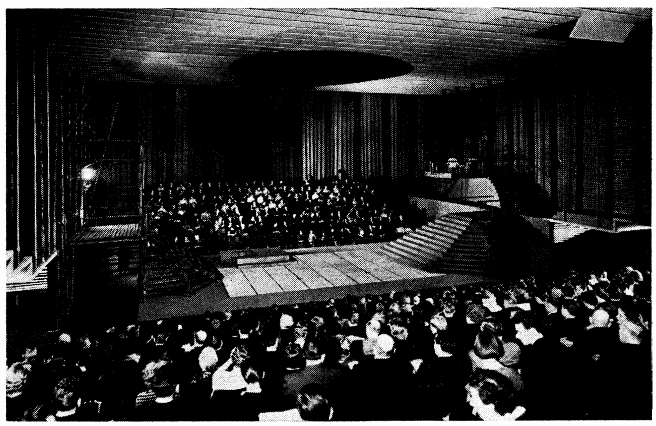


Open stage with eight acting levels, designed by Tany Moiseiwitsch, in the Stratford festival theatre, Ontario, Canada, 1956. Theatre architect: Robert Fairfield



Interior of the civic theatre at Malmö, Sweden, showing the extended proscenium which can be lowered or raised. Architects, E. Lailerstedt, S. Lewerentz and D. Hellden; 1944

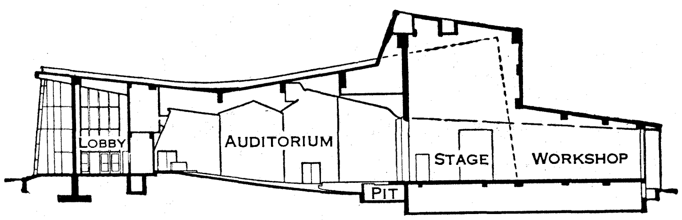
Mermaid theatre, Puddle Dock, London, showing scenery arranged on the open end-stage. Architect, E. Davies; 1959



The small theatre of the National theatre at Mannheim, Ger., arranged as a two-sided theatre in the round. Architect, G. Weber; 1955–57

MODERN THEATRES OF CANADA AND EUROPE

BY COURTESY OF (CENTRE LEFT) STRATFORD SHAKESPEAREAN FESTIVAL FOUNDATION OF CANADA PHOTOGRAPHS, (TOP) WALTER SCOTT, BRADFORD YORKSHIRE, (CENTRE RIGHT) H. STENBERGS, SWEDISH INTERNATIONAL PRESS BUREAU, (BOTTOM LEFT) ARCHITECT'S JOURNAL (BOTTOM RIGHT) GERHARD WEBER FOTO HAUSSER ter of ornamenting a street façade but of architectural composition related to landscaped approaches on an unrestricted site, with ample indoor lobbies and promenades, outdoor loggias and courtyards for the audience. In such theatres, both the interior and exterior design can organize an integrated program of theatrical and allied activities, such as the dance, concerts, recitals and art exhibitions.



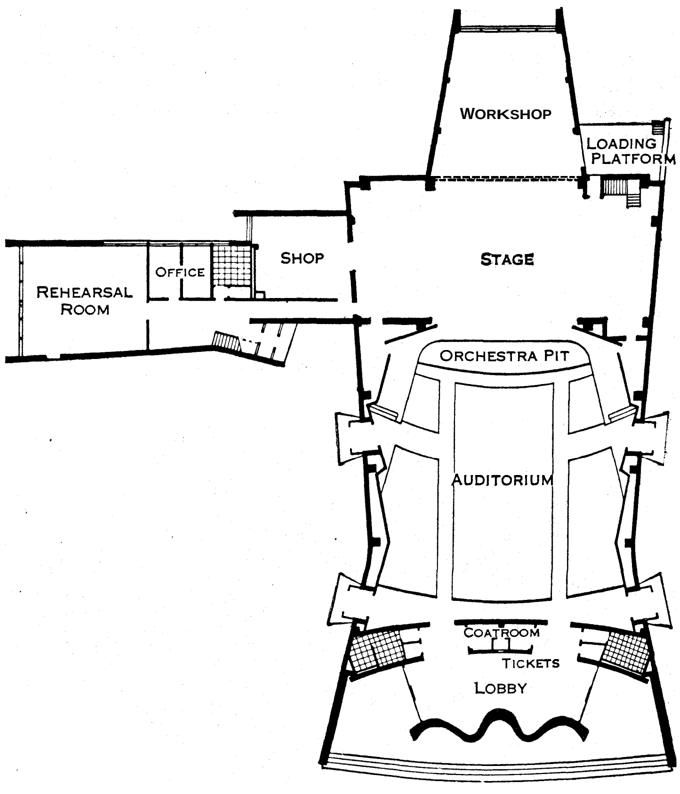
BY COURTESY OF "ARCHITECTURAL FORUM"

FIG. 27.— SECTION OF OBERLIN COLLEGE THEATRE. OBERLIN, O., HARRISON, ABRAMOWITZ AND E SNYDER, ARCHITECTS

Minimums and Alternatives.— Function determines form, and planning in turn determines the effective functioning of a building. In designing these theatres, the architect is faced with the necessity for basic minimums in regard to the stage and various alternative solutions in organizing the related units of the entire building.

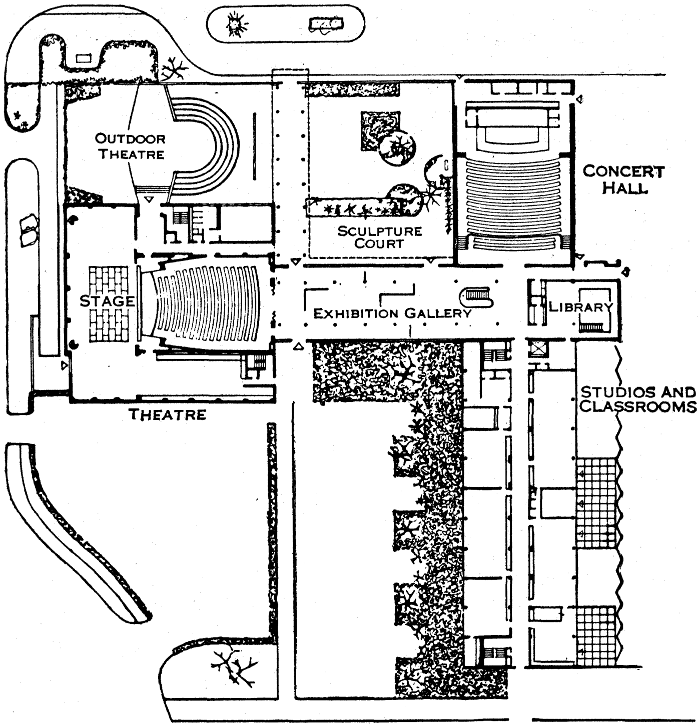
Backstage dimensions are determined by the balance of scenic units and sight lines. The minimum width of the stage should be at least twice the width of the proscenium opening; allowing half at each side for circulation and stacking space, *i.e.*, for a 25-ft. proscenium, 50 ft.; for a 30-ft. opening, 60 ft. But these are minimums.

A properly planned stage should be three times the average proscenium width. *i.e.*, 80 to 90 ft., and the height of the stage house should be 65 to 85 ft. For a stage is a space where large amounts of scenery not in use have to be stacked out of sight during or between the performances of a single play, as well as props such as furniture ranging from thrones to living room tables and chairs. However stylized a production may be. no abstract substitute for tables and chairs has been discovered. A simplified unit setting for the revival of a Greek tragedy may involve a large chorus. and the most expressionistic interpretation of a classic, Elizabethan or modern script may call for arcades, pylons, ramps, stairways and playing areas at several levels. as well as crowds of extras. Smaller groups of actors may have to exit from stage right and re-enter from stage left a few minutes later. They cannot be exoected to clamber over stacked furniture or sets to be used in the next act.



BY COURTESY OF "ARCHITECTURAL FORUM"

FIG. 28.— FLOOR PLAN, OBERLIN COLLEGE THEATRE



BY COURTESY OF "ARCHITECTURAL FORUM"

FIG. 29.— FLOOR PLAN. UNIVERSITY OF ARKANSAS THEATRE. FAYETTEVILLE, ARK.. EDWARD D. STONE. ARCHITECT (1950)

The elaborate mechanism of a series of elevator stages can be dispensed with, but a combination of a revolving stage and one or more wagon stages at stage level in off-stage wings provides an efficient way of meeting the most varied demands of a repertory program. However, an elevator forestage remains a valuable adjunct. It can form the forestage apron or be sunk to hold an orchestra or additional seats; lowered to cellar level it provides the best means of handling heavy props or scenic units and routing them to storage space.

An adequate stage house, ample in height, width and off-stage space, is the core of a theatre. Any attempt to dwarf or constrict it results in handicapping the theatre's program. A recurrent and excellent plan (which has been used for the Mannheim, Ger., Malmo, University of Wisconsin and other theatres) provides two auditoriums. a smaller one for more intimate productions, recitals and lectures. and a large one for major dramatic productions, operas and orchestral concerts. This plan has been effectively used wherever it has been adopted.

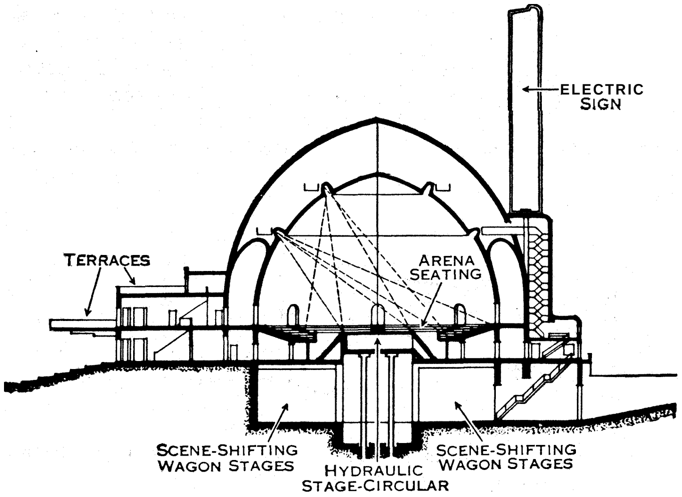
Several technical requirements remain to be considered, such as stage traps, fire precautions. lighting control and acoustics. Almost every 19th-century theatre provided a "Hamlet trap" for the burial of Ophelia. It is advisable to provide for a group of 12 or 16, each approximately 3 ft. × 3 it. 6 in., which can be lifted out to form larger openings and then replaced. However formal the stage, an asbestos curtain. connected to the skylight over the stage house on a counterweighted rope line. is an essential. In case of fire. the rope is cut and the skylight automatically opened, creating a back draft and keeping smoke out of the auditorium. For the immediate hazard of fire is primarily from smoke, injuries or asphyxiation during panic and stampede. The New York city fire code sets an excellent standard of safety in regard to the minimum width of aisles. number and size of emergency exits.

height of risers between rows of seats and the width between each row, fireproof doors backstage between the stage and workshop and storage areas! fire escapes for auditorium balconies and dressing rooms not at ground level. Where the more steeply pitched "continental" seating is adopted (so-called because it was first used in European theatres) the aisles are widened at exits provided at both ends of each aisle.

'The distribution of spot- and floodlighting also affects the design of the auditorium. In addition to the light troughs extending across the auditorium ceiling for general lighting, an additional trough is essential for spotlights that cover the forestage and the forward portion of the acting area. The fluctuations of light, the "light plot," which are an integral part of any production, require a hundred or more sources of light—spotlights and floodlights ranging in capacity from 250 to 1,500 w. each.

Lighting control has been greatly aided and simplified by the development of remote electronic control—particularly the C-I board. This board is operated from a console approximately 36 in. wide and 30 in. long and requires only a single operator for a total of 45 dimmer circuits and a maximum capacity of 300,000 w. Small master handles interlock and synchronize simultaneous lighting changes.

The dimming element, consisting of a series of thyratron tubes, can be placed below stage, thus freeing the stage area from bulky assemblages of manually controlled or motor-operated dimmer banks. Being compact, this type of control board can be placed either in a lighting booth at the rear of the auditorium or on stage at either side of the proscenium opening.



BY COURTESY OF NORMAN BEL GEDDES

FIG. 32.— NORMAN BEL GEDDES' "THEATRE #14," 1922. A PROJECT FOR A THEATRE IN THE ROUND

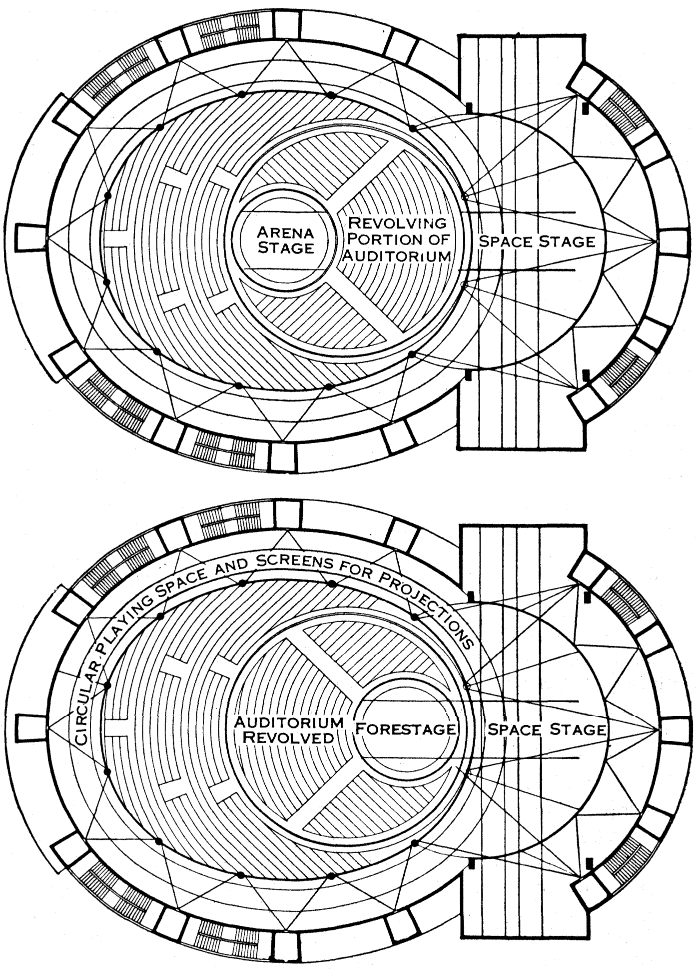
Acoustics present a special problem. The elaborate "gingerbread" ornament of the 17th- and 18th-century theatres with Baroque and Rococo ornament covering the proscenium and the entire interior, including the auditorium ceiling, the fronts of the tiers of boxes and the galleries. together with the natural resonance of wood walls and numerous draperies, provided an excellent balance of sound reflection and absorption.

Modern design with its emphasis on diffused auditorium lighting over plane surfaces of hard plaster tends to upset this balance. In general, concave surfaces whether in plane or section are to be avoided; the fan-shaped plan of the auditorium is likely to give to large surfaces of the rear wall a curve that is acoustically bad, particularly one that is struck on a centre near the stage. In general the principle to be followed is the proper balance and distribution of sound absorbing and reflecting surfaces and contours. But as their determination is a highly technical problem, unless an architect is particularly qualified, the services of an acoustic consultant are indispensable in the design of an auditorium.

Various alternative solutions can be studied in connection with the theatres at Oberlin, Sarah Lawrence and the University of Arkansas, which at the same time enable the architect to achieve fluent and simplified interior contours.

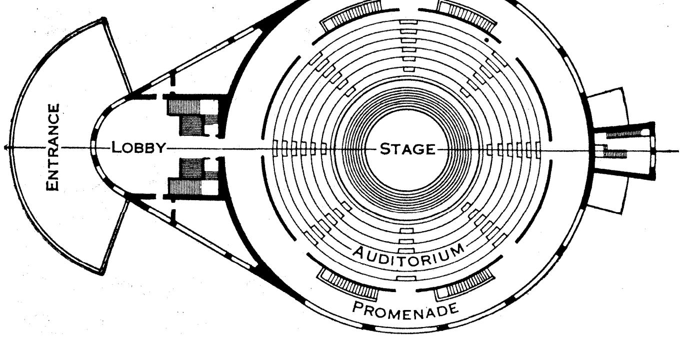
Multipurpose Theatre.—Two recently completed playhouses, at Sarah Lawrence (1951) by Marcel Breuer and at Oberlin by Harrison, Abramowitz and E. Snyder (1953), are outstanding examples of functional theatre design.

At Sarah Lawrence the various levels provide a theatre foyer that can double as an exhibition hall, a common room with a snack bar opening onto a terrace and, at a lower level, a spacious common room and dance studio. The 500-seat theatre is so flexibly arranged that it can be used for an arena style performance or for



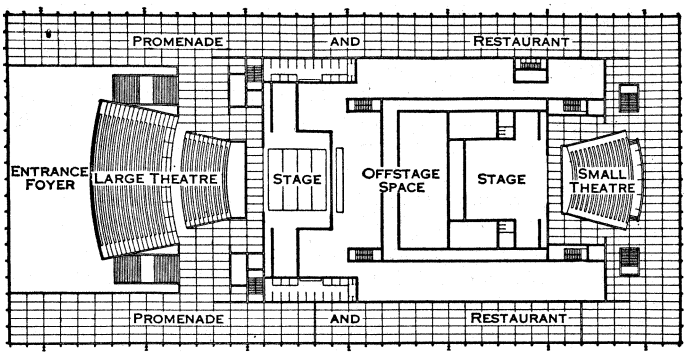
BY COURTESY OF WALTER GROPIUS

FIG. 30 AND 31.— WALTER GROPIUS' PLAN FOR A "TOTAL THEATRE," 1927. THE ARCHITECT'S AIM WAS TO CREATE AN INSTRUMENT SO FLEXIBLE THAT A DIRECTOR COULD USE A VARIETY OF FORMS OF STAGING. A SECTION OF THE AUDITORIUM COULD BE REVOLVED AS SHOWN IN THE FIGURES TO ACCOMMODATE PARTICULAR STAGING REQUIREMENTS. THE THEATRE WOULD BE EQUIPPED TO HANDLE DRAMA. OPERA. FILMS. DANCE. CHORAL AND INSTRUMENTAL MUSIC. SPORTS AND CONVENTIONS



BY COURTESY OF NORMAN BEL GEDDES

FIG. 33.— GROUND FLOOR PLAN OF "THEATRE #14"



BY COURTESY OF MIES VAN DER ROHE

FIG. 34.— FLOOR PLAN OF A THEATRE PROJECT FOR MANNHEIM, GER.. MIES VAN DER ROHE, ARCHITECT

plays within a proscenium, as a night club for student entertainments and as a lecture or concert hall. When the sliding doors at the rear of the stage are opened it can be used for open-air performances with the audience seated on the tennis-court area. The forestage is a hydraulic elevator that can provide an orchestra pit or 33 additional portable seats at floor level. A pioneer designer of metal-frame furniture. Breuer devised a new type of orchestra chair, a light seat on a tubular frame. All seats swivel, permitting spectators to turn 12° to right or left. The rows are set 42 in. apart (10 in. wider than standard), permitting exceptional ease of ingress and egress. A U-shaped balcony directly below the ceiling provides space for spotlighting the stage from any angle; at the rear there is a booth for the light control board and a motion-picture projector.

One of Breuer's tenets is that architecture tends to he too often concerned with inconsequential detail and should return to the unaffected beauty of simpler materials. Here the exterior facing of wall and terrace surfaces present the contrasted textures of rough stone, flagstone and painted brick; in the auditorium concrete block masonry contrasts with alternating brick-shaped projections. These serve to break up the surface sufficiently to secure an excellent acoustic balance together with the broken planes of the side walls, painted in contrasting tones of red and blue.

In commenting on the Oberlin theatre, the Architectural Forum said: "Few buildings in recent years have faced up to the major problems as boldly as Oberlin has faced up to them. The little auditorium, with its sway-backed roof, its strangely cubist forms and its wavy interior surfaces, tries, creatively, to answer a lot of challenging questions that most architects like to dodge . . . . Can he (the architect) 1. Design an auditorium to fit snugly around an acoustic engineer's 'optimum shape' and still get good architecture? 2. Resolve the glaring conflict . . . .between a low slung auditorium and towering stage house without making the former too high or the latter too low for good appearance? 3. Can modern architects keep on designing 'anonymous' buildings . . . or do we need a new vocabulary of expressive, modern forms that suggest clearly the purpose of the building before us?"

The problem is successfully resolved with an architectural balance of dramatic forms almost monolithic in their simplicity, further emphasized by the varying shadows cast during the course of the day. The space between the concave roof and the broken surface of the auditorium ceiling is utilized for indirect lighting troughs and troughs for spotlighting the stage, with a catwalk to service them. The convoluted screen at the entrance portico provides a dramatic background for open-air performances or open-air concerts and dances.

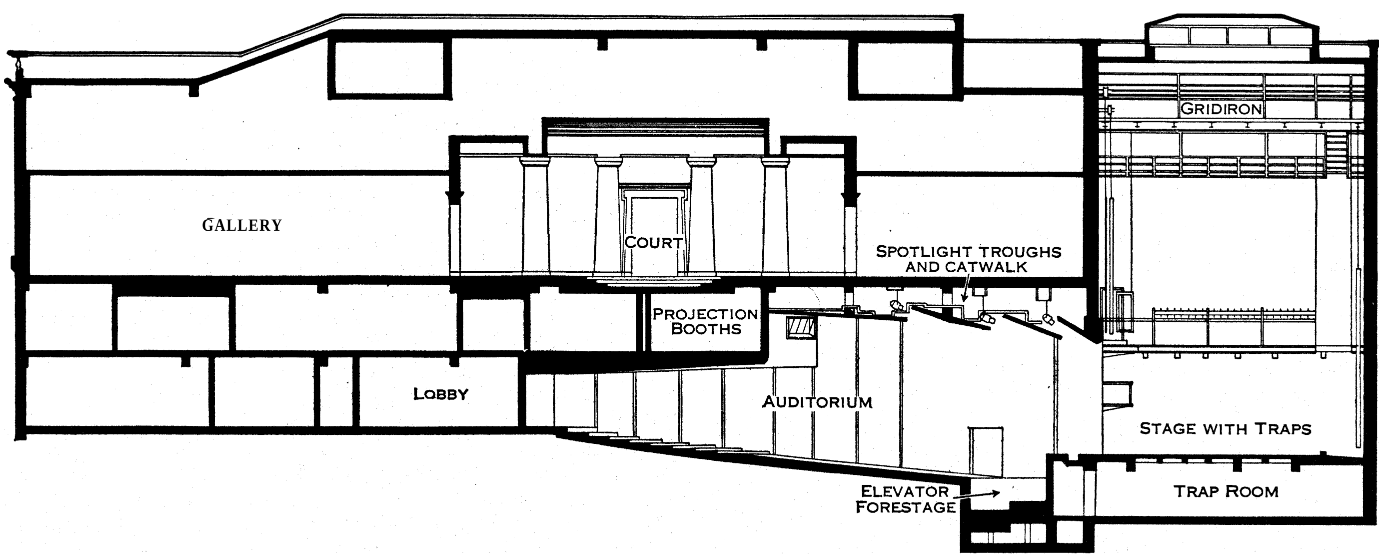
The Theatre as an Art Centre.—The program of the University of Arkansas called for a building that would be "a workshop, a place where painting, sculpture, architecture, music and dance live and grow and from which their civilizing influence spreads into our daily lives."

The building is another example of effective functional design in the general composition of its component parts, in the treatment of its various façades, in its flexible but well-integrated ground plan and general circulation among interrelated activities—painting, sculpture and architectural studios, exhibition gallery, library, sculpture court and concert hall. The stage is completely trapped and has a total width of 104 ft.; its lighting equipment is so arranged that with the curtain down and temporary seats in place it can be used as a theatre in the round; one wing connects with an open-air theatre.

The acoustic concrete blocks used for the auditorium walls have given completely satisfactory results. A scenic workshop, two stories high, 26 ft. × 56 ft. in area, connects with the stage at stage level and is overlooked by the scenic design studio, which in turn connects with a costume workshop. The building as a whole is a centre where students can develop in stimulating contact with all the arts.

Where appropriations, as in many colleges, limit the size of a playhouse to a comparatively small building, a great degree of flexibility may nevertheless be achieved, as in the theatre at Baylor university, Waco, Tex., designed by Paul Baker and completed in 1954. The main studio theatre consists of three connecting platform stages, one of which has a stage house and a proscenium opening. The acting area can be centred there, or cover all three simultaneously or in succession.

The audience, seated on swivel chairs, can turn in any direction to follow the action of a play. For an arena-type production the seats are moved to the stage level and the action takes place on the



BY COURTESY OF VIRGINIA MUSEUM OF FINE ARTS

FIG. 35.— SECTION OF THEATRE AT THE VIRGINIA MUSEUM OF FINE ARTS. RICHMOND, VA.. M. C. LEE. ARCHITECT

orchestra floor. A lighting booth suspended from the ceiling can light any or all of the stages.

Other Experimental Forms.—Mies van der Rohe's project for a National theatre at Mannheim, Ger., is unique in that it applies to theatre architecture the continuous glass and steel shell, a form which he was one of the first to develop and which later became widely used in factories, office buildings. apartment houses and country residences. The building is approximately 520 ft. long and 240 ft. wide, with a marble-faced lower story 15 ft. and an upper story 40 ft. in height. Its steel and glass walls are carried by exposed steel truss construction. Flexibility is achieved by two auditoriums placed back to back: one with 1,200 seats for operas, ballets. orchestral concerts and pageants; the other with 500 seats for intimate drama, recitals and chamber music.

The entrance foyer to the main theatre rises to the full height of the building. Two wide corridors at the theatre level, which can also be used for exhibition purposes, extend along both sides of the building and lead to a restaurant at the farther end. The continuous tinted glass walls are screened with translucent curtains that can, on occasion, be drawn to command a view of two adjacent parks, and the combination of large spaces with the curtain material used will, in the architect's judgment, give sufficient absorption to solve any acoustical problems.

Flexibility is again emphasized in Walter Gropius' project (1927) for a "total theatre." Here the entire floor of the theatre revolves so that it can be used in any one of three ways—as a circus arena, an amphitheatre with a circular stage at floor level or in conjunction with a platform stage placed above it.

Another experimental method of play production, originally known as "central staging" when first used in 1914 at Teachers college, Columbia university, has provided a simplified type of theatre construction. Glenn Hughes of the University of Washington, an early adherent, completed his Penthouse theatre in 1940. The theatre in the round, as it came to be generally called, consists of a central, circular acting area, the stage floor, where the locale of the play is suggested only by stage properties. This is surrounded by a circular tier of seats, cut by aisles for the actors' entrances and exits. This type of playhouse has proved increasingly popular for smaller audiences in civic and college groups where funds for a more elaborate modern theatre are not available.

See also references under "Theatres (Structures)" in the Index volume.

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(L. Si.)

THEBES, an ancient Greek city in Boeotia (ancient Θῆβαι, Thebae), is situated on low hilly ground north of the Asopus valley, overlooking the Ismenian plain, about 44 mi. from Athens, whence it is reached by roads and by railway. It has about 4,800 inhabitants, and is the seat of a bishop. The present town occupies the site of the ancient citadel,.the Cadmea; two fragments of ancient wall are visible on the north and another, belonging either to the citadel or the outer wall, on the south. There are remains of a Minoan "palace" and chamber tombs. The church of St. Luke, southeast of the Cadmea, is believed to contain his tomb. Two streams, rising a little to the south, flow on the two sides, the ancient Ismenus on the east and Dirce, Δ(ηί)κρ, on the west. The "waters" of Thebes are celebrated by Pindar and the Athenian poets, and the site is still, as described by Dicaearchus (3rd century B.C.), "all springs," κάθυδρος πᾶσα. From the abundance of water the neighbouring plain is fertile, but the population is scanty, and the town unimportant.

History.—The record of the earliest days of Thebes was preserved in a mass of legends. Five main cycles of story may be distinguished: (1) the foundation of the citadel Cadmea by Cadmus; (2) the building of a "seven-gated" wall by Amphion, and the cognate stories; (3) the tale of the "house of Laius," culminating in the adventures of Oedipus and the wars of the "Seven" and the Epigoni; (4) the advent of Dionysus; and (5) the exploits of Heracles. It is difficult to extract any historical fact out of this maze of myths; at most it seems safe to infer that it was one of the first Greek fortified cities.

In the period of great invasions from the north Thebes received settlers of that stock which spread over Boeotia. The military security of the city tended to raise it to a commanding position and its inhabitants endeavoured to establish a complete supremacy over the outlying towns. In the late 6th century the Thebans were brought into hostile contact with the Athenians, who helped the small fortress of Plataea to maintain its independence against them. The aversion to Athens explains the attitude of Thebes during the great Persian invasion, though it should be remembered that Herodotus, the chief authority for the period, wrote this part of his history in all probability at a period when feeling between Athens and Thebes was bitter in the extreme. Though a contingent of 400 was sent to Thermopylae (480 B.C.) and remained there with Leonidas to the end, the governing aristocracy soon after joined the enemy and fought zealously on his behalf at the battle of Plataea (479 B.C.). The victorious Greeks punished Thebes by depriving it of the presidency of the Boeotian league. In 457 B.C. Sparta, needing a counterpoise against Athens in central Greece, reinstated Thebes as the dominant power in Boeotia. The great fortress served this purpose well by holding out when the Athenians overran and occupied the rest of the country (457–447 B.C.). In the Peloponnesian War (*q.v.*) the Thebans, embittered by the support which Athens gave to the smaller Boeotian towns, and especially to Plataea, were firm allies of Sparta, which helped them to besiege Plataea and allowed them to destroy the town after capture (427 B.C.). In 424 B.C., at the head of the Boeotian levy, they inflicted a severe defeat upon an invading force of Athenians at Delium. After the downfall of Athens at the end of the Peloponnesian War the Thebans, finding that Sparta intended to protect the states which they desired to annex, broke off the alliance. In 404 B.C. they had urged the complete destruction of Athens, in 403 B.C. they secretly supported the restoration of its democracy in order to find in it a counterpoise against Sparta. A few years later, they forced on the so-called Corinthian War and formed the nucleus of the league against Sparta. The result of the war was disastrous to Thebes as the settlement of 387 B.C. stipulated the autonomy of all Greek towns and so withdrew the other Boeotians from its political control. Its power was further curtailed in 382 B.C., when a Spartan force occupied the citadel by a treacherous coup-de-main. Three years later the Spartan garrison was expelled; in the consequent wars with Sparta the Theban army, trained and led by Epaminondas and Pelopidas (*qq.v.*), proved itself the best in Greece. Some years of desultory fighting culminated in 371 B.C. in a victory over the Spartans at Leuctra (*q.v.*). The winners carried their arms into Peloponnesus and at the head of a large coalition permanently crippled the power of Sparta. But the predominance of Thebes was short-lived. The states which she protected were indisposed to commit themselves permanently to her tutelage, and the renewed rivalry of Athens prevented the formation of a Theban empire. With the death of Epaminondas in 362 B.C. the city sank again to the position of a secondary power. In a war with Phocis (356–346 B.C.) it could not even maintain its predominance in central Greece, and by inviting Philip II. of Macedon to crush the Phocians it extended that monarch's power within dangerous proximity to its frontiers. In 338 B.C. the orator Demosthenes persuaded Thebes to join Athens in a final attempt to bar Philip's advance upon Attica. The Theban contingent fought bravely in the decisive battle of Chaeronea (*q.v.*). Philip was content to deprive Thebes of her dominion over Boeotia; but a revolt against Alexander was punished by the complete destruction of the city. Thebes never again played a prominent part in history. It suffered from the establishment of Chalcis as the chief fortress of central Greece, and was severely handled by the Roman conquerors Mummius and

Sulla. In Pausanias's time (A.D. 170) its citadel alone was inhabited. During the Byzantine period it served as a place of refuge against foreign invaders, and from the 10th century became a centre of the new silk trade. In 1311 it was destroyed by the Catalans and passed out of history.

The most famous monument of ancient Thebes was the outer wall with its seven gates, which even as late as the 6th century B.C. was probably the largest of artificial Greek fortresses. Two of the springs have been identified with some probability—that of St. Theodore with the Oedipodeia, in which Oedipus is said to have purged himself from the pollution of homicide, and the Paraporti with the dragon-guarded fountain of Ares (see CADMUS). From the interest of the site in history and still more in literature, as the scene of so many dramas, the temptation to fix details has been specially strong. There are two main difficulties to contend with. The description of Pausanias was written at a time when the lower city was deserted, and only the temples and the gates left; and the references to Thebes in the Attic dramatists are, like those to Mycenae and Argos, of no topographical value.

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Ancient authorities are Herodotus, v.–ix.; Thucydides and Xenophon *(Hellenica), passim;* Diodorus, xvii., xix.; Pausanias, ix., 5–17.

THEBES (Θῆβαι), the Greek name of the ancient capital of Upper Egypt. It occurs in Homer (Il. ix. 381–4) where it has the epithet **ἑκατόμπυλος,** "hundred-gated," probably derived in the first place from the gateways of its endless temples, for Thebes was never a walled city with gates, though its vast temple enclosures in different quarters would form as many fortresses in case of siege or tumult. Its Egyptian name was Wesi (or Wis?), later Ne, "the city" (sometimes Ne-Amun, hence No-Amon in Nahum iii. 8). Ammon, Amen-Ra, or Amenrasonther ("Ammon-Ra king of the gods") was its deity, with his consort Mūt and their child Rhons. Mont also was a local deity and Hathor presided over the western cliffs of Thebes. In very ancient times the city lay on the east bank, the necropolis on the west. The chief nucleus of the ancient Wēsi was a town about the temple of Karnak: it probably reaches back to the prehistoric period. At Drah abu'l nagga, opposite to it, are tombs of its princes under the VIth Dynasty. The temple of Karnak is no doubt of immemorial antiquity. In it Senusret I. dedicated statues to his predecessors of the Vth Dynasty who had probably showed their devotion to Ammon in a substantial manner, and Cheops of the IVth Dynasty is named in it. After the end of the Old Kingdom Thebes grew from an obscure provincial town to be the seat of a strong line of princes who contended for supremacy with Heracleopolis and eventually triumphed in the XIth Dynasty. The most important monument of the Middle Kingdom now extant at Thebes is the funerary temple of Mentuhotep III at Deir el Bahri. The name Amenemhet, so common in the XIIth Dynasty, shows the importance of the Theban god at this time. It was, however, the early rulers of the XVIIIth Dynasty down to Tethmosis III. who developed Karnak, and on the west bank built the great funerary temple of Deir el Bahri and smaller temples as far south as Medinet Habu, and began the long series of royal tombs in the lonely Valley of the Kings far back in the desert. Amenophis III. continuing, transformed western Thebes monumentally: built three great temples in addition, that of Mont on the north of Karnak, the temple of Mut on the south and the temple of Ammon at Luxor, and connected the last two with the state temple of Karnak by avenues of sphinxes. The city and its monuments now covered an area about three miles square. After this Thebes experienced a serious set-back with the heresy of Ikhnaton, the son of Amenophis III. He moved his capital northward to Akhetaton (El Amarna) and strove to suppress the worship of Ammon, doing infinite damage to the monuments of Thebes by defacing his name and figure. After about twenty years, however, the reaction came, Thebes was again the capital, and a little later under Seti (Sethos) I. and Rameses II. of the XXth Dynasty it was raised to greater architectural magnificence than ever. These two kings built the great columnar hall of Karnak, added a large court with pylons to Luxor, and on the west bank built the funerary temple of Seti at Kurna, and the Ramesseum with its gigantic colossus, besides other edifices of which only traces remain. Under the XVIIIth and XIXth Dynasties Thebes was at the height of its greatness. Conquering Pharaohs brought home trains of prisoners and spoil, embassies came thither of strange people in every variety of costume and of every hue of skin, from Ethiopia, Puoni (Punt), Mesopotamia, Asia Minor, Libya, and the islands of the Mediterranean, bringing precious stones, rare animals, beautiful slaves, costly garments and vessels of gold and silver. The tombs of the XVIIIth Dynasty on the west bank and the sculptures in the temples reflect the brilliancy of these days, but with Rameses II. came the turning-point of its glories, and the efforts of all his successors combined could add little to the wonders of Thebes. The temple and tower of Rameses III. (XXth Dynasty) at Medinet Habu, his tomb in the Biban el Moluk, the temple of Khons (Rameses III. and later) and the court of Sheshonk I. (XXIInd Dynasty) at Karnak are the only great achievements.

The tide of prosperity was now flowing northward and such monumental energy as remained was expended more widely. For several centuries after the fall of the New Empire Thebes was but one of several alternating or contemporaneous capitals. Memphis, Tanis, Bubastis, Sais, Heracleopolis had at one time or another at least equal claims. The Ethiopian conquerors of Egypt made Thebes their Egyptian capital, but in 668 Assur-bani-pal sacked the city. Psammetichus did not neglect it, but Ptolemy I. gave a new capital to the upper country in the Greek foundation of Ptolemais, and thus struck a fresh blow at the prosperity of Thebes. For a short period in the reign of Epiphanes, when Upper Egypt was in rebellion against the Ptolemaic rule, Thebes was the capital of independent native dynasts. In a later rebellion, Thebes was captured after a three years' siege and severely punished by Lathyrus (Ptolemy X., Soter II.). In the reign of Augustus, having joined in the insurrection against the tax-gatherers, it was destroyed by Cornelius Gallus and became a collection of villages. Though its vast buildings have since served as quarries for mill-stones and for the lime-burner, Thebes still offers the greatest assemblage of monumental ruins in the world.

We will now briefly enumerate the principal groups of monuments. On the east bank at Karnak stand the great state temple of Amen-Ra with its obelisks of Hatshepsut and Tethmosis I. and the vast columnar hall of Rameses II.; the temple of Mūt and the well-preserved temple of Khons; the temple of Luxor and avenues of rams and sphinxes connecting all these. On the west bank, in front of the necropolis, on the edge of the desert or projecting into the cultivation, was a low row of temples: the northernmost, placed far in front of the others, is the well-preserved temple of Seti I. at Kurna; then follow the Ramesseum and Medinet Habu; and the foundations of many others can be traced. The temple of Amenophis III., to which the colossi of "Memnon" were attached, was again far forward of the line. The Ramesseum contains the remains of a stupendous seated colossus, in black granite, of its builder Rameses II., thrown on its face. When perfect it was probably 57 ft. high and weighed about 1,000 tons, surpassing the "Memnon" statues of Amenophis III. in size and weight. The temple of Rameses III. at Medinet Habu, sculptured with very interesting scenes from his Syrian, Libyan and other wars and from religious festivals, is remarkable also for the unique entrance-tower which probably formed part of the royal palace. Northward and far back in the foot-hills is the Ptolemaic temple of Deir el Medina, and beyond under the cliffs of Deir el Bahri the terrace temple of Queen Hatshepsut, the walls of which are adorned with scenes from her expedition to Puoni (Somaliland) in search of incense trees, and many other subjects. Far behind Medinet Habu are the Tombs of the Queens, where royal relatives of the XXth Dynasty are buried; and immediately behind the lofty cliffs of Deir el Bahri, but accessible only by a very circuitous route from Kurna, are the Tombs of the Kings (from Tethmosis I. onward to the end of the XXth Dynasty) in the Biban el Moluk and the Western Valley. Those of Seti I. and

Rameses III. are the most remarkable. These royal sepulchres are long galleries excavated in the rock with chambers at intervals: in one of the innermost chambers was laid the body in its sarcophagus. In the XXIst Dynasty, when tomb robberies were rife and most of their valuables had been stolen, the royal mummies were removed from place to place and at last deposited for safety in the tomb of Amenophis II. and in the burial-place of the priest-kings at Deir el Bahri. The finding of the two *cachettes* nearly intact was one of the greatest marvels of archaeological discovery. The systematic exploration of the Valley of the Tombs of the Kings was rewarded with results of the highest interest. The greatest as well as the most recent of these was the discovery in Oct. 1922 of the tomb of Tutankhamun (reigned 1360–1350 B.C.) with its magnificent equipment almost intact.

See Baedeker's *Egypt; E.* Naville, (Temple of) *Deir el Bahari,* introduction and parts i.–v. (London, 1894–1906); Sir W. M. F. Petrie, *Six Temples at Thebes* (ruined temples on west bank) (London, 1897); G. Daressy, *Notice explicative des ruines de Médinet Habu* (Cairo, 1897); G. Maspero, "Les Momies royales de Deir el Bahari" in *Mémoires de la mission archdologique française au Caire,* tome *I.;* and many other works. (F. LL. G.; X.)

THECLA, ST., one of the most celebrated saints in the Greek Church (where she is commemorated on Sept. 24) and in the Latin Church (where her festival is Sept. 23). She is honoured with the title of "protomartyr." The centre of her cult was Seleucia, in Isauria. Her basilica, south of Seleucia, on the mountain, long a popular place of pilgrimage, is mentioned in the two books of St. Basil of Seleucia. According to her *Acta,* Thecla came under the personal teaching of the apostle Paul at Iconium. In spite of their highly fabulous character (Thecla escaped from burning, from wild beasts, bulls and serpents), which caused them to be more than once condemned by the Church, the *Acta* of Paul and Thecla, which date back to the 2nd century, are interesting monuments of ancient Christian literature.

See *Acta Sanctorum,* September, vi. 546–568; J. A. Lipsius, *Acto apostolorum apocrypha* (Leipzig, 1891), i. 235–269; C. Schmidt. *Acta Pauli* (Leipzig, 1905), where an attempt is made to prove that the *Acta* of Paul and Thecla formed an integral part of the *Acta Pauli; see* also APOCRYPHAL LITERATURE; C. Holzey, *Die Thekla-Akten, ihre Verbreitung und Beurtheilung in der Kirche* (Munich, 1905).

THEGN or **THANE,** an Anglo-Saxon word meaning an attendant, servant, retainer or official. From the first, however, it had a military significance, and its usual Latin translation was *miles,* although *minister* was often used. The word is used only once in the laws before the time of Aethelstan (*c.* 895–940), but more frequently in the charters.

The thegn became a member of a territorial nobility, and the dignity of thegnhood was attainable by those who fulfilled certain conditions. In like manner a successful thegn might hope to become an earl. There were others who were thegns on account of their birth, and thus thegnhood was partly inherited and partly acquired. The thegn was inferior to the aethel, the member of a kingly family, but he was superior to the ceorl. The status of the thegn is shown by his wergild. Over a large part of England the amount of this was fixed at 1,200 shillings, or six times that of the ceorl. He was the twelfhynde man of the laws.

The increase in the number of thegns produced in time a subdivision of the order. There arose a class of king's thegns, corresponding to the earlier thegns, and a larger class of inferior thegns, some of them the thegns of bishops or of other thegns. **A** king's thegn was a person of great importance, the contemporary idea being shown by the Latin translation of the word as *comes.* He had certain special privileges. No one save the king had the right of jurisdiction over him, while by a law of Canute we learn that he paid a larger heriot than an ordinary thegn.

The 12 senior thegns of the hundred play a part, the nature of which is rather doubtful, in the development of the English system of justice. By a law of Aethelred they "seem to have acted as the judicial committee of the court for the purposes of accusation" (Holdsworth, *Hist.* Eng. ***Law,*** vol. i., 1921), and thus they have some connection with the grand jury of modern times.

The word thane was used in Scotland until the 15th century to describe an hereditary non-military tenant of the Crown.

THEILER, MAX (1899–), South African microbiologist, won the Nobel prize for medicine and physiology in 1951. He was born Jan. 30, 1899 in Pretoria, U. of S. Af., the son of Sir Arnold and Emma (Jegge) Theiler. He received his early education in South Africa and completed his medical training at St. Thomas' hospital, London, and the London School of Tropical Medicine in 1922. From 1922 to 1930 he worked in the department of tropical medicine at the Harvard Medical school in Boston. There he carried out important studies on amoebic dysentery, rat-bite fever and leptospira.

Shortly after the discovery by A. Stokes, J. H. Bauer and N. P. Hudson that yellow fever was caused by a virus transmissible to monkeys, Theiler made his first important contribution to the conquest of this disease by demonstrating that the common albino mouse was susceptible to the virus. In addition to facilitating the work on the natural history of yellow fever, Theiler's discovery led to the development of the first attenuated strain of this virus, which is still in use for human vaccination. In 1930 he joined the laboratories of the Rockefeller foundation in New York and together with E. Haagen, W. Lloyd, N. Ricci and H. Smith carried out further fundamental studies on the yellow fever virus which led to the development of the improved 17 D strain widely used for human immunization. He also discovered a natural virus disease of mice which closely simulates that of human poliomyelitis. (A. B. SN.)

THEISM, in the broadest sense, means belief in God. The word, however, is used generally with the implication that the belief is held in a conscious and rational manner, and hence Theism is usually applied only to a system of beliefs which has some claim to be regarded as a philosophy. According to the Oxford Dictionary the first occurrence of the word is in Cudworth's *Intellectual System of the Universe* (1678). The etymology of the word (θεός) would suggest that it might cover any conception of the universe which admitted the existence of Deity; but in practice Theism has come to mean a belief in one God, and the word is not easily distinguished from Monotheism, save that Theism has a more theoretical implication.

Theism as a philosophical and theological position may be distinguished from other theories. It is, of course, the direct antithesis to Atheism (*q.v.*), which, strictly speaking, is the denial that God exists. It is to be distinguished, again, from Agnosticism (*q.v.*), the view that there is no sufficient grdund for either an affirmative or negative answer to the question: Does God exist? and that the only rational attitude is absolute suspense of judgment. It should be observed, however, that there is a sense of the word Agnosticism which is not wholly incompatible with Theistic belief. The theory of Herbert Spencer, that we can know that an Ultimate Reality exists but can also know that that Reality is unknowable, is sometimes described as agnosticism. Herbert Spencer's theory, as it stands, is plainly absurd, because in order to know that the Ultimate Reality is unknowable we must know enough of the nature of the Unknowable to be justified in making this assertion about it. All reflective Theists would acknowledge, however, that there is an element of truth in the Agnostic position — the human mind is incapable of grasping completely the nature of the Divine, and though there is a genuine knowledge of God, for finite mind that knowledge must always be incomplete. It is customary to distinguish Theism from Deism (*q.v.*).

The Deists were writers on natural religion in the 18th century who shared the desire to set religion on a purely rational basis and tended, in a greater or less degree, to exclude the ideas of revelation and mystery, reducing Christianity to those truths which, it was alleged, could be attained by the unaided reason. Though some of these authors had pantheistic tendencies, the name Deism has been given to that type of theology which considers God and the world to be absolutely distinct from one another, thus conceiving the Deity as an external Creator and Governor. In the language of modern philosophy Deism is the view which emphasises the transcendence of God but denies His immanence. In contrast to Deism, Theism affirms the presence of God in the world, holding both immanence and transcendence. Pantheism (*q.v.*) presents a contrast to Theism of the opposite kind to that which we have found in Deism. Pantheistic systems, though widely different from one another in spirit and presentation, agree in making an identification between God and the Universe. It is sometimes said that Pantheism maintains divine immanence while eliminating from its creed every vestige of divine transcendeqce. This manner of expression, though open to criticism, has the merit of making clear the main difference between Pantheism and both Deism and Theism. Certain philosophical systems may be classified for this purpose under the head of Pantheism. Spinoza's philosophy of God as the Infinite Substance and some forms of Absolute Idealism, as for example, that represented in England by the late F. H. Bradley cannot be described as theistic in the narrow sense of that word and are, theologically considered, pantheistic in tendency. Dualism is to be regarded as another theory which, in some of its forms, has affinities with Theism but is in essence different. Properly, Dualism means a view of the world which attributes its existence to two different or possibly antagonistic principles both equally ultimate, whether those principles be conceived as two deities, as in some forms of Zoroastrianism, or God and matter as in Manichaeism. A modified Dualism enters into most Theistic theories, but no theory could be called fully Theistic which was satisfied with a final Dualism.

We may now proceed to state in a positive manner the general tenets of Theism. It must be remembered that pure Theism has never been a widely influential religious belief. In the historical religions Theism is mixed with other elements, or rather perhaps is the basis of them. Thus Christianity is a Theistic religion, but its distinctive characteristic is the doctrine of the Incarnation. In the same way, Mohammedanism is Theism modified by special beliefs about the revelation of Allah through Mohammed. The fundamental conception of Theism in all its developed forms is that of a Being who is at once the supreme Value and the Source of all finite existence. Theism has usually thought of the Supreme Being as in some sense personal, or at least as One with whom personal relations were possible. This Supreme Being, in Anselm's phrase, *id quo majus cogitari non potest,* is, in the Theistic view, neither identical with the Universe nor wholly aloof and separate from it. The relation of God as Cause with the world has been conceived in various ways, the most common being creation, which itself may be capable of more than one interpretation. The idea of emanation, however, has also been employed, as in the Neo-Platonic philosophy (chief exponent Plotinus, A.D. 204–270) which exercised a considerable influence upon Christian theology. The peculiarly Theistic doctrine of the relation of God with the world is often expressed by the phrase, "God is both transcendent and immanent."

ARGUMENTS FOR THEISM

Theism, being a reflective theory and not simply a religious faith, has sought to defend its position by rational arguments. Historically, three arguments have been supremely important and are sometimes known as the "traditional proofs." They are the Cosmological, the Teleological, and the Ontological arguments.

The first philosopher, at least in the West, to state an argument which he held to be demonstrative of the existence of God is Plato. The proof which he gives (in the *Laws* X.) is the starting point of the rational theology or "natural" theology which claims to establish the being of God on the ground of reason. The Laws is universally admitted to be the work of Plato's old age. In his earlier writings Plato had made use of the idea of God and indeed the conception was central in his thought. He had constantly protested against unworthy ideas of the divine and asserts both in the *Republic* and *Theaefetus* that God is perfectly good and cannot be the cause of evil. The proof in the *Laws* may be regarded as the fruit of long reflection on the problem and contains the germ of much subsequent development. The proof turns upon the existence of motion and change. Motions and changes may be divided into several classes, but there is one fundamental distinction, that between spontaneous and communicated motion. It can be shown that spontaneous motion must be prior to communicated motion, since if there is motion at all it cannot all be communicated. Now the soul is the source of spontaneous motion, as distinguished from matter which can only receive communicated motion. Hence the soul is prior to the body. The motions in the Universe which have no human origin must likewise be referred to a soul. We are thus led to the conception of a Soul of the world. But the motions of the Universe, and in particular of the heavenly bodies, are orderly and thus indicate that the World Soul is rational and good, the "mind which ordered the universe." In Plato's argument two of the "rational" proofs are joined—the Cosmological (from the existence of a universe in which motion exists to a Source of motion), and the Teleological (from the existence of order to the Divine Mind as its ground). It will be convenient to consider these arguments in their subsequent formulations separately.

The **Cosmological** Argument. — The philosophy of Aristotle is not, like that of Plato, profoundly religious in spirit, and the concept of God in Aristotle's thought has little religious significance, being mainly a metaphysical conclusion; but the formulation of the cosmological argument by Aristotle has been of primary importance for Christian philosophy. Like his master Plato, Aristotle rises to the thought of God from the fact of change and motion (κίνησις) which means for him much more than change of place. Motion is conceived by Aristotle as the passage from potentiality to actuality (δύναμις and ἐνεργεία). Every change which actually occurs is the realization of a potentiality which was hitherto latent. Associated with this conception is Aristotle's doctrine of "form" and "matter." Every concrete and finite existence is composed of matter and form and it is the latter which gives to it a specific nature. In "sublunary" existences the expression of form is always imperfect, the matter never being absorbed in the form completely. The motion and change of the world are therefore explained as the striving of the potential to become actual, of the forms to become fully realised. The universe which is in constant motion is not, however, self-explanatory; the change must have some source beyond itself. This source is God, who must be conceived as at once the First Mover and the Unmoved. There can be nothing higher than God, otherwise He himself would be moved towards that higher being. God must exist or there would be no movement. God is therefore pure form and pure actuality, in Him there is no "matter" and no potentiality. He is the realization of all form and of all potentiality. Thus God moves the world ὡς 'ερώμενον, as an object of desire; but it is an essential part of Aristotle's view that God does not desire or need the world. The world is not even known to Him as it exists in actuality. He contemplates the pure forms which are the content of His own intellect. The outcome of Aristotle's reflection is then a Deity who is completely transcendent and pure thought. All personal relations with the world, every trace of emotion and even moral goodness is excluded from his nature which is described as a thinking of thought (νόησις νοήσεως) (Aristotle, *Physics*, Bk. VIII., *Metaphysics*, Bk. XII.).

It is one of the curiosities of history that a theology so "intellectualist" should have profoundly influenced the thought of Christianity which is in spirit widely different from that of Aristotle. Yet the Aristotelian logic and metaphysics formed the basis of the great constructive systems of the middle ages, the scholastic theology, of which the greatest representative is St. Thomas Aquinas (1227–1274). The cosmological argument forms the basis of St. Thomas's rational theology. It was a fundamental conviction with him that the *preambula fidei,* the foundation truths of religion, were demonstrable by the human reason without the aid of Revelation. In his greatest, though unfinished work, the *Summa Theologica* (Pt. I., Quaest. ii., art. 3), he gives five proofs of the existence of God, of which four are versions of the cosmological argument. (1) The argument from *motion:* "Any thing which is moved is moved by some other thing . . . one thing moves another in so far as the former is in actualitv, for to move is nothing else than to draw anything from potentiality to actuality. But nothing can be brought from potentiality into actuality except by means of something which is already in actuality. . . . It is impossible that in the same respect and the same manner anything should be both moving and unmoved, or be self-moved." We cannot go on to infinity in the series of "movers" which are themselves moved, for in that case there would be no first source of movement and consequently no movement at all. We must then conclude that there is a first source of movement which is moved by nothing else—*i.e.,* God. (2) The argument from *Efficient* Causes: Experience shows that there is an order of efficient causes. Nothing can be the cause of itself, for that would imply that it was prior to itself. We cannot rest content with an indefinite series of causes and effects, because if there is no First Cause there can be no last effect. Hence we conclude that there is a First and Uncaused Cause—*i.e.,* God. (3) Argument from possible and necessary existence: Some existences are possible and not necessary, *i.e.,* they may exist or not exist, being generated and corrupted. But all existence cannot be of this nature, for unless there were necessary existence there would be no ground for possible existence. If there are necessary existences there must be an existence which is necessary in itself and does not derive the necessity of its existence from some other necessary existence. An indefinite regress is as impossible here as in the case of efficient causes. There must therefore be Something which is necessary per *se*—*i.e.,* God. (4) Argument from degree of quality or value: We find things more or less "good," "true" and "excellent." "More" or "less" is predicated according to degree of approach to a "greatest." There is therefore something which is most true, good and excellent—*i.e.,* God.

It should be observed that the first two forms of Aquinas' cosmological argument lead to the conception of a purely Transcendent Deity while the latter two suggest immanence.

The cosmological argument, very much in the form which was given to it by Aristotle and Aquinas, appears as a fundamental element in many philosophies. Mention must be made of Leibniz who supplemented it by laying down a new law of thought—the law of "sufficient reason"—according to which "for everything there must be a sufficient reason why it is so and not otherwise," thus making it clear that, for him, the basis of the cosmological argument was not empirical observation but a rational and self-evident principle—that of universal causation.

The objections to the traditional cosmological argument have been formulated by Hume and Kant. The former struck a blow at the simplest and most obvious version of the argument—that to a First Cause—by his sceptical analysis of the ideas of cause and necessary connection, though it should be noticed that he himself appears to have retained the conviction that the conception of a First Cause could not wholly be abandoned. In Hume's view, however, there is no universal principle of causation. The idea of necessary connection between phenomena is derived from habit breeding expectation, and the so-called "principle of causation" is due to nothing more than "the mind's propensity to feign," *i.e.,* it is a convenient fiction. Obviously this view, which was but the logical conclusion of the empirical movement in English philosophy, undermines the whole of our knowledge of the natural order and physical science, but it has also a direct bearing on the cosmological argument, for if causation is a principle on which we cannot rely when dealing with phenomena, we cannot use it to take us beyond phenomena to God. Kant attempted to save our knowledge of Nature from Hume's sceptical objections. He did so in a somewhat equivocal fashion. He held that the "categories" which the mind employs in synthesizing perception (cause, substance, etc.) are a *priori* in the sense that the mind does not derive them from experience but necessarily uses them in ordering experience—in short that Nature apart from Mind has no existence, but in some sense "Mind makes Nature." Kant is emphatic, however, in his limitation of this principle. The categories of the understanding are confined to dealing with phenomena. The use of such a category as causation to carry us beyond phenomena to a super-phenomenal Reality is an illegitimate—a "transcendent"—use. This is the real ground of Kant's objection; it is based upon his rigid limitation of the understanding to phenomena. Some special criticisms are also of permanent interest. Kant points out that the argument, in the only form which he discusses (that of efficient causation), does not, even if sound, lead to the conclusion that God exists, but only that a First Cause of some kind exists, and in order to attain the conception of God we need another argument—the Ontological. With reference to the alleged impossibility of conceiving an infinite series of causes, Kant remarks that the inconceivability attaches also to the idea of an uncaused cause, and there is therefore no reason why the mind should embrace one alternative rather than the other.

In spite of the objections to which the traditional form is open, the cosmological argument in a wider application has kept its power. In modern philosophy all those systems which employ the idea of an Absolute Reality arrive at the Absolute by some kind of cosmological argument. An important example of this is found in the Theistic philosophy of Hermann Lotze. The impossibility of rendering intelligible the fact of "transeunt" causation (*i.e.,* that change in one thing is the occasion of change in another thing), so long as we conceive the ultimate reality to consist of a collection of independent "reals" leads to the conception of an all embracing Absolute of which the particular things and their changes are modifications. Arguments of this type lead rather to an immanent Deity than to the transcendent God of Aristotle and Aquinas.

The cosmological argument has permanent value, though it has not the demonstrative force which was formerly attributed to it. It serves to substantiate the conclusion that "nature," whatever we may mean by that term, is not a self-explanatory system, and therefore to support the Theistic view as preferable on rational grounds to rival hypotheses. The form of the cosmological argument which begins with the apprehension of values, such as goodness and truth, has received little attention in the history of thought, but is one which has most positive weight for modern philosophy. Modern Theism would lay great stress on the contention that the existence of goodness, beauty and truth in finite experience compels us to postulate an absolute Goodness, Beauty and Truth.

The Teleological Argument.—This argument, sometimes called "the argument from design," is rightly described by Kant as the most impressive, the most easily comprehended of the traditional "proofs." Like the cosmological argument it is a posteriori in character, since it starts with the observed facts of adaptation to ends in the natural world. As we have seen, however, when referring to Plato, the teleological argument may be based upon the more general consideration of the order of the universe. The purposive character of the events of the world was a common topic of Stoic philosophers in connection with their doctrine of Providence. Here again we may turn to Thomas Aquinas for a succinct statement of the argument in its common form. It is the fifth proof of the existence of God given by that philosopher—the proof from the *gubernatio* of things. "Some things which have no power of knowing, such as natural bodies, work for ends, as is manifest from their constantly, or at least frequently, working in the same way for the attainment of that which is best. . . . Now such things as have no power of knowing do not tend towards an end unless they are directed by some being which has knowledge and intelligence." (Summa Theologica, Pt. I. Quaest. ii. art. 3.) It will be noticed that there are two elements in this argument (a) the observation of "working for ends"; (b) the inference from this to a directing Intelligence.

The evidence for working for ends or the adaptation to purposes on which stress is laid has varied; at times the main emphasis has been on general adaptation of the Universe to the existence and well-being of men or, more abstractly, to the production of values; at other times the argument has turned chiefly upon special instances of apparent design as, *e.g.,* the human eye. The latter type of reasoning was prominent among the rationalist Theologians of the 18th and 19th centuries. Paley's Natural Theology, with its famous analogy between the eye and a watch, is a familiar example of this kind of presentation.

Before proceeding to a discussion of the present position of the teleological argument it will be well to note the objections and limitations which arise on a consideration of the argument itself. These again have been clearly stated by Kant. It is obvious that the argument by itself is not sufficient to demonstrate the existence of God. Even if it be admitted that there are evidences of design, it does not follow that they are due to one Mind. The facts might be explained on the hypothesis of several intelligences. It is only when we have reached the conclusion on other grounds that the Source of Being is one, that the teleological argument may tend to show that Source to be intelligent. The argument again, tends to suggest an analogy with the carpenter or sculptor who makes the best of his material and thus to lead to the conception of God as the Architect of the Universe working upon alien material. It may be alleged further, that the argument is based upon purely subjective estimates, and implies an absurdly anthropocentric conception of the universe. It cannot be denied that the teleological conception has frequently been carried to ridiculous extremes, and attempts have been made to show that this is the "best of all possible worlds" in the sense that all its features minister to human convenience; but these extremes are no necessary part of the argument, and it may be observed that Kant himself, in the *Critique of Judgement,* allowed that the teleological judgment is necessary and inevitable in dealing with living beings and the appreciation of the beautiful.

A permanent difficulty for the teleological argument is the existence of evil, particularly of pain, waste, and the missing of apparent ends. If stress is laid on the "working towards ends" which are good, stress should equally be laid upon the working towards ends which to us appear to be bad. Additional weight has been given to this objection by the evolutionary theory of the origin of species through the struggle for existence and the survival of the fittest. The Darwinian theory of evolution seems to make death, defeat, and their concomitant pain, a necessary part of the evolutionary process. On these and other grounds it has been held, by Guyau, Bertrand Russell and many others, that there is neither beneficent nor maleficent purpose in the world, but that Nature is indifferent to the hopes, aspirations and needs of man. Some answer to these objections may be attempted. It is argued, for example, that the amount of pain in the lower orders of creation has been greatly exaggerated by the tendency to interpret the experience of the lower animals in terms of our own, and by the neglect of the consideration that the pains of anticipation are absent in sub-human creatures. Suffering in human beings again may be supposed to serve spiritual ends *(see* James Martineau, *A Study of Religion).* The most conclusive answer attempted to the problem of evil as an objection to a teleologically ordered universe is that of Leibniz, who maintained that this is the "best of all possible worlds." Any other world would have contained more evil and less good than the actually existing one. This view depends upon Leibniz's conception of the nature of possibility which, according to him, is determined, not by the arbitrary will of God, but by "eternal verities" which are absolutely valid for the Eternal Mind. Thus out of an infinite number of possible worlds the Creator chose that which included the greatest sum of good, and the evils in it exist as necessary conditions for the greater sum of good. This theory has been somewhat unfairly summed up by F. H. Bradley in the epigram, "The world is the best of all possible worlds, and everything in it is a necessary evil."

We may remark here that our view of the teleological argument will be profoundly affected by our view of the meaning of "good" and "value." If we are "hedonists," believing that good means pleasure and the absence of pain, the teleological argument will have little weight. The Universe is plainly not designed to afford the greatest possible degree of pleasurable feeling. If on the other hand, we conceive that value means the development of spiritual and moral persons the argument will appear in a different and more favourable light.

The rise of the evolutionary concept has had another and even more important effect on the teleological argument. The principle of the adaptation of species to their environment by survival of those best adapted has removed the favourite examples of teleology, such as the eye, from the sphere of directly created things and offered a "natural" explanation of their delicate adjustment. The Darwinian and post-Darwinian theories of biological evolution seemed to destroy the basis of the most popular argument for Theism. It was evident that if the argument was valid at all it needed complete restatement. Post-evolutionary exponents of the teleological argument have consequently laid stress, not on particular instances of apparent design, but on the general trend of evolution which, it is maintained, can only be explained by the hypothesis of Divine Providence. A subtle statement of this line of thought is to be found in Lord Balfour's writings, the *Foundations* of *Belief* and *Humanism and Theism,* in which he urges that, unless there is some intelligent guidance of evolution, the values of truth and beauty cannot be maintained.

The philosophical analysis of the idea of evolution in the present century has led many thinkers to abandon a purely mechanical conception of its method. The problem of newness and the development of values has engaged attention. M. Bergson has completely abandoned the mechanical view and substituted the idea of "creative evolution," new types of existence being in his theory the result of the effort of the *Élan Vital* to achieve freedom. Somewhat analogous is the conception of "emergent evolution" which was worked out by Professor S. Alexander and Professor C. Lloyd Morgan and adopted by several other English authorities. The "emergent" theory of evolution distinguishes between two types of effect, "resultants" which are the predictable outcome of previously existing conditions, and "emergents" which are specifically new and not completely predictable. New species, and in particular new types of being, such as life, consciousness and self-consciousness, would thus belong to the "emergent" type of effect. None of these writers would describe his view of evolution as definitely teleological, and Bergson is as much opposed to teleology as to mechanism; but it is obvious that such conceptions of evolution are leading in the direction of at least "immanent teleology"; and it may be argued that a purely immanent teleology is not by itself an intelligible conception. On the whole then, it may be said that the movement of thought is in favour of a restatement of the teleological argument.

The inherent tendency of the human mind to think in the teleological mode suggests that there is really an *a priori* element in the argument. The mind is irresistibly impelled to regard the Universe as rational, *i.e.,* as pervious to its categories and methods of thought. On this irresistible assumption or "act of faith" the whole structure of science is built. It is one further step in the same process to regard the Universe as rational in the fullest sense, *i.e.,* as a teleological system which exists for an end which we can accept as reason for its existence—the production of values or of good.

The Ontological Argument.—This is the only one among the traditional "proofs" which is explicitly a *priori.* It is the inference from the idea of God to the existence of God, and does not employ any data derived from observation. The argument, though adumbrated by S. Augustine, was first clearly presented by S. Anselm (1033–1109) in his work the *Proslogium.* Even the fool "who says in his heart, there is no God" has the idea of God, otherwise he would not be able to deny His existence. The idea of God is the idea of "that than which no greater can be conceived" *(id quo nihil majus cogitari potest).* Now this idea cannot be in the understanding alone, because if it were, it would not be the idea of that than which there can be nothing greater, for a Being who existed would be greater than a being who did not exist. (It should be noticed that *majus* does not mean simply magnitude but includes value.) In other words, the idea of the greatest conceivable implies the existence of that Greatest. The obvious objection to this line of reasoning was raised by Gaunilo during Anselm's lifetime in his *Liher pro Insipiente.* Gaunilo dissented from the passage from idea to existence, and adduced the famous illustration of the "perfect island," which he argued, on Anselm's principle, must exist. The essence of Anselm's reply to this objection is to draw a distinction between that which is the greatest conceivable absolutely and that which is the greatest only relatively as the member of a class. The idea of God is the idea of "that than which nothing greater can be conceived" absolutely, and to this idea alone the ontological argument applies.

The subsequent history of the ontological argument has been curious. It has been rejected by many considerable thinkers as a patent fallacy and by others regarded as the'foundation of constructive thought. Descartes. who is sometimes held to be the father of modern philosophy, adopted it in two forms as the corner stone of his system, the bridge by which he passed from universal doubt to confidence in the possibility of knowledge. Descartes places in the forefront the consideration of the possession by the mind of the idea of an infinite and perfect being, and the question how this idea can originate. I cannot derive it from myself, because I am certainly neither infinite nor perfect. The idea then implies a really existent infinite and perfect Being as its source. Descartes adds an important element to the argument by distinguishing between the positively infinite and the merely "indefinite." The latter is a negative idea implying simply the absence of limits, the former is concrete, and is the idea of God. Unless I were in possession of the positive idea of infinity and perfection I should not know myself to be finite and imperfect. Descartes also states the ontological argument very much in the form given to it by Anselm. Though in all other instances it is possible to distinguish between essence and existence and to conceive of a being as not existing, this is not possible in the single case of the idea of God. "The existence can no more be separated from the essence of God than the idea of a mountain from that of a valley. . . . It is not less impossible to conceive a God, that is, a being supremely perfect to whom existence is wanting, or who is devoid of a certain perfection than to conceive a mountain without a valley." *(Meditations* III. and *V.)* The ontological argument was also adopted by Leibniz, who made the addition to it that we need first to demonstrate that the idea of God is the idea of a possible existence.

The great flaw in the argument in its traditional form was clearly shown by Kant, who pointed out that it implies existence to be an attribute of the same nature as other attributes the absence of which would constitute imperfection, whereas this is not the case, since every concept we form is of a being as existing in some sense. Kant's illustration however, of the "hundred thalers," which are the same in properties in the imagination as in the pocket though not the same in usefulness, seems to miss the point even more obviously than Gaunilo's perfect island. The permanent value in the ontological argument has been emphasised by Hegel. It is the necessary attempt to bridge the gulf between thought and things, between concept and reality. In this sense it is really at the root of all thought. However we may express it, we are compelled to hold that what the mind necessarily thinks *qua* mind is real, that there is no impassable chasm between the *"ordo idearum"* and the *"ordo rerum."* All philosophies which distinguish between appearance and Reality on the ground that the irrational cannot be the real, rest upon something akin to the ontological argument. Probably it would be better to say, "upon an ontological assumption." The ontological argument is, in truth, an attempt to put into the form of a train of reasoning a postulate without which the mind is helpless. It may be questioned therefore whether the ontological argument or postulate leads us directly to the God of religious experience. It leads rather to the conception of an absolute or rationally coherent system of being.

Before leaving the famous "three proofs" a remark must be made on their value for modern Theism. Before Kant's drastic criticism they were taken to be demonstrative proofs of the existence of God at least by the rational theologians It is clear that as demonstrations they are unsafisfactory. This does not mean, however, that they are devoid of value. The post-Kantian Theist would, in most cases, adopt a different approach to his problem. The central question of constructive philosophy does not present itself to him in the form: given the idea of God as a belief, to find some rational proof of His existence. Rather the problem presents itself as analogous to the scientific problem: given the universe as disclosed in experience, to find the most reasonable account of it. Several hypotheses present themselves for consideration, among them Theism. The question before the mind of the philosopher, therefore, is to decide which of the possible hypotheses squares most adequately with the whole experience of the universe which is open to us. The Theist maintains that his hypothesis is the most rational in this sense. The traditional arguments, on this view, call attention to various aspects, of the universe which, when taken up into reflective thought, go to support the Theistic view. Thus in spite of their failure as demonstrative arguments they have great value as indicating lines of thought, suggested by experience, which tend to substantiate the Theistic theory. (For a fuller statement of this *see* W. R. Sorley, *Moral Values and the Idea of God,* and *W. R.* Matthews, *Studies in Christian Philosophy.)*

The change in the method of approach to which we have referred in the preceding paragraph is reflected in the type of argument on which modern Theism has laid greatest stress. Though not putting on one side the "rational" proofs, the main appeal in the philosophy of Theism has been to considerations drawn more directly from experience, and particularly from moral and religious experience.

The Moral Argument. — Kant is the historical turning-point in the philosophy of religion. His criticism of the Theistic proofs was not made in the interest of Atheism, and he was an agnostic only in the technical sense that he denied the possibility of arriving at a knowledge of God by the pure or speculative reason. Religion belongs to the sphere of moral faith, of the "practical reason." There are three postulates of the moral reason, God, Freedom and Immortality; these cannot indeed be proved in any scientific manner, but the consideration of the limits of theoretical knowledge leads us to see that the pure reason cannot disprove their validity. It remains neutral. We are therefore free to affirm the three ideas without which our moral experience of the authority of the moral law and the inexhaustible ideal of holiness could not be conceived as rational. This is Kant's fundamental position. The train of reasoning by which he seeks to establish the necessity of the postulate of God is less important, being complicated by his peculiar views of the nature of the moral experience. The argument turns on the alleged moral demand that the highest holiness should ultimately coincide with the highest happiness.

The moral argument has been presented in various forms by important writers of the 19th and 20th centuries. Theories of ethics naturally fall into two classes, (1) those which take the fundamental concept in morals to be duty and the moral law; (2) those which take the idea of the Good to be fundamental. From both of these standpoints Theistic conclusions have been defended. James Martineau in his *Types of Ethical Theory* and *A Study of Religion* adopts on the whole the first, T. H. Green's *Prolegomena to Ethics* and *W.* R. Sorley's *Moral Values and the Idea of God* are salient representatives of the second, while Dr. Hastings Rashdall's *Theory of Good and Evil* combines to some extent both points of view.

There are three elements in the moral consciousness on which stress is laid in Theistic arguments. (a) The authority which the conscience attributes to the moral ideal. This unique authority cannot, it is urged, be explained on any view which does not allow us to find the moral law in some way built into the structure of the world, grounded in Reality. Other possible accounts of the source of the sense of obligation really issue in an explaining away of the moral "ought," and hence in the consequence that the fully moral life is irrational. Further, it is urged, the Theistic view is the view which most clearly enables us to hold that the moral law is not simply imposed externally but is the expression of the deepest self and also that it is no mere individual product, but of universal validity. (b) The "objectivity" of the moral ideal. The conscience cannot be satisfied with the belief that the moral ideal is dependent upon opinion, whether of the individual or of groups. In spite of the obvious fact that moral ideas change, the moral life depends upon the conviction that the moral ideal itself is absolute. Though men's apprehension of it may grow, their apprehension does not create it. It may be argued that Theism gives us the most rational account of this aspect of the moral consciousness, since it suggests that the moral ideal may exist in the thought of God. (c) The content of the moral ideal, particularly when viewed in its social aspect. Though we know what we mean by progress, we cannot conceive any temporal condition which would be the final goal of social progress. Unless therefore we are prepared to allow that progress is towards an end which is inherently unattainable, we are led to the thought of an End which is beyond the temporal order Here again the theistic hypothesis appears to offer the most reasonable view, since it would hold that perfect communion with God and herein with all rational beings, is the nature of the highest Good. The central thought of the moral argument in all its forms is this: given man's moral experience at its highest we have the choice of regarding it as rational and significant, or of explaining it away as partially founded on a mistake with the probable consequence of weakening its effectiveness. If we choose to regard it as rational and significant Theism is the view of the world which will most adequately fulfil our demands.

The Argument from 'Values in General. — Strictly speaking the moral argument is a special case of the line of reasoning which sets out from the existence of values. The world manifests the character of having value, or of being the occasion of our apprehension of value. Truth, goodness and beauty are real in our experience. In every case however, we are led to the conception of an absolute value, a complete Truth, a perfect Good and Beauty. The very fact that we recognise degrets of truth, goodness and beauty, implies that we tacitly presuppose an absolute standard towards which the partial values which we enjoy are approximations. Nor again, can we suppose that in the end these values are opposed to one another, though in finite experience they may sometimes seem to conflict. On the contrary, the Ultimate values must form a Unity, or rather perhaps, be aspects or attributes of one Supreme Value, which is what we mean by God. This is the line of thought which carries on the Platonist tradition in Christian philosophy and is impressively stated by Dr. W. R. Inge in his *Philosophy* of *Plotinus* and other writings.

Religious Experience. — Among the ancient arguments for Theism should be enumerated the argument *e consensu Gentium*, from the agreement of the nations. The evidence to be derived from the fact that all men everywhere believed in the Divine was insisted on by the Stoics and has been held to show that the idea of God is "innate" in the human mind. Precisely in this form the reasoning is open to objection. Locke, in his polemic against "innate ideas" in general, pointed out that the argument collapsed when we asked, what idea of God is innate? for the conceptions of the divine held by savages differ profoundly from those of civilized nations. The study of Comparative Religions since the time of Locke has served to support in detail his contention; but on the other hand it has shown that religion is practically a universal phenomenon wherever the human race is found. A new and more profound approach to Theism, which has some affinity with the old argument *e consensu Gentium*, has been opened by this enlarged knowledge. It is now possible to study the religious experience of mankind as a whole. When this is done we can discern an upward movement of the experience and of the concepts of the Divine in which it finds expression. This upward movement does not take place over the whole field, but certain principles of development may be noticed which are fully exemplified only where the religious impulse has free course. The primitive ideas of animism and polydaemonism, give place to polytheism, which in turn is displaced by monotheism either in the form of pantheism or ethical monotheism. It is always open to the critic to dismiss the whole religious experience of humanity as based on illusion and mistake; but such a drastic rejection of a universal type of consciousness is hard to justify. If we base our knowledge of the Universe on experience, religious experience has a claim to be included. If further, we find that the religious experience tends to pass from obviously inadequate forms to forms which lend themselves to rational presentation, we shall be justified in regarding the later and higher as the nearest approximations so far to adequate discriminations of the Object with which all religious experience is concerned.

Parallel to this consideration of the general development of religious experience runs the evidence to be derived from a study of the great religious personalities. and particularly of the mystics. The mystical type of religious "genius" seems to enjoy an immediate contact with the Divine, and the statements made by such persons have some general agreement. Too much stress should not be laid on their testimony to the truth of Theism, since some of the evidence would support Pantheism rather than Theism, and there is a tendency among mystics to interpret their experience in terms of the religious imagery in which they have been brought up. The witness of the mystics to the supernatural is impressive, and they may be linked with the general argument from religious experience as salient instances of its power at every level. It is urged by several Christian writers that the definitely Theistic mysticism of the Christian mystics is a higher and more complete type of mysticism than any other. *(See*, for example, W. R. Inge, *Christian Mysticism,* E. Underhill, *Mysticism,* and *R.* Otto, *West Östliche Mystik.)*

In concluding this summary of grounds of Theistic belief we must remark again that few philosophical Theists would rest their case on a direc. demonstration or claim that they were in possession of an "apodeictic" argument; they would urge that the full force of the reasons in favour of Theism can only be appreciated when it is compared with other possible views of the Universe, and that several converging lines of thought form a cumulative argument which is difficult to resist.

SOME PROBLEMS OF THEISM

The Theistic view of the world is naturally impelled to articulate itself by considering the problems of the nature of God and His relations with the world. Some of the more important of these problems must now be briefly indicated.

Divine Personality. — Most Theists, if not all, would agree that God is, in some sense, personal, or at least not of a nature inferior to personality. The latter tenet seems to be implied in the Theistic hypothesis, for othenvise God could not be thought of as the Supreme Value. It is important however, to distinguish between the two propositions, "God is personal" and "God is a person." Though the second of these propositions has been held by many Theists, it is not an essential point. Orthodox Christianity cannot be cited on behalf of the belief that God is a person, for the doctrine of the Trinity would suggest that the Godhead is a Unity of Persons. No one, of course, would maintain that God is a person in precisely the same sense as human beings are persons, and in view of this some would prefer to speak of the Divine Nature as Supra-Personal, others, on the conlrary, as for example Lotze, would hold that God alone is the perfect person and that finite selves are "pale shadows" of His personality. No very vital principle is involved in this difference, so long as those who prefer the term "supra-personal" are clear that it is not a polite phrase ior "impersonal." Theistic religion is profoundly concerned to maintain that God is a being with whom personal relations are possible; if that be abandoned we shall be compelled to dismiss that religious experience, which Theists take to be the highest and most significant, as illusion. The main theoretical ground for accepting Divine Personality is the contention that personality is the highest type of existence known to us, the "bearer," the discerner, and the creator of values, and also that personal life is the most conspicuous instance of multiplicity in unity, it is, as Plotinus called it, a πλῆθος ἕν : the category of personality would appear, in its ideal form, to suggest an ultimate solution of the problem of the One and the Many. A difficulty has been raised concerning the attribution of personality to God on account of the alleged necessity of a "not-self" distinguishable from the self in all cases of self-consciousness. The discussion of this problem by Lotze in his *Microcosmus* (Bk. IX , Chap. IV.), remains the classical authority. It is noteworthy however, that this special difficulty does not press with such force upon the Trinitarian form of Theism. On any Theistic view it would appear that the created order must be in some sense a "not-self" with respect to God, since the identification of the created order with the Being of God would be Pantheism.

Divine Attributes. — The Theistic doctrine of God has usually included an account of the Divine Nature under the title of "attributes," but the error must be carefully guarded against of conceiving the Divine Nature as the sum of the Divine Attributes. They are rather different aspects from which the Divine Being may be viewed by us. The traditional division is into Metaphysical and Moral. The Scholastic Theology considered the Metaphysical Attributes to be those which refer to God as He is in

Himself and the Moral Attributes those which refer to Him in relation with the world. It may be questioned however, whether the human mind is capable of having knowledge of God of that absolute character suggested by this definition of the Metaphysical Attributes. If the division be retained it is perhaps better to say simply that by Metaphysical Attributes we mean those which have a primarily intellectual importance, such as Unity and Infinity, while by Moral we mean those which have a directly practical bearing, such as Righteousness and Love. The classification, however, is of doubtful value, since even the attributes which are most evidently "metaphysical" have profound religious results, and those which are "moral" have metaphysical import.

Reflection upon the Being of God has followed along two paths—the *via negativa,* and the *via eminentiae.* The first of these methods turns on the conception of God as the Infinite and works with a negative conception of infinity. God, being infinite, cannot be described by any predicates which would imply limitation. All positive assertions, however, imply such a limitation. It follows therefore that no positive quality can be affirmed of God, not even goodness or indeed even being, so that if we say that God is τὸ ὄν we must also say that He is equally τὸ μὴ ὄν. Clearly this method leads to a position which is hardly distinguishable from Agnosticism. The *via eminentiae* starts with the conception of God as the Ground and Source of all existence and with the postulate that the Ground must be adequate to the consequences. All positive qualities, therefore, which occur in created existence must be ascribed to God; but plainly not *"simpliciter";* they are, so to speak, raised to infinity. Knowledge is in God Omniscience, Will Omnipotence, Beauty perfect Loveliness. We must observe here that the via *eminentiae* really implies the view that evil is not positive being but privation or defect of being, a view which was held by Augustine and Aquinas; for if evil were a positive existence or quality of existence the argument of the *via eminentiae* would lead us to predicate evil of God.

The Divine Attributes have been the subject of much subtle and intricate speculation into which it is impossible to enter here. Brief remarks on two must be made, since they are of great importance in Theistic theory. Omniscience is the perfection of that quality of knowledge which is found imperfectly in some created beings. Evidently the Divine knowledge cannot suffer from the imperfections of human knowing. It is scarcely appropriate to imagine the Divine Intelligence engaged in "discursive" thought and pursuing trains of reasoning. The most adequate human knowledge is that described by Spinoza as *scientia intuitiva,* intuitive knowledge in which grounds and conclusion are apprehended in one intellectual act. Of this kind, it would seem, the Divine knowledge must be. We are brought here to the recognition of one aspect of the Divine Infinity and Eternity. Human knowing is a part of a temporal experience and therefore itself a temporal process. The Divine experience and knowledge cannot be temporal, or at least cannot be "in time." A recognition of this truth has important bearing on some of the puzzles of Christian and other Theologies connected with the Divine Foreknowledge. If the Divine Experience is not successive but simultaneous, the expression "foreknowledge" is evidently misleading and indicates that in presenting to ourselves the Divine Nature and Experience we are compelled to make use of inadequate concepts derived from our own experience, and hence to encounter problems which are insoluble because we have not the terms in which to state them accurately.

The same remarks apply to the attribute of Omnipotence in which we attempt to indicate the nature of the Divine Will. Clearly a supra-temporal will is beyond our powers of adequate conception This does not prove, as Spinoza held, that will is absent from God's experience, but it certainly shows that we cannot transfer ideas derived from our experience of finite acts of will directly to the Divine Will. The conception of Omnipotence gives rise to problems which are, in their nature, not completely soluble by human reason. Two possible meanings of the word have been suggested. It has been held, on the one hand, that omnipotence implies not only the power to do all that is possible but also that the determination of the possible is due to the will of God, so that the fundamental laws of thought and of morality are fiats of the Divine Will and not limitations upon it. On the other hand, it is held that the will of God is determined by the principles of reason and goodness which are inherent in His Nature and that omnipotence means the power to do all that is possible. Of these two views the latter is to be preferred, since the former asks us to conceive of the Divine Will as arbitrary and not in any intelligible sense either rational or good. Even so, however, it cannot be pretended that all difficulty has been removed from the conception of omnipotence, and we may perhaps be content to say, with Schleiermacher, that both omnipotence and omniscience are ways of expressing the fundamental conviction of Theism that all things ultimately depend upon God.

Creation and Self-limitation.—Theism does not identify God and the world. It maintains indeed that God is immanent in creation but also transcendent, and it holds therefore that there is a real distinction between God and the world. This distinction is expressed in the idea of Creation. Theism on the whole has preferred the idea of creation to that of emanation, which is the idea adopted by systems which lead to Pantheism. Emanation implies that the world proceeds from the Divine Being by a kind of necessary process, a common figure being that of the sun and its rays. Creation, on the other hand, emphasizes the factor of will and implies that the world exists as a result of an act of choice. Creation does not necessarily involve a belief that the world began at a definite moment of time or that the creative act of God is single; it is perfectly compatible with the belief in a continuous creation which would be in harmony with modem theories of evolution.

Any belief in creation, and indeed any belief in the reality of freedom, seems clearly to necessitate some limitation of the omnipotence and perhaps of the omniscience of God. At the same time, Theism cannot admit that any portion of existence is absolutely independent of God. To meet this dilemma the thought of a divine "self-limitation" has been employed. Admittedly this is a thought which cannot be articulated in any detail. We cannot know the conditions of such self-limitation. But the conception itself is required by the facts as they appear in religious and moral experience. We may urge that the idea is not really contradictory of omnipotence, for an omnipotence which could not limit itself would not be omnipotent. And there is no inherent difficulty in the moral attributes of God, for it may be argued that the development of free moral persons who can enter into communion with God is the ultimate purpose of creation, and that this end could not be attained apart from a limitation of the divine power which makes freedom possible and with it both moral good and moral disaster

A difference of opinion among Theists exists on the question whether creation is in any sense necessary to God. On this point traditional Christian theology and some modem idealistic interpretations of Christianity (*e.g.,* Hegel's) are at variance. Christian theology on the whole has laid down that the world is in no way necessary to God and that its creation does not add to His perfection or satisfaction. The opposite view, which emphasises the Divine immanence, holds that the world is as necessary to God as God to the world. A distinction should be made between the active and passive sense of "creation." Thus it might be conceived that creation is an essential attribute of God and at the same time that the present universe is not necessary to God, that to create is an eternal activity of God but no product of that activity is eternal. A theory of this kind would avoid the difficulties which arise when we attempt to conceive a beginning of creation. (On this point *see* further, *Studies in Christian Philosophy* by *W.* R. Matthews.)

A problem in Theistic philosophy closely connected with the foregoing is that of the place of suffering in the Divine Experience. Here again the weight of Christian thought is against the admission of anything which would seem to qualify the absolute self-sufficiency and perfection of the Divine Nature. Suffering arises through frustration and limitation, conditions which are hardly to be thocght of in connection with the Supreme Being Against this may be set some considerations arising from the problem of evil and the moral perfection which we believe God to possess. It would seem difficult to think of Divine Sympathy with suffering if suffering could not enter into the Divine Experience; and it would seem strange to ascribe moral perfection to God if self-sacrifice, which involves voluntary pain, were excluded. On these grounds many writers on Theism and Christian Theologians in the present century have argued that suffering must enter into the Divine Consciousness, and some have urged that this is really an essential element in the Christian view of the world. (For a survey of opinion on this subject see J. K. Mozley, The *Impassibility* of God.) It must be observed, however, that Theism could not admit that suffering is the dominant note of the Divine Experience. To do so would be to fall back upon the conception of a "God" so limited and struggling that He may be ultimately defeated. Our experience, however, offers us an analogy which throws light upon the problem. At the highest level of spiritual life a condition of "blessedness" has sometimes been attained which is far different from a condition of mere pleasure and absence of pain. Pain enters into it as an essential element, but the condition itself is not one of pain, rather it is one in which the self finds its truest satisfaction and which it would not exchange for any maximum of pleasant feeling. Of this kind, though in an infinitely higher degree, we may imagine the life of God to be.

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THEISS: see TISA.

THELEPTE, an ancient Roman city in western Tunisia, 35 m. S.W. of Sufetula (Sbeitla), 2,650 ft. above sea-level. The ruins are extensive, but most of the buildings are almost entirely destroyed, and only their ground plan can be recognized. To the south-west are some massive remains of baths.

THEMIS. (1) An ancient goddess, often identified with Ge, said to have been the occupier of Delphi in days before Apollo (see ORACLES). She is the mother of Prometheus (*q.v.*). (2) A goddess of justice (cf. NEMESIS). In Homer θέμις is used both as a common noun (doom, decree; cf. GREEK LAW) and as a proper name; Themis is the servant or companion of Zeus, her chief function being to summon the assemblies of both gods and men (Odyssey, ii. 68). In the Hesiodic theogony, she is the daughter of Uranus and Ge, and according to Pindar the wife of Zeus, by whose side she sits, assisting him with her advice, which is even better than that of any of the gods. She is the mother of the Horae and of the Fates (*q.v.*). Her opposite is Hybris (ὕβρις), insolent encroachment upon the rights of others. The exact relation between (1) and (2), save that they have in common the idea of stability (Θέμις, root θε, place) is obscure. Orphic poetry makes her a daughter of Helios.

See R. Hirzel, *Themis, Dike,* und *Verwandtes* (1907).

THEMISTIUS (317–?390), named *euphrades* ("eloquent"), statesman, rhetorician and philosopher. who proclaimed himself a follower of Aristotle, but also drew freely upon Plato, holding that there is no real opposition between the two. He was born in Paphlagonia and educated in philosophy by his father Eugenius. He taught at Constantinople, where, apart from a short sojourn in Rome, he resided during the rest of his life. Though a pagan, he was admitted to the senate by Constantius in 355. He was prefect of Constantinople in 384 on the nomination of Theodosius. There are extant some paraphrases of the treatises of Aristotle, which belong to the earlier years of his life, and 34 orations. The former are valuable; but the orations in which he panegyrizes successive emperors, comparing them to Plato's "true philosopher." are servile. It is the practical application of Plato's doctrine that interests him; and for him the other branches of philosophy are subordinate to ethics.

THEMISTOCLES (c. 514–449 B.C.), Athenian soldier and statesman in some respects probably the ablest and most far-sighted whom Greece produced in the first half of the 5th century. He was the son of Neocles, an Athenian of no distinction and moderate means, his mother being a Carian or a Thracian Hence according to the Periclean law ἐξ ἀμφοῖν ἀστοῖν he would not have been a free Athenian at all (see PERICLES). Thucydides observes that, though he lacked the culture typical of the Periclean age, he displayed a marvellous power of analysing a complex situation together with a genius for rapid action. Plutarch similarly enlarges on his consuming ambition for power both personal and national, and the unscrupulous ability with which he pursued his ends. Of his early years little is known. He may have been strategus of his tribe at Marathon.

At all events the death of Miltiades left the stage to Aristeides and Themistocles. It is sufficiently clear that their rivalry turned largely on the fact that Themistocles was the advocate of a policy of naval expansion. This policy was unquestionably of the highest importance to Athens and indeed to Greece. Athens was faced by the equal if not superior power of Aegina, while the danger of a renewed Persian invasion loomed large. Themistocles persuaded his countrymen to put in hand the building of 200 triremes, and to fortify the three natural harbours of Peiraeeus (see E. Gardner, Ancient Athens, 562 f.) in place of the open roadstead of Phalerum. For the building of the ships Themistocles persuaded the Athenians to allocate 100 talents obtained from the new silver mines at Laureium (*Ath.* Pol. 22) which were about to be distributed to the citizens (10 drachmae each). One hundred of the proposed 200 mere built.

He may or may not have been archon in 483, according to the Ath. *Pol.,* when this programme began. Dionysius of Halicarnassus places his archonship in 493–92, in favour of which are several considerations. In 487 the office lost much of its importance owing to the substitution of the lot for the election; the chance that the lot would at the particular crisis of 483 fall on Themistocles was obviously remote. In any case, the chief men of the other side disappear one by one — culminating in the ostracism of Aristeides in 482, and the year prior to the invasion of Xerxes found Themistocles the chief man in Athens if not in Greece. Though the Greek fleet was nominally under the control of the Spartan Eurybiades, it was Themistocles who forced the indecisive battle of Artemisium, and by his threat that he would lead the Athenian army to found a new home in the West, and by his treacherous message to Xerxes, precipitated the engagement at Salamis (see P. W. Dodd in Class *Rev.* 27, p. 117). The retirement of the Persians left the Athenians free to restore their ruined city (see ATHENS). Sparta opposed the rebuilding of the walls, but Themistocles by a subterfuge got the walls built high enough to be defensible. He also carried out his original plan of making Peiraeeus a harbour and fortress for Athens. Athens thus became the finest trade centre in Greece, and this fact, coupled with Themistocles' remission of the alien's tax (μετοίκιον) induced many foreign business men to settle in Athens.

After the crisis of the Persian invasion Themistocles and Aristeides appear to have composed their differences. But Themistocles soon began to lose the confidence of the people, partly owing to his boastfulness (it is said that he built near his own house a sanctuary to Artemis Aristoboulē "of good counsel") and partly to his alleged readiness to take bribes. Diodorus (xi. 54) and Plutarch (Themist. 23) both refer to some accusation levelled against him. There is, however, much difficulty regarding this accusation; it may be simply a misunderstanding of his ostracism. Some time between 476 and 471 he was ostracized. He took refuge eventually in Asia Minor, and was proclaimed a traitor in Athens. He was well received by the Persians and was allowed to settle in Magnesia on the Maeander. He died at Magnesia at the age of 65, and a splendid memorial was raised by the people of the town, though it is said that his bones were secretly transferred to Attica. He was worshipped by the Magnesians as a god, as we find from a coin on which he is shown with a patera in his hand and a slain bull at his feet (hence perhaps the legend that he died from drinking bull's blood: cf. Aristoph. *eq.* 83;

Diod. xi. 58; Plut. *Them.* 31).

Though his end was discreditable, though his great wealth can hardly have been obtained by loyal public service, there is no doubt that his services to Athens and to Greece were great. He created the Athenian fleet and with it the possibility of the Delian League (*q.v.*) which became the Athenian empire, and there are many indications (*e.g.,* his well-attested plan of expansion in the west) that the later imperialist ideal originated in his fertile brain.

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THÉNARD, LOUIS JACQUES (1777–1857), French chemist, author of a standard textbook on elementary chemistry and discoverer of hydrogen peroxide, was born on May 4, 1777, at La Louptière, Aube. the son of a poor peasant, who made great sacrifices for his son's education. He worked in a humble capacity in the laboratory of Louis N. Vauquelin, who procured for him various teaching posts. In 1802 when Vauquelin left the College de France, he used his influence to secure Thénard's succession to the chair of chemistry. Later, ThCnard held the chair of chemistry at the École Polytechnique and at the Sorbonne. Made a baron by Charles X in 1825, he was a peer of France (1832), deputy for Yonne (1827–30), chancellor of the university and a member of the council of education.

Thénard died in Paris on June 21, 1857, and the name of his native village was changed (1865) to Louptière-Thénard in his honour.

ThCnard was a great teacher, and his *Traité élémentaire de chimie théorique et pratique* (4 vol., 1813–16) did more, perhaps, than even his many important original discoveries to advance the cause of science. With his lifelong friend, J. L. Gay-Lussac (*q.v.*), he carried out many researches. His researches on esters (1807), sebacic acid (1802) and on bile (1807), his discovery of peroxide of hydrogen (1818) and his work on organic phosphorus compounds (1846) deserve mention. The substance known as ThCnard's blue he prepared in 1799 in response to a peremptory demand by J. A. Chaptal for a cheap colouring matter, as bright as ultramarine and capable of standing the heat of the porcelain furnace.

A list of Thénard's memoirs may be found in the Royal Society's *Catalogue of Scientific Papers.*

THEOBALD (d. 1161), archbishop of Canterbury, was of Norman parentage, but the date of his birth is unknown. Early in life he entered the abbey of Bec, of which he became prior in 1127 and abbot ten years later. In 1138 he was elected to the see of Canterbury, and as archbishop he behaved with a moderation which is in striking contrast to the conduct of his rival, Henry of Blois, bishop of Winchester. During the struggle between Stephen and Matilda it was Bishop Henry who fought for the privileges of the Church; Theobald, while showing a preference for Stephen's title, made it his rule to support the *de facto* sovereign. But as Stephen's cause gained ground the archbishop showed greater independence. He refused to consecrate the king's nephew to the see of York, and in 1148 attended the papal council of Reims in defiance of a royal prohibition. This quarrel was ended by the intercession of the queen, Matilda of Boulogne, but another, of a more serious character, was provoked by Theobald's refusal to crown Count Eustace, the eldest son of Stephen, the archbishop pleading the pope's orders as the excuse for this contumacy. In 1153 Theobald succeeded in reconciling Stephen with Henry of Anjou, and in securing for the latter the succession to the throne. He placed the interests of the Church in the hands of Thomas Becket, his archdeacon. Theobald died on April 18, 1161.

In history Theobald lives chiefly as the patron of three eminent men: Becket, who began life as a clerk in his household; Master Vacarius, the Italian jurist. who was the first to teach Roman law in England; and John of Salisbury, the learned scholar. Theobald's household was a university in little; and in it were trained many leading prelates of the next generation.

See the *Vita Theobaldi* printed in J. A. Giles, *Lanfranci Opera,* vol. i. (1844); W Hook, *Lives of the Archbishops of Canterbury,* ii. c. vi. (1862); and K. Norgate, *England under the Angevin Kings,* vol. i. (1887).

(H W. C. D.)

THEOBALD, LEWIS (1688–1744), English man of letters, playwright and Shakespearian commentator, the son of an attorney. was born at Sittingbourne, Kent. He was baptized on April 2, 1688, and was educated for the law. He translated the *Phaedo* of Plato in 1713, in 1714–15 the plays of Sophocles and of Aristophanes, and in 1716 the first book of the *Odyssey.* Meanwhile he had got into trouble in 1716 on a charge of plagiarism in his play *The Perfidious Brother.* But Theobald is remembered neither as translator, nor as original author, but for his work on the text of the Shakespeare plays.

In 1726 he produced *Shakespeare Restored, or a Specimen of the many Errors as well Committed as Unamended by Mr. Pope in his late edition of this Poet; designed not only to correct the said Edition, but to restore the true Reading of Shakespeare in all the Editions ever published* (1726). Some of his happiest emendations are to be found in this work, which conclusively proved Pope's incompetence as a Shakespearian editor.

In 1731 Theobald undertook to edit Shakespeare for Tonson the publisher. The work appeared in seven volumes in 1734, and completely superseded Pope's edition. Subsequent editors reaped, in many cases without acknowledgment or with actual scorn, the fruit of Theobald's painstaking labour, his wide learning and his critical genius.

His correspondence with Matthew Concanen, Styan Thirlby and William Warburton is to be found in Nichols's *Illustrations of Literature* (ii. 204–654), which also gives the fullest account of his life. *See* also R. F Jones, *Lewis Theobald; his contribution to English Scholarship* (1919).

THEOBALD, SAMUEL (1846–1930), U.S. ophthalmologist, was born at Baltimore, Md., on Nov. 12, 1846. After receiving his medical degree from the University of Maryland in 1867, he specialized in ophthalmology and otology, studying in Vienna and at the Royal London Ophthalmic hospital, 1870–71. Returning to Baltimore in 1871, he helped found the Baltimore Eye and Ear dispensary in 1874 and in 1882, with a few colleagues, set up the Baltimore Eye, Ear and Throat Charity hospital. He was ophthalmic surgeon at Johns Hopkins hospital (1889–1925), clinical professor of ophthalmology and otology at the Johns Hopkins School of Medicine (1896–1912) and professor of ophthalmology at the same school (1912–25).

During his career he published more than 100 articles dealing with his specialty. Among them were descriptions of new instruments, surgical procedures, case reports, etc. He also prepared reports on the relationship between general diseases and diseases of the eye and on the prevention of blindness. Among the new techniques he developed were the use of boric acid in the eye and the use of electromagnets for removing metallic particles from the eye. He also pioneered in the use of cocaine as an anesthetic.

In addition to many articles, Theobald published *Prevalent Diseases of the Eye* (1906). He was president of the American Ophthalmological society (1910) and of the Medical and Chirurgical Faculty of Maryland (1900). He died at Baltimore on Dec. 20, 1930.

THEOBROMINE: *see* PURINES.

THEOCRITUS (*c.* 310–250 B.C.), Greek poet born in Syracuse, was the creator of pastoral poetry. His poems were termed idylls (*eidyllia*) by the grammarians. The word is a diminutive of *eidos* and may mean "little poems." Some, however, interpret it as meaning "forms"; *i.e.,* the bucolic, epic or lyric forms, and apply it to Theocritus' poems because they are of many different types.

There are no sure facts as to Theocritus' life beyond those supplied by idylls xv, xvi, and xvii. One view is that after composing xvi and perhaps iv and v Theocritus left Sicily and joined the circle of Philetas in Cos, but soon found his way to Alexandria. Later, on this view, he left Egypt and went either to Cos again or to some other place; *e.g.,* Rhodes, in the eastern Aegean. Idyll vii was almost certainly written in Cos, but probably after the visit to Egypt. The rest of the poems, except xv and xvii, which were no doubt composed in Egypt, may belong to either of the visits to Cos or to that to Alexandria.

The writings of Theocritus must be handled with caution as some of the poems commonly attributed to him have little claim to authenticity. It is possible that at an early date two collections were made, one of which included a number of doubtful poems and formed a corpus of bucolic poetry, while the other was confined to those works which were considered to be by Theocritus himself. The record of these recensions is perhaps preserved by two epigrams in the Palatine anthology, one of which (9:205) proceeds from Artemidorus, the grammarian, who lived in the time of Sulla and is thought by some to have been the first editor of the bucolic poets. He says "Bucolic muses, once were ye scattered, but now one byre, one herd is yours." The second epigram (Anth. *Pal.* 9:434) is anonymous, and is translated as follows: "The Chian is another. I, Theocritus, who wrote these songs, am one of the many Syracusans, the son of Praxagoras and famed Philinna. I never sought after a strange muse." The last line may mean he wrote nothing but bucolic poems, or that he wrote only in Doric. The statement that he was a Syracusan is confirmed by allusions in the idylls.

The *Suda* lexicon states that besides the bucolic poems some persons also attribute to Theocritus the following: Daughters *of* Proetus, Hopes, Hymns, Heroines, Dirges, Lyrics, Elegies, Iambics, *Epigrams.* Except for the Hymns, Lyrics and Epigrams these works are lost.

Authentic Poems.—The poems which are generally held to be authentic comprise bucolics and mimes, epics, lyrics and epigrams.

Bucolics and Mimes.—The distinction between these is that the scenes of the former are laid in the country and those of the latter in a town. The most famous of the bucolics are i, vii, xi and vi. In i Thyrsis sings to a goatherd how Daphnis, the mythical herdsman, having defied the power of Aphrodite, dies rather than yield to a passion with which the goddess had inspired him. In xi Polyphemus is depicted as in love with the sea nymph Galatea and finding solace in song; in vi he is cured of his passion and naïvely relates how he repulses the overtures now made to him by Galatea. The monster of the Odyssey has been "written up to date" after the Alexandrian manner and has become a gentle simpleton. Idyll vii, the Harvest Home, is the most important of the bucolic poems. The scene is laid in the isle of Cos. The poet speaks in the first person and is styled Simichidas by his friends. Other poets are possibly introduced under feigned names, but the only certain identification is that of Sicelidas (line 40) as Asclepiades of Samos. Theocritus declares that he is not yet superior to the latter nor to Philetas of Cos, said to have been his teacher, but boasts that his lays have been brought by report even unto the throne of Zeus, meaning apparently that they have secured the approval of Ptolemy Philadelphus. In lines 47–48 he criticizes "the fledgelings of the Muses, who cackle against the Chian bard and find their labour lost," thus taking the side of Callimachus in his controversy with Apollonius Rhodius over the merits of epic poetry.

The other bucolic poems are less interesting. Several consist of a singing match, conducted according to the rules of amoebaean poetry, in which the second singer takes the subject chosen by the first and contributes a variation in the same air. The peasants of Theocritus differ greatly in refinement. Those in v are low fellows who indulge in coarse abuse. This idyll and iv are laid in the neighbourhood of Croton in southern Italy, and it seems that Theocritus was personally acquainted with Magna Graecia. Suspicion has been cast on viii and ix for various reasons. It is clear that they were in Virgil's Theocritus and that they passed the scrutiny of the editor who formed the short collection of Theocritean Bucolics. Nevertheless, ix at any rate is not by Theocritus.

The mimes are three in number, viz., ii, xiv, xv. In ii Simaetha, deserted by Delphis, tells the story of her love to the moon; in xiv Aeschines narrates his quarrel with his sweetheart, and is advised to go to Egypt and enlist in the army of Philadelphus; in xv Gorgo and Praxinoa go to the festival of Adonis at Alexandria. These three mimes are wonderfully natural and lifelike.

It is convenient to add to the bucolics and mimes three poems which cannot be brought into any other class: xii, a poem to a beautiful youth; xviii, the marriage song of Helen; and xxvi, the murder of Pentheus. The genuineness of the last has been attacked on account of certain crudities, but the evidence of the manuscripts and papyri is in favour of the poem. Eustathius quotes from it as the work of Theocritus.

Epics.—Two of these are encomia. In xvi the poet praises Hiero II of Syracuse, in xvii Ptolemy Philadelphus. Two are hymns, xxii to the Dioscuri and xxiv to Heracles; xiii is an epyllion, or short epic, the story of Hylas and the nymphs. It cannot be said that Theocritus exhibits signal merit in his epics. In xiii he shows some skill in word painting, in xvi a passage at the end, where he foretells the joys of peace after the enemy has been driven out of Sicily, has the true bucolic ring. The most that can be said of xxii and xxiv is that they are very dramatic. Three poems in this group can be dated, though only approximately. In xvii Theocritus celebrates the marriage of Ptolemy Philadelphus with his sister Arsinoe. This marriage is held to have taken place in 277 B.C., and Arsinoe died in June 270. This poem, therefore, together with xv, which mentions (lines 23–24) the queen as alive, must fall within this period. So probably does a lost poem called Berenice.

The encomium of Hiero seems prior to that of Philadelphus, since in it Theocritus is a hungry poet seeking for a patron, while in the other he is well satisfied with the world. Hiero first came to the front in 276–275 B.C., when he was made "general"; Theocritus speaks of his achievements as still to come (line 73), and the silence of the poet would show that Hiero's marriage to Philistis, his victory over the Mamertines at the Longanus river and his election as "king," events which are ascribed to 270–269 B.C., had not yet taken place.

Lyrics.—These number four, xxviii–xxxi. The first is a very graceful poem presented together with a distaff to. Theugenis, wife of Nicias, a doctor of Miletus, on the occasion of a voyage thither undertaken by the poet. The three other lyrics are all pederastic.

Epigrams.—These, numbering 24, are without special merit, and their authenticity is often doubtful.

Doubtful Poems.—There remain the poems which are generally considered spurious. They are as follows: xix, Love Stealing Honey, which is anonymous in the manuscripts and has a conception of love that is not Theocritean.

Of the next group—xx, The Herdsman, xxi, The Fishermen, xxiii, *The* Lover—only xxi possesses any merit. A more interesting poem is xxv, Heracles the Lion-Slayer. This is a long poem consisting of three episodes, the interview of Heracles with Augeas' bailiff, the review of the king's cattle and Heracles' recital to Phyleus, the son of Augeas, of the story of the Nemean lion. The composition is not unworthy of Theocritus. The Wooing, xxvii, contains imitations of Theocritus, but the tone and the language betray a later writer.

Language and Metre.—Theocritus wrote in various dialects according to the subject. The lyrics are in Aeolic, that being the traditional dialect for such poems. xii and xxii were written in Ionic, as is stated in titles prefixed to them, but a number of Doric forms have been inserted by the scribes. The epics in general show a mixture of Homeric, Ionic and Doric forms. The bucolics, mimes and the marriage song of Helen are in Doric, with occasional forms from other dialects.

The metre used by Theocritus in the bucolics and mimes, as well as in the epics, is the dactylic hexameter. A feature in his verse which has attracted much attention is the so-called bucolic caesura. The rule is that, if there is a pause at the end of the fourth foot, this foot must be a dactyl. This pause is common in Homer, but Theocritus uses it so frequently in the bucolics that it has become a mannerism. In the epics his practice agrees with that of Homer.

Like all the Alexandrians Theocritus had no scruples about borrowing with a variation from earlier Greek writers. Homeric phrases, adapted to a new setting, crop up everywhere in his verse, but he was no slavish imitator, and despite the scholiast it seems very improbable that in ii and xv he owed any considerable debt to Sophron, the Sicilian writer of mimes. The latter idyll has resemblances to the fourth mime of Herodas, but which preceded the other it is impossible to determine.

Theocritus' Place in Poetry.—Like his contemporary Callimachus, Theocritus was an accomplished literary artist and modern scholarship has thrown much light on the details of his craftsmanship, but, whereas the poems of Callimachus (admittedly most survive only in fragments) must remain "caviare to the general," Theocritus makes a universal appeal to the modern reader for the reason that his bucolics and mimes, however elegantly and at times eruditely expressed, reflect human nature, which Callimachus' poetry never does. This truth needs no demonstration as regards the mimes. Cynisca and her lover (in xiv) and Gorgo and Praxinoa (in xv) are manifestly real; so too, on a higher level of art, is Simaetha (in ii), as she recounts her betrayal.

The bucolics, however, have sometimes been criticized as attributing to peasants sentiments and language beyond their capacity. There is something in the criticism, but comparison with modern Greek folk songs, which owe little to literary influences, reveals many striking resemblances between them and Theocritus' bucolics and there can be little doubt that both derive from real life. That life, set in a Mediterranean scenery of flowers, sun, sea and mountainside and described by a master of style, will never lose its charm.

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THEODECTES (*c.* 380–340 B.C.), Greek rhetorician and tragic poet, of Phaselis in Lycia, pupil of Isocrates and Plato, and an intimate friend of Aristotle. He at first wrote speeches for the law courts, but subsequently composed tragedies with success. He spent most of his life at Athens, and was buried on the sacred road to Eleusis. The inhabitants of Phaselis honoured him with a statue, which was decorated with garlands by Alexander the Great on his way to the east. In the contests arranged by Artemisia, queen of Caria, at the funeral of Mausolus, Theodectes gained the prize with his tragedy *Mausolus* (extant in the 2nd century A.D.), but was defeated by Theopompus in oratory. According to the inscription on his tomb, he was eight times victorious in 13 dramatic contests. Of his tragedies (50 in number) 13 titles and some fragments remain. His treatise on the art of rhetoric (according to the *Suda* written in verse) and his speeches are lost. The names of two of the latter—*Socrates* and *Nomos* (referring to a law proposed by Theodectes for the reform of the mercenary service)—are preserved by Aristotle in his *Rhetoric.*

The *Theodectea* was probably not by Theodectes, but an earlier work of Aristotle, which was superseded by the extant *Rhetorica.*

THEODOLITE, a surveying instrument consisting of two graduated circles placed at right angles to each other, for the measurement of horizontal and vertical angles, a telescope, which turns on axes mounted centrically to the circles, and an alidade for each circle, which carries two or more verniers. The whole is supported by a pedestal resting on footscrews, which are also employed to level the instrument.

Theodolites are designed to measure horizontal angles with greater accuracy than vertical, because it is on the former that the most important work of a survey depends; measures of vertical angles are liable to be much impaired by atmospheric refraction, more particularly on long lines, so that when heights have to be determined with much accuracy the theodolite must be discarded for a levelling instrument. When truly adjusted the theodolite measures the horizontal angle between any two objects, however much they may differ in altitude, as the pole star and any terrestrial object. The instrument is made in many forms and modern surveying has introduced a great degree of accuracy. For the uses of the theodolite and other details *see* SURVEYING. The name has been a puzzle to etymologists. Various ingenious explanations have been given, all based on the apparent Greek form of the word; thus it has been derived from *θεᾶσθαι,* to see, *ὁδός,* way, and *λιτός,* smooth, plain; from *θεῖν,* to run, and *δολιχός,* long, and in other ways equally fanciful. Another imaginary origin has been suggested in a corruption of "the O deleted," *i.e.,* crossed out, the circle being crossed by diameters to show the degrees; others have found in it a corruption of "the alidade." It would appear, however, to be taken from the O. Fr. *theodolet* or *theodelet,* the name of a treatise by one Theodulus, probably a mathematician (see *Notes and Queries,* 3rd series, vii. 337, 428, etc. Skeat, *Etym. Dict.,* 1910).

THEODORA, the wife of the emperor Justinian (*see* JUSTINIAN I), was born probably in Constantinople, though according to some in Cyprus, in the early years of the 6th century, and died in 547. According to Procopius, our chief but by no means a trustworthy authority for her life, she was the daughter of Acacius, a bear-feeder of the amphitheatre at Constantinople, and while still a child appeared on the stage. Becoming a noted courtesan, she accompanied a certain Hecebolus to Pentapolis (in North Africa), of which he had been appointed governor, and, having quarrelled with him, betook herself first to Alexandria, and then back to Constantinople through the cities of Asia Minor. In Constantinople she attracted the notice of Justinian. He desired to marry her, but could not overcome the opposition of his aunt, the empress Euphemia. After her death (usually assigned to the year 523) the emperor yielded, and as a law forbade the marriage of senators with women who had followed the stage, this law was repealed. Thereupon Justinian married Theodora. They were some time after (527) admitted by Justin to a share in the sovereignty; and, on his death four months later, Justinian and Theodora became sole rulers of the Roman world. He was then about forty-four years of age, and she some twenty years younger. Procopius relates in his unpublished history (Ἀνέκδοτα) many repulsive tales regarding Theodora's early life, but his evident hatred of her, though she had been more than ten years dead when the *Anecdota* were written, and the extravagances which the book contains, oblige us to regard him as a very doubtful witness. James Bryce discovered in Rome what is believed to be the only ms. of this so-called life of Justinian; he considered it worthless as an authority.

Theodora speedily acquired unbounded influence over her husband. She had a right to interfere, for she was not merely his consort, but empress regnant. In the most terrible crisis of Justinian's reign, the great Nika insurrection of 532, her courage and firmness in refusing to fly when the rebels were attacking the palace saved her husband's crown, and no doubt strengthened her command over his mind. Officials took an oath of allegiance to her as well as to the emperor (*Nov.,* viii.). Procopius describes her as acting with the greatest cruelties. The city was full of her spies, who reported to her everything said against herself or the administration. She surrounded herself with ceremonious pomp, and required all who approached to abase themselves in a manner new even to that half-Oriental court. She constituted herself the protectress of faithless wives against outraged husbands, yet professed great zeal for the moral reformation of the city, enforcing severely the laws against vice, and immuring in a "house of repentance" on the Asiatic side of the Bosphorus five hundred courtesans whom she had swept out of the streets of the capital. How much of all this is true we have no means of determining, for it rests on the sole word of Procopius.

But there are slight indications in other writers that she had a reputation for severity.

In the religious strife which distracted the empire Theodora took part with the Monophysites. As Justinian was a warm upholder of the decrees of Chalcedon, this difference of the royal pair excited much remark and indeed much suspicion, and if it should be true that Theodora disapproved of Justinian's western conquests, her judgment must be acknowledged to have been correct.

In other matters also the wife spoke and acted very differently from the husband; but their differences do not seem to have disturbed either his affection or his confidence.

According to Procopius, Theodora had before her marriage become the mother of a son, who when grown up returned from Arabia, revealed himself to her, and forthwith disappeared forever; but this is a story to be received with distrust. That her behaviour as a wife was irreproachable may be gathered from the fact that Procopius mentions only one scandal affecting it, and that with some hesitation, the case of Areobindus. Her health was delicate, and, though she took all possible care of it, frequently quitting the capital for the seclusion of her villas on the Asiatic shore, she died comparatively young. Theodora was small in stature and rather pale, but with a graceful figure, beautiful features, and a piercing glance.

There remains in the apse of the famous church of S. Vitale at Ravenna a contemporaneous mosaic portrait of her, to which the artist, notwithstanding the stiffness of the material, has succeeded in giving some character.

Nearly all the evidence against Theodora is derived from the violently written *Anecdota* of Procopius, and has therefore been suspected. *(See* especially Débidour's *L'Impératrice The'odora.)* Modern researches, particularly those of Panchenko, the Russian scholar, have vindicated the general credibility of Procopius. Of course, he can frequently be convicted of unfairness; he always attributes the worst motives. His description of the profligacy of Theodora only proves his familiarity with the pornography of Constantinople. But it rests on the solid witness of John of Ephesus that Theodora's youth was disreputable. We gather too from other writers that she was harsh and tyrannical, as, for instance, from the references to her in the lives of the popes in the *Liber Pontificalis* (which used to pass under the name of Anastasius, the papal librarian). Her threat to the person whom she commanded to bring Vigilius to her was "nisi hoc feceris, per Viventem in saecula excoriari te faciam." Much of what we find in these lives is legendary, but they provide some evidence of Theodora's reputation. Again, (3) the statute (Cod., v, 4, 23) which repeals the older law so far as relates to *scenicae mulieres* is now generally attributed to Justin, and agrees with the statement of Procopius that an alteration of the law was made to legalize her marriage. There is therefore reason for holding that she was an actress. About the beauty, the intellectual gifts, and the imperious will of Theodora there can be no doubt. She was evidently an extraordinary person, born to shine in any station of life.

Her fortunes have employed many pens. Among the later serious works dealing with them may be mentioned M. Antonin Débidour's *L'Impératrice The'odora: Etude Critique* (1885), which endeavours to vindicate her from the aspersions of Procopius; and among more imaginative writings are Sir Henry Pottinger's interesting romance *Blue and Green* (1879), *M.* Rhangabé's tragedy Θεοδώρα (Leipzig, 1884), and M. Sardou's play *Théodora,* produced in Paris in 1884. *See* also F. Dahn's *Prokopios von Casarea* (1865) and *B.* Panchenko in "Vizant Vremennik" vol. ii, iii and, in addition, the works cited under JUSTINIAN I.

THEODORE, the name of two popes.

THEODORE I, pope from Nov. 642 to May 649, was a Greek, born in Jerusalem. Noted for his generosity to the poor, he had to devote most of his attention to the struggle against Monothelitism *(see* MONOTHELITES).

Theodore I refused to recognize the uncanonically installed patriarch of Constantinople, Paul. In 648 he excommunicated Paul's predecessor, Pyrrhus, who had relapsed into Monothelitism, and the next year he declared Paul's deposition for the same heresy.

THEODORE II, pope for 20 days in Dec. 897, recognized the validity of the acts of the deceased Pope Formosus (*q.v.*), whose outraged corpse he reburied. (A. G. Bi.)

THEODORE I (1557–1598), tsar of Russia, the son of Ivan the Terrible and Anastasia Romanova, nominally succeeded his father in 1584, but being of weak intellect was governed throughout his reign by the boyar, Boris Godunov, whose sister Irene he married in 1580. On his death-bed he is said to have left the throne to his consort, with the Patriarch Job, Boris Godunov, and Theodore Romanov, afterwards the Patriarch Philaret, as her chief counsellors. Irene, however, retired into a monastery and her brother Boris stepped into her place.

THEODORE II. (1589–1605), tsar of Russia, was the son of Tsar Boris Godunov and one of the daughters of Malyuta-Skuratov, the infamous favourite of Ivan the Terrible. Passionately beloved by his father, he received the best available education for those days, and from childhood was initiated into all the *minutiae* of government, besides sitting regularly in the council and receiving the foreign envoys. He seems to have been precociously intelligent, and the first map of Russia by a native, still preserved, is by his hand. On the sudden death of Boris he was proclaimed tsar (April 13, 1605). On July 10, he was murdered in his apartments in the Kreml.

THEODORE III. (1661–1682), tsar of Russia, was the eldest surviving son of Tsar Alexius and Maria Miloslavskaya. In 1676 he succeeded his father. He had received an excellent education at the hands of Simeon Polotsky, the most learned Slavonic monk of the day, knew Polish, and even possessed the unusual accomplishment of Latin; but, disfigured and half paralyzed by disease, he had been an invalid from his birth. In 1679 he married his first cousin Agatha and assumed the sceptre. His native energy was not crushed by his disabilities; and he soon proved as thorough a reformer as a man incompetent to lead armies and obliged to issue his orders from his litter, or his bed-chamber, could be. His consort, Agatha, shared his progressive views. On her death (July 4, 1681) Theodore married Martha Apraksina. He died on April 27, 1682, without issue.

THEODORE (602–690), seventh archbishop of Canterbury, was born at Tarsus in Cilicia in 602. On the death of Wighard, who had been sent to Pope Vitalian by Ecgberht of Kent and Oswio of Northumbria in 667, apparently for consecration as archbishop, Theodore, who had become prominent in the Eastern work of the church, was recommended by Hadrian of Niridanum to fill the vacant see. Vitalian consecrated Theodore in April 668 on condition that Hadrian, afterwards abbot of St. Peter's, Canterbury, should go with him. Hadrian was detained for some time by Ebroin, the Neustrian mayor of the palace, but Theodore reached England in May 669. According to Bede's account he made a tour of the whole of Anglo-Saxon England, reforming abuses and giving instruction as to the monastic rule and the canonical Easter. Bede also declares that he was the first archbishop to whom all the "church of the Angles" submitted.

In 673 Theodore presided at the first synod of the clergy in England which was held at Hertford. Various disciplinary regulations were emphasized, and an annual meeting arranged at a place called Cloveshoe. After this council Theodore revived the East Saxon bishopric, to which he appointed Earconwald. Soon after the first expulsion of Wilfrid in 678 he divided the Northumbrian diocese, appointing Trumwine bishop to the Picts. This led to a quarrel with Wilfrid which was not finally settled until 686–687. In 679 Theodore intervened to make peace between Ecgfrith of Northumbria and Aethelred of Mercia. He presided at other synods held in 680 at Hatfield and in 684 at Twyford, and died in 690. A penitential composed under Theodore's direction is still extant.

See Bede, *Hist. Eccl.,* edited by C. Plummer (Oxford, 1896); Eddius, *Vita Wilfridii* in J. Raine's *Historians of the Church of York,* vol. i. (London, 1879); *Anglo-Saxon Chronicle,* edited by Earle and Plummer (Oxford, 1899); Haddan and Stubbs, *Councils and Ecclesiastical Documents* (Oxford, 1869–78), iii. 173–213.

THEODORE LASCARIS (d. 1222), emperor of Nicaea, was born of a noble Byzantine family. He became the son-in-law of the Emperor Alexius III. and distinguished himself during the sieges of Constantinople by the Latins (1203–04). After the capture of the city he gathered a band of fugitives in Bithynia and established himself in the town of Nicaea. Relieved of the danger of invasion, owing to an incursion of Bulgarians into the Latin empire, he set to work to form a new Byzantine state in

Asia Minor, and in 1206 assumed the title of emperor. He defended himself stubbornly against the Latin emperor Henry, defeated his rival Alexius Comnenus of Trebizond, and carried out a successful counter-attack upon Gayath-ed-din, the sultan of Koniah. His crowning victory was gained in 1210, when in a battle near Pisidian Antioch he captured the deposed emperor Alexius III. and wrested the town itself from the Turks.

See A. Meliarakes,'*Ἱστορία τοῦ Βασιλέιου τῆς Νικάιας καὶ τοῦ Δεσποτάτου τῆς Ἠπέιρου* (Athens, 1898).

Theodore's grandson, THEODORE II. (Lascaris), emperor from 1254 to 1258, is chiefly noticeable for two brilliant campaigns by which he recovered Thrace from the Bulgarians (1255–56). His ill-health and early death prevented his making full use of his ability as a ruler.

THEODORE OF MOPSUESTIA (c. 350–428/9), early Christian theologian, the most eminent representative of the so-called school of Antioch, was born at Antioch about the middle of the 4th century and was a friend of John Chrysostom; in rhetoric the celebrated Libanius was his teacher. Soon, however, he attached himself to the school of the great exegete and ascetic, Diodorus, a presbyter in Antioch, and with only a transitory period of vacillation, from which he was won back by Chrysostom, he remained faithful to the theology and ascetic discipline of this master. Under Diodorus he became a skilful exegete, and ultimately outstripped his master in biblical learning. About 383 Theodore became a presbyter in Antioch, and began to write against Eunomius the Arian and against the christology of Apollinaris. Soon after 392 he became bishop of Mopsuestia in Cilicia (the modern Missis near Adana). As such he was held in great respect, and took part in several synods, with a reputation for orthodoxy that was never questioned. It was greatly to his advantage that in the Eastern Church the period between the years 390 and 428 was one of comparative repose. He was on friendly terms even with Cyril of Alexandria. He died in 428 or 429.

Theodore wrote commentaries on almost every book of the Old and New Testaments, of which, however, only a small proportion is now extant, as at a later period he lost credit in the church. We still possess in Greek his commentary on the Minor Prophets, in a Syriac version his commentary on St. John[1], and, in Latin translations, commentaries on the shorter Pauline epistles, besides very many fragments, especially on the epistle to the Romans. Theodore's importance as an exegete lies in two characteristics: (1) in opposition to the allegorical method he insists on getting at the literal meaning, and adheres to it when found; (2) in his interpretation of the Scriptures he takes into account the historical circumstances in which they were produced, and substitutes the historical-typological for the pneumatico-christological interpretation of prophecy; in other words, he interprets all Old Testament passages historically in the first instance, and sees the fulfilment of Old Testament prophecy in the history of Christ and His church only in so far as the entire Old Testament is a "shadow of things to come."

Theodore also was the author of a special dissertation against the allegorists, *i.e.,* against Origen and his followers, which, however, has unfortunately perished. The comparative freedom of Theodore's view of inspiration is also noteworthy. He discriminates between historical, prophetical and didactic writings, and in accordance with this distinction assumes varying degrees of inspiration. Finally, he entertained very bold opinions about the canon and several of the books included in it. He esteemed very lightly the Solomonic writings and the book of Job; Canticles he explained as a nuptial poem of Solomon's; the book of Job appeared to him in many places hardly worthy of its subject, and he censures the writer sharply; Chronicles, Ezra and Nehemiah he entirely rejected; he denied the accuracy of the titles of the Psalms, anticipated the hypothesis that many of them belong to the Maccabean age, and referred the so-called Messianic element almost invariably to the kings of Israel; he even criticized the Catholic epistles and rejected the epistle of James. Characteristics such as these bring Theodore, of all patristic writers, nearest to the modern spirit.

[1]Ed. P. B. Chahot (Paris, 1897).

LITERATURE.—Migne, *Patrol.,* ser. Gr., lxvi. The Greek fragments of Theodore's New Testament commentaries have been collected by O. Fr. Fritzsche *(Theod. Mops. in N.T. Comm.,* Turin, 1847). The commentaries on the Pauline epistles (Pitra, *Spicilegium Sotesmense,* Paris, 1852, i. 49 *seq.)* have been edited by H. B. Swete *(Theod. Mops. in Epp. B. Pauli Comm.,* i., ii., Cambridge, 1880–82), along with the Greek fragments and the fragments of the dogmatical writings; on this edition, *see* E. Schiirer, *Theol. Lit. Ztg.,* 1880–82. The commentary on the Minor Prophets will be found in Mai's *Nov. Patr. Biblioth.,* vii. 1854 (Berlin, 1834; Mai, *Script. Vet. Nov. Coll.,* vi., 1832). *See* also E. Sachau, *Theod. Mops. Fragm. Syriaca* (Leipzig, 1869); Fr. Bathgen, "Der Psalmencommentar des Theod. v. Mops. in Syr. Bearbeitung," in *Ztschr. f. Alt-Test. Wissensch.,* v. 53 *seq.,* vi., 261–288, vii. 1–60; and H. Lietzmann in *Sitzungsberichte der Kgl preuss. Akad. der Wissensch., zu Berlin,* 1902, pp. 334 *seq.* Extracts from the writings of Theodore occur in the *Catenae* of Marius Mercator, in the *Acta* of the third and fifth oecumenical councils in Facundus, Liberatus, and Theodore's chief adversary Leontius Byzantinus. E. von Dobschiitz, in *Amer. Journ. of Theol.,* ii. 353–387, published the Greek prologue of a commentary on *Acts* that is probably the work of Theodore.

The principal monograph on Theodore, apart from the prolegomena of Swete, and the same writer's article in *Dict. Christian Biog.,* iv. (1887), is that of H. Kihn *(Th. v. Mops. u. Junilius Afric. als Exegeten,* Freiburg, 1880). On his importance for the history of dogma *see* the works of Baur, Dorner, Harnack, Loofs and Seeberg. Literary and biographical details will be found in O. Fr. Fritzsche, *De Theod. Mops. Vita et Scriptis* (Halle, 1836); Fr. A. Specht, *Theod. v. Mops. u. Theodoret* (Munich, 1871); H. Kihn in the *Tub. Quartalschr.,* 1879; *E.* Nestle in *Theol. Stud. aus Würtemb.,* ii. 210 *seq.;* P. Batiffol, "Sur une Traduction Latine de Th. de Mops.," in *Ann, de Philos. Chrdt.,* 1885; Th. Zahn, "Das N. T. Theodors von Mop.," in *Neue Kirchl. Zeitschr.,* xi. 788–806; *W.* Wright, *Syriac Literature* (London, 1894); R. Duval, *La littdratwe syriaque* (Paris, 1899). (A. HA.; X.)

THEODORET, bishop of Cyrrhus, an important writer in the domains of exegesis, dogmatic theology, church history and ascetic theology, was born in Antioch, Syria, about 386. At an early age he entered the cloister; and in 423 he became bishop of Cyrrhus, a small city in a wild district between Antioch and the Euphrates, where, except for a short period of exile, he spent the remainder of his life. The date of his death is uncertain, but it must have been not earlier than 457.

Commentaries.—As an exegete Theodoret belongs to the Antiochene school, of which Diodorus of Tarsus and Theodore of Mopsuestia were the heads. He was not actually the personal disciple of either, but he adopted their methods, though without the consistency and boldness of the first-named. His extant commentaries (those on Canticles, on the Prophets, on the book of Psalms and on the Pauline epistles) are brief.

Dogmatic **Works.**—Theodoret's chief importance is as a dogmatic theologian, as the most considerable opponent of the views of Cyril and Dioscurus of Alexandria. For more than twenty years he maintained the struggle against the Alexandrian dogmatic and its formulae (*θεοτόκος, ἕνωσις καθ' ὑπόστασιν, μία ὑπόστασις ἕνωσις φυσική,* and the like), and taught that in the person of Christ we must strictly distinguish two natures (*hypostases*), which are united indeed in one person (prosopon), but are not amalgamated in essence. For these years his history coincides with that of the Eastern Church from 430 to 451, and for this very reason it is impossible to sketch it even briefly here. (See Hefele, *Conc.-gesch.,* vol. ii.) The issue was not unfavourable to Theodoret's cause, but melancholy enough for Theodoret himself: the council of Chalcedon condemned monophysitism, but he unhappily yielded to pressure so far as also to take part in pronouncing "anathema upon Nestorius, and upon all who call not the Holy Virgin Mother of God, and who divide the one Son into two."

Some of Theodoret's dogmatic works are no longer extant: of his five books On The *Incarnation,* for example, directed against Cyril after the council of Ephesus, we now possess fragments merely. A good deal of what passes under his name has been wrongly attributed to him. Certainly genuine are the refutation (*Ἀνατροπή*) of Cyril's twelve *ἀναθεματισμοί* of Nestorius, and The Mendicant, or *Πολύμορφος* (written about 446), consisting of three dialogues, entitled respectively Immutability, *Inconfusibility* and Apathy, in which the monophysitism of Cyril is opposed, and its Apollinarian character insisted on. Among the apologeticodogmatic works of Theodoret must be reckoned his ten discourses *On Providence.*

Other Works.—The 30 ascetic biographies of his *Religious History,* which has been widely read, form a pendant to the *Historia Lausiaca* of Palladius and the monkish tales of Sozomen. For the East it has had the same importance as the similar writings of Jerome, Sulpicius Severus and Cassian for the West.

BIBLIOGRAPHY.—The edition of Sirmond (Paris, 1642) was afterwards completed by Garnier (1684), who has also written dissertations on the author's works. Schulze and Nösselt published a new edition (6 vols., Halle, 1769–74) based on that of their predecessors; a glossary was afterwards added by Bauer. The reprint will be found in vols. lxxx.–lxxxiv. of Migne, and considerable portions occur in Mansi. The church history has been published frequently in connection with the histories of Socrates, Sazomen and others, *e.g.,* by Valesius (1693) and Reading (1720). There is an English translation of the history by Bloomfield Jackson in the *Nicene and Post-Nicene Fathers,* series ii., vol. iii.; the translation including also the dialogues and letters.

Besides the earlier labours of Tillemont, Ceillier Oudin, Du Pin and Fabricius and Harless, *see* Schrockh, *Kirchengesch.,* vol. xviii.; Hefele, *Conc.-gesch.,* vol. ii.; Richter, *De Theodoreto Epp. Paul. Interprete* (Leipzig, 1822); Binder, *Études sur Théodoret* (Geneva, 1844); Staudlin, *Gesch.* u. *Lit. der Kirclzengesch.* (Hanover, 1827); Kihn, *Die Bedeutung der antioch. Schule* (1866); Diestel, *Das A. T. in der christl. Kirche* (Jena, 1869); Specht, *Theodor* v. *Mopsvestia u. Tlzeodoret* v. *Cyrus* (Munich, 1871); Roos, *De Theodoreto Clementis et Eusebii Compilatore* (Halle, 1883); Nolte in the *Tubing. Quartalschr.* (1859), p. 302 *seq.;* Möller, art. "Theodoret," in Herzog-Hauck's *Realencykl.;* Venables's article in Smith and Wace's *Dict. of Christian Biography;* also Bardenhewer's *Patrologie,* p. 345 ff.
(A. HA.; X.)

THEODORIC, king of the Ostrogoths (*c.* 454–526). Referring to the article GOTHS for a general statement of the position of this, the greatest ruler that the Gothic nation produced, we add here some details of a more personal kind. Theodoric was born about the year 454, and was the son of Theudemir, one of three brothers who reigned over the East Goths, at that time settled in Pannonia. The name of Theodoric's mother was Erelieva, and she is called the concubine of Theudemir. The Byzantine historians generally call him son of Walamir, apparently because the latter was the best known member of the royal fraternity. At the age of seven he was sent as a hostage to the court of Constantinople, and there spent ten years of his life. Soon after his return to his father he secretly attacked the king of the Sarmatians, and wrested from him the important city of Singidunum (Belgrade). Theodoric took the chief part in an expedition into Moesia and Macedonia, the result of which was to settle the Ostrogoths as *foederati* in the heart of the empire. About 474 Theudemir died, and for the fourteen following years Theodoric was chiefly engaged in a series of profitless wars, partly against the emperor Zeno, but partly against a rival Gothic chieftain, another Theodoric, son of Triarius. In 488 he set out, with the sanction of the emperor, to win Italy from Odoacer. The invasion and conquest of Italy occupied more than four years (488–493). Theodoric, who marched round the head of the Venetian Gulf, had to fight a fierce battle with the Gepidae, probably in the valley of the Save. At the Sontius (Isonzo) he found his passage barred by Odoacer, over whom he gained a complete victory (28th of August 489). A yet more decisive victory followed on the 30th September at Verona. Odoacer fled to Ravenna, and it sccmcd as if the conquest of Italy was complete. At length (26th of February 493) the long and severe blockade of Ravenna was ended by a capitulation, the terms of which Theodoric disgracefully violated by slaying Odaacer with his own hand (1jth of March 493). (*See* ODOACER.)

The thirty-three years' reign of Theodoric was a time of unexampled happiness for Italy. Unbroken peace reigned within her borders (with the exception of a trifling raid made by Byzantine corsairs in 508). The venality of the Roman officials and the turbulence of the Gothic nobles were sternly repressed. Marshes were drained, harbours formed, the burden of the taxes lightened, and the state of agriculture so much improved that Italy, from a corn-importing, became a corn-exporting country. Moreover Theodoric, though adhering to the Arian creed of his forefathers, was during the greater part of his reign conspicuously impartial in religious matters. At the time of the contested papal election between Symmachus and Laurentius (496–502), Theodoric's mediation was welcomed by both contending parties. At the close of his reign (524), the emperor Justin's persecution of the Arians led him into a policy of reprisals. He forced Pope John to undertake a mission to Constantinople to plead for toleration, and on his return threw him into prison, where he died. Above all, he sullied his fame by the execution of Boethius and Symmachus. (*See* BOETHIUS, ANECIUS MANLIUS SEVERINUS.) Theodoric's death, which is said to have been hastened by remorse for the execution of Symmachus, occurred Aug. 30, 526. He was buried in the mausoleum which is one of the marvels of Ravenna (*q.v.*), and his grandson Athalaric, a boy of ten years, succeeded him, under the regency of his mother Amalasuntha.

AUTHORITIES.—The most important source for Theodoric's life reign (ed. in *Monumenta Germaniae Historica,* vol. xii.) is the *Variae* (state-papers) of Cassiodorus, chief minister of Theodoric. The most modern work is Hartmann's *Geschichte Italiens im Mittelalter,* vol. i. (Stuttgart, 1923). The English reader may consult Gibbon's *Decline and Fall,* chap. xxxix., and Hodgkin's *Italy and her Invaders,* vol. iii. (1885), his introduction to *Letters of Cassiodorus* (1886) and *Theodoric the Goth* (London and New York, 1891).

THEODORUS STUDĪTA [Theodore of the Studion] (A.D. 759–826), abbot of the monastery of the Studion, Constantinople, succeeded his uncle Plato, as head of the monastery of Saccudium in Bithynia in 794. He was banished to Thessalonica in connection with the marriage of Constantine VI. After the emperor's death in 797 he was recalled and removed with his monks to the monastery of the Studion in Constantinople, where he carried on a vigorous campaign in favour of asceticism and monastic reform. In 809 he was again banished in consequence of his refusal to hold communion with the patriarch Nicephorus, who had pardoned the priest Joseph for his part in the marriage of Constantine and Theodotē. In 811 he was recalled by Michael Rhangabes, and again banished in 814 for his opposition to Leo the Iconoclast. He was liberated in 821 by the Emperor Michael the Stammerer (Balbus). In 824 he violently attacked Michael for iconoclasm and was forced to leave Constantinople. He lived at various monasteries until his death on Nov. 11, 826. He was buried at Chalcitis, but his body was afterwards (Jan. 26, 844) removed to the Studion. He subsequently received the honours of canonization. Of his extant works the following are the most important:—The three λόγοι ἀντιρρητικοί and other works in defence of images and his *Letters.* He was also the composer of hymns; many of which are still extant. Like all the monks of the Studion, Theodore was famous for his calligraphy and industry in copying mss.

BIBLIOGRAPHY.—General edition of his works in J. P. Migne, *Patrologia Graeca,* xcix., to be supplemented (for the *Letters)* by J. Cozza-Luzzi, *Patrum Nova Bibliotheca,* viii. (1871); hymns in J. B. Pitra, *Analecta Sacra,* i. (1876). *See* also Alice Gardner, *Theodore of Studium: his Life and Times* (1905). For further bibliographical details *see* C. Krumbacher, *Gesch. der byz. Lit.* (2nd ed., 1897) and article by Von Dobschiitz in Herzog-Hauck's *Realencyclopädie für protestantische Theologie,* xix. (1907).

THEODOSIA, formerly Kaffa, a seaport and watering-place of South Russia, on the east coast of the Crimea, in 45° 3′ N., 35° 22′ E., and on the railway. It has an excellent modern harbour, which is never frozen and has a floating crane lifting 40 to 50 tons. Pop. (1939) 28,200.

The ancient Theodosia, the native name of which was Ardabda, was a colony founded from Miletus. Archaic terra-cottas show it to have been inhabited in the 6th century B.C., but it is first heard of in history as resisting the attacks of Satyrus, ruler of the Cimmerian Bosporus, *c.* 390 B.C. His successor Leucon took it and made it a great port for shipping wheat to Greece, especially to Athens. This export of wheat continued until the days of Mithradates VI. of Pontus, against whom the city revolted. Later it became a special part of the Bosporan kingdom with its own governor. In the 3rd century A.D. it was still inhabited, but seems to have been deserted not long afterwards. Besides the terra-cottas and pottery, very beautiful Greek jewellery has been found near Theodosia. It coined silver and copper during the 5th and 4th centuries B.C. The name Kaffa (Genoese *Capha,* Turk. *Kefe)* is first mentioned in the 9th century. The Genoese established themselves on the site shortly after 1266, and the settlement flourished exceedingly, being the depôt of a trade route reaching to China. It became the head of the Genoese establishments in Gazaria, the see of a bishop, and the chief port on the northern shore of the Black sea, surpassing the Venetian Tana. When the Turks took Constantinople the colony was almost cut off from the mother city, which handed it over to the enterprising bank of St. George; but it could not be saved and fell in 1475 to the Turks, who sometimes called it Kuchuk-Stambul (Little Stambul) or Constantinople, or Krym-Stambul (Stambul of Crimea). In 1771 it was taken by the Russians, and in 1783 annexed by them, whereupon the greater part of its population deserted it.

See E. von Stern, *Theodosia* (German and Russian, 1906); E. H. Minns, *Scythians and Greeks* (1909); M. Rostovtzeff, *Iranians and Greeks in South Russia* (1922); for the history of Kaffa, *see* Heyd, *Histoire du commerce du Levant au moyen âge* (1886).

THEODOSIUS, the name of three Roman emperors of the East.

THEODOSIUS I., "the Great," son of Theodosius, Valentinian's great general, who in 368–69 saved Britain from the Picts, and suppressed the revolt of Firmus in Mauretania (372). Shortly after (376), the elder Theodosius was put to death, perhaps by order of Valens. The younger Theodosius was born about the year 346. He was a native of Spain, but the exact place of his birth is uncertain. He accompanied his father into Britain (368), and a little later defeated the Sarmatians who had invaded Moesia (374). On his father's death he retired to his native place, where he lived quietly till after the great battle of Adrianople (Aug. 9, 378), when Gratian summoned him to share the empire. After gaining some fresh victories over the Sarmatians, Theodosius was made Augustus at Sirmium on Jan. 19, 379, and was assigned all the eastern provinces, including part of Illyricum. In 379 Theodosius, after reorganizing the army at Thessalonica, carried on a successful campaign of skirmishes along the Danube and induced numerous Gothic bands to give in their allegiance; his lieutenant Modares, a Gothic refugee, defeated the invaders severely in Thrace. In 381 he was called upon to meet two armies of invaders. He conducted in person the war against the Visigoths under Fritigern, this campaign, being only ended by Fritigern's death. The defence of the Danube against the Ostrogoths under Alatheus and Safrax was entrusted to the general Promotus, who severely defeated the enemy in an attempt to cross the river. Theodosius attained even greater successes by his diplomacy. He persuaded the fugitive Visigoth king Athanaric to enter his service, and enlisted 40,000 of his former enemies as *foederati*, providing them with settlements in various parts of the realm.

In 383 Theodosius created his eldest son Arcadius Augustus. The same year saw the revolt of Maximus in Britain and the murder of Gratian. For five years Theodosius consented to accept the usurper as his colleague; but when Maximus attempted a few years later to make himself master of Italy Theodosius advanced against the invader and overthrew him near Aquileia (July 28, 388). This victory was followed by the murder of Maximus and his son Victor, after whose death Theodosius conferred upon Valentinian II. all that part of the empire which his father had held. After celebrating a triumph in Rome (389) he stayed to arrange the government of Italy for another two years. If we may trust the evidence of Zosimus, from the end of the year 388 Theodosius resigned himself to gluttony and voluptuous living, from which he was only roused by the news that in the Western empire Arbogast had slain the young Emperor Valentinian and set up the grammarian Eugenius in his stead (May 15, 392).

Theodosius at once marched out against Eugenius. The armies met near the river Frigidus, some thirty-six miles distant from Aquileia. On the first day Theodosius' barbarians, engaging with those of the hostile army, were almost destroyed, and the victory seemed to be with Eugenius. After a night of prayer, towards cockcrow the emperor was cheered by a vision of St. Philip and St. John, who, mounted on white steeds, promised him success. On the second day the issue was doubtful till, if we may trust the concurrent testimony of all the contemporary church historians, a sudden gust of wind blew back the enemy's arrows on themselves. This was the turning-point of the battle: Eugenius was slain by the soldiers; and two days later Arbogast committed suicide (Sept. 5–9, 394). From the north-eastem parts of Italy Theodosius passed to Rome, where he had his son Honorius proclaimed emperor under the guardianship of Stilicho. Thence he retired to Milan, where he died of dropsy (Jan. 17, 395), leaving the empire to be divided between his two sons Honorius and Arcadius.

The chief authorities for the age of Theodosius are Ammianus Marcellinus, Zosimus, Eunapius and the ecclesiastical historians (Socrates, Sozomen, Theodoret). Much information may also be gleaned from the writings of St. Ambrose, St. Gregory of Nazianzus, Isidore of Seville, and the orators Pacatus, Libanius, Themistius. Among modern authorities see: E. Gibbon, *The Decline and Fall of the Roman Empire* (ed. Bury, 1909), chaps. 25 and 27; T. Hodgkin, *Italy and her Invaders* (Oxford, 1892), chaps. 5, 6, 8–11; A. Güldenpenning and J. Ifland, *Der Kaiser Theodosius der Grosse* (Halle, 1878); G. R. Sievers, *Studien zur Geschichte der romischen Kaiser* (Berlin, 1870), pp. 283–333, and Van Ortroy, *St. Ambroise et l'Empereur Théoduse,* Analecta Bollandiana (1904).

THEODOSIUS II. (401–450) succeeded his father Arcadius as emperor of the East in 408. During his minority the empire was ably ruled by the praetorian prefect Anthemius and Pulcheria, who became her brother's guardian in 414. Under his sister's care the young emperor grew up into a weak though amiable character. Through his generals Ardoburius and Aspar he waged two fairly successful wars against the Persians (421 and 441), and after the failure of one expedition (431) by means of a gigantic fleet put an end to the piracies of the Vandal Genseric. A Hunnish invasion in 408 was skilfully repelled, but from 441 the Balkan country was repeatedly overrun by the armies of Attila, whose incursions Theodosius feebly attempted to buy off with ever-increasing payments of tribute. His internal administration was upright and thoughtful. Among its chief events may be mentioned the council of Ephesus (434) and the publication of the *Codex Theodosianus* (438), a collection of imperial constitutions 'for the benefit of public officials. Theodosius died in 450.

See E. Gibbon, *The Decline and Fall of the Roman Empire* (ed. Bury, London, 1909) 406–414; 440–470; J. B. Bury, *Later Roman Empire,* vol. i. (1923); A. Giildenpenning, *Geschichte des ostromischen Reiches unter den Kaisern Arkadius und Theodosius II.* (Halle, 1885), pp. 172 *sqq.;* T. Mommsen and P. Meyer, *Theodosii libri XVI.* (Berlin, 1904–05; in course of revision by E. Kiegel, 1926).

THEODOSIUS III., emperor of the East (716–717), was a financial officer whom a Byzantine army rebelling against Anastasius III. unexpectedly proclaimed monarch in his stead. He captured Constantinople after a six months' siege and deposed Anastasius, but in the following year was himself forced to resign by a new usurper, Leo III (*see* LEO III, THE ISAURIAN). Theodosius ended his life in a monastery.

See G. Finlay, *History* of *Greece* (ed. 1877, Oxford), i. p. 396).

THEODOSIUS, Greek geometer and astronomer, was the author of three works included in the collection of treatises known as the "Little Astronomy" or "Astronomer" (ὁ μικρὸς ἀστρονούμενος or ἀστρονόμος). He was not "of Tripolis," but came from Bithynia, as we gather from Strabo, who mentions, among natives of Bithynia famous for their learning, "Hipparchus, Theodosius and his sons, mathematicians"; he is also evidently the Theodosius mentioned by Vitruvius as the inventor of a universal sun-dial (*horologium* πρὸς πᾶν κλίμα). He lived, therefore, not later than the 1st century B.C.

His chief work, the *Sphaerica,* in three books, is a tolerably complete treatise on the pure geometry of the sphere, and was still the classical book on the subject in Pappus's time. It does not contain (except for a faint suggestion in iii. 11–12) any trace of spherical trigonometry, which, on the other hand, was the special subject of the work with the same title by Menelaus of Alexandria, who lived at the end of the 1st century.

From the fact that both Autolycus of Pitane in his *Moving Sphere* and Euclid in his *Phaenomena* assume without proof various propositions given by Theodosius, we conclude that already in the 4th century B.C. there existed a textbook on *Sphaerica* scarcely differing, in its essential contents, from Theodosius's work; the rôle of Theodosius was therefore mainly that of editor and elaborator of previously existing material. The *Sphaerica* was translated into Arabic in the 9th century, in part by Qusṭa b. Lūqā, and in part by Thābit b. Qurra. (T. L. H.; X.)

THEODULF, bishop of Orléans, was born about the middle of the 8th century of a noble family of Gothic extraction. probably in Spain. He was made abbot of Fleury and of St. Aignan, and in 781 became bishop of Orléans. He supported Charlemagne's principles of government and educational reforms; he established schools, and was a member of the learned circle which graced the Carolingian court. In 798 he was appointed *missus dominicus,* and two years later performed such great services for Leo III as judge in the cause between the pope and his enemies that he returned from Rome with the pallium. After the death of Alcuin he became the king's principal theological adviser; it was he who made, on Charlemagne's request, a collection of the opinions of the fathers on the much disputed point of the procession of the Holy Ghost. After the death of Charlemagne he was accused, probably quite unjustly, of having taken part in the conspiracy of Bernard of Italy, and in 818 was deposed and imprisoned in a monastery at Angers.

Theodulf died in prison, probably from poison, in 821.

The complete works of Theodulf are in J. P. Migne, *Patrol. Lat.,* vol. 105 (1851). An edition of his poetry was published by E. Diimmler in the *Mon. Gernz. Hist. Poetae latini aevi carolini,* vol. i (1881).

THEOGNIS OF MEGARA (6th century B.C.), Greek poet. More than half the elegiac poetry of Greece before the Alexandrian period is included in the 1,400 lines ascribed to Theognis. This collection contains several poems acknowledged to have been composed by Tyrtaeus, Mimnermus and Solon; with two notable exceptions (T. W. Allen in *Classical Review,* Nov. 1905, and E. Harrison) modern critics unanimously regarded these elegies as intruders, that is, not admitted into his works by Theognis himself; for this and other reasons they assumed the existence of further interpolations which can no longer be detected.

The best-attested elegies are those addressed to Cyrnus, the young friend to whom Theognis imparts instruction in the ways of life. bidding him be true to the "good" cause, eschew the company of "evil" men (democrats), be loyal to his comrades and wreak cruel vengeance on his foes. Theognis lived at Megara on the isthmus of Corinth during the democratic revolution in the 6th century B.c.; some critics hold that he witnessed the "Persian terror" of 590 and 580; others, including the present writer, place his *floruit* in 545 B.C.

There is neither profound thought nor sublime poetry in the work of Theognis. but it is full of sound common sense embodied in exquisitely simple, concise and well-balanced verse. In his day verse was the recognized vehicle for political and ethical discussion, and the gnomic poets were in many ways the precursors of the philosophers and the sophists. who indeed often made their discourse turn on points raised by Theognis and his fellow moralists. For many generations Theognis was to the Greeks the moralist par excellence; Isocrates says that Hesiod, Theognis and Phocylides mere admitted to be the best teachers of practical morality; and the emperor Julian in his defense of paganism asks whether "the most wise Solomon is equal to Phocylides or Theognis or Isocrates."

Besides the elegies to Cyrnus the Theognidea comprise much miscellaneous verse that may well have come from Theognis.

See editions by *I.* Bekker (1815; 2nd ed., 1827); F. G. Welcker (1826); both are epoch-making books which no serious student can ignore; T. Bergk (1843; 4th ed., 1882; re-edited by E. Hiller, 1890, and O. Crusius, 1897); J. Sitzler (1880); E. Harrison, *Studies in Theognis,* with text (1902): T. Hudson-Williams (1910). For iurther bibliographical references *see* the two last-mentioned books. There is a prose translation by J. Banks in Bohn's Classical Library (1856), which also includes verse translations by J. Hookham Frere. (T. H.-W.; X.)

THEOLOGICAL ARTICLES: *see* RELIGION AND *THEOLOGY,* ARTICLES ON.

THEOLOGICAL EDUCATION. The Christian church has always been a teaching church. for it began with the life and work of a teacher. Christian theological education, therefore, owes its origins to his remembered command: "You shall love the Lord your God . . . with all your mind."

By the 3rd century Christian schools not only maintained the learning of Greece—dialectics, physics, geometry, astronomy, philosophy, ethics—but added to these the study of the Scriptures, of God himself (or theology) and of piety. Such were the subjects taught in Origen's schools, first at Alexandria, then (A.D. 232) at Caesarea. The school of Lucian at Xntioch became known for its historical emphases, that at Edessa for its concern for the Bible. The Nestorian school at Nisibis anticipated the medieval universities in holding its own property, enforcing its own disciplines under its own rules of behaviour and showing other signs of independence, including the exacting of a promise from students to reside at the school and to study. At Constantinople, although theological education in the east always kept itself free from state control, the patriarchal school maintained a friendly, reciprocal relation with the state university which had no faculty of theology.

Following the collapse of Rome and its culture in the 5th century, monastic and episcopal (later cathedral) schools, providing for education from childhood to priesthood, not only preserved the heritage of the ancient world through the dark ages but also led to the establishment of over 50 universities in slightly more than three centuries prior to 1400, among them Bologna (the oldest, 1088). Paris, Oxford and Cambridge.

The Reformation and After.—Education in medieval times included grammar, rhetoric and dialectic (the trivium) and mathematics, music, geometry and astronomy (the quadrivium). In the 16th century Philipp Melanchthon enlarged the trivium with Hebrew, Greek and Latin; the inclusion of theology followed. For the Reformers, as earlier for St. Thomas Aquinas, learning was of great importance. The Scriptures were their source of doctrine. The "priesthood of believers" opened the way to individual judgment which needed to be informed and the faithful required instruction to fulfill their new sense of obligation to preach to those outside the church.

Meanwhile the Church of Rome recognized that the Reformation had been caused partly by ignorance, superstition and lack of education among the clergy. At the Council of Trent, therefore, in 1546, legislation was enacted which provided for a liberal education plus professional priestly training for each diocese, permitting poor dioceses to combine, large dioceses to establish more than one seminary, but taxing the church to ensure a sound preparation for the clerical calling.

"Among the greatest achievements of the Council of Trent," writes Stephen Neill, "was its creation of the seminary. When the Protestants spoke bitterly of the returning emissaries of the Roman Church as 'Seminary priests,' the name hit the mark; these young men, trained at Douai or elsewhere, had learned discipline and devotion; they had been trained in the methods of controversy. The training might be narrow and scholastic, but it was calculated to make them more than a match for anything that they were likely to meet in England." (Stephen Neill. *Anglicanism,* p. 110, Penguin Books, Harmondsworth, 1958.)

On the North American continent Harvard college, founded in 1636, was designed to provide training for responsible service in both church and state but especially in the former. Modeled after Cambridge university, its course of study reflected medieval and Renaissance practices and continued the Reformation stress on biblical teaching and preaching. Thus, the high level of Reformation education was maintained in the new world.

Changing Patterns.—During the 18th century a candidate for the Protestant ministry in the British Isles or Korth America received little education beyond the arts degree to prepare him for his calling. If he did not attend college he mould study privately in the home of a parish minister. Or he might pursue theological training in the Protestant universities on the continent of Europe. In 1721 Harvard began in America the differentiation of theological training from general education by the establishment of the Hollis chair of divinity. Yale followed with a similar step in 1756. However. a theological student usually took his "divinity" after completion of his X.B.; the A.B., intended for all, remained the most important part of his training. To the 20th century, both in Protestantism and Catholicism, a sound education in the liberal arts remained a proper foundation for ministerial and priestly studies. "We urge," said Pius XII in the encyclical *Menti Nostrae,* "that the literary and scientific education of future priests be at least not inferior to that of laymen who take similar courses of study."

Toward the close of the 18th century, however, various forces operated strongly further to separate education for the ministry from education for other callings. One of these was the differentiation of occupations in a more highly organized society, leading to the organization of medical schools (King's college [Columbia university], Sew Tork, 1767) and schools of law (Litchfield, Conn., 1784) which did not require a previous A.B. The age of reason had run its course and some theological schools were founded in reaction against the influences of 18th-century rationalism upon the universities. Revivalism, the expansion of frontiers, the growth of denominational consciousness accompanying rapid immigration and social stratification and lively theological controversies all combined to produce a new movement, the creation of independent or separately organized theological schools.

In England. also, medical and legal studies were separated from the undergraduate universities and centred in London. For a time, academies designed for the preparation of Dissenting ministers who were barred from schools of the established church flourished. By the middle of the 19th century, however, these academies had declined and ministerial training became concentrated in theological colleges, many affiliated with universities. It was this pattern that prevailed in the British Isles after 1850. On the continent theological studies, almost entirely pursued in universities, tended to become more concerned with the scientific study of religion and, in Protestant circles. less involved in the equipment of the students for their special ministries.

To return to North America, although a school of the Dutch Reformed Church, begun in New Tork city in 1784, subsequently became the New Brunswick Theological seminary, the reasons for this important departure in theological education were most clearly stated in 1805 by John Mitchell Mason, founder of a less permanent seminary of the Associate Reformed (Presbyterianj Church. Anticipating emphases of a much later day, Mason insisted that the Scriptures be studied in their original languages; that students be encouraged to form independent judgments (a professor is "never to forget that his business is not so much to think for the students as to assist them in thinking for themselves"); that the whole person—body, mind and spirit—be simultaneously strengthened; and that the highest standards of comprehensive thoroughness and intellectual creativity be maintained against all hardened dogmatisms and considerations of expediency. In the subsequent three and a half decades about 50 Protestant seminaries were established in the United States. Because of the financial panic of 1837, there was a lull. but between 1850 and 1890 over 120 others appeared. all to some extent indebted to Mason's ideas about the role of the professor, the nature of the subject matter and the life of the student. Many of these insisted on at least a measure of administrative independence. a college course leading to a B.A. or its equivalent as a requirement for admission and attendance at the seminary for three academic years of approximately 40 weeks each.

Meanwhile, beginning in 1791 when Archbishop John Carroll established St. Mary's seminary in Baltimore, Roman Catholicism developed new seminaries n·ith the formation of new dioceses. By 1833 there were 7, by 1866 approximately 20 more and by 1943 over 250, some conducting studies at the high school and junior college level (six years), some at the senior college and specifically theological level (another six years), some working in both divisions. Some were under diocesan control, others were under religious orders, but all prepared young men exclusively for the priesthood.

The similarities between Roman Catholic and Protestant seminaries in the early 19th century are striking. Many, both Roman Catholic and Protestant, began as house schools in the home of the teacher or teachers. Gradually separate buildings and increased faculties appeared. Many were connected with a college or school. Plagued by inadequate financial resources. scarcity of students, lack of books and generally low intellectual standards and achievement, many were closed.

After 1860.—Although theological education tends to cling to the past more tenaciously than other disciplines, it could not escape the influence of vast changes in the modern world. The enormous increase in the study of the physical sciences! the historical-critical method of investigating ancient documents, the economic interpretation of history, the new psychology, the growth of secularization. the exploding population, the enlarged possibilities of communication, the practical interests of the western world. the threat to the very codtinuation of life on earth—all these and many more had their effect on seminaries and schools of theology that once were isolated from such concerns.

There are two main purposes that characterize these schools, summarized in the distinction Edward Pusey made in 1832 when he said that the British educational system was best calculated to form ministers of the church while the German system could best impart knowledge. The priest or minister is taught to be a "parson" or person worthy to represent his calling and to be respected as an ambassador of Christ, a father to a family with which he has close touch. At the same time he is a "cleric" or one who can write—one who possesses the general and special professional knowledge that enables him to maintain and advance understanding of God's ways with man.

Partly, therefore, the problem of theological education is to meet the needs of the churches and of the "coming great church." In response to the expansion of the Christian movement. the increase of population and the interests ci great ecclesiastical organizations, seminaries sprang up all over the world in great profusion. In Europe. where theology has been traditionally connected with a university faculty, the number of seminaries remained relatively constant, but in Asia, Africa and Latin America more than 200 Protestant and over 350 Roman Catholic seminaries, plus about a dozen Eastern Orthodox, had emerged by the mid-20th century. In the United States the 15 years after 1945 saw an increase in the number of Roman Catholic seminaries of more than 50% and in the United States and Canada the number of Protestant theological students more than doubled in the second quarter of the 20th century.

Problems posed by this rapid expansion were manifold: the maintenance of high standards of admission; provision for the adequate preparation of theological teachers and their lifelong growth; the preservation of the seminary's community life at a time when Protestant students tended to marry at an early age; financial support; the development of theological libraries; the employment .of modern techniques that have proved their value in other disciplines. In the non-English-speaking world, difficulties were intensified. Indigenous leadership was often scarce; the paternalism of teachers, ministers and boards from mother countries was maintained too long; schools tended to conform to patterns imposed from outside which were unsuited to a new time and place; books in many of the languages of the far-flung Christian movement were in short supply; and the rival forces of nationalism, secularism and Communism were keenly felt. Except for that of language, most of these difficulties were also apparent in certain areas of the western world, such as those with predominantly Segro populations.

On the other hand, the problem of theological education is the maintenance of theological learning. For Protestant theological schools, more than for Roman Catholic or Eastern Orthodox, there was in the 20th century, as in the 16th. a considerable expansion of the curriculum, which was generally divided into four main fields: biblical, theological or doctrinal, historical and practical. Although in Europe relatively few new courses were introduced, in Sorth America the wide diversity characteristic of the universities' offerings affected the seminary, especially in the fourth or practical field. Frequently courses were offered in the interpretation of culture and the arts, in the nature of the modern world in which the Christian church is set, in rival philosophies and in the understanding of human behaviour. Attempts were made to bring Christian insights of Scripture, theology and history to bear upon the pressing ethical problems of the modern era. Men were trained in the conduct of public worship, in the use of modern methods of communication, in the art of teaching and in the preparation and delivery of various forms of public address. Field work, internships, clinical pastoral training and practice teaching all reflected current methods of learning by doing.

To encourage the maintenance of high standards of theological education, Protestant seminaries in the United States and Canada began to meet in biennial conferences in 1918, and in 1936 formally organized the American Association of Theological Schools.

In reaction to the secularization of modern society, numerous Bible colleges or Bible schools appeared, only a few of which maintained studies at a predominantly postgraduate level. While Bible schools generally do not provide the general education that the seminaries require and thus sometimes offer a short cut to the ministry, it is to be remembered that not a few seminaries began as Bible schools.

Where theological education was under the control of the state or of a state church, as in Germany, Greece, Scandinavia, the Netherlands and England, the curriculum tended to be more traditional, with a heavy emphasis upon Scripture, its languages and the classical formulations of Christian theology. In Greece and in Sweden the majority of those enrolled in the theological faculties of the universities tended to become lay teachers rather than ordained ministers. Consequently Greek Orthodoxy, for example, finds most of its theologians among its laity.

The government of theological schools or colleges varied widely from complete independence to direct control by a university, church or department of the state. Roman Catholic schools might be under the direction of diocesan authorities or of religious orders. In the United States and the countries of the "younger churches," there were a few Protestant interdenominational seminaries and numerous schools which in one way or another co-operated with each other. The pattern of a yoked college and seminary was receding in favour of an institution with its own board of trustees and a faculty which determined academic policy. Efforts were being made in many churches to acquaint the membership with the acute problems of the seminaries, their importance as intellectual centres of the church's life and the necessity of their vastly increased support. Despite denominational rivalries, there were signs of increasing care in the location of new and the removal of older seminaries to ensure co-operation with other seminaries and universities.

Although the dual responsibility of theological schools to provide ministers for rapidly expanding churches and to maintain high standards of theological learning often caused tensions, on the whole this concern for both life and thought, both peoples and principles, both practice and knowledge was healthy. When the demands of the church were uppermost, seminaries tended to be located in places where a strong community life could be fostered and individuals nurtured in prayer, personal discipline, the church's lore and ritual and the denominational program. When the intellectual standards for the ministry were uppermost, preparation for the ministry was likely to be concentrated in university centres and in some way connected with the acquisition of an academic degree. Even in the schools with the strongest denominational ties, however, isolation was diminishing. The importance of these schools as centres of intellectual culture was being recognized. On the continent, where theology long insisted on its position as queen of the sciences and theologians were entrenched in university faculties, there was a movement, reminding the queen of her biblical role of handmaid, to establish church high schools. preacher seminars and other forms of auxiliary institutions designed to equip the ministry for its task. Throughout the world increasing stress was being put upon the theological education of the laity, reflected in the German *Kirchentag* and the establishment of over a score of lay academies, the majority in Germany.

"The lessons of history clearly demonstrate," says Yorke Allen, Jr., "that the training of the clergy is at the core of the process of maintaining any ecclesiastical organization." From the Vatican comes this word, "The Church fears neither persecutions . . . nor heresies . . . , but this one thing she does fear, ignorance of the truth."

BIBLIOGRAPHY.—The traditional prescriptions of the Holy See on clerical education are summarized in *Deus Scientiarum Dominus* (1931) and *Sedes Sapientiae* (1956) *See* also Yorke Allen, Jr , *A Seminary Survey* (1960); J Cyril Dukehart, S S , *Catholic Seminaries U S A* (1960); Lloyd Paul McDonald, S S , *The Seminary Movement in the United States; Projects, Foundations and Early Development (1784–1833)* (1927); William Stephen Morris, *The Seminary Movement in the United States: Projects, Foundations, and Early Development (1833–1866)* (1932); H Richard Niebuhr, Daniel Day Williams and James M. Gustafson, *The Advancement of Theological Education* (1957); H Richard Niebuhr, *The Purpose of the Church and Its Ministry* (1956); *H.* Richard Niebuhr and Daniel Day Williams (eds.), *The Ministry in Historical Perspectives* (1956). (C. L. TA.)

THEOLOGY, in the comprehensive sense of the name, embraces so much of philosophy as is concerned with explanation of the world in terms of a supreme mind or spirit, with the being and attributes of the Deity and His relation to nature and man and with the grounds and the limits of knowledge or belief as to such matters. It also includes the comparative study of religions and the psychology of religious experience. Specifically Christian theology, which is often what is denoted by the word "theology," sets forth the contents and implications of the revelation in Christ. It consists of a systematic exposition of doctrine and of the course of its development (dogmatic theology or dogmatics), the historical, critical and exegetical study of the Bible and the history of the church, its institutions, etc. Thus theology is a science, or a group of connected sciences, that, on the one hand, is in touch with general philosophy—as is indicated by the name of the department called "philosophy of religion," or "philosophical theology"—and, on the other hand, is more or less isolable in that it deals with the deliverances of distinctively religious experience and its pre-eminent manifestations.

The Relation of Theology to Religious Experience.—It is commonly held that religious experience contains data other than those of natural knowledge, enabling it to possess insight into reality otherwise unattainable. And we may first note the implications of this belief in their bearing on the position of theology among other departments of thought such as natural science and philosophy.

All natural knowledge, *i.e.,* knowledge of the physical world and mankind, is generally believed by philosophers to be derived originally from the impressions of sense, between which the understanding establishes relations. Out of these relations are constructed the body of common-sense knowledge, the sciences and metaphysics. Sensory perception in the first instance, and then ideas distilled from percepts evoke the feelings. desires and valuations of which aesthetic and ethical sentiments and principles are the outcome. According to this science or theory of knowledge, then, religious beliefs and theological doctrines can only be mediated by reflection on the sensible world, the mind of man and human history. On the other hand it is often claimed by theologians that religious experience is founded on apprehension of another species of the objective than the sensory or the sense derived, and on feelings, etc., induced thereby. This objective datum, evocative of unique emotional states and dispositions, is asserted to be apprehended with the same immediateness as is the sensory and so to afford a basis of knowledge about ultimate reality, independent of that on which the natural sciences are built.

If this view were beyond criticism. it would suffice to explain the uniqueness of religious experience and consequently the special characteristics of theology. And one ingredient in it certainly seems to be beyond reasonable doubt. This is that whatever there is, on the affective or emotional side of religious experience, that renders it an experience *sui generis,* or distinct from cognate kinds of experience, that peculiarity must be accounted for by the distinctiveness of the object or objects eliciting the subjective response. Religious experience, on its affective side, comprises sentiments such as loyalty and love, awe and adoration, none of which is peculiar to religion, but each of which differs somewhat from other instances of love, reverence, etc., solely in virtue of the object—deity—toward which the religious emotion is a response. Even those who incline to the opinion that there is one kind of valuation, viz., appreciation of sacredness, that is peculiar to religion throughout all the stages of its development, ascribe its peculiarity and its forthcomingness to the unique object that evokes it. But doubtfulness attaches to the further representations that this sacred, numinous or supernatural object is immediately apprehended as such; that it is irreducibly different in psychological nature from. the sensory, or rather from the image or the idea which are derived from the sensory, and that its apprehension involves a special faculty, not included among those known to ordinary psychology. In the primitive stages of religion the supernatural object seems always to be lodged in some natural object or phenomenon, which inspired emotion such as awe, as is evinced in the notions of clean and unclean, worship of animals, the dead, etc. Thus the numinous, or divine, reality, devoid of the concrete particularity that characterizes an immediate sensation or percept, and capable of entering into diverse mythologies and religions, seems rather to be of the nature of the vague generic image, derived by human imagination and idealization from impressive phenomena. And it is not enough to point to the indubitable objectivity (in the psychological sense) of this alleged numinous reality. For images and ideas, as well as percepts, are also objective; and they are as potent as actualities or real things in eliciting valuation and emotional response, provided that belief in their reality is entertained. Immediacy is a conception which plays important parts in connection with religion and theology; and attention may here be called to the ambiguity which lurks in it and is wont to be overlooked. At the moment when a particular experience, such as perceiving a familiar thing, takes place, we are not aware of performing any synthetic activities; the percept has the unity and the instantaneousness of a flash-photograph, and the whole act of perceiving seems as if unanalysable and unconditioned by previous experiences. From the standpoint of such an experience, the perception is immediate. But from the standpoint of subsequent reflection on that experience, especially if we happen to be versed in the science of psychology, the perception in question was not immediate. It was not a simple, unanalysable, unity nor unconditioned by previous mental processes and present interpretation. Its immediacy thus resolves into our unawareness, at the moment, of real mediation. Now in order to maintain that religious experience, as illustrated by the primitive instance that has been mentioned consists in immediate apprehension of a spiritual environment or a supernatural beyond, that is real or actual and not imaginal or ideal, it is essential that the immediacy involved be accounted such from the latter of the two points of view that have just been distinguished. Yet it is from the former of them alone that it can be vouched for by the religious experient, appealing only to his religious experience. Thus it is doubtful, on more than one ground, whether apprehension of the sacred and supernatural is essentially different from sensory knowledge, eked out with interpretative notions derived from human analogy, constructive imagination and idealization. It may be that the primitive notion of a god, precursor of the later conception of God, was derived by such processes from current knowledge of man, and read into some impressive natural object, constituting it numinous and capable of eliciting religious emotion.

If this view be adopted, religious experience, on its first emergence in mankind, will, mutatatis *mutandis,* have been grounded in a way similar to that in which theistic belief is grounded by the philosopher. It was the outcome of what may be called primitive philosophizing on Nature and man, and not of the exercise of an alleged transcendent faculty of intuition. Indeed it would seem that such direct touch of God upon the human soul as religion and theology imply does not admit of being discerned with real immediacy: it is a case of causal activity, which admittedly is never perceptible. And as for the rest that has been said above, its gist is contained in the generally endorsed dictum, "no man hath seen God at any time." The mystic, it is true, claims to be an exception. But it is not necessary here to weigh his testimony, partly because he can only assert, on the strength of his peculiar experiences, the specious kind of immediacy which has already been shown to be irrelevant, and partly because mystical experience seems never to have issued in theological insight and doctrine that was unknown before and otherwise. Knowledge of God would seem to be in the same case with knowledge of our own souls and of other selves, as distinct from their material bodies. In each of these instances the object is not apprehended with directness, but read in analogically; and the reading or interpretation is justified or verified (qever logically certified) by cumulative practical success. There well may have been, from the infancy of our race, a touching of man by God, even before man arrived at belief in the daemonic or the divine; but such rapport would not be religion until man had come to believe in such beings as gods. "He who cometh to God must believe that He is." That is to say, religion or religious experience presupposes, and is constituted distinctive, by a theological notion or concept. This concept cannot be in the first instance derived from religious experience, because religious experience cannot exist till the idea is forthcoming.

It is very generally taught that theology presupposes religious experience and is but the explication of it. But it is all a matter of where, in a long chain of development, we fix our starting point for consideration. In the series of natural numbers, every odd number precedes an even number and every odd number also succeeds an even number until we work back to I. Similarly, the "Athanasian" creed presupposes much Christian experience while the religious experience of Paul the Apostle differed from that of Paul the Rabbi in virtue of his acquired doctrinal belief as to the Person of Christ. But if we go back to the beginning of the series in which theology determines religious experience and in turn is determined by such experience, pursuing psychological beginnings since historical origins are beyond our ken, it would seem that, originally, some crude equivalent to natural theology must have preceded and caused the emergence of distinctively religious experience. But religious experience once having arisen in this way, it will determine theological thought; and the new thought will render possible a further advance in religious experience, and so on. Thus there is as much truth in the statement that theological doctrine determines the quality of religious experience as in the statement that religious experience and faith are presupposed by theological dogmas. When, *e.g.,* the Christian asserts that he has experience of the indwelling Christ, he is obviously interpreting his really immediate experiences, which consist in consolations, joy, peace, uplifting of the will, etc. He would not so interpret such mental happenings had not Christ been preached to him, and had he not received doctrine as to the Person of Christ which he did not make out of his individual experience. Nevertheless, it is a fact that the idea of God, both in dogmatic theology and in philosophy, was moulded by religious experience, guided both by morality and intellect, after the initial stage of the long course of religious development.

The Relation of Theology to Philosophy. — From the earliest times philosophy has had a theological side. Since the dawn of Greek science and metaphysic, philosophy, Greek and other than Greek, has produced copious speculation concerning the existence and nature of God, as well as a vast volume of thought bearing more or less direct relevance to theological problems, such as the origin, destiny and meaning of the world and human life. The greatest of philosophers have dealt with these problems and it has often been from the side of religion that great thinkers have received their chief impulse towards philosophy. Moreover theology and philosophy are largely identical in that theology is essentially metaphysics. No doubt the majority of those who profess theological beliefs hold their beliefs in complete absence of metaphysical reasoning; in that sense their belief—*i.e.,* believing—is non-metaphysical. But their beliefs—*i.e.,* their credenda —are all metaphysical dogmas or assertions about ultimate reality. They are religious beliefs in so far as they are metaphysical. For instance, that Jesus "suffered under Pontius Pilate" is, as a bare historical fact, of no religious import; but when it is intended to imply further that He suffered for us—*i.e.,* for our salvation— it is a metaphysical statement concerning the relation of God to human souls and, in virtue of that metaphysical content, is a religious doctrine.

Besides being concerned with the same metaphysical subject-matter, philosophy is involved in theology and can aid its work in various ways. Firstly, in respect of the systematization and unification of knowledge. Christian theology needs must connect its more or less separate and independently elaborated doctrines into a coherent whole. Thus Origen, one of the first Fathers to present an ordered system of Christian dogma, tells us that while the Apostles delivered themselves clearly on certain points necessary for all to understand, they left the grounds of their utterances and the more precise determination and demonstration of many doctrines to the more zealous of their successors who should be "lovers of wisdom"; and he expresses his desire to form a connected series of truths or one body of doctrine. That is the goal of dogmatic theology which would relate, *e.g.*, the doctrine of the Atonement with that of the Incarnation or the doctrine of Sin with that of Creation, and obviously such connection involves resort to philosophy. Again, the exposition of any single doctrine involves the use of interpretative ideas, such as can only be supplied by the science and philosophy current in a given age. Several doctrines that purport to be deduced from scripture alone are less the result of strict exegesis than the result of speculation applied to such material as secular knowledge was believed to have established. To give one example: the doctrine of Original Sin is not contained in the Old Testament and the only unmistakable presentation of it that can be found in the New does not appear to have been the starting-point for the first framers of the ecclesiastical doctrine. Tertullian set out from stoic psychology, Origen from the institution of infant-baptism and also from the myth of Plato concerning the fall of the soul from the celestial sphere into earthly life. But of greater importance than cases of this kind is the fact that the very terms and conceptions, requisite as a mould into which the relatively undefined traditional beliefs of the early Church must be cast in order to yield explicit and definite doctrine and, appropriated for that purpose, were supplied by Greek philosophy.

The office of philosophy within the sphere of theology, with which we have thus far been concerned, may be described as that of interpreting to the reason the contents of religious experience. The philosophy of religion seeks to show that the fundamental ideas of religion, so far from being contrary to reason or from being ideas begotten of faith indifferent to knowledge, are capable of receiving a rational, or at least a reasonable, justification in terms of philosophical principles. Philosophy, or even theology, is no substitute for religion, and, of course, does not profess to be. It professes, rather, to show the compatibility of faith with reason and knowledge and to interpret the contents of faith to the reason.

Another function of philosophy is the undertaking of a critical examination of the processes involved in what we call knowing and of the various conceptions that enter into the knowledge claimed either by common sense or the sciences, with a view to disclosing the nature, validity and limits of human knowledge. And this function has a necessary place also in the sphere of theology. There we require to understand the precise relations between what are respectively called knowledge and faith; and it is necessary to pursue the "critical regress" within the field of dogmatic theology because, as history shows, the legitimate desire for completeness of system and knowledge and for definiteness of dogmatic expression is apt to become the wish to know more than, perhaps, can be known and to know too definitely. In the middle ages, when theology was more ambitious than critical, fulness and precision were claimed in so inordinate a degree that, as a sympathetic historian has observed, an agnostic reaction was necessary in the interests of reverence. And it is always natural for theologians to betake themselves too exclusively to the drawing of inferences when more attention might profitably be devoted to the sifting of premisses. Thus it is that the word "dogmatic," which technically indicates one province of theology, has come sometimes to bear a less noble signification; and dogmatic theology has been distrusted as requiring assent to doctrines that are not self-evident and for which no proof can be supplied.

But while philosophy, as a critical method, is a corrective of dogmatism in the foregoing sense, philosophical theology is not necessarily hostile to dogma. Individual philosophers have doubtless tended to set up empty abstractions, as will presently be seen, in place of positive facts and concrete existents; but that is no necessity inherent in philosophy itself, as a pursuit.

Hegel observes in his Philosophy of Religion that in his day an anti-dogmatic spirit was abroad among dogmatic theologians, who at the same time charged philosophy with merely negative or destructive tendencies. These, he said, have thrust dogmas into the background, pronouncing them unimportant and extraneous definitions or mere phenomena of past history. Christ's work of redemption had received a very prosaic and merely psychological significance and the doctrines of the Trinity, etc., were neglected as matters of indifference, even by pious theologians. This spirit was by no means confined to Hegel's day. It might be called the temper of indefiniteness. It is met with in the supposed antitheses between kernel and husk—as if kernels ever grew without husks—and between the life and the creed—as if Christianity were not a life based on a creed, and Christian ethic did not owe its distinctiveness to its dependence on Christian doctrines. In recoiling from dogmatism such as would be over-precise, it distrusts precision of expression as such.

The necessary and intimate connection of theology, even dogmatic theology, with philosophy now having been illustrated from several sides, the two main types of method that have been employed in philosophical theology may in turn be described: they are respectively called the a priori and the empirical.

The a priori Method and Rational Theology.—Of the phrase **a** priori we can distinguish two meanings that are apt to be confounded. It may have a psychological sense, when the phrase means "contributed by the mind itself," and so is generally equivalent to "innate." It may also bear a logical sense, as when a priori truth is described as truth characterized by universality such as, in contrast with mere generality, bespeaks intrinsic or unmediated necessity. In the former case, contrast with the empirical and sense-given is pointed, in the latter case, contrast with the contingent—*i.e.,* with what is, but conceivably might have been otherwise.

It may be said, with accuracy sufficient for the present purpose, that the a priori method was introduced into philosophy and theology by Plato. He took the ideal or pure science of mathematics, which deals with the non-actual, to be the paradigm of knowledge of the actual—science and philosophy. Despising the sensory, and empirical investigation, he valued only the relations and the universal qualities manifested in facts, so that these came to be considered, not as entering into the constitution of actuality, but as existing wholly independently, and this rational or intelligible world, as contrasted with the sensorily perceived, was accounted the truly existent or the "real." Thus arose the a priori method, in the logical sense of that phrase, and the rationalistic theory of knowledge, which, without much qualification, may be said to have dominated philosophy for centuries. So long as it did not and could not—till analytical psychology was born—be suspected that sense and understanding may have a common root and that between understanding and reason there is continuity rather than disparateness, the rationalist's belief in a faculty called reason, capable of functioning in independence of sensation and sensory data, was possible and natural. This faculty was regarded by the ancient philosophers as the sole source of real, *i.e.,* higher, knowledge; as independent of body and "animal soul," and even as a participation in the Divine Reason, a "spark of Deity." Christian theologians, who found much in Plato's system that they could assimilate, also appropriated this ancient doctrine as to reason. Augustine applied it to explain the reception of supernatural truth and the divine illumination of the mind of man, and it coalesced with the Logos-doctrine of the Church. From Augustine and neoplatonism it was accepted by Descartes and so became entrenched in early modern philosophy. The existence of a lumen naturale, a faculty innate as instinct, but mediating necessary and eternal truths, was one of the tenets of rationalism and one that theologians were naturally inclined to adopt. Hence a *priori* theology, in the psychological as well as the logical sense of the phrase, flourished long. Another feature of the rationalistic and a priori theory of knowledge is its tendency to identify knowledge and thought. Knowledge (of actuality) is pre-eminently thought, but since the 18th century we have been compelled to recognize that it is also more. Further, the consistency of thought with itself was often confounded with validity—*i.e.*, with "holding of" actual things. But fiction can be consistent while not being truth about actual persons, and metageometries may be as consistent as Euclid without having any applicability to our world. Moreover, what were deemed to have been self-evident axioms, forming the basal principles of various sciences from mathematics to theology and purporting to be read off as necessary truths by pure reason, have in these latter days been accused of being either conventions, like the rules of a game, or disguised empirical inductions. These modern discoveries and the emergence of a genetic science of common or universal, as distinct from private or individual, experience have rendered tenet after tenet of the a priori school obsolete for many minds.

Turning now to the application of this method and type of philosophy to the sphere of theology, we may note that to it is due a large part of the content of the traditional conception of God and His attributes. From the patristic age to the modern period of philosophy philosophical theologians took over the concept of God as largely fashioned during the long development of religious thought, including the Hebrew thought in which Christianity has its roots. And in Hebrew religion, the transcendent attribute of Jehovah is His holiness. God is personal, not a cosmic force, interested in individuals, immanent in Nature and man. But the Greek philosophers, who founded philosophical theology, had relatively little concern with such qualifications of Deity. Greek philosophy began as cosmology and ethics was an after-development. And Greek theology was rather an academic product than born of personal experience and life. Hence, save for Plato's identification of God with the Good, it endowed God with what may roughly be called "the physical" attributes in a predominant degree. The Greek mind, not the Hebrew, is responsible for the attribute of infinity, perhaps for those of omnipotence and omniscience in their absolute and rigorous senses, and for the qualities of immutability and impassibility, the taking over of which by Fathers of the Church involved them in the difficult task of reconciling such attributes with the nature of a living Spirit. Some of the Greek theological ideas, a priori in character rather than derived from life and experience, proved to be a mould somewhat incongruous with the Hebrew-Christian content which philosophically-minded Christian doctors thrust into it. It was at once too large and too small. If immutability means more than self-consistency, and impassibility more than freedom from human anger and corporeal passions, they cannot be predicates of a God of love and a Father of spirits. Like infinity, until that concept passes over into the idea of ethical perfection, they are derived from inert matter rather than active spirit and are quasimaterialistic or mathematical rather than spiritual and ethical conceptions. "Infinity" has borne several distinct meanings, both in Greek and in later philosophy. Originally its sense seems to have been that of indeterminateness or being devoid of any particular characters, formless, indefinite and indefinable: in which case it is, of course, not predicable of any actual being. Then it came to mean the endless or limitless, what cannot be reached by successive acts of addition or division. Infinity, in this sense of the endless in time, space or number, is only relevant in mathematics; it can have no application to God, who is without parts or magnitude. Lastly, "infinity" acquired the meaning of completeness, ethical perfection and immutability. Then, however, it became a redundant word; as properly used it can be dispensed with by theology.

Even more inapt to Christian or theistic theology than some of the Greek a priori concepts is the abstractive method of arriving at a conception of God, which passed, through Philo especially, from Greek thought to some of the Fathers of the Church. The rationalistic propensity to regard the most abstract conception as the ultimately real being, coupled with the formally intellectual tendency to oust from philosophy and theology not only the anthropomorphisms of vulgar thought but also the inalienable anthropic functions of human mentality, led to usage of "the negative way." That consists in repudiating all positive characterizations of God supplied by human analogies. It has aptly been described as a deification of the word "not." Everything, it is represented, that can be affirmed of the finite must be denied of the Infinite One. Thus God becomes conceived as an indeterminate absolute, ineffable and unknowable; the living Spirit is replaced by a pure idea. The Fathers favourable to this method, who even when abstract philosophers were also pastors and curators of Christian tradition, were saved from propounding these extravagances by a wholesome inconsistency. But Philo, gnostics, and neoplatonists, who took the negative way more seriously, found it necessary, in order to bridge the impassable gulf which they set between the Infinite One and the finite world, to invent powers, aeons and emanations.

The Empirical Method and Natural Theology.—The phrase "natural theology" has usually been a synonym for "rational theology"; *e.g.,* the natural theology of the English deists, who may aptly be described as rational theists, consisted of doctrines supposed to have been discerned by human reason, its first principles being self-evident, and its secondary doctrines being deduced from them, in accordance with the a *priori* principle, that so and so is because it must be. But it is convenient to give to "natural theology" a distinctive meaning. As a synonym for "rational theology" it is superfluous; while there is a theology derivable empirically from the study of Nature, man and human history, and consequently not "rational" and a priori, for which the title "natural" is the most appropriate. It will therefore be so used in the present context.

The possibility of a theology of this kind was recognized at least as early as the time of St. Paul, who wrote that "the invisible things of [God] from the creation of the world are clearly seen, being understood by *the things that are made."* But though theology is thus derivable, it must be added that it has not as yet been derived, at least not with anything like the completeness and system possessed by some of the rational theologies that have been forthcoming between the times of, say, Aristotle and Hegel. Empiricism, in a nobler than its historical sense which degrades it to sensationism, yet awaits its master-mind comparable to a Plato or a Spinoza; hitherto, both in philosophy and theology, it has been represented but fragmentarily, and, if by able thinkers, scarcely by genius of the highest order. Some of the threads which await weaving into the texture of an empirically grounded philosophical theology by a future master-weaver are already within the common ken and may be briefly indicated.

It is admitted that theology rests on faith. Faith, in the first instance, creates ideas, such as that of God, and believes in real or actual counterparts to them. It claims to be knowledge, but is not knowledge or cannot be known to be knowledge, in the same sense that natural science is knowledge. Faith may issue in knowledge or it may not. The individual believer, whether a mystic or a non-mystic, may adopt, for the ordering of his own life, the attitude "I am certain." Therein he is invulnerable; but his faith will be a matter of personal biography and his certainty will be but subjective certitude or convincedness until reasons be forthcoming for taking the objects of his belief to be actual (as is the king of England) and not merely imaginal (as the mermaid) or purely ideal (as the line without breadth). Theology and philosophy are concerned with the knowability and the actuality of God and with the validity of statements about Him. Rational theology maintained that God's existence, etc., could be proved as coercively as a theorem in Euclid. Empirical theology denies that this is so, and empiricism asserts that knowledge, in that sense, is not forthcoming even as to the existence of other subjects or souls than one's own. Empiricism can also assert that what is called scientific knowledge and what are our most assured convictions as to the physical world rest ultimately on indemonstrable postulates or an act of faith, and observes that there is no more a rational cosmology than there is a rational theology. In both spheres verification is pragmatic and is very different from logical certification, which would only be forthcoming if science were composed of deductions from axioms, instead of inductions from facts. Thus, in the entire realm of actuality, as distinguished from that of the pure or ideal sciences, what, of courtesy, we call knowledge is after all but probable belief. We can only be reasonable, not rational.

Such is the empirical account of the relation of faith to reason, theology to science and philosophy. It follows that no proof, in the most rigid sense, of the primary dogma of theism is possible. Such proof as may be had will consist in showing that theism is the most reasonable interpretation of the world and man, and in displaying the cumulative evidence for the assertion that the cosmos is due to the conspiration of innumerable causes and adaptations, by their united and reciprocal action, to issue in a general order of Nature, such as cannot reasonably be ascribed to fortuitousness but only to design by a supreme mind that must be intelligent and moral, the ground of the Good, the Beautiful and the True. Philosophical theology will thenceforward consist in the reinterpretation of the world and human history in terms of that metaphysical conclusion.

Theology Based on Other Grounds. — After rational theology received the classic criticism of Hume and Kant, attempts were made to establish theology on a new basis. The old proofs having been shown to be either fallacious or insufficient, the theoretical knowledge-methods by which they had been mediated were renounced, as not the proper foundation of theology. But the empirical procedure, seeking for grounds of reasonable belief wherewith intellectually to justify faith, did not commend itself to the generations which succeeded Kant. In the 19th century the discovery of the deists that revealed religion presupposes natural religion was ignored; and Butler's suggestion, that what he vaguely called probability constituted our guide, was deemed inadequate. The latter line of thought was indeed pursued, without explicit awareness of the fact, by the numerous English writers who, from S. T. Coleridge onward, developed the doctrine that religious truth can only be judged and accepted by "the whole man," and not by man as merely intelligent. Recoil from discredited 18th-century rationalism, however, did not direct itself to the empiricism represented by Locke, and perhaps more faithfully, in the theological sphere, by Butler. Confusing probability, as something pertaining to common or public beliefs and "knowledge," with acceptance as merely probable on the part of the individual believer, objectors generally submitted that ardent faith is not a weighing of probabilities, nor can faith be content to stake its vital convictions on what it merely deems probable.

Of course the faithful man is certain, in the sense of being privately convinced; but what he is confident about may not have logical or scientific demonstrability from the point of view of objective or common knowledge. And it is the latter issue, not the mentality of this or that individual, with which theology is concerned. But inasmuch as this confusion of standpoints was prevalent, it is not surprising that efforts were forthcoming to find a new basis for theology such as should constitute it a science, yet vindicate subjective certitude. Schleiermacher appealed to immediate experience. But it may perhaps be said that the immediacy of which he treated is but mediateness unrecognized. When he proceeded to draw out what was implicit in his fundamental immediate truths, he reveals the presupposing of a whole system of philosophy and science. Another such attempt was that of Ritschl, who sought to make theology independent of the sciences of Nature and historical criticism, of metaphysics or theoretical (by which he seems to have meant rational) knowledge, grounding it on judgments of worth. That theology derives its arguments largely from considerations as to values is of course true. But these valuations must be appreciations of the actual, and so presuppose knowledge of the world and man, in order to yield any theistic argument. The existence of a real object, such as God or heaven, cannot be inferred from the worth of an ideal object or from doctrines about such objects. An existential science, then, cannot be extracted from considerations as to worth alone. There is room, moreover, for nothing but private faith or blind hope in the realization and conservation of the valuable, until the universe has been found, by theoretical knowledge, at least not to be of such a nature as to involve extinction of the valuable. That the good *ought* to be conserved is irrelevant to whether it *will* be conserved, until we have established a reasonable belief in a good God. Thus it would again seem that theology can only claim to be reasonable belief and that it can only provide itself with reasonable belief by interpreting the actual world. Once severed from the kind of "knowledge" on which it is dependent, it is unable to find any criterion whereby to distinguish reasoned and reasonable belief from superstition, theology from rules for pious behaviour or for pious feeling towards objects that may be but fond imaginations

Biblical and Dogmatic Theology. — Only a few words can be added here to what has been already said as to dogmatic and biblical theology, subjects on which the special headings should be consulted. There is, of course, no one theology of the Old Testament. That collection of books, belonging to different times, is constituted a unity by its record of how Hebrew monotheism gradually developed during several centuries. It describes man's groping after God, which, from the theistic point of view, is but the converse side of God's progressive revelation of Himself to man, imparting knowledge of Himself or inspiring the pursuit of religious discovery, not by overriding human faculties but by adaptation or condescension to them. God, as a Christian father expresses it, ever took man as he was, in order to make him what he was not. Thus was gradually reached the lofty and ethical conception of God and His relation to humanity which was presented by the great prophets. The Old Testament contains the history of God's preparation for the reception by humanity of the highest and fullest revelation of Himself in a human personality. The New Testament, again, contains the account of the impression produced by the life and teaching of Christ and the earliest extant interpretations of His Person. The relation of Christ to God came to be formulated in terms of the conception of incarnation; but though incarnation involves an event in "the fulness of time," the Incarnation has been by no means exclusively regarded by Christian doctors as a complete discontinuity or as but contingent on man's need of redemption. From antiquity there have been those who regard the Incarnation, on the one hand, as the last of many stages and, on the other, as part of the eternal counsel of God. The doctrine of the Incarnation and that of the Trinity which is intimately bound up with it are the two dogmas that are most distinctive of the Christian type of theism; and they are the two which for the first five centuries figure most prominently in the development of the church's doctrine. In this connection it is interesting and important to observe that during this constructive period there was a considerable approach, within the church, to that divergence as to philosophical method that has received notice in earlier sections of this article. The school of Alexandria was largely Platonist in its theological conceptions; and, setting forth from the divinity of Christ as—in a sense—a *priori* datum or prior certainty, sought as best it could to account for Christ's human nature and to explain its union with the divine nature in one person. The school of Antioch, on the other hand, was more empirical. It pursued the scientific or historical, rather than the allegorical, method of exegesis of Scripture and, in Christology, it set out from the observed facts about Christ as man, seeking how to conceive of His deity compatibly with them. The Alexandrines cherished the metaphysical concepts of substance, etc., and spoke of the union of the two natures in Christ as "hypostatic"; the Antiochenes preferred to think in terms of the ethical and spoke of a "moral harmony." For better or for worse, the former school exerted the dominating influence in the final and ecumenical formulation of orthodoxy. It transmitted doctrines expressed in terms of philosophical conceptions which the modern mind sometimes evinces a desire to discard or supersede, on the ground that they do not take account of distinctions which, once emergent, cannot be ignored, and otherwise present difficulties which, unsuspected in the past, to-day are felt to be acute.

Returning to the particular dogmas of the Trinity and the Person of Christ, we may observe that in the case of the elaboration of the former of them the search was made for a conception of the Persons of the Triune God such as should avoid the implication that God is a divine society of several individuals and also the implication that the Persons are merely temporal roles or modes of God. In other words, the great doctors from Tertullian to Aquinas who have expounded Trinitarian doctrine were feeling for a mode of being intermediate between what can be denoted by a noun and what can be denoted by an adjective, such as an attribute or a relation. Since human experience knows of no such mode of being and the conception of it cannot be elucidated by any analogy, these teachers have recognized that, in the last resort, they were dealing with mystery or with what transcends the limits of the human mind to comprehend or to conceive. And, shrinking more from tritheism than from modalism, they gave to the orthodox formulation of the doctrine of the Trinity a meaning which it is not easy to distinguish in essence from the rigidly monotheistic or monarchian conception of God as undifferentiated, save in respect of possessing a plurality of attributes or relations that are eternal and intrinsic and not merely temporary, as heresiarchs had asserted. On the other hand the doctrine of the Person of Christ which received the consent of the universal church implies that in Christ, as incarnate, there was but one subject—if this term of modern psychology accurately represents what was meant, viz., the Logos or pre-existent Son, and that our Lord's human nature was "impersonal." This would seem to involve a conception of the Trinity somewhat different from that contained in the dogma as just expounded, inasmuch as the Logos is now treated as an agent or subject and yet as distinct from God or the Father. Perhaps it is because of a sense of discrepancy in this connection that recent thought has sometimes manifested a tendency to interpret the Incarnation of the Logos in terms of the notion of divine immanence in a human personality. From this point of view, "God was in Christ . . ." would better express the Incarnation doctrine than "The Word became flesh." But the translation of these two fundamental Christian doctrines into terms of conceptions such as are serviceable in psychology and theology at the present day has not yet been accomplished.

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For further relevant literature *see* DOGMA, DOGMATIC THEOLOGY; FAITH; THEISM; and articles on specific doctrines; etc. (F. R. T.)

THEON, AELIUS, Alexandrian sophist of uncertain date, was author of a collection of *progymnasmata* (preliminary exercises) for the training of orators. The work, which probably formed an appendix to a manual of rhetoric, shows learning and taste, and contains valuable notices on the style and speeches of the masters of Attic oratory.

Theon also wrote commentaries on Xenophon, Isocrates and Demosthenes and a treatise on syntax. He is to be distinguished from the grammarian Theon, who lived in the time of Augustus and also wrote on rhetoric.

THEOPHANES, surnamed "the Confessor" (c. A.D. 758–818), Greek ascetic, chronicler and'saint, belonged to a noble and wealthy family and held several offices under Constantine V. Copronymus (741–775). He subsequently founded a monastery (τοῦ Μεγάλου 'Αγροῦ) near Sigriane. He took a strong position against the iconoclastic policy of Leo V and was imprisoned in Samothraee, where he died (818). He subsequently received the honours of canonization. He continued the Chronicle of George the Syncellus from the accession of Diocletian to the downfall of Michael I, Rhangabes (284–813). The work, although wanting in chronological accuracy, is of great value as supplying the accounts of lost authorities.

There is also extant a further continuation, ,in six books, of the *Chronicle* down to the year 961 by a number of mostly anonymous writers (called Oi μετὰ Θεοφάνην, *Scriptores post Theophanem*), who worked by the instructions of Constantine Porphyrogenitus.

Editions of the *Chronicle: Editio princeps*, J. Goar (1655); J. P. Migne, *Patrologia Graeca*, cviii; J. Classen in Bonn *Corpus Scriptorum Hist. Byzantinae* (1839–41); and C. de Boor (1883–95), with an exhaustive treatise on the manuscript and an elaborate index; E. W. Brooks in *Byzantinische Zeitschrift*, 15, p. j78 *et seq.*

Editions of the *Continuation* in J. P. Migne, *Patr. Gr.*, cix, and writer in *Sitzungsberichte der philos.-philol. und der hist. Cl. der k.* by I. Bekker, Bonn *Corpus Scriptorum Hist. Byz.* (1838); on both works and Theophanes generally, *see* C. Krumbacher, *Gcschichte der byzantinischen Literatur* (1897); *Ein Dithyrambus auf Theophanes Confessor* (a panegyric on Theophanes by a certain *protoasecretis* under Constantine Porphyrogenitus) and *Eine neue Vita des Theophanes Confessor* (anonymous), both edited by the same writer in *Sitzungsberichte der Philos.-philol. und der hist. Cl. der k. bayer. Akad. der Wissenschaften* (1896, pp. 583–625; and 1897, pp. 371–399); E. Gibbon, *Decline and Fall*, ed. by J. B. Burp, v, p. 530 (1896–1900).

THEOPHANO (d. 991), Holy Roman empress. That Theophano w s a Byzantine princess is accepted, but there is no agreement about her parentage. Some historians make her the daughter of the emperor Romanus II and Theophano, who had been an innkeeper's daughter. Others maintain that it is only certain that she was the niece of John Tzimisces, who assassinated the emperor Nicephorus II in 969 and became emperor himself.

Whatever her parentage, the princess Theophano rose to the position of imperator if one document so signed by her is proof positive. After the death of Romanus II, whom Theophano the elder was suspected of poisoning, the Holy Roman emperor Otto I, who had attacked the Byzantine possessions in Italy, proposed a marriage between the young princess and his heir, Otto. But this alliance was not favoured by the new Byzantine emperor Nicephorus Phocas, who had married the elder Theophano. It was only after the accession of John Tzimisces that the young princess's wedding was finally arranged, and the ceremony took place with much pomp in Rome in 972. Rich estates were assigned to Theophano.

In 973 she was present at the last diet presided over by Otto I before his sudden death. In the first years of Otto II's reign, Theophano's influence was overshadowed by that of her mother-in-law, the powerful Adelaide (Adelheid), but as Adelaide became estranged from her son, Theophano rose in power. She had four children: three daughters and one son, Otto, born in 980. Shortly after the birth of Otto, Theophano accompanied her husband during his campaign in Italy, which ended in a severe defeat caused by an alliance between the Arabs and the emperor of Byzantium, Basil II. While preparing a fresh campaign in Italy, and after he had arranged the election of his three-year-old son as German king, the emperor suddenly died in Rome (983). A rebellion broke out in Germany, led by Otto's cousin, Henry the Quarrelsome, duke of Bavaria. In 984 the child king was handed over to the two empresses and to his aunt, Mathilde, abbess of Quedlinburg.

Theophano ruled as empress with great success and wisdom. The education of her gifted young son she entrusted to Saxons. Her daughters were educated in the great imperial abbeys, and two, Adelaide and Sophie, became abbesses, of Quedlinburg and of Gandersheim respectively. At Easter in 991 Theophano held a diet at Quedlinburg, but, while traveling in the interests of the imperial government, died suddenly at Nijmegen on the following June 15. She was buried at Cologne, in the church of St. Pantaleon, whose relics had been the most precious part of her dowry. She was succeeded by her mother-in-law, yet only as regent, without the full authority exercised by Theophano.

In her short reign Theophano was an energetic ruler under incomparable difficulties. The manuscripts she donated to those churches and cloisters she especially favoured testify to her culture and piety.

THÉOPHILE, the name by which Théophile de Viau (or Viaud), French poet (1591–1626), is more commonly called. He was born in 1591, at Clairac, near Agen, and was educated at the Protestant college of Saumur. In 1612 he met Balzac, with whom he made an expedition to the Netherlands, which ended in a serious quarrel. On his return he seems to have been for two years a regular playwright to the actors at the Hôtel de Bourgogne.

In 1615 he attached himself to Henry, duke of Montmorency (1595–1632), under whose protection he produced the tragedy of *Pyrame et Thisbé*, acted probably about 1617. This piece, written in the extravagant Spanish-Italian manner, was ridiculed by Boileau (preface to his *Œuvres,* 1701). Théophile was a Huguenot and a freethinker, and had made unsparing use of his sharp wit in epigrams on the church and on the government. In 1619 he was banished from Paris, but was allowed to return in the next year. He then served in that year in the campaign against the Huguenots, but in the autumn was an exile in England. He was recalled in 1621, and abjured Protestantism in 1622. In 1622 he had contributed four pieces to the *Nouveau Parnasse Satirique,* a miscellany of verse by many hands. In the next year a new edition appeared, with the addition of some licentious verse, and the inscription *par le siew Théophile* on the title page. Contemporary opinion justified Théophile's denial of this ascription, but the Jesuit father, François Garasse. published a tract against him entitled La *Doctrine curieuse* (1623). Théophile was again prosecuted. This time he fled from Paris, to the court of Montmorency, and was condemned in his absence (Aug. 19, 1623) to death. On his flight to the border he was arrested, and imprisoned in the conciergerie in Paris.

Théophile defended himself in an *Apologie au roi* (1625), and was liberated in September, his sentence being commuted to banishment for life. Under Montmorency's protection he hid in Paris for some time, and subsequently accompanied his friend and patron to the south.

He died in Paris on Sept. 25, 1626.

Forty-two pamphlets on the prosecution of Théophile, written between the dates 1622 and 1626, are preserved in the Bibliothèque Nationale in Paris. The standard modern edition of the works of Théophile is that of Alleaume in the *Bibliothèque Elzévirienne* (2 vol., 1856). Besides *Pyrame et Thisbé,* his works include a paraphrase. half verse, half prose. of the *Phaedo.* There are numerous French and Latin letters, his *Apologie,* a promising fragment of comic prose narrative and a large collection of occasional verses, odes, elegies, stanzas, etc.

See K. Schirmacher, *Théophile de Viau* (1897).

THEOPHILUS, SAINT, bishop of Antioch about A.D. 180 (his chronological sketch of the history of the world ends with the death of Marcus Aurelius in that year), is known from his three apologetic treatises *To Autolycus*, preserved in a single 11th-century Greek manuscript. The first deals with Christian faith in God and in the resurrection of the dead: it may be based on catechetical instructions. The second contains theological criticism of Greek religion, philosophy and poetry, followed by a "typological" commentary on Gen. i. 1–iii, 19. The third attacks pagan writers and "proves" that Christian teaching is both better and older than that of all other peoples.

Theophilus tried to create a theology by interpreting the Bible (especially the Old Testament) in relation to contemporary rhetoric and eclectic philosophy. He gives extensive quotations from Hellenistic anthologies of poetry and philosophy, as well as from the Jewish *Sibylline Oracles.* Theophilus is the first Christian known who defined faith as necessary in any human activity (i. 8; *cf.* Cicero. *Lucull.* 109); the first to use Skeptical "modes" in attacking pagan religion; and the first to speak of the dignity of man (ii, 1) He is the earliest writer who mentions the inspiration of New Testament writings (iii, 12; *cf.* ii, 22), the triad of God, his Word and his Wisdom (though with man they form a tetrad; ii, 15). and the (Stoic-Philonic) immanent and expressed Word of God (ii, 10, 22; *see* LOGOS).

Theophilus emphasizes man's free will and his duty to keep God's law; thus he stands between the older Jewish Christianity and Greek patristic thought. Theophilus influenced Irenaeus, Tertullian and Novatian, but was later forgotten.

Nothing is known of his life. though in the 4th century he was mentioned by Lactantius and by Eusebius. His work was first published by Johannes Frisius in 1546. The best edition is that of J. C. T. Otto (1861). (R. McQ. G.)

THEOPHILUS, East Roman emperor (829–842), the second of the Phrygian dynasty, a pronounced iconoclast. In 832 he issued an edict strictly forbidding the worship of images. His whole reign was occupied in war against the caliphs of Baghdad. *(See* CALIPHATE. *The Abbasid Caliphs.)* This war mas caused by Theophilus, who afforded an asylum to a number of Persian refugees. The Roman arms were at first successful; in 837 Samosata and Zibatra (Zapetra, Sozopetra). the birthplace of al-hlu'tasim, were taken and destroyed. Eager for revenge. al-Mu'tasim assembled a vast army, one division of which defeated Theophilus, who commanded in person, at Dasymon, while the other advanced against Amorium, the cradle of the Phrygian dynasty. After a brave resistance the city fell into al-Mu'tasim's hands through treachery. Thirty thousand of the inhabitants mere slain, and the city razed to the ground.

Theophilus never recovered from the blow, and he died at the beginning of 842.

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THEOPHILUS (THEODORE NICHOLAS PASHKOVSKY) (1874–1950), primate of the Russian Orthodox Greek Catholic Church of America from 1934 to 1950, was born in Kiev province. Russia, on Feb. 19, 1874, and received his early theological training there.

Moving to the United States in 1897, he was ordained to the priesthood in San Francisco the same year. While in San Francisco, he founded that city's Russian Orthodox cathedral in 1909, replacing an older church destroyed in the great earthquake of 1906.

In 1913 Pashkovsky was transferred to Warsaw, Poland, and when World War I broke out he served with the imperial Russian army as a chaplain. Caught in the Russian Communist revolution, he had difficulty leaving the Soviet Union; but in 1922. upon being named bishop of Chicago, he returned to the United States to take up his new duties. Transferred to San Francisco in 1931, he was made presiding bishop of the Pacific coast in 1934. Later that year he was elected metropolitan archbishop of the United States and Canada.

One of the problems which faced Theophilus during his primacy was the question of whether the North American Russian Orthodox Church should reunite with the mother church in Moscow. In 1945 the American bishops voted for such a reunion, but three years of negotiations led nowhere. In 1948 the bishops reversed their stand and declared their independent status. The soviet news agency then reported that Theophilus was to be tried by the Russian Orthodox Church in the U.S.S.R. for "attempts to split the church." The trial was held *in absentia,* when the American metropolitan refused to attend.

Theophilus died in San Francisco on June 27, 1950.

THEOPHILUS (THEOPHILUS PRESBYTER, sometimes identified with ROGERUS VON HELMERSHAUSEN) *(c.* 1100), author of the *Schedula diversarum artium,* an important treatise on medieval arts, particularly that of the goldsmith. He assumed the name "Rugerus" and may have been a Greek monk who after traveling extensively in Europe settled in a Benedictine monastery at Helmershausen, near Paderborn. The *Schedula* includes a prologue treating the fall of man and the beginning of labour. The text is in three parts: book i, painting; book ii, glass windows; and book iii, metalwork from furnaces to liturgical objects. Also included are directions for niello *(q v.),* the use of precious stones, bell casting, ivory working and organ making. Many of the techniques described in the *Schedula* may be found on such 12th-century works as the portable altars of Baderborn cathedral. In spite of occasional details of alchemy and superstition, the explicitness and accuracy of the instructions suggest that Theophilus, if not a practising craftsman, was a shrewd observer.

His own Latin manuscript of the *Schedula* disappeared but numerous copies survived, such as the Codex Vidobonensis no. 2527 (Nationalbibliothek, Vienna), the Codex Gudianus no. 69 (Herzog-August Bibliothek, Wolfenbüttel) and the Codex Harleianus no. 3915 (British museum). Various translations exist in French, German and English (R. Hendrie, 1847).

See R. P. Johnson, "The Manuscripts of the Schedula of Theophilus Presbyter," *Speculum,* 4 (1938).

THEOPHRASTUS (371/370–288/287 B.C.), Greek Peripatetic philosopher, was born at Eresus on the island of Lesbos and went to Athens to study under Aristotle. The latter designated him as head of his school, the Peripatos, when he himself retired to Chalcis (322/21). It was under Theophrastus that the Peripatetic school was frequented by the highest number of pupils and auditors.

Apart from Eudemos of Rhodes, Theophrastus was the only Peripatetic who embraced Aristotle's philosophy to its full extent—metaphysics, physics, physiology, zoology, botany, ethics, politics, the history of culture, etc. His general tendency was to strengthen the systematic unity of those subjects and to reduce the transcendental or Platonic elements of the whole doctrine.

Little has been preserved of Theophrastus' works. The principal remains are nine books *On the History of Plants* and six *On the Causes of Plants.* Smaller treatises extant under his name deal with fire, winds, signs of weather, scents, sensations and other subjects; but their authenticity is in part contestable. The famous *Characters* consists of brief and vigorous delineations of moral types developed from studies that Aristotle had made for ethical and rhetorical purposes: this is the work on which La Bruyère's masterpiece was based. In his *Ethics,* known from the assaults of the Stoics, Theophrastus distinguished, as Aristotle had done, a plurality of virtues with their relative vices and acknowledged a certain importance to external goods.

Theophrastus' *Doctrines of the Natural Scientists,* as reconstructed by H. Diels in *Doxographi Graeci* (1879; reprinted 1929) provides the foundation of all history of ancient philosophy.

The works of Theophrastus were edited by F. Wimmer (1854–62); the *Characteres,* were edited by H. Diels (1909). There is an English translation of the *Characters* by Sir R. Jebb, with introduction and notes (1870; new ed. by J. E. Sandys, 1909). For the extant fragments of the *Metaphysica* of Theophrastus *see* the edition by W. D. Ross and F. H. Fobes (1929). *See* also references under "Theophrastus" in the Index volume. (F. Wi.)

THEOPHYLACT (d. *c.* 1110), biblical commentator, was born most probably at Euripus, in Euboea, about the middle of the 11th century. He became a deacon at Constantinople, attained a high reputation as a scholar, and became the tutor of Constantine Porphyrogenitus, son of the emperor Michael VII, for whom he wrote *The Education of Princes.* About 1078 he went into Bulgaria as archbishop of Achrida. In his letters he complains much of the rude manners of the Bulgarians, and he sought to be relieved of his office, but apparently without success.

Theophylact's death took place after 1107.

His commentaries on the Gospels, Acts, the Pauline epistles and the Minor Prophets are founded on those of Chrysostom, but deserve the considerable place they hold in exegetical literature for their appositeness, sobriety, accuracy and judiciousness. His other works included 130 letters and various homilies, orations and other minor pieces.

THEOPHYLLINE: *see* PURINES.

THEOPOMPUS OF CHIOS (b. *c.* 380 B.C.), Greek historian and rhetorician, whose *Philippica,* though lost in original, has survived through the work of later writers to form one element in the tradition concerning the reign of Philip II of Macedonia. He was born at Chios and in early youth seems to have spent some time at Athens, along with his father, who had been exiled because of his sympathies with Sparta. There he became a pupil of Isocrates, and rapidly made great progress in rhetoric. According to Cicero, Isocrates used to say that Ephorus required the spur but Theopompus the bridle: he once won a prize for oratory in a contest in which Isocrates himself was taking part. It is said to have been the advice of his teacher that finally determined his career as a historian—a career for which he was peculiarly qualified by his inherited wealth and his wide knowledge of men and places.

Through the influence of Alexander the Great, he was restored to Chios about 333, and figures for some time as one of the leaders of the aristocratic party in his native town. After Alexander's death he was again expelled and took refuge with Ptolemy in Egypt, where he appears to have met with a somewhat cold reception. The date of his death is unknown.

The works of Theopompus were chiefly historical. They included an epitome of Herodotus' *History* (the genuineness of which is doubted), the *Hellenica,* the *Philippica* (history of Philip of Macedon) and several panegyrics and hortatory addresses, the chief of which was the letter to Alexander. The *Hellenica* treated of the history of Greece, in 12 books, from 411 (where Thucydides breaks off) to 394—the date of the battle of Cnidus. Of this work only a few fragments survive: the attribution to it of the important historical fragment known as *Hellenica Oxyrhynchia* or "the Oxyrhynchus historian" (first published by B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri,* vol. v, no. 842, 1908) did not win acceptance. A far more elaborate work was the *Philippica* in 58 books. In this Theopompus narrated the history of Philip's reign (359–336). His narrative included not only moral and political discussions but also digressions on the names and customs of the various races and countries of which he had occasion to speak, which were so numerous that Philip V of Macedon reduced the bulk of the history from 58 to 16 books by cutting out those parts which had no connection with Macedonia. It was from this history that Pompeius Trogus (of whose *Historiae Philippicae* the epitome by Justin is extant) derived much of his material.

In spite of some extravagance both of style and judgment, examples of which can be seen in the extant fragments, it seems likely that Theopompus was the most interesting and considerable of all the Greek historians who are "lost."

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(G. T. Gh.)

THEORBO, the large double-necked bass lute much used during the 16th and 17th centuries as general bass in the orchestra. The body of the theorbo was constructed on the same principles as that of the lute. The theorbo was made in two sizes, the ordinary instrument measuring about three feet, six inches, and the Paduan, also known as archlute, about five feet.

The chitarrone, or Roman theorbo, was the largest of all, a contrabass lute in fact, and frequently stood more than 6 ft. high. *See* LUTE.

THEORELL, AXEL HUGO TEODOR (1903–), Swedish biochemist and Nobel prize winner, noted for his research on enzymes, was born at Linköping, Swed., on July 6, 1903. After taking his M.D. degree at Stockholm in 1930, he began general practice but an attack of poliomyelitis left him crippled and he decided to devote himself to research. He worked at Uppsala university, 1932–36, and also studied in Germany while holding a Rockefeller fellowship.

In 1934 Theorell produced for the first time in pure form the yellow enzyme which influences combustion in living cells. He later divided the enzyme into two parts, the coenzyme, which acts as a catalyst, and the apoenzyme, which is pure protein, and worked out the chemical chain reaction by which enzymes enable living cells to burn oxygen; that is, to breathe. He also was the first to produce pure myoglobin, the red colouring substance of muscle. He devised a method of blood examination which came to be widely used in Sweden as a test for drunkenness and also discovered an antibiotic called proaptin. These discoveries, however, were overshadowed by his work on enzyme chemistry, and he was awarded the 1955 Nobel prize for medicine for his discoveries concerning the nature and mode of action of oxidation enzymes.

Theorell was appointed director of the biochemical department of the Nobel institute at Stockholm in 1937 and became a member of the Swedish Society for Medical Research and the Swedish Academy of Science in 1942. (W. J. Bp.)

THEOREM, a term used in mathematics to represent a proposition (*q.v.*) which is to be demonstrated. In geometry, a proposition is commonly considered as a problem (a construction to be effected) or a theorem (a statement to be proved). For example, the statement: "If two lines intersect, each pair of vertical angles are equal" is a theorem. The so-called "fundamental theorem" of algebra asserts that every rational integral equation has at least one root. The Greeks also recognized a proposition lying between a theorem and a problem, the porism (*q.v.*).

See BINOMIAL THEOREM, FERMAT'S LAST THEOREM; REMAINDER THEOREM. For related terms see also AXIOM, HYPOTHESIS; POSTULATE.

THEORY has various meanings in ordinary speech and in science. It may be contrasted with practice as unverified speculation. It may be used so as to signify any hypothesis, whether confirmed or not. It may be restricted to hypotheses which have been so strongly confirmed as to become part of the accepted doctrine of a particular science. In its best use, it signifies a systematic account of some field of study, derived from a set of general propositions.

These propositions may be taken as postulates, as in pure mathematics (theory of functions, etc.), or they may be principles more or less strongly confirmed by experience, as in natural science (theory of heat, electromagnetic theory). There may be rival theories in a particular field (*e.g.,* in psychology) differing in their selection of principles, or in the emphasis laid on particular principles. 4s a science develops the part played by deductive theory in it tends to become more and more important. (See HYPOTHESIS.) (L. J. R.)

THEOSOPHY, a term used to denote those forms of philosophic and religious thought which claim a special insight into the Divine nature and its constitutive moments or processes (from Gr. theos, "god," and sophia, "wisdom"). Sometimes this insight is claimed as the result of the operation of some higher faculty or some supernatural revelation to the individual; in other instances the theosophical theory is not based upon any special illumination, but is simply put forward as the deepest speculative wisdom of its author.

In any case it is characteristic of theosophy that it starts with an explication of the Divine essence, and endeavours to deduce the phenomenal universe from the play of forces within the Divine nature itself.

General Theory. — Theosophy is thus differentiated at once from all philosophic systems which attempt to rise from an analysis of phenomena to a knowledge, more or less adequate, of the existence and nature of God. In all such systems, God is the *terminus* ad *quem,* a direct knowledge of whom is not claimed, but who is, as it were, the hypothesis adopted, with varying degrees of certainty in different thinkers, for the explanation of the facts before them. The theosophist, on the other hand, is most at his ease when moving within the circle of the Divine essence, into which he seems to claim absolute insight. This, however, would be insufficient to distinguish theosophy from those systems of philosophy which are sometimes called "speculative" and "absolute," and which also in many cases proceed deductively from the idea of God. In a wide sense the system of Hegel or the system of Spinoza may be cited as examples of what is meant. Both thinkers claim to exhibit the universe as the evolution of the Divine nature; so much is involved, indeed, in the construction of an absolute system But in such systems the known universe — the world of experience — is nowhere transcended; God is really no more than the principle of unity immanent in the whole. Hence, while the accusation of pantheism is frequently brought against these thinkers, the term theosophical is never used in their regard. A theosophical system may also be pantheistic, in tendency if not in intention; but the transcendent character of its Godhead definitely distinguishes it from the speculative philosophies which might otherwise seem to fall under the same definition. An historical survey shows, indeed, that theosophy generally arises in connection with religious needs, and is the expression of religious convictions or aspirations.

Accepting the testimony of religion that the present world lies in wickedness and imperfection, theosophy faces the problem of speculatively accounting for this state of things from the nature of the Godhead itself. It is thus in some sort a mystical philosophy of the existence of evil; or at least it assumes this form in some of its most typical representatives. The term Mysticism (*q.v.*) has properly a practical rather than a speculative reference; hut it is currently applied so as to include the systems of thought on which practical mysticism was based. Thus. to take only one prominent example, the profound speculations of Meister Eckhart (see ECRHART) are always treated under the head of Mysticism, but they might with equal right appear under the rubric Theosophy. In other words. while an emotional and practical mysticism may exist without attempting philosophically to explain itself, speculative mysticism is in current usage almost another name for theosophy.

In the above acceptation of the term, the neoplatonic doctrine of emanations from the supra-essential One, the fanciful emanation-doctrine of some of the gnostics (the aeons of the Valentinian system, for example), and the elaborate esoteric system of the Kabbalah, to which the two former in all probability largely contributed, are generally included under the head of theosophy. In the two latter instances there may be noted the allegorical interpretation of traditional doctrines and sacred writings which is a common characteristic of theosophical writers. Still more typical examples of theosophy are furnished by the mystical system of Meister Eckhart and the doctrine of Jakob Boehme (see BOHME. JAKOB), who is known as "the theosophist" *par excellence.* Eckhart's doctrine asserts behind God a predicateless Godhead. which, though unknowable not only to man hut also to itself. is. as it were, the essence or potentiality of all things. From it proceed. and in it exist, the three persons of the Trinity, conceived as stadia of an external self-revealing process. The eternal generation of the Son is for Eckhart equivalent to the eternal creation of the world. But the sensuous and phenomenal, as such, so far as they seem to imply independence of God, are mere privation and nothingness; things exist only through the presence of God in them, and the goal of creation, like its outset, is the repose of the Godhead. The soul of man, which as a microcosmos resumes the nature of things, strives by self-abnegation or self-annihilation to attain this unspeakable reunion (which Eckhart calls being "buried" in God). Regarding evil simply as privation, Eckhart does not make it the pivot of his thought as was afterward done by Boehme; but his notion of the Godhead as a dark and formless essence is a favourite thesis of theosophy.

Boehme was indebted not only to mystical theology but also to the writings of Paracelsus. This circumstance is not accidental, but points to an affinity in thought. The nature-philosophers of the Renaissance, such as Nicolaus Cusanus, Paracelsus, Cardan and others, curiously blend scientific ideas with speculative notions derived from scholastic theology, from neoplatonism and even from the Kabbalah. Hence it is customary to speak of their theories as a mixture of theosophy and physics, or theosophy and chemistry, as the case may be. Boehme offers us a natural philosophy of the same sort. As modern theosophy has nourished itself almost in every case upon the study of his works, his dominating conceptions supply us with the best illustration of the general trend of this mode of thought. His speculation turns, as has been said, upon the necessity of reconciling the existence and the might of evil with the existence of an all-embracing and all-powerful God, without falling into Manichaeism on the one hand, or, on the other, into a naturalistic pantheism that denies the reality of the distinction between good and evil. He faces the difficulty boldly, and the eternal conflict between the two may be said to furnish him with the ground-principle of his philosophy. It is in this connection that he insists on the necessity of the Nay to the Yea, of the negative to the positive. Eckhart's Godhead appears in Boehme as the abyss, the eternal nothing, the essenceless quiet (*Ungrund* and *Stille ohne Wesen* are two of Boehme's phrases). But, if this were all, the Divine Being would remain an abyss dark even to itself. In God, however, as the condition of His manifestation, lies, according to

Boehme, the "eternal nature" or the *mysterium magnum*, which is as anger to love, as darkness to light, and. in general, as the negative to the positive. This principle (which Boehme often calls the evil in God) illuminates both sides of the antithesis, and thus contains the possibility of their real existence. By the "Qual" or torture, as it were, of this diremption, the universe has qualitative existence, and is knowable. Even the three persons of the Trinity, though existing *idealiter* beforehand, attain reality only through this principle of nature in God, which is hence spoken of as their *matrix*. It forms also the matter, as it were, out of which the world is created; without the dark and fiery principle, we are told, there would be no creature. Hence God is sometimes spoken of as the father, and the eternal nature as the mother, of things. Creation (which is conceived as an eternal process) begins with the creation of the angels. The subsequent fall of Lucifer is explained as his surrender of himself to the principle of nature, instead of dwelling in the heart of God. He sought to make anger predominate over love; and he had his will, becoming prince of hell, the kingdom of God's anger, which still remains, however, an integral part of the Divine universe.

Schelling's *Philosophical Inquiries Into the Nature of Human Freedom (1809)* is almost entirely a reproduction of Boehme's ideas, and forms, along with Baader's writings, the best modern example of theosophical speculation. In his philosophy of identity Schelling (*q.v.*) had already defined the Absolute as pure indifference, or the identity of subject and object, but without advancing further into theogony. He now proceeded to distinguish three moments in God, the first of which is the pure indifference which, in a sense, precedes all existence—the primal basis or abyss, as he calls it, in agreement with Boehme. But, as there is nothing before or besides God, God must have the ground or cause of His existence in Himself. This is the second moment, called nature in God, distinguishable from God, but inseparable from Him. It is that in God which is not God Himself, it is the yearning of the eternal One to give birth to itself. This yearning is a dumb unintelligent longing, which moves like a heaving sea in obedience to some dark and indefinite law, and is powerless to fashion anything in permanence. But in correspondence to the first stirring of the Divine existence there awakes in God Himself an inner reflective perception, by means of which—since no object is possible for it but God—God beholds Himself in His own image. In this, God is for the first time as it were realized, although as yet only within Himself. This perception combines, as understanding, with the primal yearning, which becomes thereby free creative will, and works formatively in the originally lawless nature or ground. In this wise is created the world as we know it. In every natural existence there are, therefore, two principles to be distinguished: first, the dark principle, through which the being in question is separated from God, and exists, as it were, in the mere ground; and, second, the Divine principle of understanding. The first is the particular will of the creature, the second is the universal will. In irrational creatures the particular will or greed of the individual is controlled by external forces, and thus used as an instrument of the universal. But in man the two principles are consciously present together, not, however, in inseparable union, as they are in God, but with the possibility of separation. This possibility of separation is the possibility of good and evil. In Boehme's spirit, Schelling defended his idea of God as the only way of vindicating for God the consciousness which naturalism denies, and which ordinary theism emptily asserts. Among thinkers on the same lines, but more or less independent, Molitor is perhaps the most important. Swedenborg (*q.v.*) is usually reckoned among the theosophists.

THE THEOSOPHICAL SOCIETY

The term theosophy in later years obtained a wide currency in certain circles as denominating the beliefs and teachings of the Theosophical society. This society was founded in the United States in 1875 by Madame H. P. Blavatsky (*q.v.*), in connection with Col. H. S. Olcott and others. Colonel Olcott remained president of the original society till his death in 1907, when he was succeeded by Mrs. Annie Besant. But soon after the death of Madame Blavatsky (1891) a split took place which led to the formation of a separate organization in America under the leadership of William P. Judge.

The main objects of this society, as originally propounded, were:

1. To establish a nucleus of the universal brotherhood of humanity.
2. To promote the study of comparative religion and philosophy.
3. To make a systematic investigation into the mystic potencies of life and matter, or what is usually termed occultism.

Mahatmas.—According to Madame Blavatsky's original statements, this wisdom has been transmitted through the ages as a secret doctrine or esoteric teaching by a brotherhood of adepts or mahatmas scattered through the world but in close relation with one another. With a certain group of these in Tibet she claimed to be in communication. In such adepts the spiritual nature is supposed to have been so developed that the body has become the ductile instrument of the intelligence and they have thus gained a control over natural forces which enables them to bring about results that appear to be miraculous.

Religious Aspect.—The most characteristic feature of this modern "theosophical" teaching is the belief in reincarnation, and here again the close connection with Indian thought is observable. The succession of earthly lives through which the spirit advances to its goal is interpreted in strict accordance with the Brahmanic and Buddhistic doctrine of karma. First introduced in the Upanishads as the great secret which solves the problem of human destiny, karma is in a sense the logical origin of all Indian thought. It expresses the inexorable law of moral causation—whatsoever a man soweth that shall he also reap—and this law is represented as fulfilling itself in the life history of each individual agent. The consequences of a man's actions in his present life are reaped by the agent on earth in a fresh incarnation. Hence the saying, "A man is born into the world he has made." The theory of karma is thus primarily an explanation of a man's lot in the present life as determined by his own actions in a series of previous lives. If it is true that whatsoever a man soweth that shall he also reap, it must be equally true that whatsoever a man reaps that he must also have sown.

The doctrine is thus in its essence a vindication of cosmic justice in face of the perplexities caused by the apparent disregard of moral considerations in the distribution of happiness and misery in the present life. and it is in this sense that it is accepted and applied, by theosophists. (A. S. P.-P.)

THEOT, CATHERINE (d. 1794), French visionary, was born at Barenton, Manche. She was from her youth a victim of hallucinations, and after a long course of religious asceticism in the convent of the hliramiones in Paris she was placed under restraint. After she was liberated in *1782*, her early delusions concerning a Messiah became accentuated; she was assured that she was destined to be the mother of the new Messiah, and pictured to her followers the fantastic features of the coming paradise on earth.

From the idea of the advent of a Messiah to its realization was but a step, and in Robespierre the Théotists saw the redeemer of mankind. The enemies of Robespierre, resenting his theocratic aims, seized upon his relations with the Théotists. Catherine, with others, was arrested and imprisoned, and a letter to Robespierre was discovered in her house.

In the Convention M. G. A. Vadier trumped up the conspiracy of Théot, asserting that Catherine was a tool of Pitt, that the mummeries of the Théotists were but a cloak for clerical and reactionary intrigue, and hinting that Robespierre favoured their designs. The case was adjourned to the revolutionary tribunal, and figured in the proceedings of the 9th Thermidor. The accused were ultimately acquitted, but Catherine herself died in prison on Sept. 1, 1794.

THEOTOCOPULI, DOMENICO: *see* GRECO, EL.

THERA, the southernmost island of the Sporades. After the fourth crusade, when it became part of the duchy of the Archipelago, and until recent times, it was known as Santorin (*q.v.*).

THERALITE, in petrology, a group of plutonic rocks built up of basic plagioclase (labradorite), nepheline and a titaniferous augite. The name is derived from the Greek *theran*, "to pursue," since it was believed that its discovery would complete the series of basic rocks containing nepheline as an essential constituent They are classified in the nephelite-tephrite group in this series (see NEPHELINITE.)

Olivine, an alkali-amphibole, biotite and orthoclase may be present as subordinate constituents. With the exception of nepheline and orthoclase, the minerals of theralites are usually in well-shaped crystals. Nepheline itself may be largely represented by secondary zeolites.

Theralites are of comparatively rare occurrence. They are found in Bohemia in association with shonkinite, in Odenwald (Mt. Katzenbuckel) Ger.. together with pulaskite and foyaite in the Serra de Monchique, Port., in the Kola peninsula, U.S S.R. and among the Carboniferous intrusions of Ayrshire. Scot.

Closely related to the theralites are the teschenites (from Teschen, Czech.). In place of nepheline these rocks contain primary analcime, but types containing both nepheline and analcime are known. In central Scotland, around Edinburgh and Glasgow, teschenites are abundant, forming thick sills intrusive into the Carboniferous rocks. Teschenites are sometimes ophitic, *i.e.*, with augite enclosing crystals of plagioclase, and show transitions to olivine-dolerite on the one hand and to picrite on the other.

The rock known as lugarite (from Lugar, Ayrshire) is a related type containing small amounts of plagioclase but abundant analcime; nepheline is present in subordinate amounts.

Other rocks related to the theralites are the essexites and shonkinites. The former are characterized by dominant plagioclase, subordinate orthoclase, and green augite, hornblende, biotite and olivine. Nepheline also occurs commonly. By an increase in the proportion of nepheline the essexites pass into theralites. Essexites occur, together with nepheline-syenite, in Essex county, Mass., at Mt. Royal near Montreal, in southern Norway (Oslo district), at Rongstock, Czech., and among the Carboniferous teschenites of Scotland near Edinburgh and in the Campsie fells (hills), Stirlingshire. The shonkinites are dark-coloured, igneous rocks of much rarer occurrence. Augite and orthoclase are the prime constituents, but plagioclase, barkevikite, olivine, biotite and variable amounts of nepheline are present.

At Shonkin sag, in the Highwood mountains of Montana, shonkinite forms the greater part of a stratified laccolith passing at the border into a peculiar basic rock described as a leucite-basalt porphyry.

Shonkinites are also found in Ontario, British Columbia and Indonesia (Celebes. Timor). (C. E. T.; X.)

THERAMENES (d. 403 B.C.), Athenian statesman, was the adopted son of Hagnon, a prominent conservative who in 430 impeached Pericles, and after the Sicilian expedition became one of the ten pro*buli* (πρόβουλοι, commissioners) appointed to devise economies in the administration. As a pupil of the sophist Prodicus he acquired facility in public speaking. Under his father's patronage he joined in the conservative reaction which came to a head in 411, when hopes of a Persian alliance or peace with Sparta strengthened the existing dissatisfaction with the democratic rule. Theramenes specially studied the constitutional side of this movement and formulated a new party cry, "the constitution of our fathers."

It was no doubt largely due to his advocacy that the *probuli*, strengthened by additional members, were commissioned to draft new measures on behalf of the public safety and to examine the "ancestral code" of the noted Athenian statesman Cleisthenes. In their report the following measures were recommended: annulment of the act against promulgating illegal measures; abolition of pay, excepting the troops in the field and the archons (chief magistrates of Athens); restriction of the franchise to 5,000 able to serve "with person and purse"; and the appointment of a special board to choose the specified 5,000. When these proposals were passed (apparently in a packed assembly outside the walls), a constituent assembly of 100 was elected—nominally by the 5,000, who as yet were a mere phantom body, but in point of fact by the leading conspirators.

The new constitution provided for a boule whose members were to be recruited by lot from all citizens over 30; the functions of this body were to be exercised by four sections succeeding one another by yearly rotation and serving without pay; and all high officials were to be chosen by the boule out of its own members. This scheme embodied the chief reforms desired by Theramenes, and marked the triumph of his policy. Before it could be carried into effect, however, it was superseded by a "provisional constitution," which gave unlimited power to a boule of 400 (chosen by a roundabout system which favoured intrigue) and its nominees, the ten "absolute" generals. This extreme reaction displeased Theramenes, who in retaliation began to agitate for the calling of the 5,000 into real existence. Furthermore, he warned Athens against the treason of the extreme oligarchs, and induced the troops to raze a mole erected to facilitate a Spartan descent on Peiraeeus.

After the disaster of Eretrea, which caused the fall of the extremists and the institution of a government of "5,000" (*i.e.*, all citizens who could afford a suit of armour), Theramenes stood in high esteem (*see* PELOPONNESIAN WAR). After assisting in the prosecution of his former colleagues, he received the command of a squadron with which he helped to win the great victory at Cyzicus (410) and to recover the Bosporus.

After the triumph of the radical democrats which followed upon these successes he lost his high command. At Arginusae (406), he fought as a simple ship's captain. Following the battle, however, he was favoured by the generals with a commission to rescue some drowning crews—an order which proved impossible to execute with his ill-trained and exhausted troops in a heavy storm. The generals were severely criticized at Athens for this failure and an inquiry by the boule led to their arrest. While before the ecclesia they weakened their case by pleading the conflicting points that, on the one hand, the storm had made a rescue impossible and that, on the other hand, Theramenes was to blame. Theramenes in reply brought out the implied contradiction in these statements. and he was subsequently reinstated as general while the assembly condemned the accused generals to death.

Late in 40j Theramenes went as plenipotentiary to Lysander (*q.v.*) to obtain peace terms; after long negotiations he proceeded to Sparta and arranged a settlement which the Athenians ratified in April 404. In spite of this peace the disorder in Athens did not abate. The restored fugitives selected five ephors (title of the highest magistrates of Sparta), including Critias, to organize a revolution, while the radicals opposed that return to the "ancestral constitution" for which Theramenes had stipulated. At this point Lysander returned to Athens and had a constituent committee elected, of whom ten members were nominees of each section. In this body Theramenes at first assumed the chief role, and the new measures rescinding the laws against the Areopagus (the supreme tribunal of Athens) and suppressing sycophancy were well received. However, exactly as in 411, a more violent party under Critias, ignoring its real duties, appointed an autocratic boule of its own supporters, and proceeded by judicial murders and confiscations to earn for the new government the name of "the Thirty Tyrants."

Theramenes protested, and managed to have a citizen-body of 3,000 admitted to a share of the government. Critias, however, fearing a renewal of the collapse of 411, disarmed the people and decided to remove Theramenes before he could create a new democratic party. The latter successfully repelled Critias' denunciation of treason, but was later led away by violence and forced to take poison. His well-known gibe, "Here's to the noble Critias," evidenced his strength of mind at the hour of death.

Theramenes demonstrably had a definite policy throughout his career. His ideal was a return to a 6th-century constitution, which his contemporaries could equally regard as a moderate oligarchy or a restricted democracy. The main features of his plan included property qualifications for franchise, abolition of pay and transference of some judicial powers from the popular courts to a restored Areopagus.

At times he seemed likely to succeed, but amid the violent oscillations of parties he could not definitely join with any one faction, and so earned the nickname Κόθορνος (a stage-boot fitting either foot). Aristotle, however, discerned Theramenes' real policy and, like Cicero and Caesar, in later years ranked him among the greatest Athenian statesmen.

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THERAPEUTAE, an ancient sect of ascetics believed to have lived in the vicinity of Alexandria and near Lake Mareotis. They are mentioned in *De Vita Contemplativa,* attributed to the Jewish philosopher Philo (*q.v.*), which is the sole original account of the community, and they are characterized as being unusually severe in their discipline and mode of life.

According to *De Vita Contemplativa,* on joining the order a man died to the world, and so voluntarily resigned his property to his heirs. How the order itself was supported is not reported. So far as the reader is informed, prayer and study were the sole occupations of the Therapeutae. The community at Alexandria lived in mean and scattered houses, near enough to afford protection, without depriving the members of the solitude which they so valued. Each of these houses contained a chamber which was devoted to prayer and study, and into which the inmate brought nothing but the Law and the Prophets, together with the Psalms and other works which tended to the promotion of piety. At sunrise the Therapeutae prayed and again at sunset. The whole interval was devoted to a study of the internal sense of the Scriptures.

In addition to the Old Testament, the Therapeutae had books by the founders of their sect on the allegorical method of interpreting Scripture. They also contributed to sacred literature themselves in the composition of new psalms. Attendance to the ordinary needs of nature was entirely relegated to the hours of darkness. Some of these recluses ate only every second day, while others succeeded in confining the necessity for food to a single weekday. But the Sabbath was a feast on which, after attending to their souls, they indulged their bodies. But their indulgence even then did not exceed coarse bread, flavoured with salt and sometimes hyssop, and a drink of spring water. Thus during the six days of the week the Therapeutae "philosophized," each in his own cell, but on the Sabbath they met in a common assembly, where women also had places screened off from the men. and listened to a discourse from one who was the eldest and most skilled in their doctrines.

The sober celebrations of the Therapeutae on the eve of the feast of Pentecost are described. They assembled together with glad faces and in white garments, and the proceedings were begun with prayers; they stood with eyes lifted and hands stretched to heaven. After taking seats according to the order of their admission, all listened devoutly to a discourse by the president, followed by the singing of ancient and modern hymns. Then came a meal of the simple type already described. And after this a pervigilium, celebrated with antiphonal and joint singing by the men and women and with choral dancing in imitation of Moses and Miriam at the Red sea. At sunrise. turning to the east, they prayed that the light of truth might illumine their minds, and then returned to their studies. Such is the account of the Therapeutae given in De *Vita Contemplativa.*

As the result of *De Vita Contemplativa* being the only authority regarding the life and existence of the Therapeutae, a number of controversial questions concerning the sect arose. Some authorities regard the Therapeutae as a Christian order because of the similarity between their asceticism and that of Christian monasticism, but the consensus among modern scholars is that they were a radical offshoot of pre-Christian Judaism. The supposition that the Therapeutae were a branch of the Essenes was contested by A. von Harnack. While these two ascetic sects resembled each other in many instances and especially in discipline, the Therapeutae regulations were more severe.

To the modern reader the importance of the Therapeutae, as of the Essenes, lies in the evidence they afford of the existence of the monastic system long before the Christian era. No clue is given to the origin of the Therapeutae, but it is plain that they were already ancient when described in *De Vita Contemplativa.* Eusebius was so much struck by the likeness of the Therapeutae to the Christian monks of his own day as to claim that they were Christians converted by the preaching of St. Mark. He goes so far as to say that "the writings of ancient men. who were the founders of the sect" referred to by *De Vita Contemplativa,* may very well have been the Gospels and Epistles (which were not yet written). Eusebius having gone wrong on this point, others of the Fathers followed suit, so that Philo was reckoned by Jerome among the ecclesiastical writers of the Christians.

It is likely that Christianity gained adherents among the Therapeutae, and that their institutions were adapted to the new religion, just as they seem to have been borrowed by the Jews from the Egyptians.

THERAPEUTICS is the science and art of healing. The term also includes the use of drugs and other measures to prevent disease. Thus therapeutics is related to both therapy and treatment.

Types.—The scope of therapeutics is evident when the types of therapy are considered. Included are biologic therapy, which involves the use of biologic products such as serums. vaccines and antitoxins; chemotherapy, the use of specific pure chemicals to attack specific diseases; cold therapy, the use of cold objects such as ice; collapse therapy, the collapsing of an organ such as of the lung to combat tuberculosis; diathermic therapy, the use of diathermy equipment; electroshock therapy, the treatment of a patient with mental disease by passing an electrical current through the brain; endocrine or glandular therapy, the use of hormones or endocrines or secretions from glands (these may be extracted from glands or made synthetically); fever therapy, the treatment of disease by inducing a high fever in the body; heat therapy; insulin shock therapy; oxygen therapy; and radium and X-ray therapy. There are other forms of therapy but their names are usually self-explanatory and they are more or less specific in their approach, for example, gold therapy, vaccine therapy, musical therapy and physical therapy.

Practically any drug or treatment measure can be introduced and a name applied to it to describe it. Or, from another approach, practically any part of the body can be treated and the procedure called a form of therapeutics, *e.g.,* dental therapeutics or alimentary therapeutics (pertaining to the digestive tract, the stomach and intestines or bowel). Also, therapeutics may be specific or nonspecific, and it may be rational and irrational (the latter form usually employed by quacks).

Development.—At the turn of the 20th century there were only a few drugs and other measures of outstanding importance, and some of these were improperly understood. Most doctors knew the value of sun, fresh air, fresh fruit and some pain-relieving substances. but little was known of the precise way in which they served man. Furthermore, while surgery was a useful part of medical practice it was formerly fraught with danger because of the lack of satisfactory antiseptic measures. satisfactory anaesthetics and specific aids to combat shock, loss of blood and infections. It is probably safe to say that modern therapeutics really followed World War I although the foundation for its development was laid in earlier years by the work of such men as Paul Ehrlich, Robert Koch and others.

The application of measures to prevent disease and to cure those suffering from it goes back to the early history of man when someone tried to apply leaves, mud and splints and invoked blessings from the gods. Primitive man feared the unknown and attributed sickness to the displeasure of his gods or to some other factor. As he learned by trial and error the value of a few simple remedies he began the practice of medicine, although this in time fell into the hands of tribal medicine men, many of whom mere crafty and also influential because of their self-claimed mystic powers. Since many of early man's actions were based on superstitious beliefs, strange and fascinating influences were attributed to rocks, trees. clouds, rivers and other objects which man could see but could not understand. Then in time he recognized the unusual properties of animals and bushes and flowers and attributed to them life-saying value. For example, because the lion is brave, man believed that eating the heart of this animal would make him brave; because the fox can run for a long time he believed eating the lungs of a fox would make him long-winded; and because the bear is strong he thought this animal could impart to him unusual strength.

Such beliefs were largely based on ignorance, on which of course much superstition is founded. From time to time an element of truth was discovered in these practices but it took countless years to determine that fact. Man had to pass to civilized ages before he found much of therapeutic value in plants, animals and minerals. In later centuries accidental discoveries, keen observations and careful study resulted in some useful findings. For example, the value of quinine for malaria was discovered by an explorer from the old world observing the actions of Indians; the value of digitalis for heart diseases was learned by a physician in England investigating a brew made from foxglove by an elderly housewife; and the usefulness of Epsom salts was demonstrated when a farmer became curious as to why his cattle would not drink from a certain well.

Value.—Following basic chemical and physical findings in the 19th century modern chemotherapy and therapeutics were born. Drugs were purified, specific measures against disease were developed, diseases were identified and techniques for diagnosis, treatment and prevention of disease were unearthed. Some of these discoveries were based on studies seemingly unrelated to medicine. Thus, Gerhard Domagk while searching for better dyes for woollen goods found the precursor to the sulfa drugs, and Sir Alexander Fleming found penicillin by observing the growth of mould on bacteria-growing media in his bacteriologic laboratory. Regardless of the origin of therapeutic measures, however, their usefulness changed the welfare of mankind, influenced the winning of wars and was responsible for the development of huge industries. They also changed educational patterns, permitted the growth of primitive and underdeveloped areas, caused nations to work together more closely than might otherwise be possible and resulted in the creation of many laws that might not be required otherwise. They also brought medical quacks into focus more clearly.

Some idea of the value of modern therapeutics can be obtained by comparing statistics for given periods of time. During the Crimean War the French lost eight men from diseases for every one killed in battle and the Russians lost 20 to one. The common causes of death were cholera, typhus, dysentery and infections, all diseases which could later be controlled. In the Spanish-American War seven soldiers were lost for every one who died in battle. In the Civil War in the United States 50% of the wounded died, whereas in World War I 6% to 12% died, and in World War II no more than 3%. In World War I the annual death for American soldiers away from America was 12.8 for each 1,000 men abroad, and in World War II it was 0.5 per 1,000 men. In World War I 20% to 30% of soldiers who contracted pneumonia died; in World War II only 1%. In the first 40 years of the 20th century 25,000 lives in the United States were saved through better control over just five diseases, pneumonia, diphtheria, typhoid, meningitis and smallpox. In 1900 a newborn child had a life expectancy of 49.2 years but in 1940 it was 63.3 years and in 1948, 68 years.

Much of this improvement was due to better hygiene, health education, improved hospital facilities, better food, sanitary measures, better surgical techniques, improved transportation facilities and other factors. The introduction of more and purer drugs, the development of physical devices (*e.g.,* X-ray machines) and the creation of foods for special health purposes (*e.g.,* baby foods and foods for the sick) have also been important factors. The production records for a few well-known compounds show that in an average year in the middle 1940s in the United States alone there were produced 750,000 lb. of aspirin, 23,000 lb. of a vitamin, 22.000 lb. of phenobarbital and 650,000 lb. of sulfonamides. Penicillin grew in production from 400,000,000 units for January through May in 1943, to 200,000,000,000 units in December in 1944 to billions of units daily in 1955. A similar story exists for the other antibiotics.

General Problems.—There are some problems common to many diseases which must be considered when treatment is practical, particularly if drugs are involved. Thus specific orders must be given to the patient, his family or his nurse; there may be need for limiting or increasing exercise; diet may have to be controlled; and laboratory procedures may be necessary.

If a prescription is ordered the prescriber considers the age and weight of the patient, any history of allergy and the way and time of administration. In addition, there may be need for special bathing and skin, nose, eye or mouth care consideration. Many people fail to realize the importance of some of these measures that are ancillary to drug therapy. Diets alone may pose problems since there are liquid diets, soft diets, regular diets and special diets as peptic ulcer diet, bland diet, nonresidue diet, low residue diet, high residue diet, high calory diet, diets for patients with diabetes and with nephritis, high protein diet, low salt diet and others. But diets, like vitamins, can be very important in therapeutics.

Standardization of Therapeutic Agents.—In most countries throughout the world an attempt is made to ensure the marketing of satisfactory foods and drugs but in only a few countries is this carried to a degree that provides assurance for user and prescriber. Many countries use pharmacopoeias, which are books for the standardization of drugs, as a guide for quality but do not have laws to enforce them or to prevent the marketing of harmful or useless substances. There are exceptions, of course (notably Canada, Great Britain, the United States, the Netherlands and the Scandinavian countries). In the United States drugs, foods and to some extent devices which are in interstate commerce are subject to control in several ways: manufacturers, because of keen competition and the fear of adverse publicity and lawsuits as well as a growing sense of moral obligation, try to develop effective and pure drugs and foods. In addition, there is a Federal Food, Drug and Cosmetic act which governs quality, labelling and to some extent promotional claims. Acting as an agent for this and other acts is the Food and Drug administration, which can seize and examine products and inspect factories. To govern the sale of serums and vaccines there is another law and another federal agency. Some states have their own laws and agencies and one or two of the larger cities have organizations that function similarly. The medical profession is, of course, always doing its own examining through experience and even supports through the American Medical association several councils who examine drugs, foods and devices to determine their usefulness.

Drugs and foods may be tested chemically, by assay on animals and through other measures. The purer chemicals obviously pose fewer problems as a rule than the impure mixtures, many of which are of botanical or animal origin. While most drugs can be examined by chemical tests there are some that defy such an approach, an outstanding example in the 1950s being liver extract, used for treating pernicious anaemia.

Mode of Action.—The method of approach to a disease and the remedy to be used depends on several factors such as the disease involved, the depth of illness of the patient, its hazards as a public health menace and the kind of remedy available. Thus a drug may be given by mouth, injected into the skin or under the skin, or into a muscle, vein or even artery, or into other tissues of the body, or it may be applied to the skin. It may be available as a tablet, or powder, or in solution, or in a capsule or ointment.

A drug or other remedy may be given to specifically combat a disease; it may be given to help the body mobilize its own natural defense forces, as the sulfa drugs hold in check the growth of bacteria while the body overcomes those already present; it may be used to provide symptomatic relief, such as aspirin for headache; or it may be used to directly attack disease, such as X-rays for cancer. The choice of treatment depends on the cause of the disease, complications and specificity of available therapeutic measures. In addition, there is the always to be remembered adjunct to treatment, peace of mind. This is why sympathetic understanding of a health problem sometimes is more effective than the use of drugs or surgery. Kind words, a change in scenery and association with new friends often have effected miraculous improvement.

Prevention of Disease.—The prevention of disease is founded on good living, adequate sanitation and the use of specific measures against specific diseases. Some have referred to this as preventive therapeutics. School clinics, venereal disease clinics, public health laboratories, vaccination, balanced meals, extra milk for children, the addition of iodine to salt to prevent goitre, the addition of fluorine to water to prevent dental decay and the addition of vitamin D to milk and vitamin C to other foods are part of current preventive practices.

Among the diseases that can be prevented by vaccination or similar measures are smallpox, diphtheria, yellow fever, and typhoid and paratyphoid fever. Even tuberculosis and poliomyelitis may soon be controlled by vaccination as promising vaccines are now available.

Other important preventive measures supplementary to actual therapy are proper disposal of sewage, eradication of disease-carrying mosquitoes, avoidance of polluted water and isolation of people sick with infectious diseases. Since animals and birds carry many diseases to which man is susceptible, they too must be subjected to certain control measures such as testing for tuberculosis and vaccination against rabies.

Specificity of Drug Action.—One of the encouraging aspects of modern therapeutics is the specificity of drug action. Formerly drugs were not particularly specific; in fact, "shotgun therapy" was often the order of the day. Today, however, one can choose a drug for many diseases and health problems. Thus, one can choose the type of anaesthetic agent indicated for an operation; the type of drug indicated for sleeplessness and pain; the type of drug best suited to muscle spasm, or high blood pressure, or allergy, or infection. Such a direct approach was made possible by the development of more precise diagnostic techniques, by a better understanding of the functions of the body and by the combined efforts of chemists, physicians and other specially trained people who can jointly develop first in theory and then in practice the chemicals needed to combat a certain health problem.

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THERESA, ST. (1515–1582), or Teresa de Cepeda, Spanish nun, was born at Avila, in Old Castile, on March 28, 1515, and was educated in an Augustinian convent in the town. As a child she was interested in the stories of martyrs, and at the age of eighteen left home one morning, and applied for admission at the Carmelite convent of the Incarnation. She was disappointed at first at the slackness of discipline, but she appears afterward to have accommodated herself with tolerable success to the worldliness of her environment, though not without intervals of religious misgivings.

It was in the year 1554, when she was nearly 40, that the event known as her conversion took place, and the second part of her life began. The death of her father roused her to serious reflection, and one day, as she entered the oratory, she was struck by the image of the wounded Christ, placed there for an approaching festival. She fell in tears at the feet of the figure, and felt every worldly emotion die within her. The shock threw her into a trance, and these trances, accompanied by visions, recurred frequently in the subsequent part of her life. They have since been adduced as Divine attestations of her saintship, but the sisterhood in the convent set them down to possession by a devil; her new departure was caused in their eyes by no worthier motive than the desire to be peculiar and to be reputed better than other people. Theresa herself was very humble, and thought their explanation might be true; she took her case to her confessor and to the provincial-general of the Jesuits, who put her under a course of discipline. One day, while thus occupied, her trance came upon her, and she heard a voice say, "Thou shalt have no more converse with men, but with angels." After this the trance or fit always returned when she was at prayers, and she felt that Christ was close to her. Presently she was able to see Him, "exactly as He was painted rising from the sepulchre." Her confessor directed her to exorcise the figure, and she obeyed with pain, but, it is needless to say, in vain. The visions grew more and more vivid. The cross of her rosary was snatched from her hand one day, and when returned it was made of jewels more brilliant than diamonds, visible, however, to her alone. She often had an acute pain in her side, and fancied that an angel came to her with a lance tipped with fire, which he struck into her heart. August 27 is kept sacred in Spain to this mystery, which has also formed a favourite subject of Spanish painters. She also had visions of another description: she was shown hell with its horrors, and the devil would sit upon her breviary, belabour her with blows, and fill her cell with imps. For several years these experiences continued, and the verdict as to their source still remained far from unanimous.

Foundation of the Descalzos.—Meanwhile, the spread of the Reformation became the subject of much searching of hearts to pious Catholics. Theresa reflected like the rest, and her experience led her to find the real cause of the catastrophe in the relaxation of discipline within the religious orders. She formed the project of founding a house in which all the original rules of the Carmelite order would be observed. In spite of great opposition from the authorities of the order, and in particular from the prioress and sisters of the Incarnation, she persevered with her scheme, being encouraged to appeal to the pope by certain priests who saw the benefit which would accrue to the Church from her zeal.

A private house in Avila was secretly got ready to serve as a small convent, and, when the bull arrived from Rome, Theresa went out on leave from the Incarnation and installed four poor women in the new house dedicated to her patron St. Joseph. It was on Aug. 24, 1562 that Mass was said in the little chapel and the new order constituted. It was to be an order of Descalzos or Barefoots, in opposition to the relaxed parent body, the Calzados. The sisters were not to be literally shoeless, but to wear sandals of rope; they were to sleep on straw, to eat no meat, to be strictly confined to the cloister, and to live on alms without regular endowment. After lodging her four sisters, Theresa returned to the Incarnation; but, when the secret was discovered, Carmelites and townspeople were alike furious. Violence, however, was prevented, and the matter was referred to the council of state at Madrid. Philip II referred it again to the pope, and after six months a fresh bull arrived from Pius V. The provincial of her order now gave her leave to remove and take charge of her sisterhood. The number of 13, to which on grounds of discipline she had limited the foundation, was soon filled up, and Theresa spent here the five happiest years of her life. Her visions continued, and, by command of her ecclesiastical superiors, she wrote her autobiography containing a full account of these experiences though she was far from basing any claim to holiness upon them.

The general of the order visited her at Avila, and gave her powers to found other houses of Descalzos, for men as well as women. The last 15 years of her life were spent mainly in hard journeys with this end and in the continually growing labour of organization. Convents were founded at Medina, Malaga, Valladolid, Toledo, Segovia and Salamanca, and two at Alva under the patronage of the famous duke. Then she had three years of rest, as prioress of her old convent of the Incarnation. She next went to Seville to found a house, thus overstepping for the first time the boundaries of the Castiles, to which her authorization limited her. The latent hostility of the old order was aroused; the general ordered the immediate suppression of the house at Seville, and procured a bull from Gregory XIII prohibiting the further extension of the reformed houses (1575). But the movement against her came from Italy, and was resented by Philip and the Spanish authorities as undue interference; and after a fierce struggle, during which Theresa was two years under arrest at Toledo, the Carmelites were divided into two bodies in 1580, and the Descalzos obtained the right to elect their own provincial-generals. (See CARMELITES.) The few remaining years of Theresa's life were spent in the old way, organizing the order she had founded, and travelling about to open new convents. Sixteen convents and 14 monasteries were founded by her efforts; she wrote a history of her foundations, which forms a supplement to her autobiography. Her last journey of inspection was cut short at Alva, where she died on Sept 29, 1582.

Canonization. — A violet odour and a fragrant oil were said to distil from her tomb; and when it was opened nine months afterward the flesh was found uncorrupted. A hand cut off by a fervent brother was found to work miracles, and the order became convinced that their founder had been a saint. It was resolved in 1585 to remove her remains to Avila, where she was born, the sisters at Alva being consoled by permission to retain the mutilated arm.

But the family of the duke of Alva procured an order from the pope enjoining that the body should be restored to Alva, and she was accordingly laid there once more in a splendid tomb. But even then she was not allowed to rest: she was again disentombed, to be laid in a more magnificent coffin, and the greed of reverential relic-seekers made unseemly havoc of her bones.

Theresa was canonized by Gregory XV in 1622. The honour was doubtless largely due to her asceticism and mystic visions. She called herself Theresa de Jesus, to signify the closeness of her relation to the heavenly Bridegroom, who directed all her actions. Though she deprecated excess of ascetic severity in others, she scourged herself habitually, and wore a peculiarly painful haircloth. But her life shows her to have been, besides, a woman of strong practicality and good sense, full of natural shrewdness, and with unusual powers of organization. "You deceived me in saying she was a woman," writes one of her confessors; "she is a bearded man." She was brave in the face of difficulties and dangers, pure in her motives, and her utterances, some of which have been quoted, have the true ethical ring about them. Her mss. were collected by Philip II and placed in a rich case in the Escorial, the key of which the king carried about with him. Besides her autobiography and the history of her foundations, her works (all written in Spanish) contain a great number of letters and various treatises of mystical religion, the chief of which are *The Way of Perfection* and *The Castle of the Soul*. Both describe the progress of the soul toward perfect union with God.

Her works, edited by two Dominicans were first published in 1587, and have since appeared in various editions. They were afterward translated into Italian, French (4 vols., Paris, 1840–46) and Latin; an English translation of the *Life* and works (except the letters) by A. Woodhead appeared in 1669. Other translations of the *Life* are those by John Dalton (1851), who also translated *The Way of Perfection* and the *Letters* (1902), and by David Lewis (1870), who in 1871 also translated the *Foundations*. A. R. Waller repnnted Woodhead's translation of *The Way of Perfection* in "The Cloister Library" (1901). Biographies appeared soon after her death by the Jesuit Ribera, who had been her confessor (1602), and by Diego de Yepez, confessor to Philip II (1599). Details are also given in Ribadeneyra's *Flos Sanctorum* and in Alban Butler's *Lives of the Saints* (rev. 1926). A separate biography, with preface by Cardinal Manning, appeared in 1865; a full and critical edition of the *Life* is that by Mrs. G. C. Graham, 2 vols. (1894). See also H. Prinz v. Oettingen-Spielberg, *Geschichte d. heil. Theresia* (Regensburg, 1899); A. Whyte, *Santa Teresa, an Appreciation, with Some of the Best Passages of the Writings* (1897); E. Hello, *Studies in Saintship* (1903); B. Zimmerman, *Minor Works* (1913); *The Way of Perfection* (1916); *The Interior Castle* (3rd ed. 1921). A translation of the Letters with introduction by Cardinal Gasquet appeared 1919–24 (4 vols.).

THERM. A name originally employed in elementary textbooks for any thermal unit but now generally restricted to the statutory unit of heat adopted for the sale of lighting gas in terms of its calorific value. The therm is defined as being equal to 100,000 British Thermal Units (B.Th.U.), the unit of heat most commonly used for measuring the calorific value of gas or other fuels throughout the British empire and (B.T.U.) in the U.S.

THERMAE, in architecture, is a term referring to the baths of a large bathing establishment, particularly those of ancient Rome. *See* BATHS.

THERMIDOR, the name given during the French Revolution to the 11th month of the year in the republican calendar. The month fell in the hottest season of the year, beginning on July 19 or 20 and ending on Aug. 18 or 19. according to the year. The most important event that took place in this month was the revolution of 9 Thermidor year II (July 27, 1794), the so-called revolution of Thermidor, which resulted in the fall of Robespierre and the collapse of the Terror. The name Thermidorian (*Thermidorien*) was given to the authors of this revolution and to the supporters of the reactionary movement of which it was the signal. The name Thermidor is derived from the two Greek words for heat and gift.

THERMIONICS. Thermionics deals with the production of charged particles, electrons or ions, at a heated surface. Useful examples of hot surfaces are electrically heated filamentary wires or ribbons of refractory metals such as tungsten or nickel. By far the most extensive application of thermionic electron emission is in the radio receiving tube. (*See* ELECTRON *TUBE.*)

An atom may be thought of as a structure that has a specific number of electrons in constant motion around a positively charged, massive nucleus. The number of electrons characterizes the particular chemical element and is known as the atomic number. Since the positive charge on the nucleus of an atom is exactly equal in magnitude to the sum of the negative charges on the electrons that surround the nucleus. a normal atom has no net charge. In the broadest sense of the word, a thermion is produced from an atom if an electron is either added to or subtracted from a normal atom at a heated surface. The production of atomic thermions depends on physical principles that have little or no relation to the thermal production of free electrons. Therefore, since the latter phenomenon has found such extensive and valuable applications, this article will deal exclusively with electron emission from heated surfaces.

Discovery of Thermionic Emission of Electrons. — Thomas A. Edison (*1883*) discovered that electrical conduction could be maintained between a hot filament and a nearby cool metallic plate if the plate was made positive with respect to the filament. No appreciable current was observed with a negative plate. Edison concluded that negative charges of electricity (now known to be electrons) were given off the hot filament and that these charges conducted electricity across the evacuated space. W. H. Preece (188j) studied the effectin more detail and gave it the name Edison effect. J. J. Thomson (1899) established the electronic nature of the charge carrier and found that the magnitude of the charge was the same as that discovered in previous experiments with ionized particles but that its mass was less than $\frac{1}{1,800}$ that of the hydrogen ion.

Early investigators included O. W. Richardson, Max von Laue, W. Schottky (1914), I. Langmuir (*1913*) and others, who by *1920* had established many of the principles of the new field. The most advanced and widespread application of thermionic emission to electronics depends on the very high efficiency and reliability of the oxide cathode discovered by A. Wehnelt (*1903*). (*See* ELECTRICITY: *The Particles of Electricity.*)

Applications of Electronic Thermionics.—The importance of the thermionic emission of electrons can best be established by mentioning some of the applications that depend on the utilization of this phenomenon. The high-voltage hot-cathode rectifier depends on the emission of electrons into an evacuated space and in this way supplies the means of electrical conduction from the cathode to the anode of the tube structure. The latter receives electrons while it is positive with respect to the cathode. The anode structure operates at such a low temperature that its thermionic emission is exceedingly small, and therefore the tube operating as a rectifier conducts well only with the one polarity of applied voltage.

The arrival at the anode of free electrons with high energy produces X-rays as the electrons are stopped, and therefore most X-ray tubes depend upon thermionic emission for their operation. The emitted free electrons may be accelerated through certain gases and upon collision with the atoms produce atomic excitation and ionization. These are steps in the operation of fluorescent lamps, gas-filled rectifiers, grid-controlled rectifiers or thyratrons and many other devices of everyday usefulness that depend on the thermionic emission of electrons for their very existence.

The vacuum tube also depends on thermionic emission. Amplification of modulated power for telephone, radio and television communication depends on the controllability of the free electrons that have been emitted thermionically from the cathode of the structure.

Theory of Thermionic Emission.—To understand the theory of thermionic emission one must first have some knowledge of the electronic properties of atoms, molecules and solids. The fact that atoms have a "structure" that includes a positively charged heavy nucleus surrounded by a system of electrons equal in number to the atomic number of the chemical element has been mentioned above. Experiments have shown that the electrons are grouped together in electronic energy levels. In every complex atom there are two electrons very close to the nucleus which serve to fill the "K" shell.

The next one is the "L" shell with a maximum of eight electrons. Depending on the total number of electrons that are associated with each atomic nucleus to make it electrically neutral, additional shells may be filled. The outermost electrons are known as the valence electrons. The metals that are good conductors are nearly all to be found among those elements that have only one or two of these valence electrons in the outermost structural shell. The details are well understood as a result of the application of wave mechanics to the problem. (See QUANTUM MECHANICS: *Wave Mechanics.*)

The common metallic elements upon crystallization yield their valence electrons to quantum states, described best in the language of wave mechanics, that extend throughout the crystal as a whole and in that way are no longer the property of the individual atoms. The transfer of an electron from one quantum state to another always is accompanied by a change in energy of the system as a whole, and therefore the general concept that the most stable state of the system tends to be that of "least energy" implies that the electrons will occupy all of the low-energy quantum states first and that the high-energy ones will be empty.

Quantum mechanics serves as the means of determining the number of quantum states easily available to the valence electrons of a crystal. A comparison may be made between the number of states needed and those available. If the two are exactly equal then the substance is a very poor conductor, as is the case for diamond. If the available states far exceed the demand then the substance is a good conductor (for example, copper). Since at some specified temperature practically all of the low-energy quantum states in the crystal are filled and most of the high-energy states are empty, there must be some energy state (or level, as these states are often called) that will have exactly a 50% probability of being filled. This quantum state and its corresponding energy are identified by the term Fermi level, in honour of Enrico Fermi, who was one of the first to develop the quantum statistics of electrons.

It is difficult to establish a universally acceptable way of giving a numerical value to the Fermi level since the energy of an electron depends both on its location and on its momentum. In thermionic emission theory the primary interest is in the transport of electrons through the substance used as the emitter of electrons and the transport of electrons across the boundary between the metal and the surrounding space. Statistical theory tells us that no matter what the substance is on each side of any boundary established in a region in which there is thermodynamic equilibrium, the Fermi level is continuous across that boundary and the net flow of heat and electricity across the boundary will be exactly zero. As a consequence of this fact, theory provides a means of computing the "random" flow of electrons that occupy any set of quantum states of known energy relative to the Fermi level. By random flow is meant the number of electrons that cross a unit area per second in one direction. For the net current to be zero, the random flow in opposite directions must be equal in magnitude.

This discussion of statistical theory is best illustrated by the diagram of fig. 1. The vertical direction in this diagram represents relative energies of electrons and the horizontal direction represents distance. The left of the dotted vertical line is inside the conductor and the right is outside the last layer of atoms of which the crystal is made. If the potential energy of an electron is zero at a large distance away from the surface, then the potential energy inside is lower by the amount shown as W_a. This difference in potential energy is known as the elec-

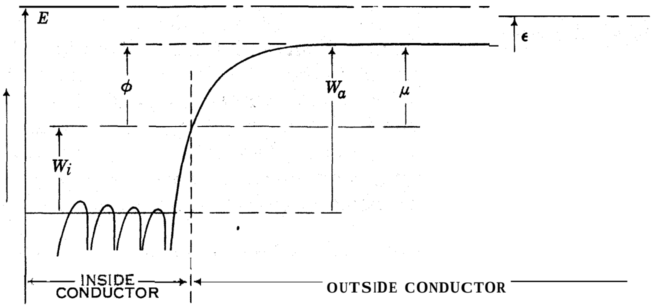

FIG. 1.— RELATIVE ENERGIES OF ELECTRONS PLOTTED AGAINST DISTANCE FROM SURFACE

W_i is the Fermi level relative to the conduction band; ϕ is the true work function in electron volts: E is the kinetic energy inside the conductor of an electron in motion perpendicular to a surface; W_a is the electron affinity; μ is the Fermi level for a low density of electrons outside; and ϵ is the kinetic energy of an electron in motion perpendicular to a surface and outside it

tron affinity of the surface. There is no single value of W_a that characterizes the particular metal of which the crystal is made, since its value depends not only on the metal but also on the particular crystallographic surface that is exposed. The usual way of defining a crystallographic direction is by the Miller indices of a line perpendicular to the surface. If reference is made to the experimental determination of the differences in W_a for the [110] direction of tungsten in comparison with the [111] direction, A. R. Hutson (1955) showed it to be at least 0.8 ev (electron volt) higher in the [110] direction. An electron volt is the energy gained or lost by an electron in moving across a region in which there is a difference in potential of one volt. Since the charge on an electron is 1.602×10^{-19} coulomb, the electron volt is 1.602×10^{-19} joule. The most convenient energy unit to use in the discussion of thermionic emission is the electron volt, and it will be used in this article.

To help orient the reader in his understanding of fig. 1, other values of the symbols will be given as they refer to tungsten. The value of W_i, which is the Fermi level with respect to the bottom of the conduction band of electrons, is 5.8 ev when it is assumed that there is one conduction electron for each tungsten atom. This number is computed by the following formula, which comes directly from the application of Fermi statistics to an assembly of free electrons of concentration n:

$$W_i = \frac{h^2}{2m}\left(\frac{3n}{8\pi}\right)^{2/3}\left\{1 - \frac{\pi^2}{12}\left[\frac{kT}{\frac{h^2}{2m}\left(\frac{3n}{8\pi}\right)^{2/3}}\right]^2\right\} \text{ in electron volts} \quad (1)$$

In this equation h is Planck's constant (6.6238×10^{-34} joule-sec.); m is the electron mass (9.107×10^{-31} kg.); q is the charge on an electron (1.602×10^{-19} coulomb); k is Boltzmann's constant (1.38042×10^{-23} joule/° K.); and T is the absolute temperature on the Kelvin scale. An evaluation of W_i as it applies to tungsten, in which there are 6.4×10^{28} atoms per cubic metre, shows that the second term which depends on the temperature T is so very small compared to unity that W_i of 5.8 ev may be used without correction over the useful range in temperature of 1,800° K. to 2,500° K. Very careful experimentation by M. H. Nichols (1940), G. F. Smith (1954) and A. R. Hutson (1955) established the value of ϕ as $4.3 + (3 \times 10^{-5})$ T for the [111] surface. It follows that W_a is close to 10.1 ev for this surface and at least 10.9 ev for the [110] surface.

The diagram shows that the Fermi level in the outside space is the negative of ϕ; that is, $\mu = -\phi$. For this statement to be exact the space must be in thermodynamic equilibrium with the metal.

The value of μ (Fermi level for a low density of electrons) may be calculated from the equilibrium density of electrons in the space by the following equation:

$$\mu = -\frac{kT}{q}\, 1n \frac{2(2\pi mkT)^{3/2}}{nh^3} \qquad (2)$$

This equation is generally applicable for electron densities less than 10^{25} electrons per cubic metre.

The quantity ϕ is the true work function. It is defined as the difference in the energy of an electron at the Fermi level and one at rest just outside the surface.

In terms of the energy diagram of fig. 1 it is possible to explain thermionic emission from a metallic conductor. With the metal at a very low temperature, the electrons fill all the quantum states from the bottom of the conduction band right up to the Fermi level and very few electrons will be found above this level. There will be some high-energy electrons, however, and the Fermi level will mark that quantum state that has a 50% probability of being occupied. As the temperature is raised, more and more electrons will occupy the high-energy states, even as high as W_a, and there will be vacancies in the states below W_i exactly equal to the number occupied above W_i.

In their random motion in the interior of the metal, many of the very high-energy electrons will approach the surface of the metal. Assume that an electron is moving at high speed in the metal and that the kinetic energy associated nith the motion toward the boundary is E. As it crosses the boundary at the surface of the metal, it gives up kinetic energy in order to do work against the electrical forces that attract the electron to this surface of the crystal. The total work is the change in potential energy W_a. The kinetic energy with which the electron escapes into the surrounding space is shown on the diagram as ϵ.

By direct calculation, quantum statistics gives equation *(3)* for all of the electron current that impinges on the boundary surface with internal kinetic energy greater than W_a. It is this value of current density (I) that is the maximum that could be observed from the surface at the specified temperature:

$$I = \left[\frac{4\pi mk^2 q}{h^3}\right] T^2 e^{-\frac{\phi q}{kT}} \qquad (3)$$

In this equation e is the base of natural logarithms *(2.71828)*. Richardson *(1912)* was one of the first to develop this equation form based on general thermodynamic reasoning. S. Dushman *(1923)* worked out the value of the universal constant, the bracketed quantity in equation (3), while R. *H.* Fowler *(1928)* and L. Nordheim (1929) developed the theoretical basis for equation *(3)* by the application of Fermi statistics.

Empirical Equations and Thermionic Constants.—The superficial approach to the experimental testing of the validity of equation *(3)* is to observe an average current density I as a function of the temperature and plot the data according to the following relation:

$$1n\left(\frac{I}{T^2}\right) = 1n\, A_R - \frac{q}{kT}\,\phi_R \qquad (4)$$

where A, is the Richardson constant as an empirical constant and ϕ_R is the Richardson work function as an empirical constant.

The observable quantity on the left of equation (4) is plotted as a function of T^{-1}, or better yet, as a function of $(1/V_T) = (q/kT)$ V, is the electron volt equivalent of temperature. Generally a straight-line relation is found and values of A, and ϕ_R are determined this way. Comparisons are often made between A_R and the theoretical value of the universal constant *(A)* of equation (3), which is defined as follows and has the value shonn:

$$A = \frac{4\pi mk^2 q}{h^3} = 120 \times 10^4 \text{ amp./metre}^2 \text{ deg}^2 \qquad (5)$$

More often than not A, is less than A, but many examples are found in which A, is much greater than A. There are a number of reasons for the shortcomings of this method:

1. A given sample generally does not exhibit a single crystallographic surface for emission and therefore the average current density I will not equal the density needed for the test of equation *(3)*. It will be less than the maximum density and greater than the minimum of the various exposed surfaces of a test sample.

2. Nothing in the theory from which equation (3) was obtained limited its use to the condition that ϕ is a constant. The fact that a straight line may be obtained as indicated above only means that the effective average work function (ϕ_{eff}) may be represented by the equation shown as

$$\phi_{\text{eff}} = \phi_R + \alpha\frac{kT}{q} = \phi_R + \alpha V_T \qquad (6)$$

where a is the temperature coefficient. Note that the energy corresponding to kT can be expressed equally well as qV_T, and the electron volt equivalent of temperature is obtained as follows:

$$V_T = \frac{kT}{q} = \frac{T}{11{,}606} \qquad (7)$$

It is not necessary to add more detail to see that the observed value of the constant A, would be altered by the factor $e^{-\alpha}$ from the theoretical A. Thus if a is negative. as it may well be when absorbed atoms of the electronegative type are present as surface impurities, A, can be very large. If a is positive then A, will be small.

3. There is still another influence that may or may not be important. This is reflection at the boundary. The theory outlined above gave the maximum current that could be observed, but if not all of the available electrons actually left the metal the current would be less.

It follows that most experiments that have been reported in the literature give values of A, and ϕ_R. These constants must be considered to have very little theoretical importance, even though they do yield numbers of engineering usefulness. These numbers may be used to predict the electron emission that will be available from similar samples, but the work function ϕ will very seldom be the true work function ϕ of equation *(3)*. The basic Richardson thermionic equation is equation (3), and there the true work function ϕ is the only correct one to use. The empirical values of constants A, and ϕ_R are referred to as the Richardson constants and carry the subscript R because they are to be used with the Richardson form of the equation given as follows:

$$I = A_R T^2 e^{-\frac{\phi_R q}{kT}} = A_R T^2 e^{-\frac{\phi_R}{V_T}} \qquad (8)$$

The Richardson work function is ϕ_R and is a constant since it was determined by the slope of the best straight line that represented experimental observations according to the linear approximation of equation (4). The Richardson thermionic constant is A,. It is also a constant since its choice is made so that at some specified temperature the value of the calculated emission is in agreement with the experimental value.

The first equation put forward by Richardson did not make use of quantum principles and was expressed as:

$$I = A_R' T^{1/2} e^{-\frac{\phi_R' q}{kT}} \qquad (9)$$

As an empirical equation this one is no better nor worse than equation (8). since in nearly every example the experimental data are equally well represented by equation (9).

Since both equations (8) and *(9)* are empirical, having engineering usefulness only, it should be clear that the following equation is more useful for this purpose:

$$I = ae^{-\frac{\Phi}{V_T}} \qquad (10)$$

The two empirical constants for this form may be determined by a direct examination of data, or they may be related to A, and ϕ_R as will be shown below. The work factor Φ in electron volts is the slope of the line given by:

$$1n\, I = ln\, a - \frac{\Phi}{V_T} \qquad (11)$$

The constant a is chosen to give correct values as was done for

A_r. The relations used to convert one set of constants to the other are:

$$\Phi = \phi_R + V_m + V_n \tag{12}$$

$$a = 10\, A_R\, T_0^2 \tag{13}$$

$$T_0 = \frac{T_m + T_n}{\ln 10} = \frac{T_m + T_n}{2.3} \tag{14}$$

In these equations T_m is the minimum temperature of the range chosen for equation (10) to be the equivalent of equation (8). The maximum temperature of the range is T_n and the corresponding electron volt values are V_m and V_n computed by equation (7). T_0 is close to the mean temperature.

A useful set of thermionic constants is given in the table. The following empirical equations may be used with the tabulated constants to calculate approximate current densities in amp./cm.^{2} from the sources listed (the information on the constants for the sources shown was obtained from various articles in scientific literature):

$$I = A_R T^2 e^{-\frac{e\varphi_R}{kT}} \qquad I = A_R T^2 e^{-\frac{b}{T}} \qquad I = A_R T^2\, 10^{-\frac{b'}{T}}$$

$$I = a e^{-\frac{e\Phi}{kT}} \qquad I = a e^{-\frac{\beta}{T}} \qquad I = a\, 10^{-\frac{\beta'}{T}}$$

Reduction in Electron Affinity.— It is only the refractory or high-melting-point pure metals that serve as practical electron emission sources, and the best is tungsten. It is used in most high-voltage rectifiers and X-ray tubes.

The great objective is to obtain more electrons for less input power to heat the source. Although heat shields can be used to reduce the total power radiated, a considerable gain may be made by surface alterations that reduce the electron affinity. Fig. 1 shows that the methods that reduce W_a will generally reduce ϕ, since

$$\phi = W_a - W_i \tag{15}$$

I. Langmuir and W. Rogers (1914) discovered that thoria (ThO_2), occluded within a tungsten wire at the time of its manufacture, could be made to yield thorium by suitable heat treatment. The thorium atoms diffuse out of particularly active regions along crystal boundaries and finally over the external surface of the tungsten wire to form a coverage less than one atom layer thick. The thorium adheres very strongly to the underlying tungsten surface and becomes polarized. The direction of the dipole corresponds to a displacement of the outermost valence electrons of the thorium toward the tungsten. This displacement or polarization of the negative charge with respect to the positive charge on the thorium nucleus creates a dipole of strength μ_t at each thorium atom. If there are n_t thorium atoms per unit area, the dipole moment per unit area will be $n_t\ \mu_t$. A dipole moment has units of (charge $\times$ length) and therefore $(n_t\ \mu_t)/\epsilon_0$ has units which are potential difference or "volts." Analysis shows that W_a is changed due to an adsorbed layer of polarized atoms according to the relation

$$W'_a = W_a - \frac{n_t \mu_t}{\epsilon_0} \tag{16}$$

In this equation ϵ_0 is the permittivity of free space (8.85×10^{-12} faradimetre). Since oxygen polarizes in the opposite direction to thorium, W'_a (reduced electron affinity) is greater than W, if a fraction of a monolayer is adsorbed. Generally the adsorption of electronegative atoms increases the electron affinity, and a decrease comes with adsorbed electropositive elements. Although the alkali metals polarize strongly, as for example cesium, it is more difficult to maintain the optimum coverage in comparison aith thorium. The approximate reduction in W, by a 0.7 coverage (10^{19} thorium atoms per square metre) may be seen from the table to be about 1.4 ev.

This reduction in electron affinity realized with thoriated filaments is sufficient to make its use of practical value in many medium-capacity power amplifier tubes. Often perfectly good tubes of this type are discarded as worthless merely because they have lost their efficiency due to some temporary overload condition. Many such tubes may be reactivated and restored to useful service.

The greatest step in the reduction of the electron affinity came with the discovery by A. Wehnelt that a coating of alkaline-earth oxides would greatly enhance the electron emission obtained from a surface at a very low temperature. This discovery led to the modern technology of the oxide cathode.

Theory of the Oxide Cathode.— The oxide cathode is generally constructed as an internally heated nickel sleeve upon which a suitably prepared barium-strontium carbonate is sprayed. The fine particles are held in a binder, which is later removed by heating. The conversion of the carbonate into the oxide takes place within the final assembly during the early stages of evacuation. The conversion is completed by maintaining the cathode at about' 1,300° K. for about one minute (G. M. Herrmann and J. S. Wagener, 1951).

Important factors that govern the procedure include: (1) the need for nickel alloys that contain reducing agents such as silicon, titanium, magnesium, etc. (E. S. Rittner, 1953); (2) development of required particle size of about two or three microns; (3) porosity after sintering of about 50% with pores of about two microns' linear dimensions; (4) cleaning of all other parts of the tube is important for maintenance of cathode emission life; (5) coating adherence is dependent on vacuum conditions, cleaning of parts and other factors.

The electron emission from this structure depends upon the transfer of electrons from the nickel base metal to the coating, the conduction through the coating and finally the emission from the coating. Barium oxide in the absence of imperfections is an insulator and therefore a very poor conductor of electrons. The electron affinity is very low for practically all insulators. The probable value of W_a for the crystals of an oxide cathode is 0.8 ev.

This great reduction in W, from the metallic value of about ten electron volts does not automatically result in the high-efficiency cathode desired because both the coating conductivity and the electron emission depend on the location of the Fermi level. Semiconductor theory shows that the presence of an amount of excess barium in the oxide of only 1 part per 1,000,000 is enough to raise the Fermi level to within 0.4 ev of the conduction band if the temperature is about 500° K. This combination gives a true work function at low temperature of

$$\phi = W_a - W_i = 0.8 - (-0.4) = 1.2 \text{ ev} \tag{17}$$

A difficulty arises with such a low concentration of excess barium because as the temperature is raised the concentration of electrons in the conduction band soon equals the number of barium

Thermionic Constants*

Source	T_m	T_n	T_0	A_R	Φ_R	b	b'	a	Φ	β	β'
Carbon	1,300	2,200	1,520	30	4.34	50,340	21,870	70×10^7	4.64	53,820	23,390
	1,300	2,200	1,520	15	4.38	50,810	22,080	35×10^7	4.68	54,290	23,590
β Iron	1,040	1,180	1,010	26	4.48	51,970	22,580	27×10^7	4.68	54,290	23,590
γ Iron	1,180	1,680	1,240	1.5	4.21	48,840	21,220	2.3×10^7	4.46	51,740	22,490
Molybdenum	1,300	2,100	1,480	115	4.37	50,690	22,020	250×10^7	4.69	54,400	23,640
	1,350	2,000	1,450	55	4.15	48,140	20,920	155×10^7	4.44	51,500	22,380
Nickel	1,300	1,700	1,300	30	4.61	53,480	23,230	50×10^7	4.86	56,380	24,490
	1,150	1,700	1,240	50	5.24	60,780	26,410	80×10^7	5.49	63,680	27,670
Platinum	1,700	2,100	1,650	32	5.32	61,710	26,810	90×10^7	5.65	65,540	28,480
Tantalum	1,200	2,000	1,390	52	4.19	48,600	21,120	100×10^7	4.47	51,850	22,530
Tungsten	1,400	2,400	1,650	72	4.52	52,430	22,780	200×10^7	4.85	56,260	24,440
Tungsten + thorium	1,200	2,000	1,390	60	4.51	52,320	22,730	120×10^7	4.79	55,560	24,140
"L" (tungsten + barium)	1,200	2,000	1,390	3	2.63	30,510	13,255	6×10^7	2.91	33,760	14,670
Lanthanum + lanthanum boride	1,300	1,700	1,300	1	1.8	20,880	9,070	2×10^7	2.06	23,900	10,380
($La + LaB_6$)	1,300	1,700	1,300	15	2.0	23,200	10,080	20×10^7	2.26	26,220	11,390
	1,100	1,900	1,300	29	2.66	30,860	13,410	50×10^7	2.92	33,870	14,720
Barium strontium oxide (BaSrO)	600	1,200	780	0.5	1.0	11,600	5,040	3×10^6	1.16	13,460	5,846

*Explanation of symbols used in tahle: T_m, minimum temperature; T_n, maximum temperature; To. close to mean temperature computed from T_m and T_n by equation (14); A_R, Richard-on constant as an empirical constant; ϕ_R, Richardson work function as an empirical constant; b, temperature equivalent of the Richardson work function; b', empirical constant; a, empirical constant computed from A_R; a, work factor in electron volts computed from ϕ_R; β and b', empirical constants.
Source: W. B. Nottingham, "Thermionic Emission," in *Handbuch* der Physik, vol. xxi (1956).

atoms and the Fermi level becomes more and more negative as shown by equation (2). It follows therefore that in order to stabilize the Fermi level, a barium concentration of 10 to 20 parts per 1,000,000 is needed.

During the life of a cathode, barium is evaporated, and it also may be lost effectively if electronegative gas such as oxygen is evolved from other parts of the tube and goes to the cathode. It is the function of the reducing agent put into the nickel alloy to maintain the required concentration of barium to compensate for these losses. The migration of the excess barium atoms is influenced by the concentration gradient and by internal electric fields. Since the flow of electrons through the coating produces a drop in potential across the coating which is positive near the exterior surface and negative at the nickel, the excess barium ions in the crystals tend to flow away from the surface. This flow reduces the concentration there and increases the resistance.

This discussion of problems of the oxide cathode serves to illustrate the complexity of the phenomena associated with its electronic properties. More detailed and quantitative studies were made by W. B. Nottingham (193'6).

Field Effects Including Space Charge.—An understanding of thermionic emission requires some knowledge of the means of its observation. The diode structure, which includes a thermionic emitter and a collector, is all that is needed.

For the purpose of cathode temperature measurement the application of a moderately strong magnetic field with its B vector perpendicular to the emitting surface is desirable. If the emitter is cylindrical and possibly surrounded by an elliptical collector as in a practical vacuum tube, then the B vector should be perpendicular to the axis of the emitter and parallel to the short axis of the collector. The purpose of this magnetic field is to cause the emitted electrons to follow spirally along the lines of magnetic field so that their trajectories will be independent of the retarding potential which is used to analyze the energy distribution associated with the electron velocity vector parallel to the magnetic field. This method of temperature determination is subject to considerable error if the magnetic field is not used.

The applied potential on the collector may be made negative with respect to the emitter, and if the tube construction is designed for low leakage between its elements the measured current will indicate the number of high-energy electrons that are emitted. An equation based on a statistical analysis relates changes in the observed current to changes in applied voltage. It is the following:

$$2.3\,(\log_{10} i - \log_{10} i_1) = \frac{q}{kT}\,(V - V_1) \qquad (18)$$

In this form of the equation, V_1 and i_1 are a reference voltage and current relative to which V is referred in that if V is more positive than V_1, the current i is greater than i_1. This equation applies over the range for which the electron flow to the collector is not influenced by space charge. Important practical purposes are served by a set of measurements of current and voltage as related by equation (18). The data points may be co-ordinated by the semilogarithmic plot suggested by this equation, and the slope of the line gives an accurate measure of the temperature T of the emitter.

Fig. 2 is the circuit diagram applicable to the measurement of the current voltage characteristic of a diode. A plot of typical data is given in fig. 3. For applied voltages more negative than the critical one, V_R, the points lie on a straight line that is accurately represented by equation (18). An applied potential more positive than V_R results in an increase in current which follows the curve shown. This departure from the straight line shows that a space-charge minimum has developed close to the collector.

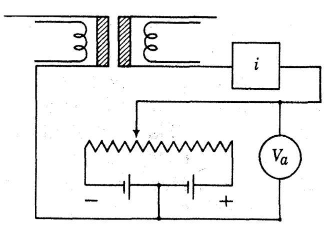

FIG. 2.—CIRCUIT DIAGRAM FOR THE MEASUREMENT OF A DIODE CHARACTERISTIC. OBSERVED CURRENT IS i; APPLIED POTENTIAL IS V_a

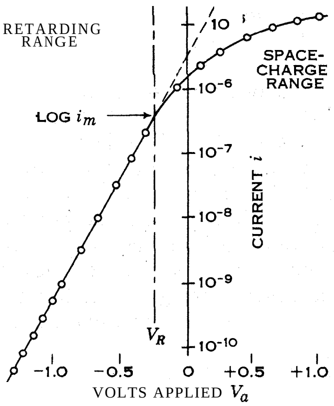

FIG 3 —SEMILOGARITHMIC PLOT OF DIODE CHARACTERISTIC

Applied voltage in retarding range more negative than V_1. Space-charge range positive with respect to V_R. Critical voltage for space-charge minimum at collector surface V_R. Diode current at critical voltage is i_m

Further changes in potential in the positive direction cause the current to increase while at the same time the space-charge minimum moves across the space between the collector and the emitter until it finally coincides with the emitter. Only under this condition is the true emission capability of the cathode determined. It is often difficult to achieve this condition with practical oxide cathodes operating at normal temperature because the Dower dissiaated at the collector may be many kilowatts. It is therefore found necessary to make the cathode evaluation over a range of lower temperature and determine suitable values of a and Φ of equation (10). Equipment has been designed which applies the high collector potential for a microsecond and repeats this application of voltage perhaps 60 times per second. The instantaneous power capacity of the collector is thus increased 16,000-fold.

Many writers evaluate ϕ_R rather than Φ and consider that the lowering of ϕ_R is the best direct indication of cathode quality. A more detailed consideration of the problem shows that ϕ_R or Φ changes very little with the activation of the cathode since the values depend only on the materials used. The true evaluation of the cathode quality depends on the determination of the α of equation (6). It is this temperature coefficient that indicates the concentration of excess barium. The higher the barium excess the lower the value of α and the higher the emission capability. Observationally the α is closely related to the a constant, which is large when α is small.

This outline showing the influences of space-charge on the observation of thermionic emission is all too brief. The details were worked out and reported by Nottingham (1956).

Under the condition of "zero field" at the emitter, the applied voltage on the collector supplies exactly that surface charge of positive electricity needed to balance the negative charge on all the electrons in transit between the emitter and the collector. Additional positive applied voltage can increase the current only at such a slow rate that the emission current is said to be saturated. For pure metals and simple composite surfaces such as thorium on tungsten, which have a high value of W_a, the most important force acting on an electron as it leaves the metal is the "mirror image" force. This fact was first pointed out by Schottky (1914), nho explained that since the total value of W_a is largely made up by the integration of the mirror image function, the application of the accelerating external field reduces the net force acting to hold the electron to the surface. This reduction permits an increase in current according to the Schottky equation as follows:

$$i = I_0\, e^{\left(\frac{q}{4\pi\epsilon_0}\right)^{1/2} \frac{q}{kT} (GV_c)^{1/2}} \qquad (19)$$

In this equation I_0 is an empirical constant (often incorrectly called the zero-field emission) and GV, is the electric field at the surface of the emitter. For high values of collector potential V_c the factor G depends only on the geometry of the diode structure, but at lower values of V_c space-charge becomes important and G becomes zero at that particular value of V_c for which the space-charge minimum coincides with the emission surface.

The problem is far more complex as the accelerating field is applied to the oxide cathode. Image forces are weaker because the oxide is more like an insulator than a conductor. The surface is generally rough enough so that the G factor is not constant and may exceed the one calculated by geometry. Space-charge effects are still important within the pores of the surface structure even though space-charge outside the surface may not be of much importance. These factors all combine to give a more rapid increase in current with applied potential than would be expected according to equation (19).

Direct Conversion of Heat to Electricity.—The diode characteristic shown in fig. 3 serves to demonstrate that thermionics may be used to convert heat to electrical power. The product $i_m V_R$ represents available power derived directly from the heated emitter. The efficiency of a vacuum diode will be very small unless the spacing is 10 microns or less. The presence of ionized cesium permits high efficiency with larger spacing. This use of thermionics is becoming more and more important for the generation of power in space vehicles.

See also ELECTRON; PHOTOELECTRICITY.

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(W. B. NO.)

THERMIONIC VALVE (THERMIONIC TUBE): *see* ELECTRON TUBE.

THERMIT, the trade name for a mixture of aluminum powder and iron oxide used in welding, in foundry work as a source of heat, and in the reduction of metal oxides. Thermit was widely used in incendiary bombs in the European theatre during World War II.

On ignition the reaction ($8Al + 3Fe_3O_4 = 9Fe + 4Al_2O_3$) gives a temperature estimated to be about 2,400° C. The reaction, stated in weight, means that 216 parts of aluminum plus 695 parts magnetite (iron oxide) equals 503 parts iron plus 408 parts slag, or approximately three parts of aluminum plus ten parts of magnetite will produce, on combustion, seven parts of iron. The iron thus produced represents about one-half the original thermit by weight and about one-third by volume.

Although the above reaction is the one commonly termed the thermit reaction, a generalized thermit reaction may be defined as an exothermic, self-propagating process in which finely divided aluminum powder is used to reduce metal oxides; the metal is liberated by direct oxidation of aluminum to aluminum oxide, with accompanying reduction of the less stable metal oxide.

Thermit was discovered by Hans Goldschmidt of Essen, Ger., in 1895, while trying to reduce chromium and manganese oxides. Goldschmidt's principal discovery related to a simple and safe method of ignition, as the action of aluminum when mixed with various oxides, sulfides and chlorides was well known. Fine aluminum powder will not react with pure iron oxide below a temperature of about 1,100° C. Previous experimenters had resorted to heating mixtures in a crucible, making the initial temperature so high that at the moment of ignition the mixture reacted with explosive violence. Goldschmidt obtained ignition of a cold mixture by means of a barium-peroxide fuse, which was set off by a storm match. Later, magnesium powder or ribbon was used, set off either in the manner described above or by a red-hot iron rod. The thermit reaction, once initiated locally in a cold mixture, then spreads through the mixture since the heat generated by the reaction will ignite adjacent regions. Goldschmidt's original U.S. patent was granted March 16, 1897, and related principally to the use of aluminum as a reducing agent for the production of carbon-free metals such as cobalt, chromium, magnesium, tungsten, etc., by what is known as an aluminothermic process.

Uses.—The thermit reaction is of importance for its use as a heat and metal source in welding, as a heat source in foundry work to supply heat to one region of a mold, and as a source of carbon-free metal. Two methods of thermit welding are used. The first method, known as the plastic method, can be used for welding pipe. In this method, the thermit is simply used as a heat source. The ends of two pieces of pipe are carefully butted together, and after being heated to forging temperature by the thermit, are forced together, completing the weld. The second method, known as the fusion method, is used to weld large metal sections, such as ship rudder frames. Here the molten iron formed by the thermit is used to join two or more large metal members. (For a detailed description of thermit fusion welding, *see* WELDING: *Aluminothermic Welding.*) Thermit welding does not compare favourably with other methods of welding and is consequently relegated to special cases such as welding very large sections and welding in areas to which equipment cannot be easily transported. The thermit reaction is used in foundry work to provide heat to the metal reservoir called the riser. Since the riser is the last to freeze, it is consequently able to feed metal to the casting as solidification proceeds. The thermit reaction is used for the manufacture of carbon-free metals either by direct ignition in a separate magnesia-lined steel crucible or by reaction in a ladle of molten metal to which the carbon-free metal is to be added. Since it is difficult to control the reaction so that it proceeds stoichiometrically, the resultant carbon-free metal usually contains small quantities of aluminum.

One of the greatest hazards in the thermit reaction results from contamination with moisture. During the reaction water is reduced and hydrogen evolved, which can produce an explosive mixture with the surrounding air. This hazard necessitates careful packaging and handling to exclude moisture from the mixture.

(J. Wu.)

THERMOCHEMISTRY is the name given to that branch of theoretical chemistry which seeks to trace the connection between the heat evolved or absorbed during a chemical reaction and the nature and course of the reaction. Chemical reactions which are accompanied by a great evolution of heat are familiar; the combustion of coal or gas, the reduction of iron ores by coke in the blast furnace, and the slaking of lime are common examples. All explosives are unstable compounds or mixtures of compounds, the gaseous reaction products of which are raised to a very high temperature by the great heat evolved by the explosion; the propulsive force is due to the great pressure exerted by the gaseous products, owing to the high temperature and to the small volume they occupy before expansion. Such reactions are familiar because their effects are so obvious. They take place so rapidly that the heat evolved cannot be dissipated without raising the products of the reaction to a high temperature. It is the effects of the high temperature that are noticed, rather than the fact that large amounts of heat are evolved. In the rusting of iron we have an example of a chemical reaction which is also accompanied by the evolution of much heat; but this fact escapes ordinary notice since the rusting usually takes place so slowly that the heat has time to dissipate without perceptibly raising the temperature of the metal.

If, however, finely divided iron filings are dropped into pure oxygen, the reaction takes place so suddenly that there is no time for the heat to get away before the particles get white hot.

Confronted with so many every-day examples of chemical reactions accompanied by evolution of heat, it is natural to assume a close connection between the energy changes and the material changes. For a long time, however, the interest of chemists was mainly occupied by material changes only. Following the general recognition of the law of conservation of matter and the gradual acceptance of Dalton's atomic theory in the early part of the 19th century, there was a great development of knowledge of the properties and composition of different chemical substances and of their action on each other. The real development of modern thermochemistry may be said to start from the recognition of the law of conservation of energy in the middle of the century. Somewhat earlier Thomas Andrews and Hess had systematically studied the thermal effects of chemical reactions taking place in solution, and Hess, as a result of his work, had formulated a law which is one of the consequences of the conservation of energy, namely, that the thermal effect of a chemical reaction is the same however it takes place.

Law of Conservation of Energy.—According to the law of conservation of energy, energy, though it can exist in many forms, is indestructible. No method is known by which it is possible to create energy out of nothing. No system is known from which it is possible to obtain useful work without an exactly correspond; ing diminution in the total energy of the system. If the system is restored to its original condition by the addition of heat, then the heat absorbed is found always to be exactly proportional to the amount of work performed by the system. A few specific examples will illustrate the application of the law to chemical processes.

(a) Heat is necessary to convert water at its boiling point into steam at the same temperature. A small part of this heat goes to perform work through expansion against atmospheric pressure; the major part is transferred into internal energy of steam molecules. The internal energy of unit mass, of water vapour is therefore considerably greater than that of unit mass of liquid water at the same temperature. When steam is condensed again to water, exactly the same amount of heat is evolved as was absorbed when it was formed.

(b) A chemical reaction, such as the combustion of petrol, can be made to take place without performance of useful work, *e.g.,* by allowing it to take place in a closed vessel. The heat evolved by the combustion of unit weight to carbon dioxide and water vapour under these conditions can be accurately measured. When petrol is burnt in an internal combustion engine, the power output (and therefore the useful work performed by combustion of unit weight), the loss of heat to the cylinder walls and the residual heat in the exhaust gases can all be measured. The sum of the heat loss to the cylinder walls, and the residual heat in the exhaust gas is always less than the total heat of combustion by an amount which is the equivalent of the work done.

(c) **A** solution of copper sulphate will react with zinc, dissolving it and depositing copper. The heat evolved by the solution of an "equivalent" of zinc can be measured. In the Daniell cell, which consists of a zinc electrode dipping into zinc sulphate solution in a porous pot, surrounded by another container where a copper electrode dips into copper sulphate solution, this chemical reaction takes place in such a way that it can yield an electric current. We can obtain work from such a cell, *e.g.,* by using it to drive a small electromotor. The work can be measured accurately. If E is the electromotive force (volts) and C the current (ampères), then work done is EC units per second. While the current is passing we can measure the heat changes in the cell itself. These are found to be small, but not zero. If we express in heat units the electrical work done by the solution of unit mass, and add (or subtract) the simultaneous evolution (or absorption) of heat in the cell, we obtain a result which is the same as that obtained when the simple reaction was allowed to take place without the production of electrical energy. Alternatively, we could join the two electrodes with a wire and measure the heat produced in the wire by the passage of the electric current and the heat produced in the cell itself at the same time. The sum of these two would be the same as the heat produced by dissolving the same weight of zinc in a similar solution of copper sulphate, but by arranging the experiment in this way, most of the heat appears outside the solution instead of inside 'it.

It will be observed that the applications of the principle of conservation of energy depend on the assumption that a unit of one kind of energy always bears a constant relation to a unit of any other kind of energy. This is a necessary deduction from the law. If a mass of m grams is held h centimetres above the earth's surface, its *potential energy* is measured by the product *mgh,* where g is the constant of gravity and mg the force (in dynes) with which the earth attracts it. If it is allowed to fall freely, and we neglect the resistance of the air, it will have a velocity of v centimetres per second just before hitting the earth. Its potential energy has then been entirely converted into *kinetic energy* which is measured by the product $\frac{1}{2}mv^2$. As no energy is lost, $\frac{1}{2}mv^2=mgh$ and $v=\sqrt{2gh}$. When it hits the earth its kinetic energy is entirely converted into heat, and the amount of heat produced is exactly proportional to $\frac{1}{2}mv^2$, or to mgh. The potential energy is so called because, if the restraining force is removed, the mass acquires kinetic energy if left to itself. The energy is originally latent and only becomes apparent when the restraining force is removed; we can speak similarly of *latent* chemical energy.

Every element and every chemical compound has a definite content of energy which varies with the temperature. We know it varies with the temperature, because if we want to raise the temperature of anything we have to put heat into it. We do not know, however, what is the total energy content of any chemical substance, nor how it is divided up within the molecules; what we can determine is the *change in total energy* content which takes place during chemical reactions, and we can express the law of conservation of energy, in its application to chemistry, in the form

$$U=A-Q,$$

where U is the*diminution in total energy content accompanying a chemical reaction, A is the work done during or by means of the reaction, and Q is the actual measured absorption of heat during the reaction. In applying this equation it is necessary to express all quantities in the same units. A, the work done by a chemical reaction, is usually either mechanical work, as in the internal combustion engine, or electrical work, as in the accumulator. The unit of mechanical work in the C.G.S. system is the *erg,* the unit of heat is the *calorie,* which is the amount of heat necessary to raise the temperature of 1 gram of water from 15° to 16° C. The expenditure of $4{\cdot}18\times10^7$ ergs, or 4.18 *joules* will produce *1* calorie of heat.

Determination of Total Energy Changes.—The realization that the total energy content of a chemical substance was a property of the substance as important as any other property, and that the changes in energy accompanying chemical reactions were closely connected with the nature of the reaction, led to a very large number of experimental determinations of heats of reaction by J. Thomsen and M. Berthelot. Heats of reaction are determined in principle by causing the reaction to take place rapidly under such conditions that its heat is transferred to a large and well stirred volume of water, which is thereby raised a few degrees in temperature. As the specific heat of water is by definition unity at 15° C, the heat evolved can be calculated if the mass of water and its rise in temperature are accurately known. Allowance must be made for the actual heating of the containing vessels and the reacting substances, and also for the loss of heat during the time the reaction takes place. This loss of heat is kept down by keeping the rise in temperature small, which necessitates the use of very sensitive thermometers. Accurate calorimetry depends essentially on making proper allowances for this loss of heat, or alternatively on methods employed to counterbalance it. In general the data given in chemical literature cannot be relied upon to within $\frac{1}{2}\%$, and in many cases the error of determination is much greater. An experimental error of this order may be serious in certain cases, as we shall see later.

It is necessary to distinguish between heats evolved when reactions take place at constant pressure and at constant volume. Only the latter accurately correspond in all instances to the change in total energy due to the reaction. If the reaction is allowed to take place at constant (atmospheric) pressure and there is a change in volume due to the reaction, then work is done, and the measured heat of reaction will not be the same as the change in total energy. In the case of reactions taking place between solids or liquids the difference is usually negligible; in cases of gases the necessary correction can be easily applied. For instance, in the combustion of methane to carbon dioxide and liquid water, $CH_4+2O_2=CO_2+2H_2O$, three volumes of mixture react to form one volume of carbon dioxide and a negligible volume of liquid water. This diminution of volume means that at constant pressure work is performed by the atmosphere. This work reappears as additional heat in the calorimeter. If we take the volume of one mol. of gas (22.4 litres) as the unit volume, the work done, $2P\times V$, according to the gas laws $=2$ RT, where R, the gas constant, is approximately 2 when the work is expressed in heat units, and T is the absolute temperature. Thus the heat of combustion of methane, measured at 18° C (or 291° absolute), should be approximately 1 200 calories higher when the combustion takes place at constant pressure. *e.g.,* when the gas is burnt in a jet, than when the mixture is burnt in a completely closed vessel. If, however, the combustion takes place above 100° C so that no water vapour condenses, there is no change of volume, and no difference between the heats evolved at constant volume and constant pressure.

Indirect *Determination.*—Many heats of reaction are difficult if not impossible to measure directly. This is true of most reactions in organic chemistry which either do not take place rapidly enough to allow of accurate measurement, or yield other products besides those under investigation. But if the heats of combustion of organic compounds are known, the heat of any conceivable reaction between such compounds can be estimated by means of the first law. Take, for example, the technically important formation of methyl alcohol from carbon monoxide and hydrogen which proceeds according to the equation, $CO+2H_2=CH_3OH$. The heat of combustion of 1 mol. of carbon monoxide to carbon dioxide at constant pressure is 68,300 calories. The heat of combustion of 2 mols. of hydrogen to *liquid* water at constant pressure is $2\times68,400$ calories$=136,800$ calories. The heat of combustion of 1 mol. of methyl alcohol in the form of vapour to carbon dioxide and liquid water is 182,000 calories. Now the total change in energy must be the same whether the carbon monoxide and hydrogen are burnt directly to carbon dioxide and water, or whether they are first transformed into methyl alcohol and then burnt. Hence the heat evolved when carbon monoxide and hydrogen unite at constant pressure to give methyl alcohol in the form of vapour is:

$$68,300+136,800-182,000=23,100 \text{ calories.}$$

This example will serve to show the importance of accuracy in calorimeter measurements. For suppose Thomsen, whose figures have been taken, underestimated the heats of combustion of carbon monoxide and hydrogen by 1%, and overestimated that of methyl alcohol by 1%, the corrected figure for the heat of reaction to methyl alcohol would then be $69,000+138,200-180,200=27,000$ calories, which is nearly 20% higher than the estimate made on the basis of Thomsen's recorded results.

Variations Due to Physical Conditions.—Since the intrinsic (total) energy of a substance varies with the conditions under which the substance exists, it is necessary in recording the mechanical data to specify the conditions of the initial and final systems. Besides change of volume, the following conditions have to be considered: (1) Dilution of solutions. (2) Physical state. (3) Temperature.

(1) *Dilution of Solutions.*—Generally speaking, there is a considerable thermal effect when a substance is dissolved in water, and this effect varies in magnitude according to the amount of water employed. It is only, however, when we deal with comparatively concentrated solutions that the heat-effect of diluting the solutions is at all great, the heat-change on diluting an already dilute solution being for most practical purposes negligible. In dealing, therefore, with dilute solutions, it is only necessary to state that the solutions are dilute, the exact degree of dilution being unimportant. It occasionally happens that a change in dilution affects the chemical action that occurs. Thus, if concentrated instead of dilute sulphuric acid acts upon zinc, the action takes place to a great extent not according to the equation $Zn+H_2SO_4=ZnSO_4+H_2$, but according to the equation $Zn+2H_2SO_4=ZnSO_4+SO_2+2H_2O$, sulphur dioxide and water being produced instead of hydrogen. Here we have a different final system with a different amount of intrinsic energy, so that the thermal effect of the action is altogether different.

(2) *Physical* State.—The physical state of the reacting substances must be considered, since comparatively large amounts of heat are absorbed on fusion and vaporization. Thus the heat of fusion of ice (for 18 grams of H_2O) is 1,440 cal, and the heat of vaporization of water at 100° for the same quantity is 9,670 cal. When a substance, *e* g., carbon, phosphorus, sulphur, exists in allotropic forms, the particular variety employed should always be stated, as the conversion of one modification into another is frequently attended by a considerable thermal effect. Thus the conversion of white into red phosphorus evolves about one-sixth of the heat of combustion of the latter in oxygen, and so the knowledge of which variety of phosphorus has been employed is of essential importance in the thermochemistry of that element (*See* POLYMORPHISM)

(3) *Influence* of Temperature.—The influence of temperature on the thermal effects of a chemical reaction is sometimes considerable. If we know the change in total energy associated with any reaction at one temperature, the first law enables us to calculate it for any other temperature. If, for example, the total energy content at temperature T_1 is U_{H_2} for 1 mol. of hydrogen, U_{O_2} for 1 mol. of oxygen, and U_{H_2O} for 1 mol. of water vapour, the change in total energy due to the combination of hydrogen and oxygen to form 2 mols. of water vapour is, say,

$$2U_{H_2}+U_{O_2}-2U_{H_2O}=U_{T_1}.$$

If we raise the temperature of 1 mol. of hydrogen (etc.) from T_1 to T_2, its total energy is increased by $(C_v)_{H_2}(T_2-T_1)$, where $(C_v)_{H_2}$ is the mean capacity for heat of 1 mol. of hydrogen at constant volume between the temperatures T_2 and T_1. This is simply a definition of what we mean by *molecular specific heats*. Hence the total energy change at the higher temperature T_2 is:

$$2\{U_{H_2}+(C_v)_{H_2}(T_2-T_1)\}+U_{O_2}+(C_v)_{O_2}(T_2-T_1)$$
$$-2\{U_{H_2O}+(C_v)_{H_2O}(T_2-T_1)\}=U_{T_2}$$

$$\therefore \quad U_{T_2}-U_{T_1}=(T_2-T_1)\{2(C_v)_{H_2}+(C_v)_{O_2}-2(C_v)_{H_2O}\}$$

We can express this most simply by saying that the rate of change of U with the temperature (dU/dT) is equal to the sum of the heat capacities of the reacting compounds minus the sum of the heat capacities of the products of the reaction.

Thermochemical Measurements.—Some general results of thermochemical measurements applied to heats of combustion, neutralization and solution may now be considered.

(a) Heats of *Combustion.*—Experiment has shown that the heat of combustion of organic substances of various kinds varies regularly with the molecular weight. The difference between the heats of combustion of two neighbouring members in a series of homologous compounds is practically constant, and the value of the constant shows very little variation as we pass from one series to another. Thus the heat of combustion of methane, CH_4, to carbon dioxide and liquid water at constant pressure is 212,000 calories; of ethane, C_2H_6, is 370,500 calories, a difference of 158,500 calories; of propane, C_3H_8, is 529,200 calories, which is 158,700 above that of ethane; and the heat of combustion of all paraffin hydrocarbons (C_nH_{2n+2}) can be expressed by the formula $212,000+158,500\ (n-1)$ or $158,500\ n+53,500$ calories, where n is the number of carbon atoms in the molecule, and the mass to which the heat of combustion refers is the molecular weight in grams of the compound

Similarly the heat of combustion of alcohols $C_nH_{2n+1}OH$, can be expressed by the formula:

$$183,000+158,800\ (n-1)$$

or

$$158,000n+34,200 \text{ calories.}$$

As a rule the addition of a CH_2 group to any organic molecule will increase the molecular heat of combustion by about 158 800 calories, but the rule is not exact, and the actual figure varies somewhat from series to series. In particular the heat of combustion of two isomeric substances, i e, substances with the same number of carbon, hydrogen, oxygen, etc., atoms in the molecule, but differently arranged are very nearly but not exactly the same. It follows that there are similar regularities in the *heats* of *formation* of organic compounds, for the heat of formation is the difference between the heat of combustion of a compound and the total heats of combustion of the carbon, hydrogen, etc., it contains.

(b) *Heats* of *Neutralization.*—The heats of neutralization of acids and bases in aqueous solution are additively composed of two terms, one being constant for a given base, the other constant for a given acid. In addition to this the further regularity has been observed that, when the powerful monobasic acids are neutralized by the powerful monacid bases in dilute solution, the heat of neutralization is in all cases the same. The following table gives the heats of neutralization of the commoner strong monobasic acids with soda:

	Formula	Cal.
Hydrochloric acid . .	HCl	137,400
Hydrobromic acid . .	HBr	137,500
Hydriodic acid . . .	HI	136,800
Nitric acid	HNO_3	136,800
Chloric acid . . .	$HClO_3$	137,600
Bromic acid . . .	$HBrO_3$	137,800

Within the error of experiment these numbers are identical.

It was at one time thought that the greater the heat of neutralization of an acid with a given base, the greater was the strength of the acid. It is now known, however, that when weak acids or bases are used, the heat of neutralization may be either greater or less than the normal value for powerful acids and bases, so that there is no proportionality, or even parallelism, between the strengths of acids and their heats of neutralization (see REACTION KINETICS).

(c) Heats of Solution.—When substances readily combine with water to form hydrates, the heat of solution in water is usually positive; when, on the other hand, they do not readily form hydrates, or when they are already hydrated, the heat of solution is usually negative. The following examples show the effect of hydration on heat of solution in a large quantity of water:

I. *Sodium Carbonate*

	Heat of solution	Heat of hydration
	cal.	cal.
Na_2CO_3 . . .	+ 5,640	. .
Na_2CO_3,H_2O . .	+ 2,250	+ 3,390
$Na_2CO_3,2H_2O$ . .	+ 20	+ 5,620
$Na_2CO_3,10H_2O$ . .	−16,160	+21,800

II. *Sodium Sulphate*

	Heat of solution	Heat of hydration
	cal.	cal.
Na_2SO_4 . . .	+ 460	. .
Na_2SO_4,H_2O . .	− 1,900	+ 2,360
$Na_2SO_4,10H_2O$ . .	−18,760	+19,200

First and Second Laws of Thermodynamics.— It should be clearly realized that the law of conservation of energy, like the law of conservation of mass, is a statement of experimental observations and in chemistry admits of no exception. All recorded observations support the law within the unavoidable errors of experiment; all deductions from the law have been amply verified. Apparent limitations of the law have been brought to light by recent physical research, and in particular through Einstein's famous theory of relativity (*q.v.*), but in ordinary chemistry we do not deal with atomic or ultra-atomic changes, but with molecular rearrangements, and the laws of conservation of energy and mass, as originally conceived, still hold good.

Reversible Chemical Reactions.—As the result of the large number of experiments made by them, Thomsen and, later, Berthelot expressed the opinion that heat of reaction must be regarded as a measure of chemical affinity, and that every chemical change tended to take a course which evolved the maximum amount of heat. Berthelot in particular regarded this as a general guiding principle in chemistry, and impressed its importance so much on others that it continued to be upheld long after Berthelot himself had recognized its error. It is not easy now to realize why this "principle" commanded such universal acceptance; simple physical transformations which took place spontaneously either with absorption or evolution of heat, according to the circumstances, must have been familiar. For instance, water will freeze spontaneously and in doing so will liberate thermal energy if the temperature is below 0°. Above 0° ice melts spontaneously and in doing so absorbs heat from its surroundings. Further, even at the time Berthelot put forward his theory, there was a growing recognition of the fact that many chemical reactions are reversible, *i.e.*, that they take place either in one direction (with evolution of heat) or in the opposite direction (with absorption of heat), according to the conditions of temperature and pressure and the relative masses of the reacting substances. So long ago as 1801, the great French chemist Berthollet had introduced the idea of "chemical equilibrium," and in the same year that Berthelot put forward his erroneous theory (1867) Guldberg and Waage published their famous book on chemical affinity, which dealt with reversible chemical reactions and in which they put forward the law of chemical mass action.

Chemical Equilibrium.—This law, in so far as chemical equilibrium is concerned, may be formulated as follows. Suppose chemical substances, A_1, A_2, etc., react to form B_1, B_2, etc. The reaction tends to proceed until a condition of equilibrium is set up, governed by the equation

$$\frac{[A_1]\times[A_2]\times \text{etc.}}{[B_1]\times[B_2]\times \text{etc.}} = K.$$

where $[A_1]$, etc., represents the concentration of the compound A_1, etc., in the equilibrium mixture. On the other hand, if the compounds B_1 and B_2 are originally brought together, then the reaction will proceed in the reverse direction with production of A_1 and A_2 until the same condition of equilibrium is set up. The value of the equilibrium constant K is itself independent of concentration—for example, in the case of gaseous reactions it is independent of pressure—but it varies with the temperature. Clearly such constants are of great significance in the study of chemical affinities. If K is very small, then the affinity of A_1 for A_2, etc., may be said to be very great, and the affinity of B_1 for B_2, etc., small, although not zero.

The important thing to notice is that every single instance of a reversible chemical reaction really disproves the Berthelot principle. Nevertheless, the principle has this much to be said for it, that most chemical reactions which take place spontaneously at low temperatures do so with evolution of heat, and that it is only when the effects of high temperatures are studied that one becomes really familiar with important reactions that take place spontaneously nith absorption of heat. There is one such reaction that is made use of daily on an enormous scale for the production of heat, namely, the reaction between steam and coke at a bright red heat to yield "water gas," a mixture of approximately equal volumes of hydrogen and carbon monoxide. As the reaction proceeds the coke cools, and at regular intervals it is necessary to shut off the supply of steam and to pass air over the coke in order to raise it again by combustion to a temperature sufficiently high to allow the reaction with steam to continue rapidly It is true that the cooling of the eoke during the passage of steam does not entirely result from the chemical reaction, for it is partly accounted for by the cooling effect of the steam itself, which is introduced to the retort at a lower temperature than the coke. But even if the steam were initially at the same temperature as the coke, it would be found that the mass gradually cooled. The spontaneous formation of nitric oxide by the passage of air through an electric arc, a process by which nitric acid is manufactured on a large scale, is also accompanied by absorption of heat. Pure nitric oxide, on the other hand. decomposes into its elements, nitrogen and oxygen. at a somewhat lower temperature with evolution of heat. Hydrogen and oxygen will combine explosively and completely at low temperatures; but steam is found to decompose spontaneously though not completely into hydrogen and oxygen if it is heated to a temperature above 2,000° C., and heat is absorbed during the decomposition. Clearly, therefore, the heat evolved during a chemical reaction cannot give a direct measure of the affinity of the reacting substances.

The first big practical advance that was made in the knowledge of the relations between thermal changes and chemical affinity was due to van't Hoff's demonstration that the law of mass action was a necessary consequence of the second law of thermodynamics and of the quantitative connection between the value of the "equilibrium constant" and the change in total energy due to the reaction. The second law of thermodynamics, like the first, is a statement of experience, perhaps one might say a collection of interrelated statements of experience. The first law states that it is impossible to create energy; the second law states that it is impossible to convert the heat energy of our surroundings continuously into useful work. The second law deals with a question which the first law does not answer, namely, under what conditions can heat energy be converted into useful work (that is to say, mechanical energy). If heat energy passes spontaneously from one body to another, the first body is said to be at a higher temperature. It is a matter of universal experience that the reverse change, *i.e.,* the passage of heat from one body to another of higher temperature never takes place spontaneously. It is also a matter of experience that any spontaneous process can be made to yield a definite amount of useful work. For instance, the cooling of a furnace is a spontaneous process. By the use of steam and suitably designed engines, it is possible to obtain useful work from this process.

Carnot's Definition.—The question how much useful work can be obtained by the spontaneous passage of heat from one temperature to another is of fundamental importance both in mechanical engineering and in chemistry. Sadi Carnot, a young French engineer, actually solved this problem in *1824* before the law of conservation of energy was universally accepted He showed that the maximum amount of work which can possibly be obtained from the "spontaneous" transference of a quantity of heat Q from a reservoir at temperature T_1 to another of the lower temperature T_2 was $Q(T_1-T_2)/T_1$. It will be noted that Carnot's result involves a quantitative definition of "absolute" temperature. The so-called "thermodynamic scale of temperatures" which is implicit in his result, is based on the behaviour of a perfect gas, the energy content of which is independent of its volume and dependent only on the temperature. The absolute temperature of a perfect gas is defined by the fundamental gas law $T=PV/R$, where P is the gas pressure, V its volume, and R a constant. The value of R depends on the units in which the pressure and volume are expressed. Many gases approach very nearly the properties of the imaginary "perfect" gas, particularly at low densities.

The next point of interest is that Carnot in deriving his result imagined a perfectly frictionless engine, with a perfect gas as a working fluid, taking heat from the high temperature reservoir (as steam takes heat from a furnace), converting part of the heat into work, and rejecting the rest to the low-temperature reservoir. The argument is that such an engine will always yield the maximum amount of work, because if it is reversed, the expenditure of work, only infinitesimally greater in amount than the engine yields on the direct operation, will suffice to restore the heat from the low temperature to the high temperature reservoir. For suppose it was possible to make another reversible and frictionless engine which was capable of converting a greater proportion of the transferred heat into work. Then it would be possible to use part of the work yielded by this change to reverse the first engine, and to restore the whole system to its original condition, leaving a definite amount of work over which has been created out of nothing. This is contrary to the first law. Hence we say that the work that can be done by a perfectly efficient reversible engine or process is independent of the nature of the process.

The Gibbs-Helmholtz Equation.— This conclusion leads to a mathematical expression of the first and second laws of thermodynhmics in a form which can be applied to all chemical as well as other phenomena. For if, instead of having a perfect engine to transfer heat from the reservoir at $T+dT$ to another at T, we allow a chemical process to take place in the first reservoir, yielding a maximum amount of work A and absorbing heat from the reservoir equal to Q, and we then reverse this chemical process in the second reservoir by the expenditure of $A-dA$ of work, we have gained an amount of work$=dA$, and if the process is conducted reversibly this work must be equal to that gained by any other perfect process; in other words, $dA=Q{\cdot}dT/T$. But Q, the heat absorbed, is equal (by the law of conservation of energy) to the maximum work A, less the diminution in total energy U, *i.e.,*

$$dA=(A-U)dT/T,$$
$$\text{or } A-U=T{\cdot}dA/dT$$

This is the relation which was deduced independently by Helmholtz and Willard Gibbs. The quantity A is the maximum amount of work that can be obtained from a (reversible) chemical process taking place spontaneously and at constant volume at the temperature T; $A+dA$ is the work that would be obtained by allowing it to take place at the same volume at the higher temperature $T+dT$; and U is the diminution of total energy which corresponds to the heat evolved when the reaction takes place without the performance of any work, *e.g.,* in a closed vessel. A is often known as the *decrease* in free energy, to distinguish it from U, the decrease in total energy.

The most direct use of this equation is found in its application to the electric cell or battery. For the electric cell is a contrivance for converting chemical energy into useful work. If the cell is reversible, the work will be the maximym obtainable from the chemical reaction which is the source of the electric current What we mean by a reversible cell is that, if a potential infinitesimally greater than that yielded by the cell is applied to the electrodes, the current will travel in the reverse direction in the cell and the chemical reaction will be reversed. The lead accumulator is nearly reversible in this sense; so is the Daniell cell. The electromotive force of the Daniell cell is found to be 1·1 volts. For every gram-equivalent of copper deposited and zinc dissolved in the cell, an amount of work is done$=EF$, where F is the quantity of electricity *(96,540* coulombs) associated with one gram-equivalent. These units can be expressed in calories; calculation shows that if E is the potential, the work done by the reaction is $23{,}050E$ calories. Hence the work done by the Daniell cell is *25,260* calories per gram-equivalent of copper deposited, The heat of the reaction, when it takes place without performance of work, is found to be *25,060* calories. Hence in this case A=U nearly. We should find therefore that dA/dT, or dE/dT, which is the change of electromotive force with the temperature, is very small. Measurement shows that it is only 0·000034 volt per degree.

Lord Kelvin put forward the view in 1851 that the electromotive force of a cell could always be calculated from the heat of the chemical reaction, that is to say from the decrease in total energy. This "law" involves the assumption that no chemical reaction can be made to yield electrical energy unless it is accompanied by a decrease in total energy. It holds approximately for the Daniell cell. and for others such as the standard Weston cell. The Helmholtz equation shows that it can only be true when the electromotive force does not change with the temperature. We are familiar now with cells which yield an electric current even if the chemical reaction is associated with an absorption of heat; we know of cells the voltage of which increases with temperature, and others in which it decreases. None of these cells obeys Kelvin's law, but the behaviour of all of them can be shown to be in exact accordance with the Helmholtz equation. The study of electric cells provides the most interesting and exact confirmation of the fundamental laws of thermodynamics.

The Van't Hoff Equation.— Apart from the combustion of coal and oil, most chemical reactions interest us more from the point of view of the nature of their products than from that of the work obtainable from them. As all chemical reactions are in principle reversible, and as many of the more important from a practical point of view can be made to proceed in one or the other direction according to conditions of temperature and pressure, it is not only of theoretical interest but of great technical importance to get an accurate picture of the relations between chemical equilibrium and thermal changes. Van't Hoff succeeded in doing this by calculating the maximum work that could be obtained from a chemical reaction taking place between gases, by the use of an imaginary "ideal" process. By the application of the second law two important results emerged:

(1) The law of mass action, first deduced from consideration of molecular theory, was shown to be a necessary consequence of the thermodynamical laws, that is to say, if a state of equilibrium exists between gases according to the chemical equation

$$n_1\mathrm{A}+n_2\mathrm{B}+\text{ etc.}=n'_1\mathrm{A}'+n'_2\mathrm{B}'+\text{ etc.}+U\text{ calories,}$$

then
$$\frac{[\mathrm{A}]^{n_1}\times[\mathrm{B}]^{n_2}\times\cdots}{[\mathrm{A}']^{n'_1}\times[\mathrm{B}']^{n'_2}\times\cdots}=K.$$

(2) *The equilibrium* constant K was shown to be connected with the temperature and the decrease in total energy through the equation

$$d \log_e K/dT = U/RT^2.$$

In practical applications it is usually more convenient to express the quantities of gases present in an equilibrium mixture in terms of their partial pressures instead of their concentrations. If there are N molecules of gas present altogether in a mixture which contains n_1 molecules of one kind, n_2 of another, and so on, the partial pressures are n_1P/N, n_2P/N, etc. where P is the total pressure. It is simple to show that

$$\frac{P_A^{n_1} \times P_B^{n_2} \times \cdots}{P_{A'}^{n'_1} \times P_{B'}^{n'_2} \times \cdots} = K_p$$

where P_A^n represents the partial pressure of A, and the new constant $K_p = K(RT)\ \Sigma_n$, Σ_n being the difference between the number of the reacting molecules and the total number formed by the reaction: $d \log_e K_p/dT = Q_p/RT^2$. It can also be easily shown that where Q_p is now not necessarily the diminution in total energy but corresponds to the heat evolved when the reaction takes place at constant pressure, nithout the performance of any work other than that caused by the change of volume, if any, associated with the reaction. This equation is similar to that found to hold good for the change of vapour pressures of liquids (and solids) with the temperature, *viz.*, $d \log_e p/dT = \lambda/RT^2$, where λ is the latent heat of evaporation of one gram molecule of the liquid or solid.

Some Thermochemical Reactions.—The application of these equations to chemistry inaugurated a new era, and led not only to a rapid extension of knowledge of chemical reaction, but also to the recognition of the connection between many apparently diverse phenomena. Some illustrations of the use of the equations will now be given.

Hydrogen and oxygen combine to form steam with evolution of heat according to the equation

$$2H_2 + O_2 = 2H_2O + 116{,}000 \text{ calories.}$$

If we start with 2 mols. of hydrogen and 1 mol. of oxygen, then according to the law of mass action an equilibrium will be reached when $2(1-x)$ mols. of water vapour are formed, and $2x$ mols. of H_2 and x mols. of O_2 are left uncombined. Supposing the volume occupied is v, then the law states that at equilibrium

$$\frac{(\text{Concn. of } H_2)^2 \times (\text{Concn. of } O_2)}{(\text{Concn. of water vapour})^2} = K$$

or

$$\frac{\frac{(2x)^2}{v} \times \frac{x}{v}}{\left\{\frac{2(1-x)}{v}\right\}^2} = K \text{ or } \frac{x^3}{(1-x)^2} \times \frac{1}{v} = K.$$

Now at ordinary temperatures, the amount of hydrogen and oxygen left uncombined is very small and escapes direct measurement. As x is small, K is also small. But van't Hoff's equation shows that, as U is large and positive, log K, and therefore K, increases with the temperature. Hence x increases with the temperature. In other words, water vapour will dissociate when the temperature is raised.

This result may be generalized. All compounds which are formed with evolution of heat tend to decompose when the temperature is raised. The same applies to molecules such as H_2, O_2, N_2, Cl_2, I_2, etc., which are formed from their atoms with evolution of heat. Conversely, compounds which are formed with absorption of heat become more stable at high temperatures. Nitric oxide cannot be made from nitrogen and oxygen at low temperatures, but is formed when air is blown through an electric arc. Hydrogen peroxide may be detected in an oxy-hydrogen flame. Calcium carbide is formed in an electric furnace at a very high temperature. If v in the equation given above is made smaller, then x must also diminish, because K is constant. High pressure tends, therefore, to assist combination or to prevent dissociation. This is the case whenever the reaction is accompanied by a decrease in the number of molecules. The synthesis of ammonia is an important technical example. Here one molecule of nitrogen combines with three molecules of hydrogen to form two of ammonia, $N_2 + 3H_2 = 2NH_3$. The mass action equation is

$$27x^4/4(1-x)^2v^2 = K,$$

where x is the fraction of nitrogen left over. If the value of v is diminished, x must also be diminished, and the amount of ammonia formed increases. As is well known, the commercial success of the process depends on very high pressure being used. If no change in the number of molecules is caused by a reaction, v cancels out, and therefore an alteration in the pressure has no effect on the equilibrium. If the number of molecules is increased, v appears in the numerator instead of the denominator, and an increase of pressure will then have the opposite effect.

The effects of pressure and temperatures on equilibrium can be generalized in the statement that the equilibrium will always adjust itself in such a way as to oppose a change in physical conditions. If the pressure is increased, the equilibrium will shift in the direction of smaller volume. When heat is added that reaction will take place which results in an absorption of heat, thus tending to stop a rise of temperature. The same applies to physical processes. Water expands when it freezes; if we compress ice at the freezing point it will do its best to diminish its volume by melting. Liquids always absorb heat when they evaporate; if heat is added to water which is boiling at atmospheric pressure, its temperature is not increased. All that happens is that it boils faster.

If a reaction between gases is studied experimentally at any one temperature and pressure, so that the equilibrium conditions are known, then the effect of a variation in pressure at that temperature can be accurately calculated provided the mixture obeys the "perfect gas" laws. If the heat of reaction is also known at that temperature, then the equilibrium for any other temperature not too far removed can be calculated from van't Hoff's equation. For integration of the equation gives

$$\log_e K = -U/RT + \text{constant},$$

if U does not change much with the temperature. Hence if K_1 and K_2 are the equilibrium constants at temperatures T_1 and T_2

$$\log_e K_1/K_2 = U(1/T_2 - 1/T_1)/R.$$

Gases and Solids.—Chemical reactions in which gases and solids take part present features of special interest. To take a simple example, carbon dioxide combines with lime to form calcium carbonate with evolution of heat:

$$\underset{\text{solid}}{CaO} + \underset{\text{gas}}{CO_2} = \underset{\text{solid}}{CaCO_3} + 42{,}500 \text{ calories.}$$

Now the pressure of saturated vapour above any solid or liquid is independent of the amount of solid or liquid present, unless the amount is very minute. If a closed space contains carbon dioxide gas, in the presence of solid calcium oxide and carbonate, there will be an equilibrium in the gaseous phase governed by the relation

$$\frac{(\text{Concn. of CaO vapour}) \times (\text{Concn. of } CO_2)}{(\text{Concn. of } CaCO_3 \text{ vapour})} = K.$$

As the concentrations of the vapours of the two solids are constant (though extremely small) at any given temperature, it follows that the concentration of carbon dioxide must also be constant. In other words its pressure is constant. Above a mixture of calcium oxide and carbonate we have, therefore, our apparent "vapour" pressure of carbon dioxide, which varies with the temperature.

The heat of the reaction is analogous to the heat of evaporation of any solid or liquid, and if P is the "vapour" pressure, which is called the dissociation pressure in this and similar cases,

$$d \log_e P/dT = Q/RT^2,$$

where Q is the heat of reaction, *i.e.*, the heat absorbed on dissociation of 1 gram-molecule, and includes the work done against atmospheric pressure by the evolution of 1 gram-molecule of carbon dioxide. The dissociation pressure, like the vapour pressure of liquids, increases with the temperature. At a high temperature, about 900° C, the dissociation pressure is equal to ordinary atmospheric pressure. If the carbonate is heated above this temperature it is converted into lime and carbon dioxide is rapidly evolved.

If other carbonates are examined it is found that the temperature at which they are converted into their oxides varies directly with their heat of dissociation as the following table shows:

Substance	Heat of dissociation	Temperature
	cals.	°C.
Silver carbonate . .	20,100	225
Lead carbonate . .	22,600	302
Manganese carbonate .	23,500	ca. 330
Calcium carbonate . .	42,500	900
Strontium carbonate .	55,800	1,150

On similar reasoning, it may be shown generally that in all reactions in which gases and solids take part, the equilibrium conditions only take account of the gases. For instance, when carbon dioxide is passed over red-hot coke it is converted into carbon monoxide with absorption of heat, $C+CO_2=2CO-38{,}500$ calories. The equilibrium condition is

$$P_{co}/P_{co2}=K \text{ or } d\log_e K_p/dT=38{,}500\ RT^2$$

from which it can be deduced (a) that the ratio CO/CO_2 in the gas mixture at equilibrium is constant if the temperature and pressure are constant; (b) that if the temperature is kept constant, and the pressure is increased, the proportion of carbon monoxide in the mixture goes down; (c) that if the temperature is increased, the proportion of carbon monoxide goes up.

In the blast furnace, air is blown through a white-hot mixture of oxides of iron and coke, and the carbon monoxide formed by the combustion of coke reduces the oxides to metallic iron. The exit gases must contain a large proportion of carbon monoxide to carbon dioxide, corresponding to the equilibrium conditions which obtain near the cooler top of the furnace. It was at one time thought that by building furnaces higher, the period of contact between the gases and the ore would result in a greater measure of reduction, a diminished proportion of carbon monoxide in the exit gases, and consequently a smaller consumption of coke per ton of ore reduced. Attempts to achieve these results, by building furnaces as high as 100 ft., failed. As Le Chatelier pointed out, if there had been a better acquaintance with the laws of chemical equilibrium, these experiments would have been unnecessary. It was an expensive, although no doubt an instructive, method of proving the correctness of one of the deductions from the second law.

Heat and Velocity of Reaction.—These examples will suffice to indicate how the quantitative application of simple fundamental thermodynamic principles has been successful in reducing to order an enormous range of observations on chemical reactions apparently very diverse in character. It has also given the chemical engineer the power to calculate the conditions for achieving the maximum technical success in the conduct of any chemical manufacture on the large scale. Unfortunately, though the application of thermodynamics has been so successful in the study of chemical equilibrium, it has as yet taught us nothing about the rate at which equilibrium is attained, or, in other words, about the rate of chemical reaction. There seems to be no direct connection between the rate of a reaction and either the heat evolved (change in total energy), or the maximum work of the reaction (change in free energy). Hydrogen has a great affinity for oxygen, and much heat is evolved when they combine; yet a mixture of them can be kept for an indefinite period of time at the ordinary temperature without a trace of combination. Nitric oxide is an extremely unstable substance at low temperature; on thermodynamical grounds we should expect that only an infinitesimal amount of it would be in equilibrium with nitrogen and oxygen at the ordinary temperature; yet it is so difficult to decompose by heat that even at 900° C it only decomposes slowly. Ammonia becomes progressively less stable as the temperature is raised. Thermodynamics indicates that in order to obtain high yields, its synthesis from nitrogen and hydrogen should be conducted at as low a temperature as possible. The reaction is, however, so slow that technical manufacture only becomes possible at temperatures so high that the yield of ammonia at atmospheric pressure is extremely small. The ill effects of the high temperature have to be counterbalanced by the use of high pressures. Nearly all gas reactions take place extremely slowly unless the temperature is very high. Nearly all, too, take place more quickly in the presence of certain solids called catalysts. The nature of the catalyst to produce the best results varies with the nature of the reaction, and though many theories have been put forward to account for their action, there is no general theory which has been successful in predicting anything—which is the ultimate test of the real value of a theory.

Free Energy.—The second law of thermodynamics deals with changes in the free energy of a system. A system only possesses "free energy" when it is capable of doing work. It is only capable of doing work if it will change spontaneously into another system of greater stability. Only an unstable system has free energy. A stable system can be changed into an unstable system by the performance of work, or by the transference of free energy from another system. The whole of life, and of civilization as we know it, depends on thermodynamic instability; as Boltzmann (1886) put it, the struggle for-existence is a struggle for free energy available for work. Nearly all manufacturing processes depend essentially on using the free energy stored in coal to convert a useless stable system into a useful unstable system. For instance, the synthetic manufacture of fertilizers depends essentially on the use of a small part of the free energy available when coal is burnt, to convert the stable system nitrogen+water, into the unstable system ammonia+oxygen. The ammonia in various forms can be made use of to fertilize plants, *i.e.,* to increase the free energy in the plant world which the animal world can convert again into useful work. The enormous amount of energy which the earth continuously receives from the sun is theoretically almost completely available for useful work, for the energy leaves the sun at a temperature over 8,000° and is finally dissipated into space at a temperature of about 300° Absolute. Calculation shows that the energy so received is at least a million times greater than the energy given by the world's power plants. But unfortunately we know of no means for making use of anything more than a minute fraction of the sun's energy. A very small part of it is converted into mechanical energy by water power plants; another very small part is used by the plant world to build up "unstable" organic compounds, and thus to supply the free energy available in food. One of the chief tasks of the scientist of the future will be to devise means for converting into useful work, or storing, a greater part of the energy received from the sun. The second law shows that this should be possible. If he does not succeed the advance, and even the maintenance, of civilization may be impossible when the energy stored in coal through the agency of the plant world in past ages is exhausted.

The Third Law of Thermodynamics.—It has already been pointed out that although the Gibbs–Helmholtz equation enables us to calculate from purely thermal data the change in any equilibrium with the temperature, it does not give any information on the actual value of the equilibrium constant unless this is already known from experimental observations under one set of conditions. To obtain the actual value from purely thermal data, it is necessary to integrate the fundamental equation $d\log_e K/dT=U/RT^2$, and integration introduces an unknown integration constant.

In 1901 Nernst advanced a method of evaluating this constant, and his theorem is often referred to as the "third law" of thermodynamics, although its universal applicability is still open to some doubt.

In Condensed Systems.—Nernst postulates that in the case of chemical reactions in condensed systems, *i.e.,* reactions in solids or between solids and liquids, not only does A become $=U$ at absolute zero $(T=0)$, as is required by the Gibbs-Helmholtz equation, but that they both reach their final (equal) value at temperatures not far removed from the absolute zero. In mathematical language, $dA/dT=dU/dT=0$ when $T=0$. Now dU/dT is equal to the difference between the sum of the molecular heat capacities (C_v) of the reacting substances and of the products. Since it is found by experiment that the specific heats of substances can be expressed with sufficient accuracy by equations of the form $C_v=a+bT+cT^2+$ etc. it follows that U can also be expressed in the form

$$U=U_0+\alpha T+\beta T^2+\gamma T^3+\ \dots$$

But if $dU/dT=0$ when $T=0$, it follows that $\alpha=0$, or

$$U=U_0+\beta T^2+\gamma T^3.$$

If this expression for U is substituted in the fundamental equation $A-U=T.\ dA/dT$, it follows that

$$A=U_0+aT-\beta T^2-\frac{\gamma}{2}T^3-\text{etc.}$$

where a is an unknown constant. But if $dA/dT=0$ when $T=0$, as Nernst postulates, a must also be equal to zero, and therefore

$$A=U_0-\beta T^2-\frac{\gamma}{2}T^3-\text{etc.}$$

Hence if the heat of reaction, and the specific heats of the substances taking part in the reaction are known, it should be possible to calculate A for any temperature.

Consider such a change as the melting point of a solid, or a transition from one modification to another such as the change from rhombic to monoclinic sulphur. Then at the temperature when the solid and liquid, or the two forms of solid, co-exist in equilibrium, A, the work obtainable from the change, is zero. If we know the heat of the reaction at this temperature (latent heat), and if we know the difference between the specific heats of the two forms over a wide range of temperature, we can express U in the form

$$U=U_0+\beta T^2+\gamma T^3+\dots$$

and therefore T, the temperature where $A=0$ (melting point, or transition point), is given by

$$U_0=\beta T^2+\frac{\gamma}{2}T^3+\cdots$$

Nernst has shown how the transition point of sulphur can be calculated in this way from purely thermal data.

The difficulty of applying the theory to a wide range of such reactions is due to the fact that the all-important knowledge of the variation of specific heats with temperature is still lacking in the majority of cases; only in the case of regularly crystallizing elements do we now know the relation accurately. Theory is insufficiently advanced to guide us in the other cases, and accurate experimental work over a great range of temperature is extremely difficult as well as laborious. Nevertheless the application of the Nernst theorem to many different types of condensed systems has been so successful, and the theorem itself is supported in so many other indirect ways, that there is little doubt as to its essential truth.

In **Gas** Reactions.—It is, however, in its extension to gas reactions that the Nernst theorem has won its most significant successes. If we substitute for U in the van't Hoff equation, the expression

$$U=U_0+\alpha T+\beta T^2+$$

we get
$$\frac{d\log_e K}{dT}=\frac{U_0}{RT^2}+\frac{\alpha}{RT}+\frac{\beta}{R}+\cdots$$

Integration gives

$$\log_e K=-\frac{U_0}{RT}+\frac{\alpha}{R}\log_e T+\frac{\beta}{R}T\cdots+\mathrm{I},$$

where I is an unknown integration constant. Since the vapour pressure (p) of a liquid is similarly connected with the latent heat (λ) by the equation $d\log_e p/dT=\lambda/RT^2$, we can also write

$$\log_e p=-\frac{\lambda_0}{RT}+\frac{\alpha_0}{R}\log_e T+\frac{\beta_0}{R}T+\text{etc.}+i,$$

where i is the unknown integration constant of the vapour Pressure curve.

Nernst shows that a consequence of his fundamental theorem is that $I=\Sigma ni$, where n is the number of molecular species taking part in the reaction; that is to say, if the reaction is

$$A+B+C+\text{ etc.}=D+E+F+\text{ etc.}$$

then
$$I=i_A+i_B+i_C+\ \dots\ -i_D-i_E-i_F\ \dots\ \text{etc.}$$

This is a most important advance, for it means that it is possible to calculate any equilibrium between gases, provided the heat of the reaction is known, and the vapour pressure curves of the molecular species taking part in the reaction.

In the absence of sufficiently accurate data to make the strict application of the Nernst theorem possible, except in a very small number of cases, Nernst has also developed an approximation formula which is of great practical use. It depends on the fact that the vapour pressure of most substances can be represented sufficiently accurately by the equation

$$\log_{10}p=-\frac{\lambda_0}{4{\cdot}57T}+1{\cdot}75\log_{10}T-\frac{\beta T}{4{\cdot}57}+C.$$

C, the so-called *conventional* chemical *constant*, is itself found to be approximately $0{\cdot}14\ \lambda/T_0$, where λ is the latent heat at the boiling point T_0. For most substances which are liquid at the ordinary temperature, $\lambda/T_0=22$ approximately, and therefore $C=3{\cdot}1$. Only a few substances give values for C under 3; mainly they vary between 3 and 3.5.

On the basis of this semi-empirical vapour-pressure equation the corresponding formula for gaseous equilibria becomes:

$$\log_{10}K_p=-\frac{Q_p}{4{\cdot}57T}+\Sigma n{\cdot}1{\cdot}75\log_{10}T+\frac{\beta}{4.57}T+\Sigma nC$$

which may as a rule be further simplified by omitting the term $\frac{\beta}{4{\cdot}57}T$, thus giving:

$$\log_{10}K_p=-\frac{Q_p}{4{\cdot}57T}+\Sigma n{\cdot}1{\cdot}75\log_{10}T+\Sigma nC.$$

Now it is not pretended that an equation of this form represents actual results with accuracy. Its claim of utility is that it is based generally on correct principles, and that in actual practice it represents with considerable success the effect of temperature on chemical equilibria. A few examples will show how this claim is borne out.

(a) Consider the reaction:

$$2CO+O_2=2CO_2+136{,}000\text{ calories.}$$

K_p, the equilibrium constant, is $P^2_{CO}\times P_{O_2}/P^2_{CO_2}$, where P_{CO}, etc., represents the partial pressure of CO, etc., in the equilibrium mixture. Q_p, the heat of reaction at constant pressure and room temperature, is 136,000 calories. Σn is the difference between the number of molecules on the left and right hand sides of the chemical equation, *i.e.*, $\Sigma n=1$; ΣnC is twice the chemical constant of CO plus the chemical constant of O_2 minus twice the chemical constant of CO_2, *i.e.*,

$$\Sigma nC=2\times 3{\cdot}5+2{\cdot}8-2\times 3{\cdot}2=3{\cdot}4.$$

$$\therefore\ \log K_p=-\frac{136{,}000}{4{\cdot}57T}+1{\cdot}75\log T+3{\cdot}4.$$

At 2,000° Abs. K_p calculated from this equation is 2×10^{-6} whereas the most recent results indicate that this value is reached at 2,020° Absolute. When CO_2 is half dissociated, there are 0·5 molecules of CO_2, 0·5 of CO, and 0·25 of O_2 present at equilibrium. If the total pressure is 1 atmosphere, the partial pressures of

CO and CO_2 are $\frac{0.5}{1.25}$ atmos., and of O_2, $\frac{0.25}{1.25}$ atmos.; therefore, $K_p=0.2$. The corresponding temperature is calculated from the above equation to be 2,930° Abs., whilst the temperature actually observed is 3,100°.

(b) If the reaction brings about no change in the number of molecules, the second term of the equation vanishes, and the third usually becomes very small. For instance

$$2NO=N_2+O_2+43,200 \text{ cals.}$$

and
$$\log K_p=\log\frac{P^2_{NO}}{P_{N_2}\times P_{O_2}}=-\frac{43,200}{4.57T}+1.6=-\frac{9,450}{T}+1.6.$$

This shows, in accordance with observation, that only at very high temperatures are appreciable quantities of nitric oxide formed from nitrogen and oxygen.

(c) If on the other hand, the change in the number of molecules is big, then the first term of the equation may be of little influence. For instance, the probability of a high-boiling paraffin hydrocarbon being formed from hydrogen and carbon can be calculated:

$$nC+(n+1)H_2=C_nH_{2n+2}+Q \text{ calories.}$$

Thomsen's experiments have shown that the heat of formation of such a hydrocarbon from its elements is given approximately by $Q_p=(7n+15)1{,}000$. As the chemical constant of H_2 is 1.6, and of C_nH_{2n+2} about 3.0 we have

$$\log K_p=\log\frac{P^{n+1}_{H_2}}{P_{C_nH_{2n+2}}}=-\frac{1000(7n+15)}{4.57T}+n\times1.75\log T+1.6n-1.4.$$

Suppose $T=773°$, *i.e.*, 500° C. Then

$$\log\frac{P^{n+1}_{H_2}}{P_{C_nH_{2n+2}}}=-1.98n-4.24+5.06n+1.6n-1.4=4.68n-5.64.$$

If $n=1$, *i.e.*, if the hydrocarbon formed is methane, CH_4, then

$$\log\frac{P^2_{H_2}}{P_{CH_4}}=-0.96 \text{ or } \frac{P^2_{H_2}}{P_{CH_4}}=0.11$$

from which it can be calculated that if hydrogen is passed over carbon at 500° C., the issuing gas should contain about 70% of methane if equilibrium is reached. Experimental results agree quite well with this. If, however, $n=7$, *i.e.*, if the hydrocarbon is heptane, C_7H_{16}, which boils at about 100° C., $\log\frac{P^8_{H_2}}{P_{C_7H_{16}}}$ is over 27, or $\frac{P^8_{H_2}}{P_{C_7H_{16}}}$ is over 10^{27}, which means that the amount of heptane formed at atmospheric pressure will be quite negligible. All the higher liquid hydrocarbons, such as occur in natural petroleum oil, are thermodynamically unstable at ordinary temperatures. They tend to pass into carbon and methane, but the velocity of this reaction at ordinary temperatures is very slow. If they are heated, however, they are "cracked"; hydrocarbons of lower boiling point, such as occur in petrol, are formed, and coke and gas are formed at the same time. If the cracking is continued for a long time at atmospheric pressure, the whole liquid forms into coke and gas (mainly methane). But high pressure tends to prevent the formation of gas and coke, and to give therefore a higher yield of "petrol." This is in complete general agreement with the Nernst equation, which enables us to predict approximately the conditions for the best technical success.

The further development of the third law, and its quantitative application to chemical problems depends on the provision of accurate data on the specific heats of substances over a wide range of temperature. The increase in the specific heat of gases as the temperature is raised lacks at present any sound theoretical explanation. The classical kinetic theory of gases does not account for it, and the more recent developments of the quantum theory have hitherto failed to be of assistance. But there can be little doubt that the third law provides in principle a complete explanation of the connection between chemical equilibria and the thermal changes associated with chemical reactions.

(H. T. T.)

THERMODYNAMICS. The name thermodynamics (from Gr. θερμός, hot, δύναμις, power), was originally given to the branch of science dealing with the motive power of heat, or the transformations of heat into mechanical work, or vice versa. A summary of the historical development of thermodynamics from this point of view is included in the article HEAT. Further illustrations relating to heat-engines will be found in the articles INTERNAL COMBUSTION ENGINES and STEAM: *Steam Engine.* The subject was soon extended to include other applications of the same general principles: (1) the conservation of energy, and (2) Carnot's principle of the reversible cycle, which are commonly known as the first and second laws of thermodynamics. The present article is intended to deal mainly with applications of these principles to the relations between the physical properties of a simple substance. Further applications to physical chemistry, dealing with the conditions of equilibrium between different substances, are dealt with in a separate section.

THERMODYNAMICS AND HEAT ENGINES

Definitions of Symbols.—The principal physical properties of the working fluid with which we are concerned in the case of heat-engines are the specific volume V, the intrinsic energy E, the total heat H and the entropy Φ, all of which are measured per unit mass of the substance considered. The laws of thermodynamics require certain general relations between these properties and their derivatives, as affected by additions of heat Q per unit mass, or by variations in the imposed conditions of temperature T and pressure P. It should be observed that in all these relations P is the absolute pressure and not the gauge-pressure; and that T is measured on the absolute scale, as defined by Carnot's principle which differs very little from absolute temperature on the scale of a gas thermometer. Temperature measured on the same scale from 0° C. is denoted by t, so that $T=t+273.1°$. The total heat H is defined as $E+aPV$ in thermal units, including the equivalent aPV of the work PV done by the pressure P on the volume V of unit mass. The entropy Φ of a quantity of heat Q supplied at a temperature T is defined as Q/T. The entropy of a substance per unit mass is the property which remains constant in adiabatic expansion, when no heat is supplied by friction or otherwise, as will be more fully explained in a later section, in connection with the second law of thermodynamics.

Applications of the First Law.—The intrinsic energy E denotes the quantity of energy existing in unit mass of the substance in any given state, which may in general be specified by its volume V and temperature T. We have no means of measuring the total quantity of energy contained in any body in a given state, but it suffices to be able to measure changes of E from any convenient state E_o selected as the zero. Any such change from E_o to E may be measured by observing the quantity of heat Q required to produce the change and the work W done by the substance per unit mass in the process. Assuming that no energy is lost, the application of the first law to this case gives the obvious relation

$$Q=E-E_o+W/J. \qquad (1)$$

In any equation of this kind it is tacitly understood that all the terms are reckoned per unit mass of the substance, and are expressed in terms of the same units, either units of work or units of heat as desired. The general practice in dealing with heat-engines is to measure Q, E, and H in thermal units per unit mass, and to reduce W to thermal units by dividing by the appropriate value of the mechanical equivalent J. In nearly all cases W represents work done by expansion $V-V_o$ against a uniform pressure P, in which case $W=P(V-V_o)$, if P remains constant during the expansion, and equation (1) takes the form

$$Q=E-E_o+aP(V-V_o)=H-H_o, \text{ at const. } P, \qquad (2)$$

where the total heat H is defined as $E+aPV$, and a is the factor required for reducing PV to heat units per unit mass. The factor required for this purpose in practice is seldom $1/J$, because pressure-gauges are never graduated in lb./sq.ft. or kg./sq mi., but often in arbitrary units such as inches of mercury.

Specific Heats.—If the heat Q is added at constant volume, $V=V_o$, and $W=o$, so that $Q=E-E_o$. If $T-T_o$ is the rise of temperature, we observe that the increase of E per degree at constant volume V_o is equal to $Q/(T-T_o)$, which is by definition the specific heat s at constant volume. Similarly $(H-H_o)/(T-T_o)$ from (2) is equal to the specific heat S at constant pressure. Thus the values of E along a line of constant volume on any diagram may be found from observations of the specific heat s at constant volume. Similarly values of H along a line of constant pressure may be deduced from observations of the specific heat S at constant P.

Thus $H-H_o=S(T-T_o)$ at const. P,

and $E-E_o=s(T-T_o)$ at const. V. (3)

These simple relations between H and S, and E and s, are exact for all substances at all temperatures in consequence of the definition of H, and are often very useful. But the specific heats S and s may vary widely with temperature and pressure, in which case it is usually better to measure H or E directly, in place of trying to deduce them from empirical formulae for S or s. In the case of solids or liquids, since V is small and varies little with T, the variation of E at constant pressure, such as atmospheric, does not differ appreciably from that of H. But the variation of H at *constant* volume may greatly exceed that of E under the same condition on account of the high pressures developed. In practice it is usually preferable to measure the value of H and deduce that of E, if required, by subtracting aPV.

Application to Gases.--In the case of ideal gases obeying the law $aPV=RT$, it follows directly from the general relations (3) that the difference $S-s$ is constant and equal to R. It will be shown later that the specific heats of such gases cannot vary with pressure, though they may vary considerably with temperature, while the difference S — s remains constant, as in the case of hydrogen. (See HEAT.) On the other hand, vapours, like steam, though they usually approximate closely to the law $aPV=RT$ at low pressures, show large deviations from the gas-laws at high pressures near saturation, and the value of S shows a wide range of variation with *pressure,* especially near the critical point. Fortunately these variations can be deduced from the thermodynamical relations given in a later section of this article.

Cycle or Cyclical Process.--The application of the first law, as expressed in (1), to the cycle of a steam-engine, in which the working fluid is restored to its initial state of water at each repetition of the cycle, is fully considered in the articles already referred to. Briefly stated, if $E=E_o$ at the conclusion of the cycle Σ_o, it follows from (1) that the algebraic sum ΣQ of all the quantities of heat Q received and rejected by the working substance during the cycle must be equal to the net balance of work done by the engine per cycle, work done by the fluid in expansion being reckoned positive, and work done on the fluid in compression being reckoned negative. With this understanding the formula for the cycle may be expressed as follows,

$$\Sigma Q=\Sigma W=\int PdV. \qquad (4)$$

In an ideal reversible engine, in which no heat is lost and no work is wasted in friction, the area of the cycle on the PV diagram, expressed by the integral of PdV taken round the cycle, will represent the maximum work obtainable from the cycle considered. In any actual engine some of the heat received by the working fluid is lost before it has contributed its full quota of work, and some of the work done is reconverted into heat by internal friction and is rejected in the form of heat. If the properties of the working fluid are known, such losses may be estimated in the reciprocating engine by comparing the ideal diagram, as calculated, with the actual diagram as observed with the indicator. (See STEAM: Steam Engine.) In the case of a turbine, to which the indicator method is inapplicable, it is necessary to use a different kind of diagram, or the ideal output may be calculated from the properties of the working fluid, and compared with that actually realised.

Frictionless Adiabatic Expansion.—The term "adiabatic" implies that there is no gain or loss of heat by the working fluid. Putting Q=O in (1) we see that in this case E — E, must be equal to $-W/J$, or the intrinsic energy of the working fluid is diminished by an amount equivalent to the work done. If no work is wasted in friction, this represents the most efficient method of conversion of heat into work, which is the ultimate aim of every heat-engine. To calculate the work done from the integral of PdV under this condition, it is necessary to know the form of the expansion curve on the PV diagram, or the adiabatic equation representing the relation between P and V for the working fluid employed, which requires an appeal to experiment. Watt made the first experiments of this kind with his indicator, but found the expansion curve for a slow speed engine using wet steam to be approximately PV=constant, the same as Boyle's law for the expansion of a gas at constant temperature, whereas the fall of pressure in adiabatic expansion should have been more rapid than that given by Boyle's law owing to the fall of temperature. Watt was well aware that this anomaly was due to partial condensation of the steam on admission by the cool walls of the cylinder, followed by re-evaporation towards the end of the stroke, which made the conditions far from adiabatic. Laplace subsequently showed (see HEAT) that the rate of drop of pressure dP/dV in the adiabatic expansion of a gas must exceed that for the same state at constant temperature, in the ratio, $S/s=\gamma$, of the specific heats. Assuming Boyle's law for a gas at constant temperature, and y =constant in adiabatic expansion, it followed that the adiabatic equation must be of the form, $PV^\gamma=$constant for a gas.

The adiabatic equation of Laplace and Poisson for a gas, was established long before the first law of thermodynamics was formulated, and has proved to be the most convenient type of equation for the purpose. But with the assistance of the laws of thermodynamics, the scope of the adiabatic equation in this form may be considerably extended. Thus with the assistance of the first law, in the form in which it is usually employed for mathematical purposes, namely

$$dQ=dE+aPdV=dH-aVdP \qquad (5)$$

the adiabatic equation, $PV^\gamma=$constant, may be shown to apply generally to any kind of substance, not necessarily a perfect gas, for which the change of intrinsic energy in any transformation is proportional to that of aPV; or more generally that it will be of the form $P(V-b)^\gamma=$constant, provided that the expression for the intrinsic energy E satisfies the condition,

$$E-B=naP(V-b) \qquad (6)$$

in which B, b, and n are constants depending on the substance, and $\gamma=1+1/n$.

To prove this relation, we put $dQ=o$ in (5) as the general condition for the adiabatic, and equate dE as obtained from (6) to $-aPdV$, which gives,

$$an(V-b)dP+a(n+1)PdV=o. \qquad (7)$$

Dividing by $aP(V-b)$ and integrating we obtain

$$n\log P+(n+1)\log(V-b)=\text{constant} \qquad (8)$$

which when put in the exponential form becomes

$$P(V-b)^{n+1/n}=\text{constant}. \qquad (9)$$

It will be observed that the value of the index y is *constant*, and is not necessarily equal to the ratio of the specific heats, which may vary widely with pressure. This is fortunate, because an equation of this type is of little practical use if the index is variable.

With the assistance of the second law of thermodynamics in addition to (5) and (6), it will be shown in a later section that the same adiabatic, (9) may be put in either of the equivalent forms

$$P/T^{n+1}=\text{constant}=k_1 \text{ or } (V-b)T^n=\text{constant}=k_2 \qquad (10)$$

and that $P(V-b)/T=k_1k_2=$constant, along an adiabatic, though it is not necessarily constant under other conditions.

Experimental Verification of the Adiabatic.—The most direct way of testing the adiabatic equation is to use a cylinder containing a constant charge of gas or vapour which is alternately compressed and expanded by a reciprocating piston. Indicator cards give fairly accurate values of the actual volume and pressure, if the clearance is carefully measured, the pressure scale calibrated, and everything in perfect adjustment. But in working

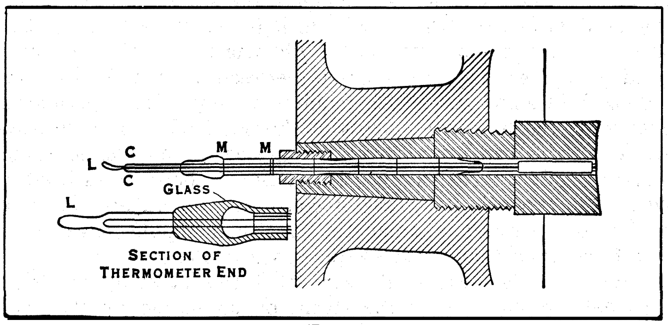


FIG. 1

over large ranges of pressure, as is necessary for a satisfactory verification, there are formidable difficulties due to the wide variation of heat exchanges between the charge and the walls of the cylinder at different points of the stroke. These effects are further complicated by accidental leakage past the piston, and, in the case of steam, by the risk of condensation, both of which affect V indirectly by reducing the apparent mass of the charge. The most complete method of eliminating these uncertain sources of error, which profoundly affect the uniformity of V throughout the cylinder, is to observe, instead of the relation between P and V, the relation between T and P, as given by the adiabatic equation in the form (10), deduced from the second law. In this case the temperature observed in the middle of the cylinder will be practically unaffected by the action of the walls, and is determined solely by the actual pressure as observed with the indicator. We are no longer concerned with the *theoretical* pressure, corresponding to the compression ratio by volume, which might be realized in the absence of condensation or leakage or heat-loss to the walls. These effects will still reduce the observed pressure below the theoretical value, but will not affect the relation between pressure and temperature. The success of the thermometric method depends on the construction of a thermometer sufficiently sensitive to follow the rapid variations of temperature without appreciable lag, and on obtaining simultaneous readings of the relative values of the pressure with the same order of accuracy at the maximum and minimum points of the cycle. It is easy to cover the range of temperature with a single thermometer, but, the pressure range being upwards of 10/1, it is necessary to use a separate indicator with a light spring for the low pressures. Applied in this manner the method is particularly suited to give the best average value of the index over large ranges of pressure and temperature. The procedure may be varied when it is desired to obtain the value of the index at some particular point of the scale, *e.g.*, at high or low temperatures.

The annexed figure 1 shows one of the thermometers employed for this purpose, mounted on the piston of a steam-engine for observing the adiabatic relation between P and T for dry steam. The sensitive portion of the thermometer consisted of a differential loop L of fine platinum wire a thousandth of an inch in diameter and 1 inch in length. The fine wire was connected to thick platinum leads, insulated by being fused through a glass tube MM held in a gland in the centre of the piston. The platinum leads in the glass tube were connected to insulated copper leads, which were carried out to the measuring apparatus through a hole 2 ft. long bored through the piston rod. Since the ends of the fine wire, where it is attached to the thick platinum leads, cannot follow the rapid variations of temperature of the steam, it is necessary with this type of thermometer to compensate these end-effects by connecting a short loop of the same fine wire to the ends of the compensating leads CC. The quantity measured being the difference of resistance of the long and short loops, all such end-effects are automatically eliminated. Readings of temperature were taken with the aid of a periodic contact (mounted on the revolving shaft) which could be adjusted, while the engine was running, in such a way as to close the circuit of the galvanometer at any desired point of the stroke. It was found possible to read the temperature to one or two tenths of 1° C at the maximum and minimum points, with the engine running at 100 rev./min. and a range of temperature of about 300° C between maximum and minimum. Readings taken at intermediate points, where the temperature was changing at the rate of more than 500° C per second, showed very good agreement, but could not be utilised in the calculation because the simultaneous values of the pressure could not be located with sufficient accuracy on the steep part of the indicator curve, whereas the maxima and minima could be measured with the greatest precision. The ports of the cylinder used in these experiments were caulked with lead to prevent leakage, and the cylinder was heated by steam in the jackets and steam-chest to minimize condensation. The flywheel was belted to an electric motor and driven at a steady speed by a large storage battery. The observations covered a range of temperature from 100° to 420° C, but could not be extended beyond 150 lb. pressure by this method, owing to deficient strength of the engine and driving gear. The results obtained with several different thermometers and indicators, showed that the adiabatic index for steam must be very nearly constant over this range of pressure and temperature with a value given by $n+1=13/3$ in (10), or $\gamma=1{\cdot}300$ in the relation (9) between P and V. Recent observations on the total heat H up to 4,000 lb. pressure, have shown that the same relation holds for dry steam with remarkable accuracy in the critical region, in spite of enormous variations in the ratio of the specific heats. The importance of this result in practice lies in the fact that it gives a very simple expression (6) for E or H in terms of P and V, or for V in terms of H and P, in addition to giving the simplest possible expressions for the work done in adiabatic expansion, or for the discharge through a nozzle, the utility of which can hardly be exaggerated in practical thermodynamics. Similar relations, but with $\gamma=1{\cdot}40$ or $n=2.5$, have long been applied to the case of atmospheric air, which forms the chief constituent of the working fluid in the internal combustion engine. But in the case of air the application is much more simple and obvious, because air obeys the gas equation $aPV=RT$ very closely, and its specific heats vary very little with pressure under ordinary conditions.

The Energy Equation in Steady Flow.—The flow of a fluid through a pipe or any closed apparatus, is said to be "steady" when the mass M per second passing any cross-section X is the same at every point, and remains constant during the flow. This implies that the fluid is supplied at a steady rate by some external agent (*e.g.*, a pump or boiler) at a constant pressure and temperature, in which case the whole apparatus traversed by the fluid will soon settle down into a steady state in which the values of P, V, and T remain constant at each point, though they will not be the same at different points, if the section X varies from point to point, or if the fluid receives heat or does work at a steady rate during its passage. It follows from the law of conservation of mass that, when the mass-flow M is constant at every point, the velocity U of the fluid at any section X is given in terms of V by the relation

$$U=kMV/X \qquad (11)$$

where k is a constant depending on the units employed.

A second relation follows from the law of conservation of energy, since the energy existing in any section must remain constant when the conditions are steady. The total energy carried into any section by the fluid per unit mass in thermal units will consist of its intrinsic energy E', together with the equivalent $aP'V'$ of the work done by the pump, and with the kinetic energy of flow, $K'=U^2/2Jg$, reduced to thermal units by the factor $1/Jg$. Thus the total energy carried in by the fluid may be represented briefly by $H'+K'$. Similarly the total energy carried out of the same section by the fluid may be represented by

$H''+K''$. But with the energy carried out we must include the equivalent W/J of any work done by the apparatus, and any heat Q lost by radiation or convection, both measured per unit mass of the fluid passing through. Collecting the terms, the general equation may be written

$$H'-H''=K''-K'+W/J+Q. \qquad (12)$$

The steam-turbine may be taken as a typical example. $H'-H''$ represents the drop of total heat of the fluid, or more briefly

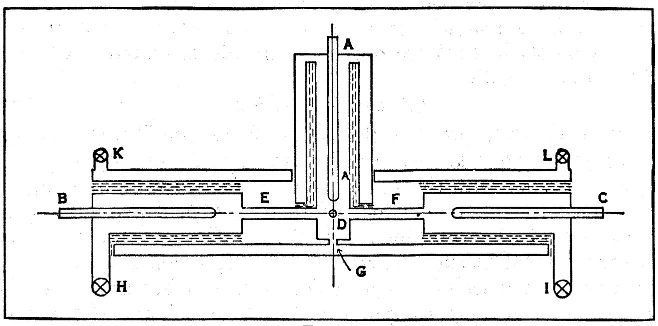


FIG. 2

the 'Heat-drop,' between the inflow and outflow of any section. In an efficient machine, this heat-drop is very nearly equivalent to the external work W done by the steam on the revolving blades. The external heat-loss Q is a small percentage of the whole. The kinetic energy K'' of the steam leaving the section usually exceeds K', that of the steam entering and $K''-K'$ represents a similar percentage loss. The greater part of the loss in a turbine is that due to internal friction, by which part of the available kinetic energy is reconverted into heat. This part of the loss is included in the total heat H'' carried out by the steam. If there were no friction or heat-loss, the drop of total heat, representing heat converted into kinetic energy or work, would be that obtainable in frictionless adiabatic expansion between the same limits of pressure, which may be found from the tables and compared with the actual performance to estimate the efficiency. The method of doing this will be explained later, when some of the simpler applications of equation *(12)* have been illustrated.

The Throttling Method.—The function of a throttle, or reducing-valve, is to regulate the flow, or change the state of the fluid, by lowering the pressure without altering the total heat. The throttle, having no moving parts, cannot do any external work, so that $W=0$ in equation *(12)*. In this case, most of the kinetic energy is reconverted into heat by friction, so that K'' can be made nearly equal to K' under favourable conditions. The equation then reduces to the form

$$H'=H''+Q \qquad (13)$$

The chief use of the equation in this form is to find the value of the total heat H' at a high pressure by throttling to a lower pressure, such as atmospheric, and observing the temperature T''. The total heat H'' at the lower temperature and pressure may be regarded as known by equation *(3)*-*in* terms of the specific heat S. Thus the required value of H at T and P is given by *(13)* if the heat-loss Q can be determined. The best way of doing this is to employ a differential calorimeter as shown in fig. 2. The high pressure steam enters the centre pocket at the back and circulates round the thermometer tube *(A)* for measuring the initial temperature. The initial pressure is measured at the same point through the connection (D) to the high pressure gauge. The main current then divides right and left through the throttle tubes (E) and (F) to the side pockets (B) and (*C*) where the temperature of the throttled steam is measured. These pockets are precisely similar, and are lagged and jacketed with throttled steam in order to reduce heat-loss, which would otherwise be rather large at high temperatures. The throttle tubes are fitted with a progressive series of throttles and baffles, designed to give maximum friction and reduce the kinetic energy to a negligible quantity. Using single and double dashes to distinguish the two sides, the flows M' and M'' on either side, as defined above can be adjusted in any desired ratio. The rate of heat-loss $M'Q'$ per second will evidently be nearly equal to the rate of heat-loss $M''Q''$ from the other side. Hence Q and Q'' (per unit mass) will be inversely as the flows, which are condensed and measured separately. For instance, if $M'=2M''$, we have $Q''=2Q'$, and $Q'=H'-H''$, by taking the difference between the two equations

$$H'+Q'=H_0=H''+Q'' \qquad (14)$$

where H_0 represents the total heat in the centre pocket. Whence $H_0=2H'-H''$, both of which are known from the observed temperatures t' and t''. Since S is nearly constant for steam at atmospheric pressure, it usually suffices to correct the observed temperature t' for heat-loss by adding $(t'-t'')\ M''/(M'-M'')$, as in the following example. Starting with steam at *3,805* lb. pressure and 426·6° C, the observed temperatures on either side after throttling to *16* lb. were $t'=120{\cdot}3°$ C and $t''=114{\cdot}1°$ C, the ratio $M''/(M'-M'')$ being 0·97. The correction to t' for heat-loss is $0{\cdot}97\times6{\cdot}2°=6{\cdot}0°$, giving 126·3° C for the corrected temperature, at which $H_0=652{\cdot}4$ cal. C, as given in the tables at *16* lb. This method is one of the simplest for measuring H at high pressures and temperatures, but cannot be applied if H is less than *640* cal., because the throttled steam would be wet. Thus in measuring H at the critical point, 374° C, and 3,222 lb , where its value is only *554.4* cal. it is necessary to use the jacketed condenser method as described in the article CALORIMETRY. This method is rather more difficult. but has the advantage of applying equally to the case of water.

Discharge Through a Nozzle.—The function of a nozzle in a turbine is to convert as much as possible of the total heat of the steam into kinetic energy for turning the wheels. For this reason the nozzle is formed with a bell-mouth on the high pressure side tapering smoothly to a nearly parallel throat, so as to produce a uniform jet of high velocity with the least possible friction or turbulence. In this respect the nozzle is the opposite of the throttle which reconverts as much as possible of the kinetic energy into heat, leaving the total heat practically unaltered. In one respect it is like the throttle, in that it has no moving parts and does no external work in itself, so that $W=0$ in equation (12), when applied to either nozzle or throttle. The heat-loss Q in the case of a nozzle is also very small compared with the heat-flow, which is usually large owing to the high velocity of flow. Neglecting W and Q on this account, the heat-drop is the exact equivalent of the kinetic energy generated, thus equation *(12)* becomes

$$H_1-H_2=K_2-K_1=(U_2^2-U_1^2)/2Jg, \qquad (15)$$

in which the constant Jg is required for reducing $U^2/2$ to heat units. It may be observed that equation (15) remains true if any proportion of the kinetic energy generated is reconverted into heat by friction, since this has the effect of increasing H_2 exactly as much as it reduces K_2. As a rule the initial velocity is small and K_1 is almost negligible in comparison with K_2. The velocity generated may then be calculated from the heat-drop by the formula

$$U_2=(2Jg)^{\frac{1}{2}}\ (H_1-H_2)^{\frac{1}{2}} \qquad (16)$$

If H is taken in calories C and U in feet per sec., the value of the constant is *300.2*, or a heat-drop of 1 cal. C will correspond to a velocity of *300* ft./sec.; or 100 cal. to 3,002 ft./sec. A velocity of 100 ft./sec., or *70* miles per hour, though not unimportant in meteorology, may often be neglected in dealing with turbines, as it corresponds to only $\frac{1}{9}$th of a calorie C. Other conditions being equal, the heat-drop and velocity will evidently be greatest in the absence of friction, or in frictionless adiabatic expansion as defined by putting $dQ=0$ in equation *(5)*. This gives the condition $dH=aVdP$ for finding the heat-drop by integrating $aVdP$ along the adiabatic (9) between the given limits of pressure P_1 to P_2. Neglecting b, this reduces to the simple form,

$$H_1-H_2=(H_1-B)(1-T_2/T_1) \qquad (17)$$

where $T_2/T_1=(P_2/P_1)^{\frac{3}{13}}$, for steam *by* equation (10) with $n+1=13/3$.

Having found the heat-drop, which is preferably obtained from the Tables, the velocity U_2 follows from (15), or from (16) if U_1 is small. The discharge M is easily obtained from (11) in terms of the area of the throat X, and the volume V_2 at the same point. The latter is most easily obtained from H and P by the general relation (6), which may be put in the form,

$$V=(H-B)/a(n+1)P=2\cdot2436(H-B)/P. \qquad (18)$$

Maximum Discharge.—It results from the form of these equations that for any given nozzle or throat area X, for a given initial state of the steam as defined by P_o and V_o, the discharge M will at first increase as the final pressure P is lowered, but will ultimately reach a very definite maximum, when $P/P_o=0\cdot546$ in the case of steam. Differentiating (11) to find the condition under which M is a maximum, we have $d(U/V)=0$, or $dU/dV=U/V$. Putting (15) in the form $U^2-U_o^2=2Jg(H_o-H_o)$, differentiating with regard to V, and remembering that U_o and H_o are constant, we obtain

$$-Jg(dH/dV)=U(dU/dV)=U^2/V. \qquad (19)$$

Since by (5) $dH/dV=aV(dP/dV)$ in adiabatic expansion, this may be written,

$$-aJg(dP/dV)=(U/V)^2=(kM/X)^2 \qquad (20)$$

giving the discharge M/X per unit area of throat in terms of dP/dV in the throat. Since equation (20) for $(U/V)^2$ in terms of dP/dV is the general expression for the velocity of sound U in any fluid, we infer that, when M/X is a maximum, the exit velocity of the fluid relative to the throat must be equal to the velocity of sound in the same fluid under the same conditions. Thus no drop of pressure beyond the throat could travel back fast enough through the fluid to affect its state in the throat or increase the discharge. In the case of any fluid like steam, having the adiabatic equation (g), $dP/dV=-\gamma P/(V-b)$, which when substituted in (20) gives the discharge in terms of P and V in the throat. To find a numerical formula for the maximum discharge in the case of steam (for which $\gamma=1\cdot3$) in terms of the initial conditions, P_o, V_o, we have the approximate relations (omitting b, which is very small), which follow from (20),

$$(H_o-H)/(H_o-B)=(\gamma-1)/(\gamma+1)=3/23 \qquad (21)$$

$$P/P_o=0\cdot5457,\ V/V_o=1\cdot5934 \qquad (22)$$

which give for the discharge M/X in lb. per sec. per sq.in. of throat (k = 144),

$$M/X=U/144V=0\cdot3155\ (P_o/V_o)^{1/2} \qquad (23)$$

when P is in lb. per sq.in., U in ft./sec. and V in cu.ft. per lb. The correction for b is less than $\frac{1}{20}$ of 1 per cent when $P_o=300$ lb.

Applications of **Carnot's** Principle.—The whole science of thermodynamics may be said to date from the establishment by Sadi Carnot (1824) of the principle limiting the amount of work obtainable from heat under given conditions. The reasoning by which Carnot established his principle is outlined in the article HEAT, and is justly regarded as one of the most remarkable triumphs of the deductive method, but the experimental data available at the time were far too scanty and inaccurate to supply conclusive proof. With the advance of experimental methods Carnot's predictions have been abundantly verified in every conceivable instance, and have formed the basis of the development of all kinds of heat-engines in theory and practice. The important applications to heat-engines are discussed elsewhere in their proper place. We are here concerned chiefly with the applications of the principle to the thermodynamical relations between the various properties of any substance, and to the conditions which determine the possible states of equilibrium. Carnot in applying his principle to such cases put it in the following form as being most convenient for the purpose. If a quantity of heat Q is supplied to any substance at a constant temperature t, the work dW obtainable from Q by an ideal reversible engine working in a cycle of range dt must be proportional to Qdt multiplied by some function of the temperature, F't, which must be the same for all substances. Putting this statement in the form of an equation, we find

$$dW/dt=QF't, \qquad (24)$$

as given by Carnot, and applied by him to the following simple cases:

Clapeyron's Equation.—In the vaporisation of unit mass of steam in a boiler, the whole work of expansion W along the isothermal at constant pressure and temperature, would evidently be equal to $p(V-v)$, the product of the vapour-pressure p by the increase of volume from that of water v to that of steam V. Thus the work dW/dt obtainable in a cycle of range dt would be $(V-v)dp/dt$, where dp/dt is the rate of increase of the steam-pressure per degree rise of temperature. The heat Q absorbed in the vaporisation of unit mass is the latent heat L. Substituting these symbols in (24) we obtain the result commonly known as Clapeyron's equation,

$$(V-v)dp/dt=LF't, \qquad (25)$$

which evidently represents the condition of equilibrium between liquid and vapour at any temperature, and is applicable to any other substance with the same value of F't at the same temperature, but with different values of L, V, and p, depending on the properties of the substance considered. Carnot employed this relation for calculating the value of his function F't at 100° C from the properties of steam, which were roughly known at this temperature. Taking L = 540 cal. $dp/dt=27.2$ mm. of mercury, or 370 kg./sq. metre, and $V-v=1\cdot670$ cb.m./kg., we find F't = 1·135 kilogram metres per kilocalorie for the work obtainable in a cycle of 1° range at 100° C. We may remark in passing that the value found is equal to 427/373, being the mechanical equivalent of the kilocalorie in kgm. divided by the absolute temperature. This implies that the whole of the heat could be converted into work if the range of the cycle were extended to the absolute zero with the same rate of production of work per degree fall. But Carnot, who had at that time no knowledge of the value of the mechanical equivalent, naturally failed to notice this remarkable coincidence, though the result he obtained for *F't* was correct.

Lowering of *the* Freezing Point of *Ice* by Pressure.—The application of Carnot's equation (25) to the rate of increase of vapour-pressure dp/dt with temperature, or to the rise of the boiling-point dt/dp with pressure (which are merely different ways of expressing the same property of the substance) is easily made in any case in which the latent heat L and volume V of the vapour are known, and affords in fact one of the most direct methods of verifying Carnot's principle by experiment. A more dramatic verification was that made by James Thomson (1851), who observed that equation (25) must apply just as exactly to the equilibrium between liquid and solid at the freezing-point, as to that between liquid and vapour at the boiling-point. In the case of solid and liquid, L is the latent heat of fusion, and V–v is the increase of volume in melting, which is positive for a substance like wax which expands in melting, but negative for a substance like water which expands on freezing. Thus in the case of wax, the sign of dt/dp should be positive, or the melting point should be raised by pressure (as is always the case for the boiling-point), whereas in the case of water the sign should be negative, or the freezing-point should be lowered by pressure. Taking the known values of L and V–v for water and ice, he predicted that the freezing-point of water should be lowered 0·0075° C per atmosphere of pressure, a result which was immediately verified by his brother, Lord Kelvin, and materially assisted in the final establishment of the second law of thermodynamics.

Application to Gases, Absolute Scale of T.—The application of Carnot's equation (24) to the case of a gas obeying the law PV = RT, is equally simple. The whole work W done in isothermal expansion, is represented by the analytical expression RT $\ln$ r, where $\ln r$ denotes the natural logarithm of the ratio of expansion. It immediately follows, as Carnot remarks, that $dW/dt=R\ln r$, or is simply equal to W/T. Thus equation (24) reduces to the form,

$$W/T=Q\,F't. \qquad (26)$$

Carnot deduced from this relation that the ratio W/Q of the work done to the heat absorbed in isothermal expansion must be the same for all gases at the same temperature, and that if equal volumes of different gases were taken at the same temperature and pressure (or masses proportional to the molecular weights) the heat Q absorbed in isothermal expansion must be the same for all gases under similar conditions since the work W was the same for all. It followed as a special case that the *difference* of the specific heats at constant pressure and volume, being the heat absorbed in an isothermal expansion equal to V/T, must be the same for equal volumes of all gases. His endeavours to extract a value of $F't$ from this relation gave results similar to those obtained from steam and other vapours, but failed to give a decisive conclusion owing to the uncertainty of the ratios of the specific heats as deduced from the velocity of sound. At a date when Joule *(1845)* proved by direct experiment that the heat absorbed by a gas in isothermal expansion was approximately *equivalent* to the work done, it became evident, by substituting $W=JQ$ in equation *(26)* that the value of $F't$ must be nearly equal to J/T for all substances. But since according to Regnault's experiments *(1847)* the temperature scales of actual gases differed quite appreciably different gases would give different values of T at the same temperature, and it was impossible to say which should be selected. The essential point of Carnot's principle being that the value of $F't$ was *the same* for all substances at the same temperature, the most logical method was that proposed by Kelvin, to define absolute temperature T as being proportional to the reciprocal of Carnot's function. Exact consistency with Carnot's principle and with the law of conservation of energy could thus be secured, while leaving the deviation of the scale of any particular gas from the absolute scale thus defined to be determined by experiment in each case.

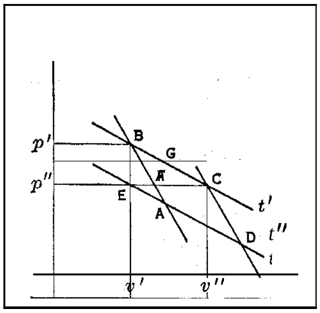


FIG. 3

Carnot Cycle of Finite Range —If we substitute J/T for $F't$ in Carnot's equation (24) in accordance with the definition of absolute temperature T, and also write $W=JQ$ as required by the first law, the equation reduces to the form $dQ/dT=Q/T$, which tacitly involves the law of conservation of energy in addition to the adoption of Carnot's principle for the definition of the scale of temperature The relation in this form implies that, if the range of the cycle is extended to any lower temperature, the ratio Q/T will remain constant, and the heat converted into work will increase in direct proportion to the range of temperature, since the constant ratio Q/T is equal to dQ/dT representing the heat converted into work per degree fall. Thus the formula for a Carnot cycle of finite range, in which a quantity of heat Q is supplied to the working substance at T', and a quantity Q'' is rejected at T'', with the conversion of heat $Q'-Q''$ into work W, reduces to the simplest possible form, namely,

$$W/(T'-T'')=J(Q'-Q'')/(T'-T'')=JQ'/T'=JQ''/T'', \quad (27)$$

in which the reduction factor J may be omitted if Q is expressed in work units.

Entropy.--The quantity Q/T which remains constant in a Carnot cycle of any range bounded by two adiabatics, is called the entropy of the heat Q supplied at a temperature T. According to *(27)* the entropy of the heat supplied at T', is equal to the entropy of the heat rejected at T''. The entropy difference between any two adiabatics is constant, or the adiabatics are lines of constant entropy, and are often called isentropics. The thermal equivalent of the work done in any Carnot cycle is the product of the entropy supplied, namely Q'/T', by the range of temperature $T'-T''$. This relation is frequently the most convenient for calculating the work obtainable, not only in a Carnot cycle, but also in a cycle of any form.

Clapeyron's Relations.—Clapeyron *(1834)* observed that Carnot's principle, as represented by equation (24), implied the existence of certain general relations between the quantity of heat absorbed in isothermal expansion and the pressure and expansion coefficients of the working substance. He employed the indicator diagram, as illustrated in fig. 3, for the deduction of these relations by a method equivalent to that employed by Maxwell, *Theory of Heat (1870)*. The coordinates of the point B are the pressure p', and the volume v' of unit mass of the substance at a temperature t'. Let the substance expand from B to C along the isothermal at t' absorbing a small quantity of heat dQ, while its volume increases from v' to v'', and its pressure diminishes from p' to p''. Draw the line of constant volume v' through B intersecting the line of constant pressure p'' through C in the point E. Through E draw the isothermal EAD at the temperature t''. Complete the Carnot cycle by drawing the adiabatics BA and CD through B and C. In the limit, when the difference of temperature $t'-t''$ is small, it may be represented by dt as in Carnot's equation (24), and the form of the cycle $ABCD$ will become a parallelogram as indicated in the figure. The area $ABCD$ represents the work dW done in the elementary cycle, and is equal to that of the rectangle $BE \times EC$, or to $(p'-p'')(v''-v')$. Making these substitutions in Carnot's equation (24), we obtain the general relation,

$$(p'-p'')(v''-v')/(t'-t'')=F't \times dQ. \quad (28)$$

In order to interpret this relation in terms of the pressure coefficient at constant volume, or the expansion coefficient at constant pressure, as may be desired, we may in the first place transfer $v''-v'$ to the right hand side of the equation. We then dbserve that $p'-p''$ is the increase of pressure BE at constant volume corresponding to the increase of temperature $t'-t''$, so that the ratio represents the familiar pressure-coefficient at constant volume, denoted by $(dp/dt)_v$ in the usual notation of partial differential coefficients. Similarly $dQ/(v''-v')$, being the ratio of the heat absorbed at constant temperature to the corresponding increase of volume, may be denoted by $(dQ/dv)_t$ in the same notation. If we also substitute J/T for $F't$ in accordance with the definition of absolute temperature, we obtain,

$$T(dp/dt)_v=J(dQ/dv)_t \quad (29)$$

which is often called the first thermodynamical relation, and was in fact employed by Kelvin as a general expression for Carnot's principle in his first exposition of the equations of thermodynamics (1851), except that he retained the symbol μ for $F't$, following Clapeyron, in place of substituting J/T, as in (29), according to modern practice.

Pressure and Expansion Coefficients.—The utility of a relation of this kind lies in the fact that small quantities of heat absorbed in expansion are very difficult to measure, but can usually be calculated with the aid of relations like *(29)* in terms of other coefficients, such as the pressure coefficient. Many examples of this will be given later. If the relation *(29)* itself is not directly applicable, it can usually be transformed by purely mathematical relations between the various coefficients into a different shape which is more convenient for the purpose required For instance the pressure coefficient $(dp/dt)_v$ is seldom directly measurable in the case of a solid or a liquid, owing to the difficulty of keeping the volume constant while the temperature is being raised. The difficulty of measuring the pressure-coefficient may be avoided by using the familiar relation,

$$(dp/dt)_v=-(dp/dv)_t(dv/dt)_p \quad (30)$$

giving the required value in terms of the isothermal elasticity and the coefficient of expansion at constant pressure, both of which can be measured. Relation *(30)* is one of the commonest examples in practice of the general relation between the partial differential coefficients of any three quantities, such as x, y, z, connected by a single equation, such that any one of the three may be regarded as a function of the other two. It is most easily remembered in the cyclical form,

$$(dx/dy)_z(dy/dz)_x(dz/dx)_y=-1. \quad (31)$$

from which any required relation of this type such as (30) may be written down by replacing p, v, t, by $x. y, z$, or *vice versa.* But as relations of this type are usually required in the form (30), it may be as well to explain how they are deduced from first principles. The volume v of unit mass of any substance depends on the temperature t and the pressure p either of which may vary independently of the other. Any expansion due to change of temperature alone, is found by multiplying the rise of temperature dt by the expansion per degree at constant pressure, represented by the coefficient $(dv/dt)_p$. Similarly any change of volume due to increase of pressure alone, is given by the product of the increase of pressure dp by the isothermal compressibility $(dv/dp)_t$. In the general case, when both p and t change, the whole expansion dv is the sum of the two independent effects,

$$dv=(dv/dt)_p dt+(dv/dp)_t dp. \tag{32}$$

Similar formulae apply to all other properties of the substance depending on p and t and are frequently required in thermodynamics. In the case of the volume v, it is immediately obvious from *(32)* that, if the compression due to increase of pressure dp is equal to the expansion due to increase of temperature dt, the volume will remain constant, or $dv=0$. The ratio of dp to dt at constant volume, or the required coefficient $(dp/dt)_v$, is obtained in terms of the other two by putting $dv=0$ in (32), dividing by dt and transposing, which gives the required relation in the form *(30)* if we observe that the isothermal elasticity $(dp/dv)_t$ is the reciprocal of the isothermal compressibility $(dv/dp)_t$.

Second Relation.—From the first thermodynamical relation, as given in equation (29), Clapeyron deduced his second relation, for the heat evolved in isothermal compression, by substituting for $(dp/dt)_v$ the expression given in (30), which leads immediately to the corresponding expression for $(dQ/dp)_t$,

$$T(dv/dt)_p=-J(dQ/dp)_t \tag{33}$$

in terms of the coefficient of expansion at constant pressure. The negative sign in this relation indicates that heat is *evolved* by an increase of pressure, whereas heat is absorbed when the volume increases. There are several other thermodynamical relations, which are in effect equivalent to Carnot's equation (24), but the two originally given by Clapeyron are the most useful, and suffice for the majority of practical requirements. It will be observed that they are not independent relations, since one can be deduced from the other by a purely mathematical transformation, but either may be employed as required with the certainty of obtaining results consistent with the laws of thermodynamics.

Specific Heats.—The specific heats are among the most familiar and useful coefficients in practice since they are commonly required for calculating quantities of heat. They are usually measured by observing the quantity of heat given up by a body in cooling through a large range of temperature, and are often treated as constants. But in addition to the variation with temperature, as illustrated in the articles HEAT and CALORIMETRY, the results found may depend to a great extent on other conditions, such as pressure, in a manner subject to the laws of thermodynamics and amenable to calculation. In dealing with variable specific heats, the general expression for the specific heat of any substance at a temperature T is the ratio dQ/dT of the small quantity of heat dQ supplied per unit mass to the corresponding rise of temperature dT produced; but it is also necessary to specify the conditions under which the measurement is made, as these may affect the result. The two simplest cases are those in which the specific heat is measured, (a) at constant pressure, (b) at constant volume, though the latter condition can seldom be realised satisfactorily in the case of a solid or liquid. For this reason it is useful to have a relation giving the specific heat at constant volume in terms of that at constant pressure. The required relation may be obtained most directly by the aid of Clapeyron's relation *(33)* in the following manner, which also gives incidentally the expression for any other variety of specific heat.

Difference of *Specific* Heats.—To find a general expression for the specific heat dQ/dT under any condition, write down the general expression for dQ in terms of dt and dp, exactly as for v in (32), by simply replacing the letter v in *(32)* by the letter Q, and divide each term in the expression by dt, thus we obtain,

$$dQ/dt=(dQ/dt)_p+(dQ/dp)_t dp/dt. \tag{34}$$

The first term on the right, namely $(dQ/dt)_p$, representing the heat absorbed per unit mass per degree rise of temperature at constant pressure, is obviously the specific heat as ordinarily measured at constant pressure, which may be denoted by S_p. The next coefficient, $(dQ/dp)_t$, represents the heat evolved per unit mass per unit increase of p in isothermal compression. The value of this is given by Clapeyron's second relation *(33)* in terms of the coefficient $(dv/dt)_p$. Since the specific heat is usually required in thermal units, it is best to retain the reduction factor $1/J$, explicitly in equations expressed in thermal units, in which it is usually represented by the single letter a for convenience in writing or printing. The last factor dp/dt must be taken to correspond with the condition under which the specific heat dQ/dt is desired. Thus if we require the specific heat at constant volume $(dQ/dt)_v$, or S_v, we must also append the suffix v to dp/dt implying that it must be taken at constant volume. Making these substitutions in *(34)* we obtain the required expression for S_v,

$$S_v=(dQ/dt)_v=S_p-aT(dv/dt)_p(dp/dt)_v \tag{35}$$

Saturation Specific Heat.—As a further illustration of the same method, if we require the specific heat S_s of a wet vapour maintained in the state of saturation, implied by the suffix s, we have merely to replace the suffix v in (35) by the suffix s, thus,

$$S_s=(dQ/dt)_s=S_p-aT(dv/dt)_p(dp/dt)_s \tag{36}$$

in which $(dp/dt)_s$ represents the rate of increase of saturation pressure p with temperature, which is usually much larger than $(dp/dt)_v$ for the *dry* vapour. For this reason S_s is often negative, whereas S_v though smaller than S_p, is always positive. Thus, in the case of wet steam at 100° C, $S_s=-1{\cdot}04$.

By means of these and similar relations the variation of any specific heat can be calculated if one specific heat, such as S_p or S_v is known by experiment at the required temperature. In some cases these variations may be considerable, especially near the critical point of any substance. In general, if the path on the indicator diagram along which the specific heat is to be measured approaches the isothermal, the specific heat will become very large. If the path coincides with the isothermal, the specific heat becomes infinite, because there is finite absorption of heat while $dt=0$. When the path on the diagram is a little steeper than the isothermal the specific heat becomes *negative,* changing from positive to negative infinity in crossing the line. For any path between the isothermal and the adiabatic the specific heat is negative, falling to zero when the path coincides with the adiabatic $(dQ=0)$, and changing to positive again on the other side. Such changes would be very troublesome to deal with in experimental work, if the thermodynamic relations did not afford a complete method of taking them into account.

Cooling Effect in Adiabatic Expansion.—The efficiency of any heat engine depends primarily on the range of temperature through which the working fluid can be cooled while converting its heat energy into work done in adiabatic expansion. It is important for this reason to be able to observe and calculate the cooling effect, which is most conveniently defined as the ratio of the drop of temperature dt to the drop of pressure dp under the condition that no heat is supplied to the working fluid, and that the expansion is frictionless and reversible. The heating effect in compression is the same coefficient with the signs of both dp and dt reversed, so that its value is the same as that of the cooling effect in expansion. To find a thermodynamic expression for the cooling effect under the condition $dQ=0$, we may put $dQ/dt=0$ in the general expression *(34)* for the specific heat; in which case we must also take dp/dt in *(34)* under the same condition at constant Q, *i.e.*, we must write $(dp/dt)_Q$, which is the reciprocal of the required cooling effect $(dt/dp)_Q$. Substituting as before from Clapeyron's relation (33), we obtain immediately,

$$S_p(dt/dp)_Q=+aT(dv/dt)_p \tag{37}$$

which gives a general expression for the cooling effect, in terms of the specific heat and the coefficient of expansion, both at constant pressure, and comparatively easy to determine by experiment.

Thus if the specific heat of a *liquid* and its coefficient of expansion are known, as is the case for most liquids, it is easy to calculate the heating effect of a sudden compression. The effect is zero for water at its point of maximum density, but increases rapidly with the coefficient of expansion, since S is nearly constant.

In the case of a gas or vapour, which approximates to the equation $aPV=RT$ at low pressures, since (dV/dt) approaches the limit R/aP, the expression for the cooling effect becomes RT/SP, corresponding to the adiabatic equation in the form (10), with $SIR=n+1$. This shows that. if a vapour, like steam, obeys an adiabatic equation of this type with n constant, the limiting value S_o of its specific heat at zero pressure must be constant; *i.e.*, independent of the temperature. Conversely in the case of a gas, such as hydrogen, which follows the law $aPV=RT$ very accurately, there will be no variation of S with pressure, but any variation of S with temperature requires a corresponding variation in the index n+ 1, and in the cooling effect, which is equal to $T/(n+1)P$. In such a case, it is often much easier to measure the cooling effect directly with a thermometer of a well-adapted type than it is to measure the specific heat itself at high or low temperatures. The variation of the specific heat with temperature may then be deduced from observations of the cooling effect. This method was applied by Makower (*Phil. Mag.*, Feb. 1903) to verify the constancy of S in the case of steam by observing the cooling effect in a jacketed vessel at 110° C. By allowing the steam to expand suddenly from a pressure of 81 cm. to atmospheric and observing the corresponding drop of temperature, he found a value of the index $\gamma=1.304$, agreeing closely with that deduced from the engine experiments at much higher temperatures and pressures, as previously described. Brinkworth (Proc. Roy. *Soc.*, 1925) employed a similar method for verifying the variation of the specific heat of hydrogen at low temperatures. It will readily be understood that it is most important in all such cases to have an exact thermodynamical relation such as (37) between the coefficients to be measured. Otherwise the interpretation of the results is apt to be uncertain Thus it is usually possible to allow for the small variations of dv/dt in reducing the results, and similarly for the variations of S with pressure.

The **Joule-Thomson** Cooling Effect.—This is the most important coefficient of its type, and is most easily measured in steady flow. It was first measured by Joule and Thomson (1852), and was defined by them as the ratio of the drop of temperature to the drop of pressure in a pure throttling process, in which the kinetic energy generated by the pressure drop is completely reconverted into heat without any external heat loss. Under these conditions. as explained previously. the value of H is the same after passing the throttle as in the initial state, except that in any actual experiment at high temperatures it is necessary to make a small correction for heat loss. Since H remains constant in a pure throttling process, the cooling effect in throttling may be defined as the ratio of dT to dP at constant H and may be denoted by $(dT/dP)_H$ provided that small changes of temperature are being dealt with. In the example previously cited concern was only with the fact that the value of H at the high initial pressure and temperature must be the same as that observed at atmospheric pressure after throttling when corrected for heat loss. The drop of temperature amounted to more than 300° C., but the cooling effect represented by the ratio 300.3°/3789 lb., or 0.07925° per pound, does not enter explicitly into the calculation. though it might be described as the mean cooling effect over the given range. To find the limiting value of the cooling effect at a particular temperature and pressure, it is of course necessary to make measurements over much smaller ranges of temperature.

Variation of H *With* P.—The cooling effect C at constant H as thus defined is the ratio of the two partial differential coefficients of H with respect to P and T, thus,

$$C=(dT/dP)_H=-(dH/dP)_T/(dH/dT)_P \qquad (38)$$

This does not involve thermodynamics, but is merely a special case of the formal relation (30), as is easily verified by writing H in place of V in (30). Putting S for $(dH/dT)_P$, the specific heat at constant pressure, the useful relation $(dH/dP)_T=-SC$, giving the variation of H with P at constant T in terms of the specific heat S and the cooling effect C, which are the most easily measured of all coefficients, is given. Another expression for the same coefficient may be obtained by applying the two laws of thermodynamics. From the first law in the form $dH=dQ+aVdP$, as given in (5), dividing by dP at constant T,

$$(dH/dP)=(dQ/dP)_T+aV=-aT(dV/dT)_P+aV \qquad (39)$$

in which the second law is involved in the substitution for (dQ/dP) from Clapeyron's second thermodynamical relation (33), is found.

Joule-Thomson Equation.—The utility of relation (39) lies in the fact that it supplies the necessary and sufficient condition which must be satisfied by any expressions selected to represent H and V (the two most important thermodynamical properties of any substance) in order to render such expressions consistent with the laws of thermodynamics. Joule and Thomson made use of (39) in the form

$$SC=aT^2(d(V/T)/dT)_p \qquad (40)$$

in order to deduce an expression for V consistent with their observations on the cooling effect. Their experiments showed that C was approximately independent of the pressure, but varied as $1/T^2$ with temperature for air and CO_2 over the range 0° to 100° C. Integrating (40) at constant P, with S constant, and $C=K/T^2$, they obtained the solution:

$$-SK/3T^3=aV/T-R/P \qquad (41)$$

in which the constant of integration R/P was determined by the condition that the equation must approximate to the form $aPV=RT$ when T is very large. The small term $SK/3T^3$, which may be written $SC/3T$, represents the deviations of the actual gas, air or CO,, from the ideal state, in terms of the observed values of S and C for the gas employed. Thus equation (41) makes it possible to deduce the absolute temperature T from the observed temperature by air thermometer as defined in terms of P and V, but the process of reduction is far from being as simple as it might appear to be at first sight.

Moreover the original Joule-Thomson equation as given in (41), though it showed that the deviations of air from the ideal state must be very small, was somewhat unsatisfactory in other respects. It failed to explain the heating effect observed in the case of hydrogen, and made no allowance for the known variation of specific heat in the case of CO,. These difficulties may be avoided in practice by reversing the procedure. Assume a convenient type of equation for V, differentiate to find the expression for SC as in (39), and determine the constants by comparison with experimental results for S and C.

Modified Equation.—A suitable equation of a type similar to (41) is the following,

$$V-b=RT/aP-c, \text{ where } c=c_1(T/T)^n \qquad (42)$$

The small constant b, called the covolume, may be regarded as representing the limiting volume of the molecules at high temperatures and pressures. The small correction term c, called the coaggregation volume, represents the defect from the ideal volume caused by coaggregation or pairing of molecules. This is assumed to vary inversely as the nth power of T, and c_1 is the value of c at any convenient temperature T such as 0_o C. On this assumption c is a function of the temperature only, and $dc/dt=-nc/T$. Differentiating equation (42) in order to find SC as given by (39) or (40),

$$SC=aT(dV/dT)_P-aV=a(n+1)c-ab \qquad (43)$$

from which the values of the constants c, n, and b, may be deduced, when the values of S and C are known by observations taken over a sufficient range, is obtained. It is easy in this way to take account of any variations of S with temperature or pressure. The slope of the isothermals on the Amagat diagram, in which PV is plotted against P, is represented by $d(PV)/dP=-c+b$, and is positive in the case of hydrogen (for which PV increases with P) because b is so much larger than c at ordinary temperatures. For the same reason the cooling effect G is negative, as found by Joule and Thomson, who observed a rise of temperature with drop of pressure in throttling. This result is explained by (42), if b exceeds $(n+1)c$, as is actually the case with hydrogen.

Expression for the Total Heat **H.**—The same equation (42) may be employed as a simple illustration of the general method of deducing consistent expressions for the total heat and the entropy of a substance when an equation for V in terms of P and T has been obtained by the above method. To find an expression for H we start with the general formula for dH in terms of S and C, thus,

$$dH = SdT - SCdP. \qquad (44)$$

Since the value of H depends only on the state, we may perform the integration along any convenient path, starting from any convenient zero. The simplest method is to integrate the first term from o to T at zero pressure, since the value of S at zero pressure, denoted by S_o, is a function of the temperature only. We may denote this integral by S_mT where S_m is the mean value of S_o from o to T. We then have to add the integral of the second term at constant T from $P=o$ to P. In the present case, since SC is a function of T only, as given by (43), the integral of $SCdP$ is simply SCP. Adding the two terms, we obtain the general expression for H at T and P,

$$H - B = S_mT - SCP \qquad (45)$$

in which the constant of integration B is determined by reference to any known value of H at some definite point, such as 100° C and atmospheric pressure. In the case of steam, S_m may be taken as constant and equal to S_o.

Variation of the Specific Heat *S with Pressure.*—According to (45) the specific heat S at constant pressure will be a function of both temperature and pressure. The required expression for S is easily obtained by differentiating (45) at constant pressure, thus,

$$S = (dH/dT)_p = S_o + an(n+1)cP/T. \qquad (46)$$

This shows that, with an equation of the type (41) or (42), S cannot be constant, as assumed by Joule and Thomson in the integration of (40), and invalidates their method of deducing (41), but the same objection does not apply to the reverse procedure employed in deducing (42). The variation of S with pressure at constant temperature for any equation of this type can also be obtained from the consideration that H is a definite function of P and T depending only on the state, so that if we differentiate S as found in (46) with regard to P at constant T, we must obtain identically the same result, namely $d^2H/dPdT$, as by differentiating $(dH/dP)_T$ (or $-SC$) with regard to T at constant P. Using the general expression for SC given in (39), we obtain,

$$(dS/dP)_T = -(dSC/dT)_P = -aT(d^2V/dT^2)_P \qquad (47)$$

which shows that S cannot be independent of the pressure, if SC is a function of the temperature. From another point of view (47) represents the condition that dH as given in (44) should be the exact differential of a definite function of P and T, as must be the case if H is a property of the substance depending only on the state as defined by P and T. On the other hand if we apply the same condition to the general expression for dQ, namely,

$$dQ = SdT - aT(dV/dT)_P dP \qquad (48)$$

we observe that (47) cannot be satisfied in the case of dQ consistently with the second law of thermodynamics, because the heat added in any transformation is not simply a property of the substance depending on the initial and final states, but depends essentially on the process by which the transformation is effected. In other words, dQ is not the exact differential of any function of P and T, and cannot be integrated without knowing the relation between P and T defining the process. But if the path is given, Q can always be found from (48). Thus if the path on the indicator diagram is a straight line defined by $dP = kdT$, $dQ/dT = S - akT(dV/dT)_P$, and the required value of Q can be found for any substance for which the specific heat and the coefficient of expansion are known. The heat required for any transformation is often required in practice, and may always be obtained in this way, if the path is given.

Expression for the Entropy Φ.—If a small quantity of heat dQ per unit mass is supplied to any substance at a temperature T, the corresponding increase of entropy $d\Phi$ is dQ/T. Thus we obtain immediately from (48),

$$d\Phi = dQ/T = (S/T)dT - a(dV/dT)_P dP. \qquad (49)$$

If we apply the mathematical test for an exact differential, as in (47), we find,

$$(d[S/T]/dP)_T = (1/T)(dS/dP)_T = -a(d^2V/dT^2)_P \qquad (50)$$

which, it will be observed, is precisely the same as that found for dH. We conclude that 4, like H may be regarded as a property of the substance depending only on the state, and capable of tabulation in terms of P and T.

Since Φ itself cannot be measured in practice in any convenient manner, it is usually deduced for any substance from the expression found by experiment for H. Since $dQ = dH - aVdP$, by (5), taking dH from (44), we obtain,

$$d\Phi = dQ/T = (S/T)dT - (SC/T + aV/T)dP \qquad (51)$$

which is seen to be identical with (49) if we substitute for SC from (39). This may be integrated, as in the case of H, from o to T at zero pressure, with $S = S_o$, and from o to P at constant T. Taking as an example the simple equation (42) for V, with SC from (43), we find the expression,

$$\Phi - A = \int (S_o/T)dT - \int (R/P + anc/T)dP$$
$$= S_o \ln T - R\ln P - ancP/T \qquad (\ln = \text{rat. log.}) \qquad (52)$$

in which A is the constant of integration determined in the usual manner.

Use of the Entropy.—It should be observed that the entropy is not an independent property of the substance, since it can be deduced from H and V, but it is most useful in practice for defining the process of frictionless adiabatic expansion, and for deducing the maximum work obtainable from a quantity of heat supplied to the working substance under specified conditions. As a simple example we may take the case of the steam-turbine. Any part of the heat received (*e.g.*, in the superheater) at the constant initial pressure P' is represented in virtue of relation (3) by the increase DR of the total heat of the steam over the range considered. Let $D\Phi$ represent the increase of entropy taken from the tables over the same range of temperature. In the ideal cycle after adiabatic expansion the corresponding part of the heat rejected at the constant temperature T'' of the condenser will be $T''D\Phi$. The difference $DH - T''D\Phi$ represents the work obtainable from this part DH of the heat supplied, and the ideal efficiency is given by $1 - T''D\Phi/DH$. Thus it becomes possible to estimate the thermal efficiencies of different stages of the heating system, as depending on the temperature T' of heat reception by the working fluid.

The equivalent of the work theoretically obtainable in any part of an ideal cycle included between two adiabatics may also be found by subtracting the heat-drop along the lower adiabatic from that along the higher adiabatic. This gives the same result as subtracting the heat rejected from the heat received, but saves trouble in calculation if tables of adiabatic heat-drop are available.

If the "mean effective temperature" T_m of heat reception DH at constant pressure P is defined as being equal to $DH/D\Phi$, the expression for the ideal efficiency of the cycle between the two adiabatics differing in entropy by D4, reduces to the form $1 - T''/T_m$, the same as that of a Carnot cycle in which all the heat is received at one temperature T_m. As G. M. Clarke has pointed out, the mean effective temperature thus defined affords a convenient method of expression for the ideal efficiency of any cycle as compared with the Carnot cycle. But it does not supersede the use of the entropy, which is required in order to be able to calculate T_m.

Efficiency of Expansion in a Turbine.—The foregoing method of finding the efficiency of an ideal cycle, or part of a cycle, between two adiabatics, depends on assuming that the useful work done is equal to the excess of the heat received over that rejected by the working fluid, and is restricted to the case in which no losses are incurred in expansion, and all the heat is rejected at one temperature T'', as in the condenser of a steam-engine or turbine. The method gives the fraction of the heat received in any part of the heating system which could be converted into work by a perfect engine under the conditions imposed. On the other hand, in analysing the performance of an actual engine or turbine, it is necessary to take account of losses incurred in the engine during the expansion, and to compare the actual performance with that obtainable in adiabatic expansion under ideal conditions over the same range. The general principle of the method by which this may be accomplished in the case of a turbine is as follows:

The Case of Dry Steam.—As explained previously, and implied by equation (12), the drop of H in expansion through a turbine, when corrected for the minor losses Q and K, is the equivalent of the useful work done by the steam. So long as the steam is dry, the value of H at any point of the expansion can be determined by observing the pressure and temperature, and the actual drop of H, denoted by DH, between any two points can be deduced. The work theoretically obtainable in frictionless expansion can also be found from the adiabatic equation as shown in (17). The ratio of the actual hcat-drop DH, as corrected, to the adiabatic heat-drop for the same drop of pressure, gives the efficiency of any stage or section of the turbine. This simple method fails when the steam is wet, as usually happens towards the end of the expansion, because there is no satisfactory means of measuring the degree of wetness under these conditions at low pressures. But if the initial value Φ of the entropy is known, the adiabatic heat drop can still be found from the final temperature T'', with the aid of the tables giving H_s'' and Φ_s'' for dry saturated steam, since for wet steam in the state H'', Φ'', at any temperature T'' we have the simple relation,

$$H_s''-H''=T''(\Phi_s''-\Phi''). \tag{53}$$

Heat-Drop for *Wet Steam.*—Putting $\Phi''=\Phi'$ in (53) the final H'' for wet steam at T'', in adiabatic expansion, is obtained in terms of the tabulated values H_s and Φ_s. Thus we obtain for the adiabatic heat-drop from the initial state H', Φ'.

$$H'-H''=H'-H_s''+T''(\Phi_s''-\Phi'). \tag{54}$$

Equation (54) is also the appropriate equation to employ for finding the adiabatic heat-drop over the whole range of expansion in the turbine, from admission to exhaust, when the final state of the steam is wet, as is usually the case with a condensing engine. It is equally applicable to the case of a reciprocating engine, since the discontinuities involved in the operation of this type of engine are supposed to be absent from the ideal cycle. The heat-drop thus found may be compared with the work actually done per lb. of steam, as deduced from measurements of the feed and the power, for which see STEAM: Steam Engine.

Equation (53), with Φ'' constant and equal to Φ' may be regarded as the simplest and most useful form of the adiabatic giving the final value H'' of the total heat for a wet vapour, when tables of Φ and H are available. It may be expressed if desired in terms of H and T only, but cannot be put in the usual form (9) or (10) (as is often attempted), because the value of the index γ varies so much with temperature and wetness as to make the equation difficult to use and less accurate in practice than measurements on a diagram.

Types of Characteristic Equation.—The general relation between P, V, and T, which exists for any substance in various states is commonly called the characteristic equation, or equation of state, of the substance. It has often been thought possible to include both liquid and vapour states in a single equation, such as that of van der Waals, since the properties of the two states a p proximate to each other in the critical region, and show a continuous transition above the critical pressure. This will be further discussed in the article VAPORIZATION dealing with the relations between the two states. For the present purpose we may confine our attention to a few simple types of equation for the gas or vapour state, which is of primary importance in practice in relation to heat engines. It appears that all simple substances with stable molecules tend to approximate in the vapour state at low pressures to the ideal gas equation PV= RT, in which the value of the constant R varies inversely as the molecular weight (if V is the volume of unit mass) and is equal to the difference of the specific heats in work units. An equation of this type receives a satisfactory physical explanation on the kinetic theory of gases, but it is the province of thermodynamics to indicate how the simple gas equation must be modified to take account of deviations from the ideal state, and to interpret the results of various experimental methods as applied to the problem.

One of the commonest methods of measuring these deviations is to observe the variation of the volume with pressure at constant temperature. The values of the product PV should then be constant if Boyle's law is obeyed, and should give a horizontal line on the PV—P diagram. As a rule the isothermal lines thus plotted from observations at various constant temperatures, are nearly straight for a moderate range of pressure at each temperature, but have a downward slope, represented by $d(PV)/dP=-c$, where c diminishes with rise of temperature as the vapour approximates more closely to the ideal state. Observations of this kind could be represented by an equation of the type (42) by assuming PV to be proportional to T at low pressures, and choosing c, or $c-b$, to be a suitable function of the temperature. But even if all the isothermals were found to be horizontal, this method by itself would not prove that PV was proportional to the absolute temperature, as in $PV=RT$, since Boyle's law would be perfectly satisfied by an equation of the type, $PV=F(T)$, with $F(T)$ any arbitrary function of the temperature.

Fortunately the Joule-Thomson method, as described on page 98, affords an independent means of verifying the form of the characteristic equation. It has the additional advantages of being easy to apply and of measuring the small deviation itself, without requiring any absolute measurements of volume, which are essential to the Boyle's law method, and very exacting. As shown by the thermodynamic expression (40) for the cooling effect, any substance for which $C=0$ must have a characteristic equation of the general type $V/T=F(P)$, in which $F(P)$ represents any arbitrary function of the pressure. The ideal gas, $PV=RT$ is a special case for which $F(P)=R/P$. The condition $C=0$ by itself leaves the form of $F(P)$ indeterminate. But when the same gas also satisfies Boyle's law, which requires a characteristic equation of the form $PV=F(T)$, the two conditions can be simultaneously satisfied only by the ideal gas equation PV=RT. Joule and Thomson were therefore justified in their choice of the constant of integration R/P in equation (41), since the gases they employed also satisfied Boyle's law at low pressures.

Type of Equation Required by *Condition* (6).—Another case of practical interest is to find the general form of characteristic equation compatible with condition (6), and with the simple form of adiabatic equation (9), which follows by the first law of thermodynamics from the assumption that the change of intrinsic energy is proportional to that of aPV as expressed in (6). Equations (6) and (9) make no mention of temperature, and it is obvious that the deduction of the relation between PV and T must essentially involve an appeal to the second law with its implicit definition of T. The most direct way of doing this is to find the two specific heats, S_p and S_v, from H and E as given by (6), and to equate the difference, S_p-S_v, thus found to the expression (3j) for the difference of the specific heats as given by the second law. Thus by differentiating (6) at constant volume we obtain for the specific heat S_v,

$$S_v=(dE/dT)_v=an(V-b)(dP/dT)_v. \tag{55}$$

Similarly by adding aPV to (6) to give H— Binstead of $E-B$, and differentiating H at constant pressure, we obtain for the specific heat S_p,

$$S_p=(dH/T)_p=a(n+1)P(dV/dT)_p. \tag{56}$$

Substituting the difference of these two expressions for S_p-S_v in (35), and dividing by $a(dP/dT)_v(dV/dT)_p$, we obtain the required expression for T in terms of P and V in the form of a differential equation, namely,

$$T=(n+1)P(dT/dP)_v-n(V-b)(dT/dV)_p \tag{57}$$

which is a special case of Lagrange's linear equation, and is easily solved as follows.

(a) Write down the corresponding subsidiary equations of Lagrange, namely,

$$dT/T=dP/(n+1)P=-dV/n(V-b) \tag{58}$$

(b) Find any two independent solutions of these equations. The two simplest and most obvious solutions of (58) are those given in (10) above, which are alternative forms of the adiabatic equation, and are also solutions of (57). (c) To find the most general solution. including all other possible solutions, make one of these expressions an arbitrary function of the other. This will be the most general form of characteristic equation consistent with (6) and (9). The most convenient form for most practical purposes, giving V explicitly as a function of P and T, is as follows,

$$P(V-b)/T=F(P/T^{n+1}) \qquad (59)$$

which is expressed in words by stating that $P(V-b)/T$ must be constant along any adiabatic represented by $P/T^{n+1}=\text{constant}$. Thus (59) includes all possible forms of characteristic equation consistent with the adiabatic found experimentally for steam, and with the expression (6) for the intrinsic energy, which was assumed as the basis of the equations first proposed for steam by the writer (Proc. R.S. 1900, p. 269). At that time none of the experimental evidence available, except that for the adiabatic, extended much beyond 200 lb. pressure and 200° C, and the state of knowledge did not justify going further than the first approximation represented by equation (42), in which the arbitrary function F was assumed to be of the simple form $R/a-cP/T$. This proved to be a very good approximation and amply sufficient at moderate pressures or high superheats, but it appeared that higher powers of cP/T would be required at higher pressures. and that no equation of this type could represent the accepted theory of the critical state, as represented by the van der Waals equation.

While retaining the fundamental assumption (6) it would evidently be possible to construct an equation of the van der Waals type, giving P as a cubic function of $1/(V-b)$, by replacing P/T^{n+1} in (59) by $1/(V-b)T^n$, as follows,

$$aP(V-b)/RT=1-c/(V-b)+c^2/3(V-b)^2 \qquad (60)$$

which would give a critical point of the usual type defined by the conditions,

$$V-b=c=RT/3aP, \qquad (61)$$

but in the absence of accurate experimental data it was impossible to predict that this would be more satisfactory than (59) in terms of P, whereas it would certainly be much less convenient for practical calculations.

It has recently been found possible (Proc. R.S. Sept. 1928), to extend the experimental range for water and steam to 400° C and 4,000 lb. pressure, including the whole of the critical region. Results obtained for water, by the steady flow method described in the article CALORIMETRY, verify the thermodynamic equation there given for the total heat with extreme accuracy up to the critical point. Those for steam disagree materially on several fundamental points with the accepted theory of the critical state, and appear to show that an equation of the type (59) is capable of representing the critical phenomena with much greater accuracy than any equation of the van der Waals type. Since the points in question are of primary importance with respect to the relations between the liquid and vapour states, they are further discussed in the article VAPORIZATION, though they also afford a good illustration of the application of the laws of thermodynamics to experimental research.

As it would be impossible within the limits of this article to illustrate or explain adequately the applications which have been made of the principles of thermodynamics, it has been necessary to select such illustrations only as are required for reference in other articles, or could not be found elsewhere. For fuller details and explanations of the elements of the subject, the reader must refer to general treatises, such as Ewing's *Thermodynamics* for Engineers (Cambridge, 1920), Birtwistle's The Principles of Thermodynamics (2nd ed , Cambridge, 1927) or Preston's Theory *of* Heat (5th ed., 1928). One or two chapters on the subject are also generally included in treatises on the steam engine or other heat engines, such as those of Rankine. Ewing, or Perry. Of greater interest, especially from a historical point of view, are the original papers of Joule, Kelvin and Rankine. A more elaborate treatment of the subject will be found in many foreign treatises, such as those of Clausius, Zeuner, Duhem, Bertrand, Planck and others. (H. L. C.)

THERMODYNAMICS AND PHYSICAL CHEMISTRY

Introductory.— The principles of thermodynamics (introduced in their modern form by Clausius in 1850) are the basis of a method of dealing with mechanical problems in which heat exchanges take place, without the necessity arising of considering the detailed mechanical structure of a system. The system may consist of an assemblage of an enormous number of molecules in agitated movement and exerting attractions and repulsions upon one another. Very little can be found out about the individual motions and positions of these particles. Thermodynamics provides a means of examining certain properties of matter in bulk. The principles that are discovered form the basis of the preceding article and reference must be made to that article for their description and proof. They are applied there mainly to the properties of steam and its applications to steam-engines. In the present article which deals with the application to bodies in general we must be content with summarizing the fundamental facts which will be utilized.

i. The intrinsic or internal energy of a body can change by the entry of heat (by conduction or radiation) and by the performance of external work, i.e., $dE=dQ-dW$ provided the system remains sensibly in equilibrium (*Conservation of energy*).

ii. A body may get hotter even if no heat flows in. The energy depends on the temperature and this is increased if work is done upon the system even when dQ is zero (Adiabatic *changes*).

iii. The energy, E, depends only upon the state; so that, in whatever way the system is changed, if the original state is returned to, the initial value, E, is recovered.

iv. The work done depends in general not only upon the initial and final states but also upon the path of transformation.

This results from the fact that three variables at least are necessary to specify the state, viz., pressure, volume and temperature, and they are connected by only one equation (the equation of state). The work done is in each case $\int pdV$. In a complete cycle the work done is equal to the area enclosed by the cycle on a p, V diagram. For any given value of V, T and therefore p may have different values on the return and forward paths and the cycle encloses an area. It follows that for an *isothermal* reversible cycle the pressure for any given volume is fixed and the work done must be zero for the path then returns on itself.

v. The energy E depends on both the temperature and the volume: for internal work can be done against molecular attractions when the volume changes.

When the system is subjected to a uniform pressure the fundamental equation becomes $dH=CdT+ldv$.

We select unit mass for consideration. In this case C is the specific heat at constant volume and $l\left(=\frac{\Delta H}{\Delta v}\right)$ is the latent heat of expansion. In the case of a perfect gas, for which the characteristic equation is $pv=RT$ and for which no internal attractions exist, so that the internal work is zero

$$dH=C_vdT+pdv$$

which can be put in the alternative forms (by using the characteristic equation)

$$dH=C_pdT-vdp=\frac{1}{R}(C_ppdv+C_vvdp)$$

where C_v and C_p are the specific heats at constant volume and at constant pressure.

From these for adiabatic changes ($dH=0$)

$$C_vdT+\frac{RT}{V}dv=0 \quad \text{or} \quad vT^{C_v/R}=\text{const.}$$

$$C_pdT-\frac{RT}{p}dp=0 \quad \text{or} \quad \frac{T^{C_p/R}}{P}-\text{const.}$$

and $$C_ppdv+C_vvdp=0 \quad \text{or} \quad pv^{C_p/C_v}=\text{const.}$$

The work done is $\int pdv=-C_v\int dT=C_v(T_1-T_2)$.

It is presumed that the changes are reversible throughout. A very quick change is always irreversible owing to the rushes of material that take place. The only way to bring about approximate reversibility is to keep the heat from getting in or out as well as possible by means of non-conducting boundaries.

vi. The second law of thermodynamics enables relations to be found between the several quantities (or their derived quantities). According to this law the work that can be done in a reversible Carnot cycle is the maximum possible for the two extreme temperatures concerned, and, *independently of the working substance*, the work done divided by the heat taken in at the higher temperature is equal to $(T_1-T_2)/T_1$: where T_1 and T_2 are absolute temperatures on the perfect gas scale. This ratio is called the efficiency.

[This law is derived from the fact that heat can only flow *down* a gradient of temperature. Clausius showed that if a more efficient performance were obtainable it would be possible to make a hot body hotter while simultaneously a cold one became colder without any performance of work. This would entail that heat flowed *up* the temperature gradient.]

vii. Since the efficiency is also given by $\frac{W}{Q_1}=\frac{Q_1-Q_2}{Q_1}$ we deduce that $\frac{Q_1}{T_1}=\frac{Q_2}{T_2}$.

Now in a Carnot cycle Q_1 and Q_2 are the only transfers of heat (each at constant temperature); if therefore me define a quantity ϕ such that $Td\phi=dQ$ this quantity ϕ undergoes zero change in any complete reversible cycle. It is called the entropy of the system per unit mass.

For irreversible changes this definition is not complete. In such changes there is kinetic energy of matter in bulk; and friction which is alnays present is continually frittering the motion down into heat. If we regard the system as an assemblage of small elements rubbing against one another the heat produced flows across the boundaries of these elements. In doing so some has entered each element and produces the same changes of p, v, T and entropy as any heat entry would do. When this heat production and corresponding entropy change is summed up for the whole system we have

$$Td\phi=d(Q+q)$$

where q is the heat produced by friction inside the walls of the complete system. Since friction never produces "cold," dq is always positive and consequently for any change

$$Td\phi\geqq dQ.$$

Cases in which the equality sign holds are ideal cases only; but they are approximated to more nearly the nearer a system keeps in equilibrium states throughout.

The quantity T_1 is, as we have said, the absolute temperature according to a perfect gas scale. We could have defined it alternatively in terms of the efficiency equation and it is therefore called the *thermodynamic* temperature. It would have been necessary then to show that it is identical with the ideal gas scale.

The advantage gained by introducing the conception of entropy is that it provides us with a function of Q which depends (unlike Q itself) only upon the state of the system, provided that we measure it for reversible changes only.

viii. When any property of the state of a system (say E) is defined completely by two independent variables (say x and y) so that we can write

$$dl3=adx+bdy$$

where $$a=\left(\frac{\partial E}{\partial x}\right)_y \quad\text{and}\quad b=\left(\frac{\partial E}{\partial y}\right)_x$$

the following mathematical relation must be valid, viz.:

$$\left(\frac{\partial a}{\partial y}\right)_x=\left(\frac{\partial b}{\partial x}\right)_y$$

the suffixes denoting quantities which remain constant during the partial differentiations to which they are appended.

This mathematical relation can be applied in the case of reversible changes to E and + which depend only on the state but it cannot be applied to Q or to W, which depend upon the path taken between the extreme states. In consequence some writers prefer not to use the expressions dQ and dW for small changes in Q and W because, for example, these may each acquire different values whether the "co-ordinates" of the system (e.g., v, T) have changed on *the* whole or not. Small changes in quantities which depend only upon the state are said to be perfect differentials.

When there are more than two independent variables we can apply the same theorem to any two of them in turn. For example, adding a third term cdz, we have the additional relations

$$\left(\frac{\partial a}{\partial z}\right)_{x,y}=\left(\frac{\partial c}{\partial x}\right)_{y,z} \quad\text{and}\quad \left(\frac{\partial b}{\partial z}\right)_{y,x}=\left(\frac{\partial c}{\partial y}\right)_{z,x}$$

where two of the independent variables are kept constant in each differentiation.

The employment of thermodynamics in the study of various systems consists very largely of the application of this important mathematical theorem. We shall apply it first to homogeneous systems in equilibrium.

Homogeneous **Systems.—A** homogeneous system is alike in all its parts. Its state can be defined in terms of its pressure, volume and temperature. Any one of these three may be eliminated by means of the so-called characteristic equation when it is known; so that Q, ϕ, E may be taken as functions of T and v, of T and p, or of p and v. Since each portion is the same as any other we can deal with unit mass. Since equilibrium exists the temperature and pressure will be uniform throughout. No assumption will be made as to the molecular constitution of the system; nor, until applications are considered will any assumption be made as to the form of the characteristic equation.

For such a system we can write:

$$dQ=dE+pdv=C_vdT+ldv$$

also $$d\phi=(dQ)/T.$$

so that $$dE=C_vdT+(l-p)dv$$

and $$d\phi=\frac{C_vdT}{T}+\frac{l}{T}\,dv.$$

It follows that (a) $$\left(\frac{\partial C_v}{\partial v}\right)_T=\frac{\partial}{\partial T}(l-p)_v$$

(b) $$\frac{1}{T}\left(\frac{\partial C_v}{\partial v}\right)_T=\left(\frac{\partial}{\partial T}\frac{l}{T}\right)_v.$$

The latter (b) multiplied by T gives

$$\left(\frac{\partial C_v}{\partial v}\right)_T=\frac{\partial l}{\partial T}-\frac{l}{T}$$

which, comparing with (a), giver $l=\mathrm{T}\left(\frac{\partial p}{\partial T}\right)_v$

and $$\left(\frac{\partial C_v}{\partial v}\right)_T=T\left(\frac{\partial^2 p}{\partial T^2}\right)_v.$$

For a perfect gas $pv=\mathrm{RT}$, whence $\mathrm{T}\left(\frac{\partial p}{\partial T}\right)_v=p$ and $\left(\frac{\partial C_v}{\partial v}\right)_T=0.$

For a van der Waals gas 3+ – $(v-b)=\mathrm{RT}$, so that

$$T\left(\frac{\partial p}{\partial T}\right)_v=p+\frac{a}{v^2} \quad\text{and}\quad \left(\frac{\partial C_v}{\partial v}\right)_T=0;$$

whence $dQ=C_vdT+\frac{adv}{v^2}+pdv$; the term $\frac{a}{v^2}dv$ shows how the energy depends upon the volume.

It will be noticed that these are all cross-relations between different terms. There is no thermodynamical relation giving $\frac{\partial C_v}{\partial T}$ because C_v and T both refer to the same term. We know nothing about C_v as a function of T except from experiment and from tentative mechanical theory.

In a similar way if $dQ=C_pdT+l'dp$ (T and p being taken as independent variables) me have

(a) $$dE=C_pdT+l'dp-pdv$$

and (b) $$d\phi=\frac{C_pdT}{T}+\frac{l'dp}{T}.$$

Now $d(pv)=pdv+vdp$; and if this be added to both sides of (a) we have $d(E+pv)=C_pdT+(l'+v)dp$. Since, the product pv

returns to a fixed value whenever p and v do therefore $E+pv$ also depends on the state alone and its change is defined here in terms of dT and dp. Hence

$$\left(\frac{\partial C_p}{\partial p}\right)_T = \left[\frac{\partial}{\partial T}(l'+v)\right]_p$$

and
$$\left[\frac{\partial}{\partial p}\left(\frac{C_p}{T}\right)\right]_T = \left[\frac{\partial}{\partial T}\left(\frac{l'}{T}\right)\right]_p$$

which yield finally $l' = -T\left(\frac{\partial v}{\partial T}\right)_p$ and $\left(\frac{\partial C_p}{\partial p}\right)_T = -T\left(\frac{\partial^2 v}{\partial T^2}\right)_p$

It is to be noted that these equations in reality express the connections that must e s b e e n e properties of a substance in order to bring about the universality of the value of the efficiency if the substances were employed as the working substances in reversible engines working between two given temperatures. A high vapour pressure or a low boiling point does not lead to higher efficiency, the variables being so interconnected that this is impossible.

The above equations hold for any homogeneous systems. The equation

$$dQ = C_v dT + T\left(\frac{\partial p}{\partial T}\right)_v dv$$

is exceedingly important, embodying all that can be learned from the two thermodynamical principles, and serving as a secondary starting point from which other relations may be obtained without further reference to the two principles. For example if x is any other variable we can write

$$\left(\frac{dQ}{dT}\right)_x = C_v + T\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{dv}{dT}\right)_x$$

the suffix x indicating that x is to be kept constant during the differentiation. For example, if $x=p$ (the pressure), $\left(\frac{dQ}{dT}\right)_x = C_p$ (the specific heat at constant pressure) and we have

$$C_p = C_v + T\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_p$$

which is an expression for the difference between the two principal specific heats. For a perfect gas the right hand side equals R, the gas constant. For a van der Waals fluid it equals

$$R \Big/ \left(1 - \frac{2a}{v^3}\cdot\frac{(v-b)^2}{RT}\right).$$

Berthelot's equation of state is very widely used in calculating the difference of the specific heats. The equation is

$$\left(\alpha + \frac{16}{3\gamma\beta^2}\right)\left(\beta - \frac{1}{4}\right) = \frac{32}{9}\gamma.$$

It is given here in its "reduced" form; *i.e.*, the actual pressures, volumes and temperatures are given as the fractions α, β, γ of their respective critical values. Calculating in the same way, this equation leads to

$$C_p - C_v = \frac{32}{9}\frac{p_c v_c}{T_c}\left(1 + \frac{6}{\gamma^2\beta}\right) \text{ approximately}$$

when β is large compared with unity. This can be written

$$C_p - C_v = R\left(1 + \frac{6}{\gamma^2\beta}\right) \doteqdot R\left(1 + \frac{27}{16}\frac{\alpha}{\gamma^3}\right)$$

where R is the characteristic constant of the gas.

Callendar's simplified equation, $v-b = RT/p - c/T^n$ leads to

$$C_p - C_v = R\left(1 + \frac{ncp}{RT^{n+1}}\right)^2.$$

The last two equations are only applicable when the density is moderate.

Saturation Values.—As a second application, let x denote a change along the line of saturated vapour; then $\left(\frac{dQ}{dT}\right)_x$ becomes σ, the specific heat of saturated vapour, and

$$\sigma = C_v + T\left(\frac{\partial p}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_{\text{sat.}}$$

Now $\left(\frac{\partial p}{\partial T}\right)_v$ is always positive and $\left(\frac{\partial v}{\partial T}\right)_{\text{sat}}$ is always negative so that σ is always less than C_v and it may even be negative. This latter is the case for steam at all temperatures. The values for sulphur dioxide have also been studied in detail experimentally by Mathias (*Comptes Rendus*, t. cxix. p. 849). The importance of this substance in mechanical refrigeration warrants quoting the values in some detail:

t° C	0	20	40	60	80	100	110
σ	−0·410	−0·357	−0.300	−0·235	−0·165	+0·027	+0·062
t° C	120	125	130	140	150	155	..
σ	−0·078	−0·176	−0·306	−0·620	−1·253	−3·850	..

It appears that for this substance σ is negative except between the temperatures 97·5° C and 114° C. When plotted against temperature the curve is an inverted unsymmetrical U. This is so for all substances but in many cases it lies wholly in the negative region. The value of σ for the liquid along the saturation line has also been studied by Mathias. It is positive (because for the liquid $\left(\frac{\partial v}{\partial T}\right)_{\text{sat}}$ is positive) and changes from 0·315 at −20° C to 1·800 at 155° C.

We can start equally well from the equation

$$dQ = C_p dT - T\left(\frac{\partial v}{\partial T}\right)_p dp$$

and find
$$\sigma = C_p - T\left(\frac{\partial v}{\partial T}\right)_p \left(\frac{dp}{dT}\right)_{\text{sat}}$$

The thermodynamic equations employed above are exact. It should be noted, however, that the characteristic equations are only approximate at best. The underlying assumption that is made in deriving them is that the system consists of molecules alike in all respects. Even in such a case it is not to be expected that the p, v, T, equation should be of a simple form. It is much simplified by the fact that we are only concerned with average values. No instrument is capable of measuring either the pressure or temperature at a single point and a single moment of time. Each quantity measured is an average value over such a volume or area or time as to maintain a constant value in the equilibrium state. For real fluids molecules may be of different kinds and may be associated with one another in different ways which change with the volume and temperature. In such cases the connection between p, v and T is bound to be of a more elaborate character. The only assumption that has been made is that for a definite p, v, T, the constitution is the same whenever these return, after changes, to their original values.

Entropy.—Since $dQ = C_v dT + p dv$ for a perfect gas the entropy change is

$$d\phi = \frac{dQ}{T} = C_v\frac{dT}{T} + R\frac{dv}{v};$$

whence
$$\phi_2 - \phi_1 = C_v \log_e \frac{T_2}{T_1} + R \log_e \frac{v_2}{v_1}$$

$$= C_p \log_e \frac{T_2}{T_1} - R \log_e \frac{p_2}{p_1}.$$

For a van der Waals fluid

$$dQ = C_v dT + T\left(\frac{\partial p}{\partial T}\right)_v dv$$

$$= C_v dT + \frac{RT}{v-b} dv$$

and
$$\frac{dQ}{T} = C_v \frac{dT}{T} + \frac{R}{v-b}\, dv.$$

Now C_v for such a fluid may be a function of T but not of v, and experiment shows that, for many gases, it is very nearly a linear function of T through a range of seven or eight hundred degrees centigrade. If we write $C_v = c + gT$

$$\phi_2 - \phi_1 = c \log\frac{T_2}{T_1} + g(T_2 - T_1) + R \log\frac{v_2 - b}{v_1 - b}.$$

Thermodynamic Potentials.—It has been explained that, when the possibility of irreversible changes is taken into account the increase in entropy is always greater than that calculated from the heat entry from outside the system, *i.e.*, we may write

$$Td\phi = dQ + Pos.$$

where Pos. is a positive quantity. In the ideal case of a reversible change this positive quantity becomes zero. For any change therefore

$$dE = dQ - pdV$$
$$= Td\phi - pdv - Pos.$$

If we subtract $d(T\phi)$ from both sides

$$d(E - T\phi) = -\phi dT - pdv - Pos.$$

If the change is at constant temperature $\phi dT = 0$.

To the quantity brackets on the left Helmholtz gave the name free energy. Representing it by F we write, at constant temperature

$$-dF = +pdv + Pos;$$

i.e., the isothermal decrease of free energy is equal to the work done by the system plus a positive quantity. Since, for a reversible change, Pos = zero, the work done is then a maximum for a given isothermal diminution of free energy. This is known as the principle of maximum work.

The isothermal change of free energy may be greater or less than the change of energy, E, because nothing is specified as to whether heat enters or leaves the system during the isothermal change. For in such a change

$$dE = dF - Td\phi \quad (dT = 0)$$

and $Td\phi (= dQ)$ may be positive or negative.

If the change is made at constant temperature and constant volume $-dF = Pos.$ Hence in any such change the free energy can only decrease.

If the free energy reaches a minimum value in such a change no further decrease can occur. The system (at constant temperature and volume) must then be in equilibrium.

In ordinary mechanics a system is in equilibrium when its potential energy is a minimum. In this more general problem where thermal changes must be allowed for this property belongs to the free energy. The theorem is general; no assumption has been made in regard to the constitution of the system. Unfortunately difficulties arise in attempting to apply it excepting in the case of an ideal gas mixture.

For such an ideal mixture the various components of the system are independent of one another. The total pressure, energy, entropy, and free energy are given by the sums of the values for the separate components.

Let the constant volume and temperature be V and T, and let the contents consist of a number of gases capable of reacting according to the general law of chemical combination

$$\nu_1 A_1 + \nu_2 A_2 + \cdots = \nu_s A_s + \nu_t A_t + \cdots$$

and let them be present when in equilibrium in the proportions

$$N_1 N_2 \ldots N_s N_t \cdots$$

where the values of N are the numbers of molecules of the various kinds present. It is necessary, in the first case, to calculate the free energy per molecule of each component.

Now reckoning from any arbitrary temperature T_0 we may write

$$E = C_v(T - T_0)$$

$$\phi = C_v \log\frac{T}{T_0} + R(\log v - \log v_0)$$

$$= C_v \log T + R \log\frac{V}{N} + k$$

where k is a constant and the other quantities are the values per molecule. Hence

$$F = C_v T + TC_v \log T + RT\log\frac{V}{N} + kT - C_v T_0.$$

Since the temperature is to be treated as constant we may conveniently divide by it and write

$$F/T = C_v + C_v \log T + R\log\frac{V}{N} + k - \frac{C_v T_0}{T}$$

and for N molecules of any one kind this must be multiplied by N. Now the total value of the free energy is $\sum(NF)$ and this, or its value divided by the constant T, is to be a minimum for equilibrium, *i.e.*,

$$\sum \frac{1}{T}\left(F + \frac{dF}{dN}\right) dN$$

must equal zero. But owing to the laws of chemical combination any changes of the quantities must satisfy the equations

$$\frac{dN_1}{\nu_1} = \frac{dN_2}{\nu_2} = \cdots - \frac{dN_s}{\nu_s} = -\frac{dN_t}{\nu_t}.$$

Hence $$\sum_{1,2\text{ etc.}}\left(F + \frac{dF}{dN}\right)\nu = \sum_{s,t\text{ etc.}}\left(F + \frac{dF}{dN}\right)\nu.$$

Performing the operations after dividing by T it follows that

$$\sum_{1,\text{ etc.}}\left(C_v + C_v\log T + R\log\frac{V}{N} + k - \frac{C_v T_0}{T} - \frac{KN}{N}\right)\nu = \sum_{s,t,\text{ etc.}}(\quad)\nu;$$

or $$\sum_{1,2\text{ etc.}} R\nu \log\frac{V}{N} = \sum_{s,t\text{ etc.}} R\nu\log\frac{V}{N} + \text{function of } T \text{ alone};$$

or $$\log\frac{V^{\nu_1+\nu_2} \cdots {}^{-\nu_s-\nu_t}}{N_1^{\nu_1} N_2^{\nu_2} \cdots N_s^{-\nu_s} N_t^{-\nu_t}} = \text{function of } T.$$

This is the equation of chemical equilibrium at constant volume and temperature. If we write $\frac{N_1}{V} = n_1$, $\frac{N_2}{V} = n_2$, etc., it becomes

$$\log\frac{\cdots n_t^{\nu_t} \cdots}{n_1^{\nu_1} n_2^{\nu_2} \cdots} = \text{function of } T.$$

The quantity under the logarithm sign is the equilibrium constant for constant temperature and volume. If the equation in terms of N_1, N_2 etc. is examined it will be seen that when

$$\nu_1 + \nu_2 + \cdots = \nu_s + \nu_t \cdots$$

a change of volume will not disturb the equilibrium. On the other hand if $\nu_1 + \nu_2 + \cdots$ is the greater sum then an increase of V will increase the values of N_1, N_2, etc. and diminish those of N_s, N_t, etc.

The former case would be illustrated by a reaction such as

$$\begin{array}{ccc} H_2 + Cl_2 & \rightleftharpoons & 2HCl \\ N_1 \quad N_2 & & N_3 \end{array}$$

where $\nu_1 = 1$, $\nu_2 = 1$ and $\nu_3 = 2$; and the latter case by

$$2H_2 + O_2 \rightleftharpoons 2H_2O$$

in which the $\sum(\nu)$ on the left is one greater than of the one on the right. This is stated without prejudice to the question as to whether the above reactions usually occur or not.

The function of temperature involves the specific heats (or molecular heats), which depend upon the temperature in a way undeterminable by thermodynamics, as well as the constants of integration. The values of the specific heats can however be ascertained by experiment and thus the value of the equilibrium constant at any temperature can be calculated within a constant.

Any deviation that is found from these conclusions may leave it a moot point whether the reactions are not of the specified type or whether the deviations are due to departures from the ideal gas law.

The equilibrium constant was first given by Guldberg and Waage. They based it on the laws of probability of encounters between the reacting molecules. Taking the probability of an encounter of any molecule of the first with one of another kind as proportional to N_1, the probability that ν_1 of them will simultaneously collide is $N_1 N_1 N_1 N_1 \ldots$ to ν_1 terms; that is, it is $N_1^{\nu_1}$. Similarly for N_2 the required probability is $N_2^{\nu_2}$. Further the probability that the two groups shall collide simultaneously is $N_1^{\nu_1} N_2^{\nu}$, and so on. Some slight departure from the gas law is needed in order that collisions may occur at all; for if the molecules had no volume there would be nothing to collide against. But if the volume occupies a sensible proportion of the total system, corrections are required to Guldberg and Waage's law; and any attractions between the molecules, which will necessarily increase the number of collisions, necessitates still further corrections, so that this niethod of attacking the problem lands us in difficulties. The same is true of the thermodynamic method which has been given in detail, when other characteristic equations are employed; even the total pressure is not the sum of the "partial" pressures as it would be according to Dalton's law. The additive law breaks down also for all the other functions (E, ϕ, etc.). We shall return to the problem after dealing with heterogeneous equilibria.

But first some of the other properties of the free energy must be stated. Since for reversible changes $dF = -\phi dT - p dv$ it follows that

$$\left(\frac{\partial F}{\partial T}\right)_v = -\phi \text{ and } \left(\frac{\partial F}{\partial v}\right)_T = -p.$$

But $$F = E - T\phi = E + T\left(\frac{\partial F}{\partial T}\right)_v.$$

Therefore $$T\left(\frac{\partial F}{\partial T}\right)_v - F = -E$$

or $$\frac{\partial}{\partial T}\left(\frac{F}{T}\right)_v = -\frac{E}{T^2}.$$

It should be noted that the decrease of F in a reaction is often represented by A and the corresponding *evolution* of energy (*i.e.*, the heat of reaction at constant volume) by U. In terms of these quantities the equation becomes

$$T\frac{\partial A}{\partial T} - A = -U$$

which is of the same form as before.

Again, since F depends, in reversible changes, only upon the state (because E, T, and ϕ so depend) it follows that

$$\frac{\partial^2 F}{\partial v\, \partial T} = \frac{\partial^2 F}{\partial T\, \partial v}$$

and therefore $$-\left(\frac{\partial \phi}{\partial v}\right)_T = -\left(\frac{\partial p}{\partial T}\right)_v.$$

Since, we can write $Td\phi = dQ$ this is identical with the equation already found, viz.:

$$\left(\frac{\partial H}{\partial v}\right)_T = l = T\left(\frac{\partial p}{\partial T}\right)_v.$$

Heterogeneous Systems.—A heterogeneous system is one in which the whole system can be divided into discrete parts each of which is homogeneous but differs from its neighbours. Each is called a "phase". 'Cl'ithout at first considering such systems in general we may take the familiar case of a vessel containing a liquid and its vapour or a solid and a liquid. These can at certain temperatures be in equilibrium with one another. Putting aside the effects of gravity and other body forces, when equilibrium exists the pressure must be uniform throughout the system for mechanical reasons, provided there is no curved interface between the phases; and the temperature must be uniform throughout for reasons depending upon conduction and radiation. The values of these variables are independent of the relative amounts of liquid and vapour. Let $1-m$ and m be the masses of the two phases in a system of unit mass; and let v_1 and v_2 be their specific volumes (*i.e.*, volumes per unit mass) then the total volume is $(1-m)v_1 + mv_2$. The uniform pressure is the saturation pressure; we denote it by the symbol a the value of which experiment shows to be independent of the volume but dependent upon the temperature. The total energy is $E = (1-m)E_1 + mE_2$ where E_1 and E_2 are the energies per unit mass of the respective phases. The entropy is $\phi = (1-m)\phi_1 + m\phi_2$. Any heat that enters may be divided into two parts corresponding to the phases it passes into. Since the law of summation obviously applies throughout we can write

$$dQ = CdT + ldV \text{ as before}$$
$$= \{(1-m)\sigma_1 + m\sigma_2\}\, dT + ld\,((1-m)\, v_1 + mv_2\}$$

provided, at least, that neither of the phases vanishes. Now the same considerations as before give

$$l = T\left(\frac{\partial \pi}{\partial T}\right)_v = T\frac{\partial \pi}{\partial T}$$

since π is independent of V. The change of volume is $(v_2 - v_1)dm$ so that the equation becomes

$$dQ = ((1-m)\sigma_1 + m\sigma_2\}\, dT + T(v_2 - v_1)\frac{d\pi}{dT}\,dm.$$

The heat taken in when unit mass evaporates at constant temperature is called the latent heat of evaporation; it is equal to the coefficient of dm and is therefore

$$L = T\,(v_2 - v_1)\frac{d\pi}{dT}$$

This is the equation of latent heat for a change of phase first given in the present form in 18jo by Clausius but actually found to be verified by experiments made in the case of the change of ice into water by Lord Kelvin in 1850 before he had accepted the law of the conservation of energy. These experiments were first interpreted in terms of a calculation made by his brother James Thomson in 1849 based upon Carnot's theory of the conservation of heat (not energy)—the effect to be expected from lowering a quantity of heat through one degree being determined, *not* by theory, but by comparison with results obtained from Regnault's expcrimcnts on steam. The lowering caused by an increase of the equilibrium pressure π by 140 atmospheres is about one degree centigrade. It is a lowering in the case of ice-water because $v_{\text{ice}} > v_{\text{water}}$; it is a rise in the transition temperature (*i.e.*, the boiling point) in the case of water-steam because $v_{\text{steam}} > v_{\text{water}}$. We can conveniently take the equation in the form

$$dQ = \{(1-m)\sigma_1 + m\sigma_2\}\, dT + Ldm$$

so that the independent variables become T and m. Consider now an adiabatic change, $dQ = 0$; then

$$\frac{dm}{dT} = -\frac{(1-m)\sigma_1 + m\sigma_2}{L}$$

Since the symbols σ_1, σ_2 stand for saturation values, σ_1 is positive but σ_2 may be negative. If we write $(-\sigma_2)$ in such case for its positive numerical value we find that dm will be negative when dT is negative provided that $(1-m)\sigma_1$ is numerically less than $m(-\sigma_2)$, *i.e.*, that liquid will form in the case of water-steam when the temperature lowers. Since the water deposits most readily on particles of dust, etc., in the vessel a cloud will appear. This is obviously most likely to happen when the amount of water initially present $(1-m)$ is small compared with the amount of vapour (m). In the case of a positive value for σ_2 no cloud can form.

A reversible *isothermal* expansion of a mixture of water and steam always causes evaporation.

Phase **Rule.**—We have considered the co-existence of water and steam and of ice and water in separate phases. The possibility of this co-existence is determined by the *phase rule* due to Willard Gibbs. The dividing surfaces between the phases are presumed to be plane so as to exclude effects arising from surface tension. The phase rule asserts that the number of independent variations of which a system of co-existent phases is capable is $C+2-P$ where C is the number of independently variable *components* in the whole system. The term *component* must be carefully distinguished from *constituent*. Thus in dealing with water and steam, hydrogen and oxygen are constituents of each phase, but since they can only vary in chemically combining proportions it would be sufficient to specify either of them or even the amount of water present. Thus there is only one component in this case. If free hydrogen (or oxygen) were present as well in excess there would be an additional component and there is again an arbitrary choice as to the two components to be selected. The proof of the rule is that the system of phases is completely specified by the temperature, pressure and the data for the C components and between these $C+2$ quantities there are P independent relations (one for each phase), which characterize the system of phases.

For example, in the case of water which can exist (not necessarily co-exist) as ice, water or steam there is one component and three possible phases so that if all are present $C+2-P=0$ and there is no disposable relation—their states (defined by v and T) are absolutely fixed. If only two of the phases are present $C+2-P=1$; there is therefore one relation between various values of p and T for equilibrium. This relation gives the vapour pressure line or, in the case of ice and water, the connection between pressure and freezing-point. Again if there is only one phase present, there are two disposable relations; in other words the pressure and temperature can vary independently of each other. The number of disposable relations is known as the number of degrees of freedom (F) so that

$$C+2-P=F$$

When the number of phases that co-exist is the greatest possible the value of F is zero. Of these phases not more than one can be gaseous because the components mix in such a phase in all proportions, so that two gaseous phases would intermingle and reduce to a single phase.

In considering the equilibrium of such a system it is necessary to introduce a new function of the variables; this is done in such a way that the independent variables become T and p. As before we have

$$Td\phi=dQ+Pos.$$

where *Pos.* stands for a positive quantity. Hence

$$dE=dQ-pdv=Td\phi-pdv-Pos.$$

Adding to both sides $d\,(pv-T\phi)$

$$d(E-T\phi+pv)=-\phi dT+vdp-Pos.$$

It follows that if the quantity in brackets on the left is calculated for the whole system its value can only decrease in any change of the system that takes place at constant pressure and temperature. Or again, if an infinitesimal change, in which p' and T are kept constant, is made about a state of equilibrium, the change on the left hand side is zero. It is sometimes called the *thermodynamic potential at constant pressure and temperature* (Duhem); or since it is concerned with the equilibrium of co-existent phases it may be called the *paraphase potential* and will be denoted by ζ.

One Component System.—Let there be one component only ($C=1$). Then if there are two phases there is one degree of freedom. There must therefore be a connection between p and T; this connection is the vapour pressure curve if the two phases are liquid and vapour. Let the values of ζ per unit mass be ζ_1 for liquid and ζ_2 for the vapour. The total potential is therefore

$$\zeta=(1-m)\zeta_1+m\zeta_2.$$

Now for equilibrium

$$d\zeta=-\zeta_1dm+\zeta_2dm=0.$$

Therefore $\qquad \zeta_1=\zeta_2$

that is the potentials per unit mass are the same for the two phases. Similarly for solid and liquid

$$\zeta_0=\zeta_1$$

and for solid and vapour.

$$\zeta_0=\zeta_2.$$

These three equations specify three curves on a pT diagram. The first two curves intersect at a point given by $\zeta_2=\zeta_1=\zeta_0$. This point also satisfies all three curves. Thus the three equilibrium curves must intersect at one point. This point is called the *triple point.* Further they cannot all intersect at any other common point for according to the phase rule there are no degrees of freedom when the three phases meet—the point of meeting is absolutely determinate.

Now the equations for these potentials are:

$$d\zeta_2=-\phi_2dT+v_2dp,$$
$$d\zeta_1=-\phi_1dT+v_1dp,$$
$$d\zeta_0=-\phi_0dT+v_0dp.$$

Whence $\qquad d(\zeta_2-\zeta_1)=-(\phi_2-\phi_1)dT+(v_2-v_1)dp=0$

for all points on the curve connecting p and T which are common to both vapour and liquid. Hence this curve is also defined by

$$\phi_2-\phi_1=(v_2-v_1)\frac{dp}{dT}.$$

The left hand side is $\dfrac{\text{latent heat}}{T}=\dfrac{L_{12}}{T}$.

Therefore $\qquad L_{12}=T\,(v_2-v_1)\,\dfrac{dp_{12}}{dT}$; Liquid→Vapour.

Similarly for the two other curves,

$$L_{01}=T\,(v_1-v_0)\,\frac{dp_{01}}{dT}\text{; Solid→Liquid,}$$

and $\qquad L_{02}=T(v_2-v_0)\,\dfrac{dp_{02}}{dT}$; Solid → Vapour.

These are simply Clausius equations for the three possible changes of phase.

The trigonometric tangent to the slope of any one of the p, T, curves is given by the value of $\dfrac{dp}{dT}$ for the curve, i.e.,

$$\frac{dp_{12}}{dT}=\frac{\phi_2-\phi_1}{v_2-v_1};\ \frac{dp_{01}}{dT}=\frac{\phi_1-\phi_0}{v_1-v_0}\text{ and }\frac{dp_{02}}{dT}=\frac{\phi_2-\phi_0}{v_2-v_0}.$$

Hence at the triple point these are obviously connected by the relation

$$(v_2-v_1)\,\frac{dp_{12}}{dT}+(v_1-v_0)\,\frac{dp_{01}}{dT}+(v_0-v_2)\,\frac{dp_{02}}{dT}=0$$

and therefore, at the triple point,

$$L_{02}=L_{01}+L_{12}.$$

This relation does not hold at any other point.

It must be emphasized that in the above no assumption is made as to whether the single component is associated or not; nor whether it is equally associated in the several phases nor that the degree of association remains unchanged when the temperature changes, nor even that the matter in the phase consists of molecules. The decision in regard to such questions has no bearing on the investigations of this part of the subject. What we do assume is that each of the homogeneous phases is quite definite when the temperature and the specific volume are definitely given.

Many Components.—When there are many components in each phase the subject becomes too complicated to be dealt with in this short article. The thermodynamics potential ζ for each phase mill depend upon the masses of the components as well as upon T and p. When its value is differentiated at constant temperature and pressure and equated to zero an equation is obtained of the form $\mu_1dm_1+\mu_2dm_2+\ldots=0$. The coefficients μ_1, μ_2, etc., are called the chemical potentials of the several components in the particular phase. The final result is that the chemical potential of any one component must be the same for all the phases that are coexistent. The problem of heterogeneous equilibrium in the general case would therefore be solved if only it were possible to obtain ζ as an explicit function of all the masses. This is not possible unless the ideal gas laws are assumed.

OSMOTIC PHENOMENA

When a tube has its lower end stopped by a suitable membrane and is partly full of a solution; and the lower end is dipped in pure solvent, a difference of level is often maintained in the final state of equilibrium. It is necessary that the membrane shall be permeable to the solvent but not to the solute—it shall be only *semi-permeable* in fact. If it is permeable to both, equilibrium can only be attained when the concentration on both sides has come to the same value by diffusion. Semi-permeable membranes are easily obtained that will act for months with hundreds of atmospheres difference of pressure between the two sides.

Unglazed earthenware impregnated with colloidal ferrocyanide of copper by an electrolytic method constitutes such a membrane, impermeable to sugar and many salts but permeable to water. It is only the final state of equilibrium that will be considered in this place. When all flow is over, there is a difference of pressure between the two sides of the membrane: this difference of pressure is called the *osmotic pressure*. It is, in general, a property not of the solution alone but involves the solvent also. Loose definitions based upon the properties of dilute solutions should be carefully avoided. The thermodynamical study of osmotic pressure is based upon the impossibility of obtaining external work from an isothermal reversible cycle. (The efficiency of such a cycle is zero.) It is possible to evaporate a unit mass of the solvent from the solute, to change its pressure so that it can then be passed reversibly into the liquid solvent, and finally to pass it back into the solution through the osmotic membrane. This cyclic series of operations can all be conducted isothermally and reversibly. In order that the concentration shall keep constant during the changes it is necessary that the mass of the solution shall be practically infinite or that the unit mass be infinitesimal. The algebra can be much simplified if a modification is made in the process. Any term, representing external work done is an expression of the type $\int_1^2 p\,dv$. Now, integrating by parts, $\int_1^2 p\,dv = p_2v_2 - p_1v_1 - \int_1^2 v\,dp$; and for a complete cycle of changes $\sum(p_2v_2 - p_1v_1)$ must equal zero and consequently adding expressions such as $p\,dv$ comes, for the whole cycle, to the same thing as adding expressions such as $\int v\,dp$ for the several stages. The imagined process can be supposed carried out in an arrangement such as is shown in fig. 1 (called by van't Hoff an equilibrium box and used by him for dilute solutions only). The solution and solvent are on opposite sides of a semi-permeable membrane C and enclosed by means of ordinary pistons A and B. Lateral cylinders are also provided with pistons; these cylinders are connected with the main cylinders by means of membranes permeable to the vapour alone. The solution is at a hydrostatic pressure p and any vapour in its lateral cylinder at a pressure π_p which corresponds to the particular pressure of the solution; similarly for the solvent and its vapour we have the pressures π_o and $\pi_{o_{p_o}}$. In making these provisions it is being definitely recognized that the vapour pressure depends, not only upon the temperature but also upon the pressure of the solution or solvent (an example of this will be dealt with in connection with interfacial effects).

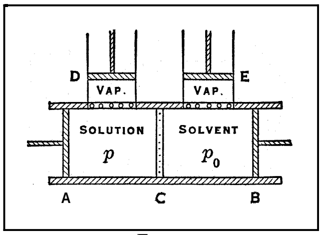


FIG. 1

The cyclic series of operations and the values of $v\,dp$ corresponding to them are as follows:—(The value of $\int v\,dp$ in each stage is denoted by S).

i. Remove unit mass (supposed infinitesimal compared with the total mass so as not sensibly to alter the concentration) of solvent from the solution by means of the lateral cylinder. Piston A requires to be moved to the right to effect this transfer. Since the pressures keep constant, $S_1 = 0$.

ii. Change the pressure of the vapour removed, from π_p to $\pi_{o_{p_o}}$: then $S_2 = \int_{\pi_p}^{\pi_o p_o} v\,d\pi$ where v is the specific volume of the vapour.

iii. Pass the vapour into the solvent reversibly at constant pressure:

$$S_3 = 0.$$

iv. Pass unit mass of solvent into solution through C at constant pressures (by moving A and B suitably):

$$S_4 = 0.$$

Adding all the values of S we obtain

$$\int_{\pi_p}^{\pi_o p_o} v\,d\pi = 0 \quad \text{whence } \pi_{o p_o} = \pi_p.$$

Thus it appears that the vapour pressure of the solution when the latter is at the pressure p must equal that of the solvent when at a pressure p_o where $p - p_o$ is the osmotic pressure. It must be remembered that the standard vapour pressures as usually measured are for the cases when the liquids are at the pressures of their vapours alone.

It can easily be seen that this must be the case. For if, otherwise, πp is greater than $\pi_{o_{p_o}}$ it would only be necessary to put the lateral cylinders into communication for a flow of vapour to take place from left to right. This would cause fresh evaporation from the solution (to maintain the equilibrium value of vapour pressure) and (for a similar reason) condensation of vapour into the solvent. Since the evaporation from the solution would increase the concentration a flow through C from the solvent would take place to maintain the equilibrium. This action would go on unceasingly and a particular kind of perpetual motion would be obtained. Unless we are prepared to admit the possibility of this type of perpetual motion, we must deny the assumption of any difference between the vapour pressures of the solvent and solution when measured under equilibrium conditions for the two *liquids*. That the vapour pressure of a pure liquid must depend upon the hydrostatic pressure was first shown by Sir William Thomson (Lord Kelvin). If a vertical capillary tube be placed in water, *e.g.*, under the bell jar of an air pump so that the air can be removed, the water stands in the tube at a higher level than outside by the amount h where $g\rho h = 2\sigma/r$, $\rho =$ density of the liquid, σ the surface tension and r the radius of the tube. (See SURFACE TENSION.) Now the vapour constitutes an atmosphere and between the inside and outside levels there is a difference of vapour pressure of $g\rho' h$ approximately where ρ' is the density of the vapour. Now the essential difference between the liquid inside and out is that at the upper level inside it is at a less hydrostatic pressure than outside (equilibrium being maintained by the effects of the curvature of the surface).

Hence
$$\frac{d\pi}{dp} = \frac{g\rho' h}{g\rho h}$$
$$= \frac{\rho'}{\rho} \text{ approximately.}$$

It is easy to show that this is not approximate merely but exact for a pure liquid. In the case of a solution however it requires modification (Porter, *Roy. Soc. Proc.* A. 79, p. 519 [1907]). To examine the case of a solution enclose a large volume V of solution in a cylinder, under pressure, fitted with a lateral chamber such as on the left of fig. 1 replacing the membrane C by a solid base. Conduct a cyclic series of operation as follows:—

i. Remove unit mass of vapour at constant pressure by means of the lateral cylinder: the volume of the solution diminishes by s (say) and the vapour increases by v:

$$S_1 = 0.$$

ii. Compress the vapour removed and the solution to new *equilibrium* values:

$$S_2 = \int_p^{p'} (V - s)\,dp + \int_{\pi_p}^{\pi_{p'}} v\,d\pi.$$

iii. Pass the removed vapour back into the solution at constant pressure for each:

$$S_3 = 0.$$

iv. Compress solution by restoring the original pressure:

$$S_4 = \int_{p'}^{p} V\,dp$$

If these changes are conducted isothermally and reversibly they must add to zero. Hence

$$\int_{\pi_p}^{\pi_{p'}} v\,d\pi = \int_p^{p'} s\,dp \text{ exactly.}$$

Since this is true, however small the change of pressure, we can write it in the differential form

$$d\pi/dp = \frac{s}{v}$$

or more precisely (owing to the fact that all the quantities depend upon the pressures)

$$\frac{d\pi_p}{dp} = \frac{s_p}{v_\pi}.$$

The quantity s stands for the shrinkage of the volume of the solution when unit mass of soivent is removed from it, the unit mass being so small (or the volume so large) that no sensible change of concentration occurs. Combining this result with the proved fact that in the state of equilibrium $\pi_p = \pi_{o p_o}$ we can obtain an expression for the osmotic pressure, $p - p_o$. For, employing the integral form, the limits being from the standard values of the vapour pressures to the equilibrium values of the pressures

$$\int_{\pi_\pi}^{p} s\,dp = \int_{\pi_\pi}^{\pi_p} v\,d\pi \quad \text{and} \quad \int_{\pi_{o\pi_o}}^{p_o} u\,dp_o = \int_{\pi_{o\pi_o}}^{\pi_{op_o}} v\,d\pi,$$

where π_π and $\pi_{o\pi_o}$ are the standard vapour pressures. Subtracting these, we obtain an exact equation for the osmotic pressure

$$s\,dp - \int_{\pi_{o\pi_o}}^{p_o} u\,dp_o = \int_{\pi_\pi}^{\pi_p} v\,d\pi + \int_{\pi_{op_o}}^{\pi_{o\pi_o}} v\,d\pi = \int_{\pi_\pi}^{\pi_{o\pi_o}} v\,dp$$

because $\pi_p = \pi_{op_o}$.

From this equation simpler approximate equations can be deduced to fit particular cases.

The equality in the equilibrium vapour pressures may be shown in another way. In fig. 2 is represented a domed chamber separated into two portions: in the lower part, by a membrane semi-permeable to solvent liquid; in the upper part, by one semi-permeable to solvent vapour. The lower part contains solution and solvent on the opposite sides of the membrane, the upper part contains, besides the vapour, sufficient air on each side to make up the total pressures to p and p_o respectively. If the pressures due to the vapours are not equal it is easily seen as before that a *perpetuum mobile* will be set up.

It ought to be added that, in the exact equation for the osmotic pressure, there is no assumption as to the molecular state. in either the liquid or vapour phases. Any influence that the degree of association or dissociation may have is all taken into account by the numerical values that can be found by direct experiment for u, s, and the standard vapour pressures. When the approximate equation is used, the values of R and u (or s) both refer to unit mass and there is no reference to molecules. If we consider (so-called) molecular values by multiplying u, s, and R by such a factor that R becomes the universal value of the gas constant it may be presumed that this multiplier is at least an approximation to the molecular weight of the vapour in the *vapour state* but still no information is obtained as to the molecular state of either solvent or solute in the liquids. Such information as we have concerning molecular states is obtained by the aid of gas theory as distinct from thermodynamics.

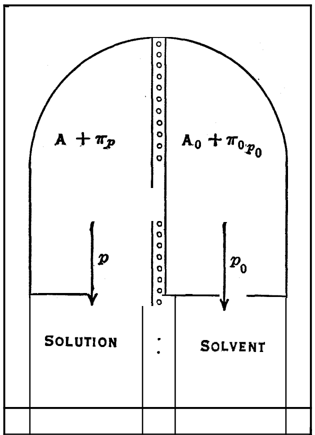


FIG. 2

General Use of Semi-permeable **Membranes.**—Imaginary semi-permeable membranes are made great use of in theoretical investigations, as in the above case. Doubt has often been raised as to the validity of this procedure at any rate in those cases for which no real membrane of the kind has been manufactured. We know that such membranes are obtainable in certain cases; *e.g.*, hot silica ("fused quartz") transmits helium and not nitrogen; hot cast iron transmits hydrogen; indiarubber is permeable to carbon dioxide. The curved surface to a liquid maintains a difference of pressure between the interior and exterior and thereby acts as a membrane semi-permeable to the *vapour;* and between a solution and the liquid solvent, as it has been already stated, very perfect membranes can be obtained. In reality, in order to employ the thermodynamical argument, it is unnecessarv that it should be possible to make any such membrane. Clerk Maxwell introduced the idea of "demons" instructed to let very fast molecules pass through an opening and stop the slow ones, thereby increasing the effective temperature on one side of a partition and diminishing that on the other. In this way he was able to show that the second law of thermodynamics does not hold for individual molecules but only for matter in the bulk. In like manner we may suppose a row of good demons turning back all the sugar molecules and letting the water molecules through in such a way that the average distribution of the water molecules in the solvent region is maintained in equilibrium. Such a row of demons will be doing precisely what our semi-permeable membrane is supposed to do and the average force per unit area they exert (viz.: $p - p_o$) corresponds exactly to the osmotic pressure. It should be noted that it is not exactly equal to the pressure the sugar molecules would exert if they were a gas with its molecules equally crowded, because there is a differential effect due to the difference of density of the water on the two sides; but in dilute solutions it is not far from this value. The most unsympathetic view that is permissible in connection with the use of membranes is that they provide a picturesque way of carrying out the virtual displacements of concentrations, etc., which are employed in the applications of the thermodynamic potentials to equilibrium problems.

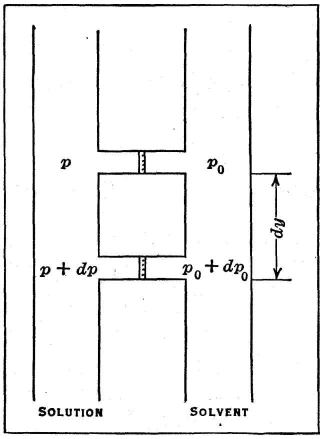


FIG. 3

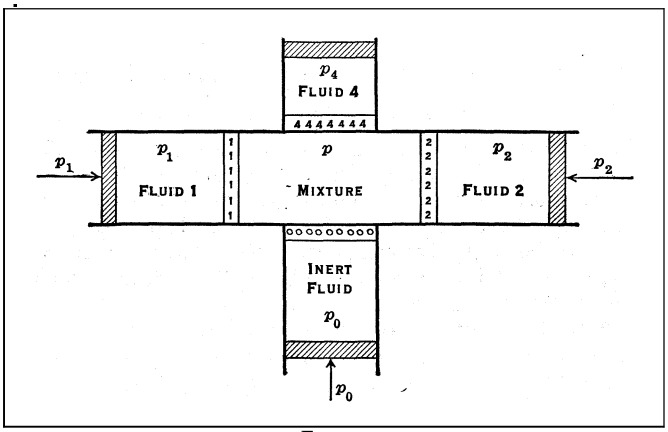


FIG. 4

Effect of **Gravity.**—We can apply the membrane method to the effect of gravity in producing a gradient of concentration with the depth In a solution. Columns of solution and solvent are connected across through semi-permeable membranes at two levels aistant dy apart (fig. 3). The densities being ρ and ρ_o we have, on the solution side, $dp = g\rho dy$ where dy is positive when measured downwards and, on the solvent side, $dp_o = g\rho_o dy$ so that $d(p - p_o) = g(\rho - \rho_o)dy$. But $p - p_o$ is the osmotic pressure, P, so the equation gives $dP/dy = g(\rho - \rho_o)$ or $dP/dp = \frac{\rho - \rho_o}{\rho}$.

If we differentiate, with respect to p, the exact equation for the osmotic pressure the result is $sdp=udp_o$

or
$$\frac{d(p-p_o)}{dp}=\frac{u-s}{s}$$

This differs from the above value; but the value just given is the variation when the concentration is kept constant; the other is the total variation. In fact we can write

$$\frac{dP}{dp}=\frac{\partial P}{\partial p}+\frac{\partial P}{\partial c}\cdot\frac{dc}{dy}$$

where c is the concentration (measured in any convenient way); i.e,

$$\frac{p-p_o}{p}=\frac{u-s}{s}+\frac{\partial P}{\partial c}\cdot\frac{dc}{dy}.$$

For dilute solutions $\frac{\partial p}{\partial c}$ follows nearly the gas law. If its exact value is known, either in consequence of this law or from experiment, the value of dc/dy can be determined. This result is of wide application. There is no assumption that it is limited to true solutions. Applied to a gamboge suspension it gives Perrin's Law of the distribution with depth when the concentration is small, and allows also a calculation to be made of the very great deviations from Perrin's Law of distribution when the concentration is great. (Trans. Far. *Soc.* XVIII. [1922]; XIX. [1923]; XXI., 63, 66 [1925]).

Application of Membranes to Homogeneous **Equilibrium.**—An interesting application can be made of semi-permeable membranes to determine the equilibrium constant for homogeneous equilibrium. Fig. 4 indicates the kind of equilibrium box required. The equilibrium which is taken as the type is that for which the chemical equation is

$$\nu_1A_1+\nu_2A_2\rightleftharpoons\nu_3A_3+\nu_4A_4;$$

and in addition an inert gas is supposed to be present, indicated by A_0; this takes no part in the reaction but modifies the total pressure of the mixture. By appropriate movement of the semi-permeable membranes a cycle of changes is carried on leading eventually to the equation

$$\nu_1\int^{p_1}u_1dp_1+\nu_2\int^{p_2}u_2dp_2-\nu_3\int^{p_3}u_3dp_3-\nu_4\int^{p_4}u_4dp_4$$
$$=\text{function of the temperature alone.}$$

This reduces to the mass action law when gas values are inserted. For detailed information in regard to its derivation reference must be made to the original paper (Trans. Far. Society, 1919). Since the membranes may be made permeable to the *vapours* of the respective components the values of u and p may be taken to stand for the specific volumes (or molecular volumes) and pressures of these vapours.

Duhem-Margules Equation.—This information is in part supplied for condensed systems by a theorem put forward by Duhem in 1887 and subsequently interpreted by Margules (1895). By means of an equilibrium box similar to that in fig. 4 we can produce the series of changes indicated in fig. 5. The case of a homogeneous mixture of two components will be considered so that only two lateral cylinders are needed. Fig. 5 consists of three diagrams, one for each separated vapour and one for the liquid mixture. It should be mentioned that from a theoretical

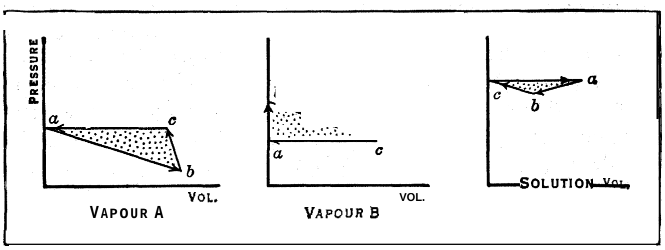


FIG. 5

point of view (thermodynamically) there is no difference between a solution and a mixture, at least, a mixture of molecular type (coarse emulsions must be excluded). Again, the operations must be isothermal and reversible. The presence of each component in the mixture lowers the vapour pressure of the other component. Throughout each change the pressure in the lateral chambers must be perpetually maintained in equilibrium with the mixture by suitably moving the pistons. The detailed changes are as follows:

i. Remove a definite fraction, say fn_1 of the molecules n_1 in the mixture. The pressure in A cylinder goes down along ab, that of B goes up—in both cases because the relative concentration of B is increased—along ab (on the B diagram). The mixture also changes along ab.

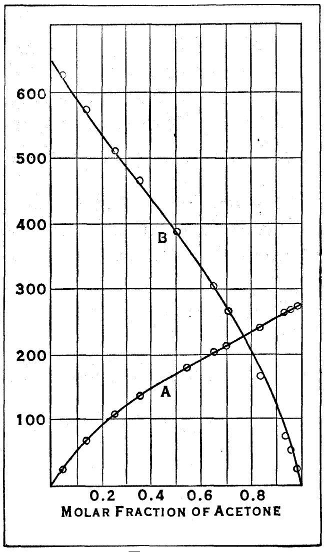


FIG. 6

ii. Remove the same *fraction* fn_2 of the molecules of B. The pressure in B goes down along bc (on B diagram) and that of A goes up along bc (on A diagram); and that of the mixture changes along bc (on the third diagram). The solution is now of the same concentration as at first and consequently the pressures at c must in each chamber be the same as at first, *i* e., as at a.

iii. Lastly return the vapours in A and B to the mixture adjusting the rates of transfer so that the concentration of the mixture remains constant. The changes in the three diagrams are in each case along ca and the original state is restored.

We will neglect the changes of volume of the solution because, for usual cases they are exceedingly small compared with the vapour changes. The total work done is the difference of the areas of the triangles on A and B; or

$$fn_1v_1\frac{\partial\pi_1}{\partial n_1}+fn_2v_2\frac{\partial\pi_2}{\partial n_1}$$

and this sum must equal zero. So far we might have considered masses instead of numbers of molecules (for,the problem has nothing essential to do with molecules). We can no put $\pi v_1=n_1RT$ and $\pi_2v_2=n_2RT$, where R is the same for both. The values of n_1 must now mean the numbers of molecules in the mixture reckoned as of the same constitution (*i.e.*, either single or double molecules, etc.) as in the vapour state; and similarly for n_2. So that

$$\frac{n_1}{\pi_1}\frac{\partial\pi_1}{\partial n_1}+\frac{n_2}{\pi_2}\frac{\partial\pi_2}{\partial n_1}=0.$$

The differential coefficients are partials, the value of n_2 being constant during the change represented. We can usefully represent the concentrations by molar fractions, that is, $\mu_1=n_1/(n_1+n_2)$ and $\mu_2=n_2/(n_1+n_2)$ so that $\mu_1+\mu_2=1$.

When this is done the equation becomes

$$\frac{\mu_1}{\pi_1}\frac{d\pi_1}{d\mu_1}+\frac{\mu_2}{\pi_1}\frac{d\pi_2}{d\mu_1}=0$$

or
$$\mu_1\frac{d}{d\mu_1}\log\pi_1=\mu_2\frac{d}{d\mu_2}\log\pi_2$$

since $d\mu_2=-d\mu_1$. The advantage of the transformation to molar fractions is that the equation has been reduced to a symmetrical form the right hand being the same function of μ_2 that the left is of μ_1. This is the Margules-Duhem equation. It is not quite exact because the vapours have been treated as ideal gases and the changes of the volume of the mixture have been neglected. For practical purposes, however, it is probably very much more accurate than experiments require. The implication of the equation is that each side of it must be the same *symmetrical* function of μ_1 and μ_2; *i.e.*, it must be of the form $f(\mu_1\mu_2)$ and this must be the *same* for both vapours. Unfortunately the law imposes no further restriction upon this function so that an endless number of cases can arise. Suitable simple values for the functions are 1, $\mu_1\mu_2$, $\mu_1^2\mu_2^2$, etc., each of which may be multiplied by an arbitrary constant and any number of terms may be taken simultaneously. For any such function the equation can be integrated and it takes the form

$$\log\frac{\pi_1}{\Pi_1}=a\log\mu_1+\beta\mu_2^2+\gamma\mu_2^2(1+3\mu_1)\ \text{etc.}$$

and $$\log\frac{\pi_2}{\Pi_2}=a\log\mu_2+\beta\mu_1^2+\gamma\mu_1^2(1+3\mu_2)\ \text{etc.}$$

where Π_1 and Π_2 are the vapour pressures of the pure components and the constants α, β, γ, etc. must be the same for both. If the first term on the right is sufficient we have

$$\frac{\pi_1}{\Pi_1}=\mu^{\alpha 1}=\left(\frac{n_1}{n_1+n_2}\right)^\alpha=\left(1-\frac{n_2}{n_1+n_2}\right)^\alpha\doteqdot 1-\frac{an_2}{n_1+n_2}$$

when n_2 is small.

This is practically Raoult's law when allowance is made for dissociation. In very many cases two terms are necessary and a is often unity. The equation then becomes

$$\log\frac{\pi_1}{\Pi_1\,\mu_1}=\beta\mu_2^2.$$

In fig. 6 the curves for a mixture of acetone and ether are given. The value of β was determined from one point on the acetone curve but it fits equally well the curve for either. The base line gives the molar % of acetone when read from left to right but it equally well gives the percentage of ether when read from right to left. The experimental points were determined by J. Sameshima (*Amer.* J. of *Sc.* XL., 1482, 1918). Examination of the equation shows that in this group of examples there is only one parameter, viz.: β. In fig. 7 the shapes of the curves are shown for different values of β, the ordinates being π/Π. Examples can be found for many values of β. For sulphuric acid and water $\beta=-0{\cdot}6$ except for dilute solutions, when a more complicated formula is necessary. Fig. 8 gives the case of gold in mercury. In this example four terms are required. If the base line is read from left to right the curve is the vapour pressure for mercury; if the base line is read from right to left the curve gives the vapour pressure (though exceedingly small) of gold in mercury. In both cases these are the values of π_1, π_2 which require to be inserted in the equations for the constant of homogeneous equilibrium. The central part of the curve, which slopes downward, is easily shown to be in an unstable region. Where the curve is horizontal (towards the right of the figure) is the concentration at which the equilibrium becomes unstable; in other words it represents the *saturation* concentration of the solution of gold. The vapour pressure of the gold should at that point be the same as that of pure gold and that is seen to be the case by examining the curve reversed. Calcium chloride in water also requires four terms; curves are shown on fig. 9 for this case at two temperatures.

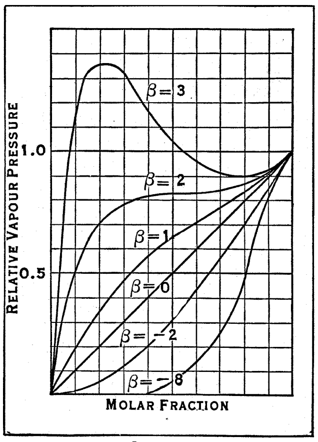


FIG. 7

Taking these cases as examples there is little likelihood of the vapour pressures required for the calculation of the equilibrium constant being determinable by any a *priori* method and resort must be made to direct experiment—at any rate for the determination of a few typical values from ahich the constants can be deduced. Further information can be found in Trans. Far. *Soc.*, 15 (1920), 24, 344, 405, 543 (1928). In the first of these papers a general form of equation is developed for three or more components.

Interfacial Effects.—In considering equilibrium the interface between any two phases was considered as being plane. It is only if it is plane that the pressure is uniform over the whole system. There is a change of pressure on crossing the boundary equal to $\sigma\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$ where σ is the surface tension and R_1 and R_2 are the radii of curvature in any two mutually rectangular planes. (See SURFACE TENSION.) The pressure is greater on the concave side (as in a soap bubble.) We have seen that it increases the vapour pressure if convex outward; it increases the density also and, indeed, it may be expected to change all the properties which depend upon these. For example, the position of the triple point is shifted when either the liquid or the solid phase has curved boundaries. An equivalent change of pressure produced in any way has the same effect. As a matter of fact, the independent atmosphere of air acting in addition to the vapour pressure on ice and water shifts the triple point from .0075° C. to exactly zero. It clearly must do so because the ice water line under the pressure of one atmosphere goes through 0° C., and not .0075° C. and the triple point lies on this line. (*Phil. Mag.*, xxix. 143, 1915.)

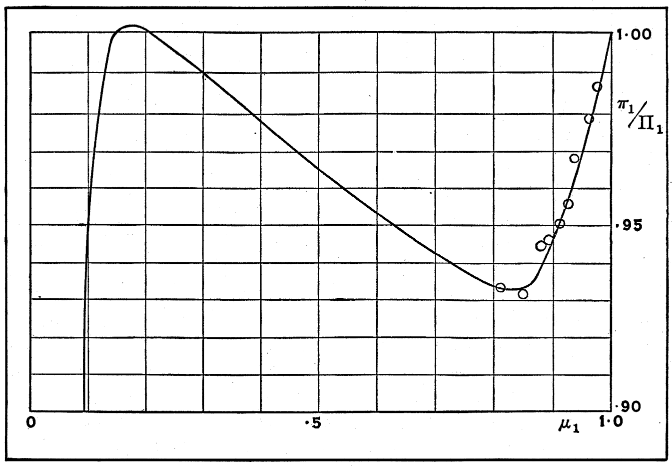


FIG. 8

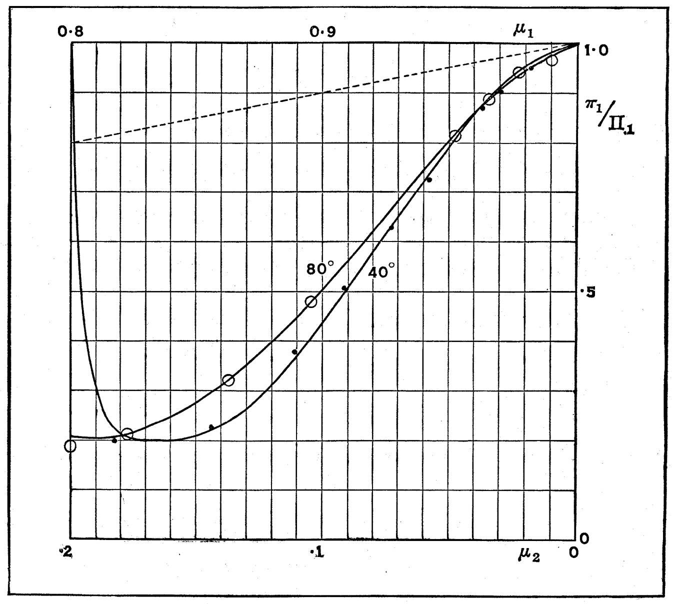


FIG. 9

There is another effect at the interface which is present even if this surface is plane. Consider a solution in equilibrium with its vapour. The presence of the solute either increases or diminishes the surface tension; for most salts it is an increase, for many organic substances such as oils, soaps, etc., it is a decrease; and the change is greater the greater the amount of the solute. Now the existence of surface tension is a demonstration of the possession by a surface lamina of more potential energy than a lamina in the body of the phase. The tendency being for the potential energy to take the lowest possible value, solute (being free to be displaced) will move toward the surface lamina or away from it according to which change will diminish the surface tension. In strictness therefore, the two phases are not delimited by mathematically sharp boundaries: there is an intervening lamina whose structure depends upon both phases and is different from that in the body of either. This subject was first studied in detail by Willard Gibbs. Following him, we replace the actual distribution of material by a uniform distribution in each phase and superimpose upon this an *extra* distribution (which may be negative) representing the excess per unit area of any component in this superficial lamina. This excess is called the surface concentration and is usually denoted by a. When a surface tension is measured experimentally it is the value as modified by the surface layer which is actually determined. One effect of this nonuniform distribution of the solute is that when the solute tends to lower the surface considerably, small traces of it added to the pure solvent are sufficient to produce very considerable lowering. In fig. 10, the curve shows the change of surface tension with the amount of soap added to the solute. An amount of soap equal to a concentration of 0.2% produces a lowering to practically the same value as for a concentrated solution and a great part of this reduction is produced by the first traces of soap that are added and go almost completely to the surface layer.

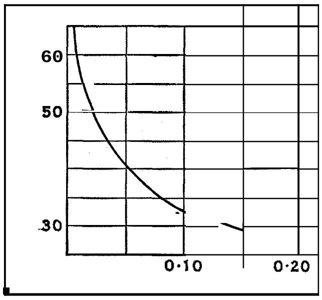


FIG. 10

Willard Gibbs investigated thermodynamically the "surface-concentration" to be expected.. External work is done not only in expansion of volume (pdv) but also in the extension of the surface area ($-\sigma dA$). Hence $dE = Td\phi - \pi dV + \sigma dA$ for reversible changes or $d(E - T\phi + \pi V) = -\phi dT + Vd\pi + \sigma dA$.

Since $E - T\phi + \pi V$ depends only upon the state

$$\left(\frac{\partial V}{\partial A}\right)_\pi = \left(\frac{\partial \sigma}{\partial \pi}\right)_A$$

Representing quantities for the liquid and vapour phases with suffixes 1 and 2 respectively, $dV_2 = \frac{RT}{a} dN_2$ is given where V is the volume of the vapour, a the vapour pressure and N_2 the number of molecules in the vapour. In the liquid let n_1 equal total number of molecules of the solute and N_1 those of the solvent in the solution. Imagine a virtual displacement from the liquid to vapour phase at constant temperature and concentration produced by an extension of the area. For unit increase of area n_1 changes by $-\frac{dn_1}{dA}$; and for the concentration to keep constant $\frac{dn_1}{n_1} = \frac{dN_1}{N_1}$ so that dN_1 molecules of solvent evaporate. But $dN_2 = -dN_1 = -\frac{N_1}{n_1} dn_1$. The change of volume dV is practically dV_2 (*i.e.*, neglecting change of volume of the liquid).

Hence $$\left(\frac{\partial V}{\partial A}\right)_\pi = -\left(\frac{RTN_1 dn_A}{n\pi dA}\right),$$

Again $$\left(\frac{\partial \sigma}{\partial \pi}\right)_A = \left(\frac{\partial \sigma}{\partial n} \cdot \frac{dn}{d\pi}\right)_A = -\frac{N_1}{\pi}\left(\frac{\partial \sigma}{\partial n}\right)_A$$

in which an approximate value of the change of π with n has been inserted. Hence finally

$$\frac{dn_A}{dA} = \Gamma = -\frac{n}{RT}\frac{d\sigma}{dn}$$

where n_A are the excess molecules of solute in unit surface layer. This is a maximum value for Γ, since more exact expressions for the vapour pressure tend to reduce it. For strong solutions of sugar the simple expression goes up to four times the more exact value; but for dilute solutions it must be very near the truth.

THERMAL EFFECTS

The thermal changes that take place in the case of dilution of solutions can be examined in a similar way to other latent heats. If we enclose a solution and the solvent on opposite sides of an osmotic membrane in an "equilibrium box" it is easy to carry out a Carnot cycle of changes for which the efficiency is $\frac{dT}{T}$.

We deduce, for the reversible latent heat of dilution corresponding to unit mass of solvent entering, the expression,

$$H_{\text{reversible}} = T\left(s\frac{dp}{dT} - u\frac{dp_0}{dT}\right) \text{ exactly.}$$

For the corresponding change of energy we must subtract the external work done, viz.: $sdp - udp_0$; whence

$$\Delta E = s\left(T\frac{dp}{dT} - p\right) - u\left(T\frac{dp_0}{dT} - p_0\right)$$

This latter must be very nearly the irreversible heat absorbed on stirring solvent into the solution instead of through an osmotic membrane; because in the stirring process, the whole being at ordinary pressure, there is very little external work done and the latent heat is practically the energy change. When p_0 is small throughout,

$$H_{\text{reversible}} \text{ is practically } Ts\frac{dP}{dT}$$

and $$\Delta E \text{ is practically } s\left(T\frac{dP}{dT} - P\right)$$

where P is the osmotic pressure. Connecting P with the vapour pressure by the usual substitution $Ps = RT \log\frac{\pi_0}{\pi_\pi}$,

$$\Delta E = T^2 s \frac{\partial}{\partial T}\left(\frac{R}{s}\log\frac{\pi_0}{\pi_\pi}\right)$$

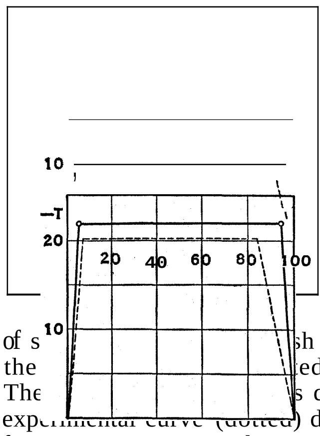
and, if s and R are independent of temperature, this becomes the same as an approximate equation given by Kirchhoff. If this irreversible heat of dilution is zero, $\log\frac{\pi_0}{\pi_\pi}$ must be independent of temperature.

This approximate law is known as von Babo's law.

Freezing Points.—When a solution is in equilibrium with the solid phase of the solvent it is at its freezing point, and must have the same vapour pressure as the solid. Different solutions in the same solvent must have the same freezing points if their vapour pressures (and therefore their osmotic pressures) are the same.

Cryohydric Points.—If, at the freezing point, the solution of one is saturated it is then at a cryohydric point. A solution of common salt is at the point at about $-22°$ C.

Freezing mixtures depend upon the fact that if salt be added to ice it will dissolve and cool the system owing to the latent heat



of s... h salt further cooling goes on until the ... ed at the final temperature reached. The ... s quantities is shown in fig. 11. The exp... (dotted) differs from the curve, calculated from an approximate theory, mainly owing to the thermal capacity of the containing vessel. It will be seen that the relative proportions of ice and salt may be varied within wide limits and the cryohydric temperature will be approached. When the material cooled by the mixture has considerable thermal capacity the greatest chance of producing the lowest temperature is when the amount of salt is about 30 per cent.

Irreversible Processes.—Owing to the universality of frictional forces every process that we can conduct is in reality irreversible. Trains require to be driven even on the level; ocean waves subside and winds cease soon after the cause producing them has ceased to be effective. The motion of the piston of an engine allows the steam to be set in motion and the kinetic energy that corresponds is ultimately transformed into molecular energy and is mainly unavailable for doing useful work. It is true that so far as a difference of temperature is set up by friction some of the temperature energy may be transferred into work but the amount is incommensurable with the loss.

The most typically irreversible process is that in which a fluid is forced through a nozzle or a porous plug. Considering the steady state of adiabatic flow only, we have (i.) an equality of the mass leaving and entering the plug, (ii.) an equality of the energy leaving and entering. The energy is in part the intrinsic energy E (per unit mass) and in part energy of motion in bulk, $\frac{1}{2}$ velocity squared (per unit mass). Further the incoming fluid does work p_1v_1 in forcing the fluid through and the outgoing fluid does work p_2v_2 in forcing out the fluid in front of it; the gain of energy on this account is $p_1v_1-p_2v_2$. Hence the total gain of energy inside the plug is

$$E_1+p_1v_1+\tfrac{1}{2}V_1^2-(E_2+p_2v_2+\tfrac{1}{2}V_2^2)$$

and in the steady adiabatic state of flow this is zero. We assume that the two positions at which the energies are reckoned are well outside the plug so that we can consider the velocity, etc., as uniformly distributed across the cross section. When the 'narrows' inside the throttle or plug are reached the velocity attains a high value and a high viscous resistance is met with so that even V_2 may be small in spite of the great difference of pressure on the two sides and further dissipation of energy takes place in the eddies that form on emergence. The result is that the fluid is much hotter on emergence than if it had expanded between the same extreme pressures reversibly and adiabatically in a cylinder. We suppose for simplicity only a small difference of pressure, etc., so that

$$d(E+pv)=-d(\tfrac{1}{2}V^2).$$

If the motion has been linear and without friction it is known from hydrodynamics that

$$d(\tfrac{1}{2}V^2)=-vdp$$

so that the equation would reduce to

$$dE+pdv=o,$$

which as we know represents the heat entry in a reversible process. To consider such a process would be equivalent, for example, to discussing the oscillation of a frictionless pendulum. Such a pendulum would go on vibrating without loss of amplitude for ever and every half period it would perfectly reverse its path. The lack of reversibility of a real pendulum is entirely due to its meeting with frictional resistance to its motion. The loss of kinetic energy on the average is represented by the extra temperature of the bob and air, together with the energy which is radiated out. This 'loss' of energy of visible motion corresponds to an increase in the internal energy of the system such as would be caused by an entry of heat from outside and it produces the same effects. Similarly in the problem of the flow of fluid if we add the frictional heat dq to the actual value of $d(\frac{1}{2}V^2)$ it may be expected by the law of conservation to give $-vdp$. Hence

$$d(E+pv)=-d(\tfrac{1}{2}V^2)=-vdp+dq$$

or

$$dE+pdv=dq.$$

Hence the actual value of the change on the left side is precisely the same as it would be if heat dq had entered *reversibly* from *outside* the system. In reality no heat has entered from outside but the frictional heat produces precisely the same effect as if it had done so. The essential difference between the two cases is that if we were to reverse the reversible system the corresponding heat would be given out; but the frictional heat is always positive in whichever sense the transformation proceeds. Since dq produces the same effects as if it had come from outside reversibly it must increase the entropy by the amount dq/T although the change is really adiabatic so far as the whole system is concerned. This can be illustrated by supposing the fluid to be an ideal gas. In such a case the increase of entropy is $C_v \log\frac{T_2}{T_1}+R\log\frac{v_2}{v_1}$. But

$$dE=C_vdT \text{ and } pv=RT;$$

hence

$$d(E+pv)=(C_v+R)\,dT.$$

Neglecting $d(\frac{1}{2}V^2)$, as we can do when the flow is slow (because it depends upon the square of V and the other changes are of the first order of small quantities), this must be zero, i.e., $dT=o$; so that no change of temperature occurs. Hence $T_2=T_1$ and $\phi_2-\phi_1=R\log\frac{v_2}{v_1}$. Further $v_2>v_1$ because $p_1>p_2$. So there is a positive increase of entropy, and its value is $R\log\frac{v_2}{v_1}=-\frac{1}{T}\int vdp$ as we inferred it to be. Since $E+pv$ (which is called the *enthalpy*) is a quantity which depends only upon the state we can calculate it for any change (adiabatic or otherwise) between the extreme states. It is most convenient to calculate it for a reversible change (which may not be adiabatic). Starting from

$$dq=dE+pdv$$

$$d(E+pv)=dq+vdp$$

$$=C_pdT-T\left(\frac{\partial v}{\partial T}\right)_p dp+vdp.$$

Hence if $E+pv$ has the same value as at first the right hand must also be zero or

$$\left(\frac{dT}{dp}\right)_{E+pv}=\frac{T(\partial v/\partial T)_p-v}{C_p}$$

The left hand side is the amount the temperature falls in the plug experiment for unit fall of pressure. It will be zero (as it is for a perfect gas) provided that

$$T\left(\frac{\partial v}{\partial T}\right)_p-v=o$$

or (by integration)

$$v=Tf(p),$$

where $f(p)$ stands for any function of the pressure. Kelvin and Joule found experimentally that at moderate pressures air and carbon dioxide cool in the process while hydrogen warms. In reality all fluids (gaseous or liquid) at certain temperatures and pressures undergo neither warming nor cooling in the prscess. At sufficiently high or sufficiently low temperatures all get hotter; in an intermediate region of temperatures they may get cooler but they fail to do so if the pressure is above a certain limit which appears to be at about 15 times the critical pressure (*Trans. Far. Soc.*, *Discussion* on the production end utilization of *cold*: President's opening remarks, 1922).

General.—The conclusions drawn from thermodynamics can be confirmed and extended by the aid of the principles generalized in mechanics which enable problems to be approached from a different aspect. The two fields of enquiry overlap. The thermodynamical way ignores the precise mechanism of the various transformations: making use of principles which are independent of the particular mechanism. This does not exclude the possibility of information being obtained in other ways which are not as independent of it and by which it may ultimately be possible to formulate with some degree of precision the nature of that mechanism. Such methods are of course less abstract in the picture with which they present us but enormous difficulties are met with in dealing even with the simpler phenomena.

It is possible to examine the movements of the hands of a watch and to detect and discuss certain regularities of their movement; but it is another matter to predict (without taking the watch to pieces) what the precise mechanism inside may be. The problems that are met with in chemical and other reactions are much more complicated than the movements of the hands of the watch. It is only very gradually that an imperfect picture is being created. Such help as is being given it by statistical mechanics is exceedingly valuable; but it is outside the scope of this article.

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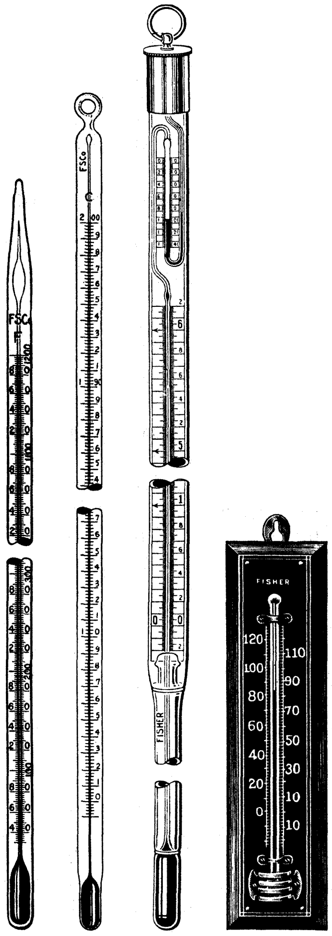
THERMOMETRY is the art of measuring temperature. Temperature may be defined as the thermal state of a body considered with reference to its ability to communicate heat to other bodies. Instruments used for this purpose are known as thermometers, or sometimes. when they are used to measure temperatures above a red heat, as pyrometers.

This article, treating the subject in a generally historical order, is divided into the following sections:

I. EARLY DEVELOPMENT

1. Thermometry.— Of the two commonly practised basic methods of measurement, namely, by contact and by radiation, only the first was known for more than two centuries following the invention of the faulty air thermoscope of Galileo Galilei, and the hermetically sealed Florentine thermometers first developed in the middle of the 17th century. H. L. Callendar, in the article on HEAT, states that "the type of thermometer familiar at the present time, containing a liquid hermetically sealed in a glass bulb with a fine tube attached. was first brought into general use by the grand duke Ferdinand II of Tuscany, and he is said to have possessed such instruments as early as 1654 . . . Alcohol was the liquid first employed and the degrees, intended to represent thousandths of the volume of the bulb, were marked with small beads of enamel fused on the stem. . . ."

Gabriel Daniel Fahrenheit (1686–1736), a modest German instrument maker, native of Danzig and long a resident of Holland, is said to have invented in 1714 the mercury-in-glass thermometer and the scale of temperature by which his name is daily remembered in English-speaking countries. In devising a scale for his thermometer, Fahrenheit chose as the zero the lowest temperature obtainable with a mixture of ice and common salt, and first proposed to divide the interval between this temperature and that of the limit of the heat which is found in the blood of a healthy man, into 12 divisions, subsequently increasing the number to 96, purely as an arbitrary measure of convenience. Fahrenheit had previously shown that pure water while freezing in the presence of pure ice always gave the same reading on his thermometer. and



A B C D

BY COURTESY OF FISHER SCIENTIFIC CO

FIG. 1.—MERCURY-IN-GLASS THERMOMETERS

(A) Extra hard glass for 1.200° F. (649° C.) in 2° divisions; (B) precision type for 2000 C. in 0.20 divisions: (C) Beckmann differential, 60 range in 0.01° divisions; (D) common household type for indoor or outdoor use

he invented the mercury thermometer so that he could observe the constancy of the boiling point of water, a report of which he had read in the History of the Sciences issued by the Royal Academy of Paris. These two points on his thermometer (later fully recognized as fixed points) were observed at the 32nd and 212th divisions, respectively. His thermometer must have had a rather uniform bore for him to have observed 212° as the boiling point of water, but not precisely so, because the blood temperature of a healthy man was observed as 96°, and is now known to be 2° to 3° higher. The so-called Fahrenheit scale, having an interval of 180° between the freezing and boiling points of water, went rapidly into general use. and is still retained in most English-speaking countries as the most convenient? particularly for meteorological work, because of its small degrees. . R. A. F. de Réaumur, French naturalist (1683–1757), proposed in 1730 to divide the interval into 80°, and his scale is used in many countries. Anders Celsius (1701–1744), Swedish astronomer at Uppsala, is credited with first proposing to make the interval roo°. as it is on the centigrade scale.

During the century after Fahrenheit. the mercury-in-glass thermometer became an instrument of useful precision and the basis of all temperature measurements, the thermal expansion of liquids being the only recognized means for measuring temperatures. The principles of thermodynamics were not well established, nor did the knowledge of the behaviour of gases extend much beyond the information afforded by the laws of Robert Boyle (discovered independently by E. Mariotte) and J. Charles (anticipating J. L. Gay-Lussac, 1802). No material success was attained. in the experimental use of a gas thermometer, and measurements were limited to the range of the mercury thermometer graduated from −40° to 300° centigrade. The lower limit was determined by the freezing of mercury at −39.87' C. (modern value), and the upper range was roughly limited by its high vapour pressure, which reaches atmospheric pressure at approximately 357° C. (675° F.). The thermometers of that period had to be kept well below this temperature because within the thermometer in the capillary space above the mercury there was no gas under pressure, as usually found in thermometers many years later, to prevent the mercury from boiling and from distilling into the capillary. The upper limit was not affected by the softening of the glass which would probably have withstood a temperature

Degrees Centigrade (° C.) Versus Degrees Fahrenheit (° F.j

° C.	° F.	° C.	° F.
5,000	9,032	100	212
2,000	3,632	0	32
1,500	2,732	—40	—40
1,000	1,832	—100	—148
500	932	—273.16	—459.69

To convert ° F. into ° C., first subtract 32, then take 5/9 of the remainder. To convert ° C. into ° F., first multiply by 9/5, then add 32.

above 400° C.

2. Pyrometry.—In order to measure higher temperatures than these early thermometers could withstand, James Prinsep (1828), interested in alloys of gold, silver and platinum. and wanting to measure their melting points, made a large bulb of gold connected with a sensitive manometer with which to maintain the gas (air) at constant pressure within, and connected also with a reservoir of olive oil. Temperatures were measured by weighing the oil that had to be removed from the manometer, as the air expanded, in order to maintain the level constant. This could be considered the beginning of gas thermometry. Prinsep's measurements were limited in the upper range by the melting point of gold, found to be 1,063° C. near the close of the century. Others, including Sir Humphry Davy, used the Prinsep method without much improvement, until Claude Servais Mathias Pouillet (1836) made a bulb of platinum and improved the experimental procedure, which was further improved in 1847 by Henri Victor Regnault, and in the 1880s by Callendar and his associates. The high melting point (1,773° C.) of platinum extended the upper limit of measurement many hundreds of degrees. Pouillet also studied the relation between temperature and radiation from glowing solids. Thomas Johann Seebeck had discovered in 1821 that an electric current flows in a closed circuit of two dissimilar metals when the junctions of the metals are maintained at different temperatures, and Henri Becquerel had tried a platinum-palladium junction in 1830

The methods of gas thermometry continued to be improved throughout the 19th century. Regnault had shown in 1847 that the gas thermometer could afford precision in the range 0° to 100° C. He attained a precision sufficient to detect differences in the expansion coefficients of some of the more readily condensible gases. but not of hydrogen and nitrogen. which were found to expand one part in approximately 273 per ° C at 0° C. During this period the mercury thermometer remained the primary and most reliable means for measuring temperatures in practical applications.

In order to understand the trends of subsequent developments, it will be necessary to review briefly some of the scientific progress of the times. (See HEAT; THERMODYNAMICS.) Sadi Carnot, a French physicist, had described in 1824 his ideal reversible heat engine, and had endeavoured to prove on theoretical grounds that the efficiency of his ideal engine was the maximum possible and dependent only on the limits of temperature between which it works. Neither Carnot's proof nor that of many others appeared to be fully satisfactory for many years. The mechanical theory of heat, i e., the interpretation that heat is energy subject to the law of conservation, was slowly displacing the older theory that heat is an imponderable fluid uith the pouer of penetrating all substances. Quoting Callendar, "The honour of placing the mechanical theory of heat on a sound experimental basis belongs almost exclusively to [J. P.] Joule, who shoned by direct experiment that in all the most important cases in uhich heat was generated by the expenditure of mechanical work, or mechanical uork was produced at the expense of heat, there was a constant ratio of equivalence between the heat generated and the uork expended and vice versa." Joule reported his long series of brilliant experiments in a series of papers from 1840–43, and in 1848 he wrote to William Thomson (Lord Kelvin) to point out that according to his experiments, the efficiency of Carnot's engine must be proportional to $1/T$, the absolute temperature appearing in the equation $pv = \mathrm{RT}$, representing the combined laws of Charles and Boyle for the expansion of gases. This equation was known to be a good approximation for the air thermometer between 0° and 100° C if T be put equal to t(°C.) plus 273. At this time, thermodynamics was making rapid strides and the experimental work was all based on the centigrade scale as defined by the mercury thermometer and the value 273 for T-t. In 1852 Thomson gave as the expression for the efficiency of the Carnot cycle on the evidence of Joule's experiment:

$$W/Q = (t_1 - t_0)/(t_1 + 273) = (T_1 - T_0)/T_1$$

where Q is the amount of heat an engine receives and W the work

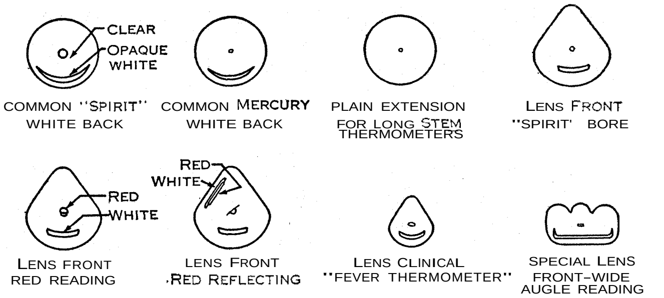


FIG. 2.— CROSS SECTIONS (DOUBLE SIZE) OF THE STEMS OF PRINCIPAL TYPES OF MERCURY-IN-GLASS THERMOMETERS CONTRASTING VARIOUS SCHEMES FOR PROMOTING EASE IN OBSERVING THE POSITION OF THE MERCURY

it performs. Thomson had realized that in the ideal heat engine lay a means for measuring temperature independently of the property of any substance. Four years earlier he had proposed for this purpose to write W/Q equal to a constant, but as the experimental evidence accumulated he proposed in 1854 to define the thermodynamic scale according to the above equation, thus making this equation exact, and to determine by experiment how far the scale of the gas thermometer departed from the ideal scale. With this object in mind he devised a very delicate method, knonn as the porous plug experiment (see THERMODYNAMICS), to measure the temperature change accompanying the expansion of a gas in the absence of any conversion of heat to kinetic energy. Joule and Thomson carried out a long and famous series of experiments. and finally reported in the *Philosophical* Transactions (1862) that the deviations of the air thermometer from the absolute scale as above defined are almost negligible, and that in the case of the gas hydrogen, the deviations are so small that a thermometer containing this gas may be taken for all practical purposes as agreeing exactly with the absolute scale at all ordinary temperatures.

It should be carefully noted that the above equation. defining the thermodynamic temperature scale. does not determine any numbers for temperatures, but only defines the ratio of T_0 to T_1 as equal to $1 - W/Q$. Thus any number may be selected for one fixed point, for example, the ice point. leaving the intervals between this point and all others such as the steam point subject to experimental determination; or we can select any convenient interval such as that between the ice and steam points, leaving both their values above absolute zero subject to experiment. At the time Lord Kelvin was faced with making one of the selections, Regnault had been using air thermometers in his laboratory in preference to mercury thermometers because of the capricious performance of the latter, and had been accustomed to basing his calculations on the difference between the ice and steam points. Had Kelvin suggested, and the suggestion prevailed, that a number be permanently assigned to the ice point on the thermodynamic scale, the differences of the t o scales at all other points would have had to be tabulated, and the lengthy tables revised from time to time in order to fit the results of future experiments. Kelvin chose to suggest that the ice-steam interval be fixed at 100° and this suggestion prevailed until 1954. (See below The *International* Temperature *Scale*.) The thermodynamic scale is known simply as the Kelvin scale, temperatures on it being designated °K. The symbol in equations is usually T.

3. Further Developments and Various **Inventions.**—Although the measurements of Regnault in the 1840s and '50s with his gas thermometers in the range 0° to 100° C. were in error by a few tenths of a degree according to modern data, he was probably attaining a precision of about 0.1°. and his mercury thermometers did not compare favourably with this precision, varying erratically by tenths of a degree within that range and much more at higher temperatures. Very little was known at the time about annealing glass, so it was customary to age the green or new thermometers for many weeks. during which the ice point would slowly rise by a degree or more as the strains in the glass slowly decreased. These strains would never disappear and the thermometers nould give readings at the fixed points such as ice and steam. differing by tenths of a degree, sometimes changing for months. On the other hand, it mas thought that the gas thermometer was providing measurements agreeing with the Kelvin scale to better than 0.1°. For these reasons the gas thermometers, especially the constant volume hydrogen thermometer came to be regarded as the ultimate standard for laboratory work at ordinary temperatures.

The mercury thermometer was also improved during this period by the introduction of nitrogen into the capillary bore above the mercury. Before this time the thermometers had been sealed after filling, while the bulb was kept hot enough to run the thread of mercury to the upper end of the stem. Thus when the bulb cooled, the space above the mercury contained only its vapour at a pressure corresponding to the temperature of the space. By introducing nitrogen into the bulb at some lower temperature, the pressure of the gas will increase as the mercury rises, and counteract the vapour pressure rising with increasing temperature. The use of nitrogen not only prevents the mercury in the bulb from vaporizing but also retards the vaporization into the space occupied by the nitrogen. In order to best match the varying pressure of the mercury, the proper size of the expansion chamber at the upper end is calculated according to the size of the bore. This calculation is necessary because pressures of a few hundred pounds per square inch are required at the highest temperatures at which the thermometer can be used. These gas-filled thermometers extended the useful range toward the softening temperature of the glass and in order to take full advantage of the new method of filling, harder glasses were developed; *i.e.,* glasses with higher softening temperatures. The first of these were the so-called *verre dur* of France and the type Jena 16, III, of Germany. Filling the thermometers with nitrogen spoiled them for the most precise laboratory measurements, because the varying pressures made the scale nonuniform and prevented the application of corrections, but it made them better for general and industrial applications. The useful range was raised to nearly 500° C. (932° F.), although the accuracy above 400° C. was low.

Another invention of the period was the clinical thermometer in a form much as it is currently known. This is essentially a maximum-reading thermometer, that is, designed to indicate the highest temperature to which it has been subjected after the mercury has been shaken down. It is made by collapsing a bubble blown in the stem, while the glass is soft, between the bulb and the part of the stem to be calibrated. Expert workmanship closes the bore or passage almost completely so that as the temperature falls the mercury thread breaks at the constriction, leaving all that has remained above to be observed at leisure. The bulbs of these thermometers are made small, cylindrical and thin-walled, so that they will come up to the maximum temperature as rapidly as possible. Most clinical, sometimes called medical, thermometers require three minutes or more for all the mercury to reach the body temperature. The small bulbs require that the bore also be exceptionally small, and this requirement in turn has led to the so-called lens-front stems designed to magnify the thread of mercury for easier reading. The scales of these thermometers range from about 33" to 42° C. or 92" to 108° F.

Other developments of the period were the resistance thermometer of fine platinum wire first tried by W. Siemens in 1871 without success; the pyrometric cones made of clays and other minerals for the ceramic industries, said to be used first by C. Lauth and J. H. L. Vogt in 1882 but highly developed by H. Seger and fully described by him in 1886; the thermopile consisting of a large number of closely grouped thermojunctions, devised by Francesco Rossetti in 1879, for measuring heat radiation; and many improvements in electrical measuring instruments including the moving-coil reflecting galvanometer by J. Arsène d'Arsonval in 1882. (See INSTRUMENTS, ELECTRICAL MEASURING). Attempts to estimate very high temperatures by radiation methods met slight success. Josef Stefan had suggested in 1879 that the earlier measurements by John Tyndall on the radiation from incandescent platinum could be represented by the equation $J = \sigma T^4$, and this was established as the law for total radiation (radiation of all wave lengths) by Ludwig Boltzmann in 1884, who in theory substituted radiation as the working substance in a Carnot cycle. This law has since been known as the Stefan-Boltzmann law, and has had considerable influence on theories of physics, but its use in pyrometric measurements has been limited mainly to industrial applications.

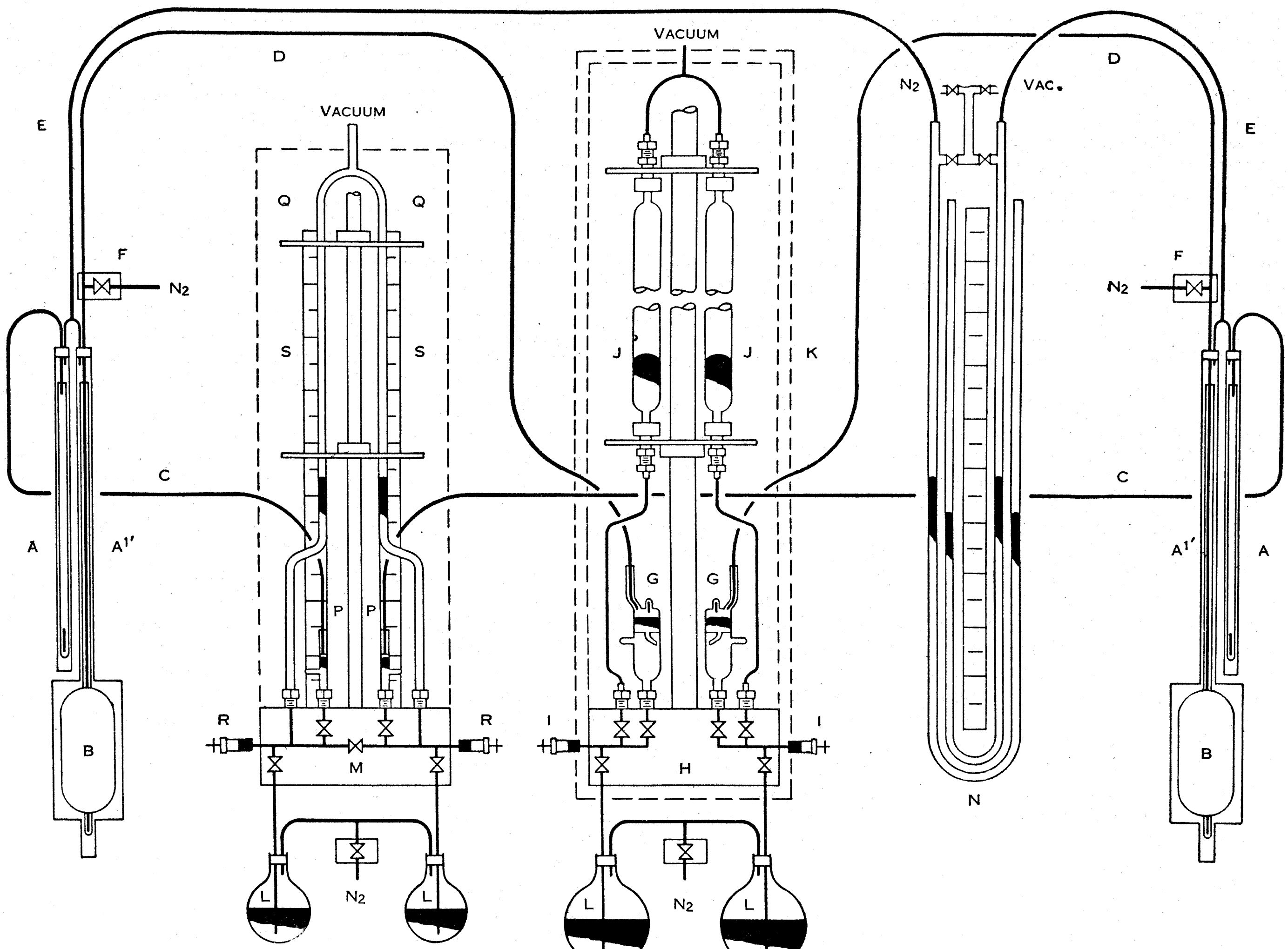
II. DEVELOPMENT OF PRECISE THERMOMETRY

1. Expansion Thermometry. — The famous researches of Callendar and his associates at the Imperial College of Science, London, and the equally well-known work of P. Chappuis at the Bureau Internationale des Poids et Mésures, Paris, began in the late 1880s and continued into the early 1900s. These were the beginnings of modern precise thermometry. Chappuis undertook the task of comparing with the highest attainable precision, the temperature scales of carefully made hard-glass mercury thermometers (not nitrogen-filled) and a constant-volume hydrogen thermometer having a platinum-iridium bulb. This work covered the range from 0° to 100° C. and was designed to aid in the establishment of standardized temperature measurements in various countries by supplying standard mercury thermometers thus calibrated. The probable accuracy of the individual degrees thus determined, *i.e.,* of the international scale of temperatures in this range, was stated by Chappuis to be 0.002°. Callendar developed a compensated constant-pressure gas thermometer with a glass or porcelain bulb and a delicate, sensitive manometer for the close maintenance of a constant pressure, and carried his measurements beyond the boiling point of sulfur. He reported with Ezer Griffiths that the sulfur point was 444.53' C. His interests led him to develop also the platinum resistance thermometer as an instrument of great precision, and to compare it with the gas thermometer up to about 550° C., and to devise the well-known Callendar formulas for expressing the relation between resistance and temperature. Applying these equations for extrapolating, he determined the melting point of silver as 961° and that of gold as 1,061° C., values in error by only 0.8° and 2°, respectively, from the values adopted in 1948 on the international temperature scale.

During the early work of Chappuis and Callendar, the platinum-rhodium thermocouple was made by Henry le Châtelier, the famous pioneer of industrial pyrometry, to combine with a high resistance galvanometer in portable form for practical purposes. At the same time C. Barus, at the U.S. geological survey in Washington, was completing a most extensive and thorough study of the thermoelectric properties of a large number of metals and alloys, finally choosing the platinum-iridium alloy to combine with platinum as a thermocouple. Barus was using a constant-pressure gas thermometer with a porcelain bulb surrounded by a rotating muffle in a gas furnace, to measure temperatures up to 1,200° C. for the purpose of calibrating his thermocouples. In the same year in which Barus published his final memoir (1892), L. Holborn and Wilhelm Wien at the Reichsanstalt in Berlin, reported their work comparing an air thermometer with the platinum-rhodium thermocouple up to about 1,300° C. Barus retired from the field in that year, but Holborn and Wien continued with a more refractory porcelain bulb which enabled them to exceed 1,400° C. a few years later. These pioneering efforts at measuring high temperatures with gas thermometers were very instructive as to methods and techniques but of little value for their numerical results.

An international committee on weights and measures passed a resolution adopted in 1887, that: "The international committee on weights and measures adopts as the standard thermometric scale for the international service of weights and measures the centigrade scale of the hydrogen thermometer; having as fixed points the temperature of melting ice (0°) and the vapour of distilled water boiling (100°) at standard atmospheric pressure, the hydrogen being taken at an initial manometric pressure of one meter of mercury — that is to say, 1,000/760 = 1.3158 times the standard atmospheric pressure."

The effect of this action and the subsequent remarkable work of Chappuis at the international bureau was felt mainly in the limited range between the ice and steam points, and here the matter stood officially for more than a quarter of a century. Chappuis had transferred the hydrogen scale to four primary standard mercurial thermometers of French hard glass made by Tonnelot, and by



FROM BEATTIE, "PROCEEDINGS OF AMERICAN ACADEMY OF ARTS AND SCIENCES" (1941)

FIG. 3.—EXPERIMENTAL GAS-THERMOMETER SYSTEM CONSTRUCTED IN DUPLICATE

The three pressure systems are designed for operating the nitrogen-filled thermometers at constant volume: (1) the main system, B,A1', (F),D,G,H,J; (2) the auxiliary system, A,C,P,M,Q, for determining the correction for the dead space, the region of large thermal gradient; and (3) the external pressure adjusting system, steel case to E to N. Mercury reservoirs L are connected through steel blocks H and M to the manometers G, J and P,Q. Bulb is of vitreous silica and connections are steel capillaries and stopcocks. K is a thermostated housing

means of these four, many other mercury thermometers were standardized for distribution.

Precise thermometry at high temperatures may mean, for example, a precision of 0.1° at the melting point of gold (1 063° C.) as compared with 0.001° at 50° C. However, such precision at high temperatures has never been attained with gas thermometers. From 1892 to 1911 the principal contributions to high-temperature gas thermometry were by Holborn and A. L. Day at the Reichsanstalt in 1899, using a platinum bulb and nitrogen; by J. A. Harker at the National Physical laboratory of England in 1904, using a porcelain bulb and nitrogen; by A. Jaquerod and F. L. Perrot in 1905, using a silica bulb and various gases and, for the first time, an electric resistance furnace; by Holborn and S. Valentiner in 1906, using one bulb of platinum-10% iridium and another of pure iridium. both with nitrogen; by Day and J. K. Clement in 1908, using platinum alloy bulbs with nitrogen; and finally by Day and R. B. Sosrnan using the same type of bulbs of 10% iridium or 20% rhodium with nitrogen at constant volume. Day and Sosman began their work in 1904 at the U.S. geological survey where the measurements reached 1,150° C., then finished the work at the geophysical laboratory of the Carnegie institution, Washington, D.C. Here they reached the melting point of palladium reported as 1,549.2 ± 2°, determined the melting points of a series of eight metals from zinc to palladium, and transferred all their measurements to a group of platinum-10% rhodium thermocouples, for which they set up interpolation formulas. The monumental and classical work of Day and Sosman has not been duplicated and probably will not again be attempted because of the increased knowledge of other methods of measurement at high temperatures. However, for the next generation, radiation (optical) methods depended upon extrapolation from the melting points of gold and palladium, as determined by Day and Sosman.

2. Optical and Radiation Thermometry.— During these wonderful developments of gas thermometry. the laws of radiation were gradually taking form. As early as 1860. G. R. Kirchhoff had conceived the idea of the complete radiator, that is, one which has the maximum radiation possible for a given temperature, and which absorbs completely any incident radiation. This idea is experimentally realized by a hollow enclosure having a small opening. Kirchhoff's complete radiator is called a black body (*q.v.*) in physics. He had also concluded that the radiation emission coefficient of any substance is equal to its absorption coefficient, and had called attention to the simple principle that the absorption coefficient plus the reflection coefficient is equal to unity. In 1893 Wien began his studies of the laws of spectral distribution of the radiation from a black body, first reporting the displacement law, which states that the product of the wave length of maximum energy density and the absolute temperature is a constant. Later he published the results of further theoretical considerations, in which he was led to the conclusion that the radiation $J(\lambda, T)$ corresponding to any wave length λ is $J = c_1/[\lambda^5 e^{c_2/\lambda T}]$.

Wien was awarded the Nobel prize in 1911 for his work on black-body radiation. His second law was confirmed by many experimenters in the visible spectrum; but when in 1900 H. Rubens and F. Kurlbaum tested it at long wave lengths and found their results in serious disagreement with the law. Max Planck suggested that they add -1 to the denominator. This modified equation was found to fit the data, and when Planck tried to derive it, he had to assume that the energy of radiation is emitted in multiples of indivisible quanta of energy. Planck's formula remains in modern physics, although its derivation by him has been superseded by modern explanations from statistical mechanics. Planck received the Nobel prize in physics (1918), principally for his quantum theory. The Planck law was the last radiation law to appear, up to the late 1950s, which bore directly on thermometric measurements, but in the final analysis the constant c_2 in this law is best evaluated by its interrelations with many other physical constants. The Stefan-Boltzmann law has not helped precise thermometry, and the value of c_2 derived from the Stefan-Boltzmann constant, σ, is farther from the mean than is any other derived value.

E. Becquerel suggested as early as 1864 that high temperatures could be measured by the intensity of red radiation from incandescent bodies, but it was not until 1892 that the first pyrometer using the idea was invented. Le Châtelier designed a photometric instrument, one for comparing the brightnesses of two sources of light. He arranged a 45° mirror for reflecting the light from a standard source. within the beam from the source being measured. The mirror was mounted in the middle of a telescope, and the light from the standard source was matched with that from the other source by means of absorbing glasses and an iris diaphragm to reduce the brightness of the viewed source to that of the standard. in this case an oil lamp. The measuring scale was placed on the iris diaphragm. A red glass in the eyepiece limited the light to the red region and thus improved the accuracy of brightness matching, which is difficult when the two halves of a photometric field are sensibly different in colour. Preceding Wien, Le Châtelier set up empirical formulas obtained by measuring temperatures with other means to calibrate his instrument.

Others attempted to improve Le Chbtelier's pyrometer, notably Shore and again C. Fery, but none of the forms was completely successful. Perhaps the most complicated optical pyrometer to remain in use and on the market for years was that of H. Wanner (1894), who modified A. Konig's spectrophotometer for temperature measurement. Wanner retained the oil lamp as a standard of brightness but included a small carbon filament lamp as a secondary standard. Both of these pyrometers were improved somewhat by the adaptation of the standard Hefner amyl-acetate lamp. but the Wanner instrument suffered especially in that the form of the source viewed was not visible. It was made more readily portable than the former and became well known in industrial fields, being gradually displaced by the disappearing filament optical pyrometer in the Holborn-Kurlbaum (1901) form of the E. F. Morse invention. If the current through the filament of an electric lamp is slowly increased, the filament glows red at first, then orange, yellow and white. If this filament is placed in the plane of the image of an incandescent object, in a telescope or microscope, the current through the lamp can be adjusted until the filament or a part of it matches the brightness of the image. When this condition obtains, part of the filament becomes invisible against the background of the bright image, and the current required becomes a measure of the temperature of the object. Red glasses are used in the eyepiece to provide the higher accuracy of monochromatic photometry, and absorbing screens are used between the object and the filament to reduce the brightness of the image to the calibrated range of the filament.

C. W. Waidner and G. K. Burgess (1905), at the U.S. national bureau of standards (NBS), studied and reported on the optical pyrometers described above and found that only the latter, disappearing filament form gave promise of affording precision. F. Henning (1910) and C. E. Mendenhall (1911) proposed to modify this form by the substitution of a spectrometer for the red glass, and also for measurements at different wave lengths, but it was learned that this did not increase the precision and it did raise the lower limit of temperatures measurable, because of the reduced amount of light passed by the slits of the spectrometer. W. E. Forsythe (1915) showed that an effective wave length can be calculated for a proper type of red glass with just as definite results as can be obtained with the best monochromator, even when the latter has its slits so narrow that less light is transmitted. P. D. Foote, F. L. Mohler and C. O. Fairchild (1917) calculated the preferred form of spectral transmission of absorption screens to provide a perfect colour match of filament and image, and Forsythe (1915) found experimentally that sectored disks employed to reduce the illumination from the source should be placed near the image. A. G. Worthing and Forsythe (1914) constructed a laboratory form of the instrument for the special purpose of measuring the temperatures of the filaments of tungsten lamps, and found that diffraction effects at the filament of the pyrometer lamp destroyed the equality of brightness of filament and image, making it necessary to give careful attention to the limiting stops or diaphragms in the optical system. Fairchild and W. H. Hoover (1923) showed both theoretically and by experiment that the effects of diffraction can be completely eliminated by proper selection of stops and increased the precision of the instrument to a high degree, obtaining a precision of 0.2° at the melting points of gold and copper, corresponding to 0.4° at the melting point of palladium. They also studied the effects of diffraction with sharp-edged flat filaments, and Fairchild (1920) constructed tungsten pyrometer lamps with optically flat windows. These features were incorporated in the improved form of the instrument required to attain the precision noted.

While the instrument itself was being perfected: many workers in various laboratories were carrying on much experimental work needed to convert experimental data into temperature and to realize more nearly the thermodynamic scale. . Mendenhall (1911) first pointed out that the temperature scale based on the Wien-Planck law is in fact based on a single temperature and the selected value of c_2 in the equation, and that a calibration of the instrument is preferably carried out on this basis. H. E. Ives (1912), P. G. Nutting (1914), W. W. Coblentz and Emerson (1917), E. P. Hyde, Forsythe and F. E. Cady (1918), and finally K. S. Gibson and E. P. T. Tyndall (1923), in extensive and painstaking spectrophotometric tests, measured the relative luminosity function of the eyes of many observers, providing data necessary in all photometric measurements and required in the calculations of optical pyrometry. During this period also a great amount of data was accumulated on the spectral transmission (and its variation with room temperature) of the red glasses and absorption glasses used in fundamental measurements. Foote (1917), in the pyrometry symposium of the Faraday society, summarized the interrelations of the constants c_2 and σ with Planck's constant. h. A score or more of scientists from 1898 on experimentally determined values for the Stefan-Boltzmann constant, σ, among whom should be noted for their pioneer work, Kurlbaum, Féry and M. Drecq, Valentiner, W. Gerlach and Coblentz. By 1926 the value of c_2 had been fairly well established as equal to 1.432 cm. degrees, but later determinations altered this mean by a significant amount (see *The International Temperature Scale,* below).

3. Electrical Thermometry. — Precise resistance thermometry began with the work of Callendar cited above, who found that previous efforts had evidently been careless of the contamination of the fine platinum wire by the reduction of silica in the porcelain spool on which the platinum was wound. Callendar supported the wire on the edges of clean sheet mica so that the wire would be as little contaminated and strained as possible. His results were strikingly successful and he was able to improve his precision again and again over a period of many years. It was no doubt fortunate that, from the beginning of Callendar's work, the metal platinum was available in relatively high ,purity. Owing to the tremendous difficulties of using gas thermometers in experimental work. the use of the Callendar thermometer grew rapidly in all of the principal laboratories of the world, following not only the original studies of Callendar in comparing it with a gas thermometer, but also the work of Chappuis and Harker (1900), Holborn and Henning (1908–11) and Henning and W. Heuse (1921). Various forms of instruments for measuring resistance with sufficient accuracy were developed as their need appeared. Callendar first used an ordinary Wheatstone bridge with a two-lead thermometer, but soon improved the arrangement with Griffiths by including a pair of dummy leads in the parallel arm of the bridge. F. E. Smith (1912) improved this by attaching two leads to each end of the resistor and switching the connections in such manner as to eliminate the inequality of the two current leads. He also developed special forms of the Kelvin double bridge having six decades. with which measurements could be made by a single reading after three of the leads were adjusted to equality. E. F. Mueller (1916–17) designed a six-decade Wheatstone bridge arranged to avoid the errors of contact resistances and with means for determining the bridge zero and for commutation of the leads. Provisions for readily calibrating these bridges by comparison with a single standard resistor were also included in the arrangements. In order to attain a precision of 1 part in 10,000,000 or better, the resistor coils of manganin were immersed in a thermostated oil bath. Others chose to use potentiometric measurements which require the same four attached leads plus a standard resistor with its four leads.

Precise thermometry by means of thermocouples received at least a very favourable start in the investigations of Holborn and Day at the Reichsanstalt in 1900, when they compared the platinum, platinum-10% rhodium thermocouple with the gas thermometer at several good fixed points between 300° and 1,100° C. and found that a simple parabolic expression, $E = a + bt + ct^2$ would represent the relation between electromotive force (e.m.f.) and temperature within experimental error (a few tenths of a degree). Waidncr and Burgess at the bureau of standards (1909) compared a number of these rare-metal couples with platinum resistance thermometers at five fixed points from the melting point of zinc (c. 419°) to that of copper (1,083°), and indirectly confirmed the results of Holborn and Day. However, the interpolation formulas of Day and Sosman mentioned in an earlier paragraph, extended from 320° to 1.550° C., and their temperature–e.m.f. tables were standards of reference for some years. These were not only based on gas thermometer measurements, but represented concurrent researches of the highest order of thoroughness—especially as to the purity of all the metals involved—by their associate, E. T. Allen. The precision of electrical measurements attained by another associate. W. P. White, was amazing in excellence. Improved tables were published by other associates, J. Johnston (1912) and L. H. Adams (1913–14 and 1919), the latter publications including tables for copper-constantan up to 385° C., calculated from the formula, $E = a - b(1 - e^{-ct})$, wherein e is the Naperian base. The precision implied in these tables is not attainable without the precise and accurate measurement of small voltages. Quoting from Day and Sosman's *High* Temperature Gas Thermometry: "Briefly, it may be noted in passing that all the thermoelectric measurements without exception were made with . . . a potentiometer of Wolff standard construction by direct comparison mith a saturated cadmium cell. The cell first used was one of a series described in a previous paper, which has been compared from time to time with the standard cells of the national bureau of standards and has never been found to contain an error greater than one or two parts in 100.000."

Thus the art of electrical measurements per se had kept pace with the art of electrical thermometry. The development of potentiometers (potentiometer here used is not to be confused with its use by electronic engineers to mean a voltage divider) suitable for the measurement of small e.m.f.s as required in this art had extended from 1890 to 1910, the Wolff instrument mentioned incorporating the principles developed by several different writers including H. Hausrauth, W. P. White and H. Diesselhorst. It was a five-dial instrument designed to measure 0.1 microvolt with exactness, and contained no slide-wire usually found in potentiometers designed for less accurate work. The standard of reference in the use of a potentiometer is the standard of voltage made available for practical use in the standard cell, which maintains a constant voltage when it is not drained by an appreciable current.

III. DEVELOPMENT OF INDUSTRIAL THERMOMETRY

1. Introduction in Industry.—There are no records of the slow growth of mercurial thermometry from the time of its invention by Fahrenheit in 1714 to the period of Regnault in the 1840s, and few beyond that date to the end of the 19th century, but there were many makers of these thermometers in the early part of the century and their use no doubt grew with such industries as steam power and chemicals which were making good progress in the middle of the century. Mercury thermometers enclosed in metal protecting sheaths with attached scale-housings for the ruggedness required in plant or factory were to become common articles of commerce knonn simply as industrial thermometers. Thus protected they cannot give the accuracy of a bare thermometer because of the flow of heat out through the sheath; nevertheless they have proved to be indispensable in a multitude of applications. Another instrument of industrial importance was the dial thermometer. sometimes called a pressure-spring thermometer. In this instrument, a liquid or gas is enclosed in a metal bulb connected by a capillary metal tube to the pressure spring a modification of the Bourdon tube found in pressure gauges. This may take the form of a spiral or helix of a flattened metal tube which reacts to internal pressure by a slight unwinding. One end of the tube is fixed and the other end is attached to a mechanism for turning a pointer around the dial scale. The early (before 1911) forms were crude and not compensated for simple errors such as expansion of the fluid in the connecting capillary and spring. Thermocouples made of base metals had begun to compete with the Le Châtelier couple because of their lower cost and higher thermoelectric power. Iron was still considered unsuitable for a thermocouple element and many combinations of metals and alloys were tried. The most successful of these was invented by M. A. L. Marsh, who combined an alloy of nickel-2% aluminum with nickel-10% chromium. This thermocouple was found to be serviceable as high as 1,100° C.. and generated an e.m.f. four to five times as large as did the platinum alloy couple of Le Châtelier. The optical pyrometers of the Holborn-Kurlbaum and the Wanner types were in extensive use; likewise the radiation pyrometers of Féry, C. E. Foster and C. B. Thwing. A commercial form of Callendar's resistance thermometer was having considerable success. Rugged low-resistance millivoltmeters were available for use with thermocouples and radiation receivers, and the earliest forms of recording instruments were manufactured in considerable quantities. Of these the recorder developed by Callendar with its Wheatstone bridge circuit for his resistance thermometers, various recording millivoltmeters and the Leeds and Northrup recording potentiometer were outstanding examples.

2. Industrial Thermometry up to 1920.—The earliest symposium of note was that of the Faraday society held in London in 1917. It was entitled "Pyrometers and Pyrometry" and the papers and discussion indicated primary interests in the high-temperature industries such as metals, glass and ceramics. The consensus of this symposium was that the industries mentioned would profit a good deal from the proper use of pyrometers, but that the instruments must be improved both in ruggedness and accuracy, and the persons using them must learn much more about them. In thermoelectric pyrometry, it was reported that (1) base-metal thermocouples are inhomogeneous and so cannot provide the accuracy of rare-metal couples; (2) low-resistance millivoltmeters may be robust but the errors are too large, hence high-resistance meters should be used and are on the market; (3) potentiometers are not useful in industry because they are not self-indicating; (4) recorders (millivoltmeter type) are expensive, not properly designed and give too much trouble; and (5) pyrometers should be manufactured with more uniformity so that couples and meters can be interchanged. The inherent limitations and larger errors of radiation pyrometers were discussed both on scientific and practical grounds, but their unsuitability for portable use was not yet clear. No particular type was outstanding. Optical pyrometry had not reached many hands and there mas a prevalent idea that too much knowledge was necessary to make good use of it. The disappearing-filament type was competing on even terms mith the Wanner (spectrophotometric) instrument.

Just two years after this symposium in London the first of a series of very important symposia on temperature to be held in the

United States was held in Chicago (1919). This "Symposium on Pyrometry," as it was called, was more comprehensive and rather systematically covered the whole subject as a science, and applications of varied character. The symposium was the final work of a pyrometer committee of the National Research council, which committee had been formed at the suggestion of H. M. Howe, chairman of the engineering division of the council, "for the purpose of developing a pyrometric method suitable for open-hearth steel practice so that the effects of temperature in the various stages of the processes of steel making might be correlated quantitatively with the other factors influencing the production of sound steel." The symposium constituted a special series of sessions of a meeting of the American Institute of Mining and Metallurgical Engineers, which published the 59 papers in book form.

There were a number of striking conditions revealed by this symposium: (1) Some U.S. industries had advanced tremendously during the preceding few years in the application of pyrometry, but these industries were only the high-temperature ones, particularly metals and to some extent glass, ceramics and portland cement. (2) It was taken for granted that industrial pyrometry was an important technologic field. (3) Once again there was slight scientific interest in industrial thermometry — that is, thermometry below a red heat. (4) A great many engineering colleges were teaching pyrometry and probably a little thermometry. (5) Electrical thermometry had not yet seriously invaded the field of expansion thermometry at lower temperatures. (6) Automatic control (regulation) by means of electrical instruments was barely started, as on-and-off control only, and the physicists and metallurgists currently interested in pyrometry were not in touch with mechanical engineers who had developed the art of automatic throttling control of steam engines, which the latter called governing. (7) Industrial standards of accuracy had progressed slowly and were still well behind those available from the bureau of standards and other research laboratories.

The symposium showed that base-metal thermocouples had finally found established acceptance for industrial use, the combinations — copper-constantan, iron-constantan and chromel-alumel — being well known. The last named is the combination nickel-10% chromium with nickel-2% aluminum, previously mentioned, the words chrome1 and alumel being originally trade names for these two alloys. Considerable stress was directed toward the high resistance millivoltmeter, placing the low-resistance instruments in an inferior class. Of course this developement was partially the result of the growing use of industrial forms of potentiometers, particularly the recording potentiometer invented by Morris Leeds of the Leeds and Northrup Co. It was apparent that industry was becoming accustomed to the higher costs of good pyrometers, and not only the recording potentiometer but a number of good recording millivoltmeters were to be on the market for many years. About one quarter of the symposium papers were written primarily or partially around the theory and applications of the disappearing-filament optical pyrometer. A number of these were of course concerned with laboratory methods, for example, of determining the temperatures of tungsten lamp filaments and methods of standardizing. It was forcefully brought out that industry needed a mass of new data about the emissivity of nonblack bodies, in order to make the optical pyrometer fully useful in any form. Theories of radiation as applied to nonblack bodies were more fully developed to the advantage of industrial applications. Perhaps the optical pyrometer was being used beyond its properly established sphere at this time. At any rate, the limitations of both optical and radiation pyrometry were ably treated, and ample warning was issued to persons in industry by the students of the science. A new form of resistance thermometer appeared in which a fine platinum ribbon is wound on a small tube made of fused quartz, and over this is melted down an outer jacket of the same material, completely sealing in the platinum resistor and protecting it from contamination by industrial gases. This device was to meet much success even for temperatures as high as 900° C. The errors caused by strains in the embedded platinum amounted to a small fraction of a degree at moderate temperatures, other errors being due mainly to the difficulty of protecting the leads close to the resistor. Resistance thermometers made of nickel wire protected for use up to 500° C. were also described, but there seems to have been no attention to the molecular change taking place in nickel at about 325° C., which unfits this metal for such use in this range and bevond.

IV. MODERN THERMOMETRY FROM 1920

The second and third U.S. symposia on temperature, which were held in 1939 and 1954 in New York city and Washington, D.C., respectively, revealed the remarkable growth in thermometry since the first symposium. The second symposium was held under the auspices of the American Institute of Physics and the third under the joint auspices of that institute, the national bureau of standards and the office of ordnance research, U.S. army. The papers presented at these symposia were published in 1941 and 1955 under the titles *Temperature — Its Measurement and Control in Science and Industry,* vol. i and ii respectively. (Henceforth, they will be referred to as *Temperature I* and *Temperature II*). These texts treat rather exhaustively the status of modern thermometry up to 1954. *Temperature I* contains approximately 125 papers on such widely diverse scientific and technological subjects as temperature scales, precision thermometry, temperature in biology, automatic temperature regulation and recording, etc. *Temperature II* contains 24 papers with the emphasis on standards and extremely low and high temperatures. There is only one paper on industrial thermometry and none on thermocouples, optical pyrometry or thermometry in the biological sciences. Apparently the development of applied thermometry was considerably less between 1939 and 1954 than between 1919 and 1939.

1. The International Temperature Scale.—The thermodynamic temperature scale has long been recognized as the fundamental scale to which all temperatures should ultimately refer. However, experimental difficulties inherent in measuring temperature on the thermodynamic scale led the seventh General Conference on Weights and Measures, a diplomatic body representing 33 nations and having the power to adopt recommendations concerning standards of weights and measures for international use, to adopt a practical scale in 1927. This scale was intended to be as close to the thermodynamic scale as possible but more conveniently realized and reproducible. National laboratories used this scale and urged scientists and industrial workers to do the same. The scale was named the international temperature scale and the most recent revision (as of the latter 1950s) is known as the international temperature scale of 1948. The official text of this scale is contained in the *Procès-Verbaux des Séances du Comite international des Poids et Mesures,* t. xxi (1948). The following is a translation of the official text for the defining part of the scale by H. F. Stimson in the *Journal of Research of the National Bureau of Standards,* vol. 42 (1949).

1. Temperatures on the International Temperature Scale of 1948 will be designated as "°C" or "°C (Int. 1948)" and denoted by the symbol, *t*.

2. The scale is based upon a number of fixed and reproducible equilibrium temperatures (fixed points) to which numerical values are assigned, and upon specified formulas for the relations between temperature and the indications of the instruments calibrated at these fixed points.

3. The fixed points and the numerical values assigned to them are given in Table I. These values, in each case, define the equilibrium

TABLE I. — *Fundamental and Primary Fixed Points Under the Standard Pressure of 1,013,250 dynes/cm²*

	Temp. °C.
(a) Temperature of equilibrium between liquid oxygen and its vapour (oxygen point)	−182.970
(b) Temperature of equilibrium between ice and air saturated water (ice point) *fundamental fixed point*	0
(c) Temperature of equilibrium between liquid water and its vapour (steam point) *fundamental fixed point*	100
(d) Temperature of equilibrium between liquid sulfur and its vapour (sulfur point)	444.600
(e) Temperature of equilibrium between solid and liquid silver (silver point)	960.8
(f) Temperature of equilibrium between solid and liquid gold (gold point)	1063.0

temperature corresponding to a pressure of 1 standard atmosphere, defined as 1,013,250 dynes/cm². The last decimal place given for each of the values of the primary fixed points only represents the degree of reproducibility of that fixed point.

4. The means available for interpolation lead to a division of the stale into four parts.

(a) From 0° C to the freezing point of antimony the temperature, t, is defined by the formula

$$R_t = R_0(1 + At + Bt^2),$$

where R_t is the resistance, at temperature, t, of the platinum resistor between the branch points formed by the junctions of the current and potential leads of a standard resistance thermometer The constant, R_0, is the resistance at 0° C, and the constants, A and B, are to be determined from measured values of R_t at the steam and sulfur points. The platinum in a standard resistance thermometer shall be annealed, and of such purity that R_{100}/R_0 is greater than 1 3910.

(b) From the oxygen point to 0° C, the temperature, t, is defined by the iormula

$$R_t = R_0[1 + At + Bt^2 + C(t - 100)t^3]$$

where R_t, R_0, A, and B are determined in the same manner as in (a) above, and the constant, C, is calculated from the measured value of R_t at the oxygen point.

(c) From the freezing point of antimony to the gold point, the temperature, t, is defined by the formula

$$E = a + bt + ct^2$$

where E is the electromotive force of a standard thermocouple of platinum and platinum-rhodium alloy when one junction is at 0° C and the other is at the temperature, t. The constants, a, b, and c, are to he calculated irom measured values of E at the freezing point of antimony and at the silver and gold points. The antimony used in determining these constants shall be such that its freezing temperature, determined with a standard resistance thermometer, is not lower than 630.3" C. Alternatively the thermocouple may be calibrated by direct comparison with a standard resistance thermometer in a bath at any uniform temperature between 630.3° and 630.7° C.

The platinum wire of the standard thermocouple shall be annealed and of such purity that the ratio R_{100}/R_0 is greater than 1.3910. The alloy wire shall consist nominally of go percent platinum and 10 percent rhodium by weight. When one junction is at 0° C, and the other at the freezing point of antimony (630.5" C), silver, or gold, the completed thermocouple shall have electromotive forces, in microvolts, such that

$$E_{\mathrm{Au}} = 10{,}300 \pm 50\mu v$$
$$E_{\mathrm{Au}} - E_{\mathrm{Ag}} = 1185 + 0.158(E_{\mathrm{Au}} - 10{,}310) \pm 3\mu v$$
$$E_{\mathrm{Au}} - E_{\mathrm{Sb}} = 4776 + 0.631(E_{\mathrm{Au}} - 10{,}310) \pm 5\mu v$$

(d) Above the gold point the temperature, t, is defined by the formula

$$\frac{J_t}{J_{\mathrm{Au}}} = \frac{e^{\frac{c_2}{\lambda(t_{\mathrm{Au}}+T_0)}} - 1}{e^{\frac{c_2}{\lambda(t+T_0)}} - 1}$$

in which J_t and J_{Au} are the radiant energies per unit wave length interval at wave length, λ, emitted per unit time by unit area of a black body at the temperature, t, and at the gold point, t_{Au}, respectively; c_2 is 1.438 cm degrees; T_0 is the temperature of the ice point in °K; λ is a wave length of the visible spectrum; e is the base of Naperian logarithms.

Recommendations for experimentally realizing the above defined scale also are included in the official text and may be found in Stimson's translation.

Gntil 1948 the thermodynamic scale was defined on the basis of the 100-degree temperature interval between the ice and steam points. Lord Kelvin, who originally defined the scale in this manner in 1854, recommended that when a single fixed point was sufficiently well known it would be preferable to define the scale using this one point. In 1948 the ninth general conference redefined the thermodynamic scale in this way using the triple point of pure water (temperature of equilibrium between ice, liquid water and water vapour), and in 1954 the tenth general conference approved the value of 273.16° K. for this point. The zero of the thermodynamic centigrade scale was still the freezing point of water but defined to be .0100 degrees below the triple point. Since the thermodynamic scale is the fundamental temperature scale, it is of some interest to compare it with the international temperature scale of 1948. The latter scale is not defined below the boiling point of oxygen. In the temperature range from the oxygen point to the ice point, measurements by Von W. Heuse and J. Otto at the Physikalisch-Technische Reichsanstalt in 1932 and W. H. Keesom and B. G. Dammers at the University of Leiden, Netherlands, in 1935 indicated that the two scales agreed within 0.01°. A determination of the thermodynamic temperature of the oxygen point at Pennsylvania State university, University Park, in 1953 by G. W. Moessen, J. G. Aston and R. G. Ascah gave −183.00" C. (therm. cent. 1954). Intercomparison by J. A. Beattie at the Rfassachusetts Institute of Technology. Cambridge, of two nitrogen gas thermometers with platinum resistance thermometers between the ice and sulfur points indicated that the thermodynamic scale was about 0.006° lower at the steam point and 0.1° higher at the sulfur point than the international scale of 1948. A redetermination of the gold point utilizing gas thermometry was reported in 1957 by H. Moser, Otto and W. Thomas at the Physikalisch-Technische Bundesanstalt and in 1956 by J. Oishi, M. Awano and T. Mochizuki at the Tokyo Institute of Technology. The values were 1064.76° C. and 1063.69" C. respectively. The latter workers also reported a value of 961.28° C. for the silver point. Above the gold point, differences between the fundamental and practical scales can be estimated from estimates of the difference between defined and true values of t_{Au}, c_2 and T_0. The uncertainty in T_0 can be neglected compared with that of t_{Au}. From an analysis of variance of data on atomic constants J. W. DuMond and E. R. Cohen at the California Institute of Technology, Pasadena. reported in 1955 the value of 1.43888 cm. degree for c_2; and in 1957 from a similar analysis J. A. Bearden and E. H. Watts at the Johns Hopkins university, Baltimore, Md., reported 1.43886 cm. degree. If the correct value for c_2 were 1.439 and t_{Au} were 1,064° C., the thermodynamic temperature above the gold point would be about 0.07% higher than that of the international scale of 1948.

2. Gas Thermometry.—Modern industrial gas thermometry is practised to a limited extent because of the difficulty of correcting for the expansion of the gas in the connecting tube between the bulb and the pressure measuring device, such as the Bourdon tube, or pressure spring. On the other hand. scientific interest in precise gas thermometry has not lagged. It has been directed to the accumulation of more exact knowledge of the properties of real gases such as nitrogen, hydrogen and helium and the derivation of corrections to be applied to the real gas thermometer scale to convert them to the thermodynamic scale, which would be realized by an ideal gas. Gas thermometry is intimately related to many fields of physics and chemistry through the relation of the universal gas constant R (in the equation of a perfect gas, $pv = \mathrm{RT}$) to many other constants, and through the dependence of much of the exact knowledge of these other constants on the value of the ice point, T_0, on the Kelvin or thermodynamic scale. These relations have benefited the art tremendously by maintaining a scientific interest in ever seeking to improve the accuracy of measurements not only at ordinary and high temperatures but at very low temperatures approaching zero on the Kelvin scale. The knowledge of phenomena near zero depends first on the accuracy of the value selected for T_0.

General thermodynamic theory of the departures of the properties of real gases from the laws of an ideal gas lead to the result $pv = \mathrm{KT} + Bp$ for moderate pressures (one or two atmospheres). For the three commonly used thermometric gases mentioned above, the term Bp amounts to less than 0.1% of RT at 0° C. and one atmosphere. The coefficient B, called the second virial coefficient, is a function of both temperature and pressure, but because Bp is so small. B values may be determined with satisfactory accuracy by varying pv at a constant temperature and writing $B = V - RT/p$. In the language of the investigators in this field, the slopes of the pv isotherms of any gas serve in themselves to determine the departure of the gas from ideal, without the use of any other data. Some investigators set up equations for B as a function of T and use them to smooth the data. B values can also be calculated from the Joule-Thompson coefficient, μ, and the specific heat, C_p, at constant pressure. Most of the data on gas scale corrections are, however, based on the compressibility, the pv isotherms.

Work in precise gas thermometry has been carried out principally in the laboratories of the bureau of standards, the University of

Leiden, Massachusetts Institute of Technology, the University of Wisconsin, Pennsylvania State university and the Reichsanstalt. Reports are found in the publications of the institutions and especially in *Physical Review; Zeitschrift fur Physik; Annalen der Physik; Proceedings of the Section of Sciences* of the Royal Netherlands Academy of Sciences; *Philosophical Magazine; Proceedings of the American Academy of Arts and Sciences. Temperature I* and *Temperature II* contain a number of important articles in this field and extensive references.

Some of the results of this work have been mentioned already in comparing the international temperature scale with the thermodynamic centigrade scale. In addition, Moessen, in a dissertation submitted to the Pennsylvania State university in June 1955, reported a value of 20 365° ± .005° K. for the boiling point of hydrogen. In 1954 the national bureau of standards started a gas thermometer program under the direction of Stimson to determine the ratio of thermodynamic temperatures up to the silver point to that of the steam point. An accuracy of 0 01 degree appeared to be attainable. The basis for this improvement is the precision manometer described in *Temperature II*, the extremely small dead-space volume and the excellent temperature control and uniformity of temperature inherent in the design.

3. Modern Mercury-in-Glass Thermometry.— This is by far the most important division in point of numbers of thermometers used, diversity of applications and general renonn. While the mercury thermometer has lost its standing as a primary standard, having given up such a distinction to the platinum resistance thermometer, it must still be regarded in its better grades of workmanship as an instrument capable of furnishing a highly useful accuracy of indication Particularly is this true in the range from slightly above −40° to 150° C., where accuracies of near 0.01° are attainable in experienced hands. A thermometer of such a grade has its scale etched directly on the glass stem. When one considers that the thermal volume expansion of mercury is only about 180 parts per 1,000,000 per °C at room temperature, and that an accuracy of indicating an expansion of only 180 parts in 100,000,000 is attainable, the amazing performance of so simple a device can more readily be appreciated. It is the more remarkable in view of the natural instability of glass, even of the special hard glasses employed. To be sure, such an accuracy is obtained only under carefully prescribed conditions of manufacture, calibration and use First, the thermometer must have been properly annealed during its making, filled with the purest of mercury and sealed off with the correct pressure of nitrogen in the capillary space; *i.e.*, just sufficient to prevent the mercury from easily separating during rough handling. Some manufacturers age their thermometers for extended periods at as high a temperature as they can withstand after filling and sealing. This is supposedly an inferior method. Next, the calibration must proceed at a series of successively higher temperatures. must include the ice point and must be carried out with mercury in the stem extending out of the hot bath only far enough to be seen. Now, when the thermometer is used, the measurements must be made under a similar set of conditions. If a thermometer thus calibrated is heated to a higher temperature after having been, for instance, at the ice point for several days, the bulb will expand within a few minutes to the size it had at this temperature during its original calibration. If it then is cooled back to zero the bulb will not promptly contract to the corresponding volume, but will be slightly larger and will gradually shrink to its original size over several days. During this period the thermometer reads low because the bulb is larger than normal. This error is called the ice-point depression, a uell-knonn characteristic of even the best thermometers. The depression at any temperature amounts to nearly 0.01° for every 10 degrees of cooling from a higher temperature, if the observation is made within a few minutes of the attainment of the lower temperature. Thus it is apparent that a thermometer graduated in tenths of a degree per division would reveal this phenomenon of hysteresis, but that one graduated in whole degrees would not, unless each division were very large.

The thermometer described in the previous paragraph is known as a total immersion thermometer because it has been calibrated and is normally used with all of its mercury immersed except the tiny bit required to be visible outside of the hot bath. If it is necessary to use it with a considerable part of the capillary thread of mercury extending out of the bath. corrections for this length of emergent stem can be approximated.

A formula for this is: stem correction $= 0.00016n(T - t)$ where n is the number of degrees centigrade emergent from the bath. T is the temperature in °C. of the bath and t is the average temperature of the emergent stem. If the calculation is in °F. the coefficient is 5/9 as much. This correction is seldom attempted since the advent of the resistance thermometer and the practice of making many mercury thermometers calibrated for partial immersion. Partial immersion thermometers, so-called, afford relatively accurate indications only when they are used under conditions closely approximating those prevailing during their calibration. They are nevertheless the commoner form of industrial thermometer, particularly when enclosed in a protective sheath and windowed frame.

The upper limit of temperature for which these thermometers can be designed depends not only upon the softening range of the glass but also upon the high vapour pressure of mercury. The commonest glasses made expressly for thermometers permit reliable use up to about 400° C. (752° F.). Those glasses usually contain lead, and the harder borosilicate glasses raise the limit to about 500° C. (932° F.). Still harder glasses which raise the limit to about 650° C. (1,202° F.) are used to some extent. but suffer the competition of thermocouples.

High-temperature thermometers have been made of fused silica filled with the metal gallium which melts at approximately 30° C. (86" F.) and boils above 1,600° C. The lower vapour pressure of the liquid gallium at high temperatures is a real advantage, but capillary tubes of fused silica are difficult to make because of the high melting point (1,710° C.) of this oxide, and the combination has not been extensively employed. The lower limit of mercury-in-glass thermometers has been extended by alloying thallium with the mercury in a percentage close to the composition having the lowest melting point (eutectic mixture). This is at 9.3% thallium, the melting point being −59° C. (−74° F.). Such a thermometer is easier to make than the gallium-in-silica, and has been used in limited quantities, but both meet the competition of forms of thermometers described in other paragraphs.

Thermometric Lag.—Whenever a thermometer at one temperature is suddenly immersed in a fluid medium at a higher temperature, heat flows into the thermometer, raising its temperature rapidly at first and more slowly as the temperature of the medium is approached. After a sufficient lapse of time no further change of the thermometer can be detected and it is then assumed that the temperature of the medium is indicated. Also if a thermometer is immersed in a medium whose temperature is varying, the thermometer will always be at a different temperature, lower or higher than the medium depending on whether its temperature is rising or falling. It is said that the temperature of the thermometer lags that of the medium. This subject is frequently discussed in relation to mercury-in-glass thermometers, perhaps because such a thermometer, when immersed bare in a stirred bath, lags the temperature of the bath in a manner that can be expressed by a simple law, as shown by D. R. Harper in a bureau of standards bulletin (1912). This law is usually referred to as Newton's law of cooling and as applied in this case states that the rate of change of temperature of the thermometer is proportional to the difference between its temperature and that of the bath. Perhaps it is clearer to consider the thermometer as having a bulb of glass, a poor conductor of heat, full of mercury, a far better conductor, being also a liquid in which convection currents assist in the transfer. The rate of heat flow through the glass of the bulb, according to J. B. Fourier's law, is proportional to the temperature gradient. As given by Harper:

$$\frac{d\theta}{dt} = \frac{1}{\lambda}(u - \theta)$$

where u is the temperature of the bath at time t, θ is the temperature of the thermometer at the same time and λ is a constant with respect to u, 8 and t.

Considering only the case of a constant temperature of a stirred bath, the solution is:

$$(\theta - u) = (\theta_0 - u)e^{-t/\lambda}$$

where e is the base of natural (Napierian) logarithms, approximately 2.718, and θ_0 is the temperature at the start of reckoning time, (t = o). At the time $t = \lambda$, $(\theta - u) = (8, - u)/e = .37$ $(\theta_0 - u)$, that is λ is the time required for the temperature difference to be reduced to 37% of the initial difference. This value of A is called the time constant of the thermometer under the special conditions of the bath, as to substance (water, oil. etc.) and stirring. An ordinary bare laboratory thermometer has a time or lag constant of 2 to 3 seconds in a well-stirred water bath. 5 or 6 seconds in oil and about 1 minute in well-stirred air to 3 or more minutes in still air. The time required for the difference to decrease to 1% of the initial difference is 4.6λ and the time to reach 0.1% is 6.9λ. For example a bare thermometer for which A is 2 seconds, when immersed in a stirred water bath which is 10° hotter than the thermometer, will warm 6.3° in 2 seconds, 9.9° in 9.2 seconds and 9.99" in 13.8 seconds.

Harper has shown that a bare thermometer in a bath whose temperature is rising at a constant rate lags in temperature behind that of the bath by λ seconds, if the thermometer has been in the bath long enough to attain the same rate of rise.

These simple relations do not apply to thermometers in a sheath or to other cases where more than one layer of substance is found between the bath and the mercury. Nevertheless thermometers in many forms are arbitrarily characterized by assigning them an experimentally determined lag constant equal to the time required to change 63% of the initial temperature difference as described above. Occasionally this property is based on common logarithms, in which case the constant corresponds to a change of 90% (10% residual).

Liquid-in-Glass Thermometers other than mercury-filled are employed to a considerable extent for measuring temperatures below the freezing point of mercury. The (ethyl) alcohol thermometer is the best known of these, and is used to cover the range from 70° down to −80° C. Many organic liquids can be used, the special requirements being low freezing point, low viscosity, nontoxicity and ability to dissolve a dye and remain stable. Pentane thermometers are useful from 30° down to approximately −200° C., and toluene (occasionally called toluol) thermometers are useful from 150° to −80° C. These liquids, and for that matter most organic liquids, have an expansion coefficient many times larger than that of mercury, hence these so-called spirit thermometers are characterized by a large diameter of the capillary and superior visibility of the red-dyed column of liquid. The liquids are somewhat prone to separate in the column but the droplets are readily rejoined by tapping a side of the stem. Because these liquids all wet the glass, forming a deep meniscus, the top of the column is not so accurately observable as that of a mercury column. Also, during a decrease of temperature, the receding liquid leaves a thin film on the glass, which runs down slowly. While this distributed liquid is running down, the thermometer indicates too low a temperature. In spite of these disadvantages such thermometers are widely used, often in the same ranges as mercury-filled, particularly because of the ease of observing the large red column. Before sealing the top of these thermometers after filling the bulb and sufficient of the bore, the bulb is cooled with dry ice (solid CO_2) and the space above the liquid is left full of air, which materially reduces distillation into the space and separatian of the liquid column.

Fine annealing of the glass of thermometers to be filled with an organic liquid is not generally practised nor is it as essential as in the case of mercury, because of the relatively large expansion coefficient of such liquids and the consequent lesser effect of changes in the volume of the bulb. Also these thermometers are not intended to be read as closely as the mercury-filled.

4. Modern **Dial** Thermometers. — Modern dial thermometers have great industrial importance. rivaled only by mercury-in-glass, in point of numbers manufactured and used. Though there are

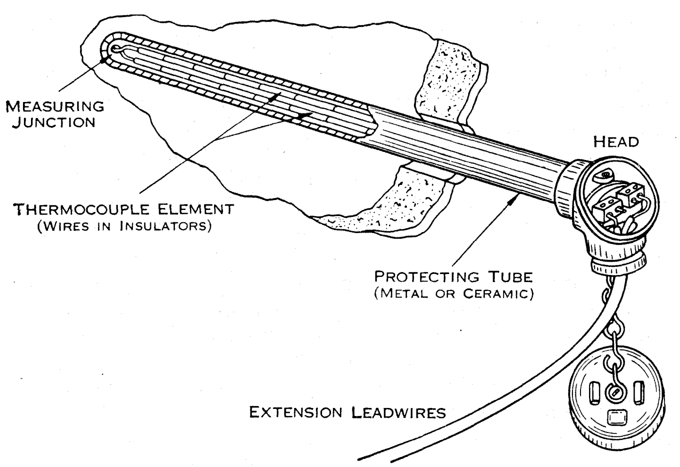


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FIG. 4.— INSTALLATION OF INDUSTRIAL FORM OF THERMOCOUPLE THROUGH FURNACE WALL SHOWN CUT AWAY. THE EXTENSION LEADWIRES ARE CONNECTED TO AN ELECTRICAL MEASURING INSTRUMENT, ORDINARILY READING TEMPERATURE

many types including solid, liquid, gas or liquid-vapour filled, this article will discuss only the liquid-filled The usual liquid is mercury, again because of its long range of usefulness — from −40° to someuhat above 500° C. The major portion of the mercury is contained in a strong steel (sometimes stainless) bulb to which is welded a long steel capillary tube having a bore about .01 in. in diameter. The other end of the tube is welded to a Bourdon tube, sometimes called a pressure spring, also of steel, mounted in a case and attached through a mechanism to a rotating pointer. The entire closed system of bulb, tube and flattened pressure spring which has been wound into a spiral or helix, is filled with mercury (to the exclusion of any gas or 10%-boiling liquid) under a pressure of a few hundred pounds at room temperature. Higher temperatures increase this pressure so that it is maintained well above the vapour pressure of the mercury, while not exceeding the limited strength of the pressure spring, which is highly strained as the liquid expands. With a proper connecting mechanism. the scale of such a thermometer is very nearly uniform and the instrument is a widely accepted article of commerce. In its more highly developed form the expansion of the mercury in the tube and spring is compensated so that tubes up to 250 ft. or more in length can be used without material loss of accuracy. Two forms of compensating device are employed. One consists of a duplicate capillary tube, also containing mercury, and attached to a second pressure spring which opposes the main spring, and the other consists of a wire of nickel steel threaded through the single tube. This wire is selected to have a negligible expansion (*e.g.*, invar) and the space between it and the wall of the capillary bore is adjusted to vary with temperature in correspondence with the expansion of the mercury. A bimetallic spring can be used to separately compensate for the expansion of the liquid in the pressure spring. Such thermometers, especially with the connecting tube protected uith an armour of flexible metal or rubber, successfully compete with electrical thermometers and are also made into recorders and automatic controllers of various forms. Organic liquids are occasionally substituted for mercury, but their higher expansions are offset by the primary necessity in any case of keeping the volume of the bore and spring small compared with that of the bulb. Furthermore, none of them have a range of the liquid state comparing favourably with that of mercury. One rather surprising characteristic of the mercury-filled thermometer described in this paragraph is that the bulb, filled with so heavy a liquid, can be elevated far above the pressure spring without introducing serious errors. This is because the small error results in the main only from the distortion of the stiff walls of the bulb, uhich takes place with the change of pressure as the bulb is raised. The presence of a small amount of gas or uater, for example, entrapped in the bulb would alter this favourable performance. Details on other types of dial thermometers can be obtained from H. J. Hoge's paper on "Temperature Measurement in Engineering" in *Temperature II*.

5. Electrical Thermometry.— This is a rather loose expression and here is intended to include resistance and thermoelectric instruments; that is, in the first subdivision, "a thermometer in which the resistance of a definite part, the resistor, serves as a measure of temperature," and in the second subdivision, "a thermometer whose indications depend upon the e.m.f. of a thermocouple. It ordinarily consists of a thermocouple, connecting leads, and an instrument for measuring e.m.f." A thermocouple is "a pair of dissimilar electrically conducting materials joined together at one end, in which a difference in temperature of the junctions from that of the other ends generates an e.m.f."

The resistance thermometer affords the greatest precision of all forms of temperature-measuring devices in ranges below 660° C., and in its finest constructions is widely used in scientific and industrial laboratories. On the other hand it is made in rugged and less expensive forms for use in measuring the temperatures of manufacturing processes, rotating machines, stationary structures, air and air-conditioning equipment, and a multitude of other applications where temperatures do not exceed about 150° C. (302° F.). Most industrial forms employ a resistor of nickel wire (occasionally copper or platinum wire) wound in a helix or coil and protected in a sealed metal tube. For higher temperatures platinum is used because nickel undergoes a molecular transformation between 300° and 350° C., accompanied by troublesome changes in resistance with rising and falling temperatures; also it is not available in high purity, and cannot be annealed satisfactorily after winding in the form of insulated wire. Platinum can readily be obtained with a purity better than 99.999%, and for industrial use thermometers made of such metal do not require annealing at a high temperature, to reproduce a standard resistance-temperature relation. Platinum resistance thermometers made up in strain-free form (as taught by T. S. Sligh, Beattie and C. H. Meyers) and mounted in hermetically sealed pyrex glass or quartz tubes filled with clean dry air, nitrogen or helium for small lag, display an astonishing stability of resistance even to temperatures as high as 700° C. Slow changes of resistance of a few parts per 1,000,000 can be detected, however, during long continued use, and proper corrections to a few parts in 10,000,000 are on occasion reliably applied. These thermometers have four leads usually made of gold wire, extending from the coil to the head. Short lengths (an inch or so) of platinum wire connect the gold to the resistor in order to reduce the heat conduction to the leads. A convenient value of the resistance for most purposes is 25.5 ohms such that the variation is approximately 0.1 ohm per degree centigrade.

In 1942 Hoge and F. G. Brickwedde intercompared eight platinum resistance thermometers between −183° and 445° C. Excluding one thermometer which had an unusual characteristic, the maximum deviation among the thermometers was 0.0065° between −183° and 0° C., 0.0015° between 0° and 100° C. and 0.0105° between 100° and 445° C. As a result of the availability of purer platinum and improvements in technique of measurement and design of instruments, the above differences would certainly be less with thermometers made and measured in 1957. An upper limit of the precision available can be obtained by results at the fixed points. A precision of about ±.0002° has been attained at the oxygen point, ±.0001° at the triple point, +.0002° at the steam point and ±.002° at the sulfur point. A description of the apparatus used at the national bureau of standards and National Physical laboratory in order to achieve this precision can be found in *Temperature* II. Studies conducted by E. H. McLaren at the National Research council. Ottawa, Can., on the freezing point of high-purity zinc have shown a precision ten times greater than that realized at the sulfur point. Thus, substitution of the zinc point for the sulfur point would improve even further the remarkable precision and accuracy of platinum resistance thermometers.

J. A. Hall states in *Temperature II* that "the work with resistance thermometers at high temperatures has suggested that it may be possible to extend the range of the resistance thermometer as the standard interpolation instrument up to 1,063° C., eliminating the thermocouple entirely." Since 1957 the national laboratories have been investigating this possibility. Work by J. P. Evans at the national bureau of standards has indicated that lack of stability at the higher temperatures and development of a sufficiently sensitive and precise potentiometric method of resistance measurement are two of the major problems. Changes in thermometer calibration could be very large. even at 800° C., requiring a calibration every time the thermometer is used. Extreme care in protecting the platinum from any trace of chemical contamination reduces this change. The potentiometric method of resistance measurement appears necessary because the replacement of the gold leads with platinum (in order to reach 1,063° C.) made the lead resistance comparable to that of the temperature-measuring element and varying too rapidly to be eliminated with sufficient accuracy in a bridge measurement. In spite of these difficulties, a platinum resistance thermometer will probably replace the thermocouple as a standard thermometer to the gold point improving the precision by a factor of about ten.

The expression $R_t = R_0(1 + At + Bt^2)$ for the relation between resistance and temperature for platinum. as found above in the definition of the international temperature scale gives the same set of resistance-temperature values as the original Callendar formula:

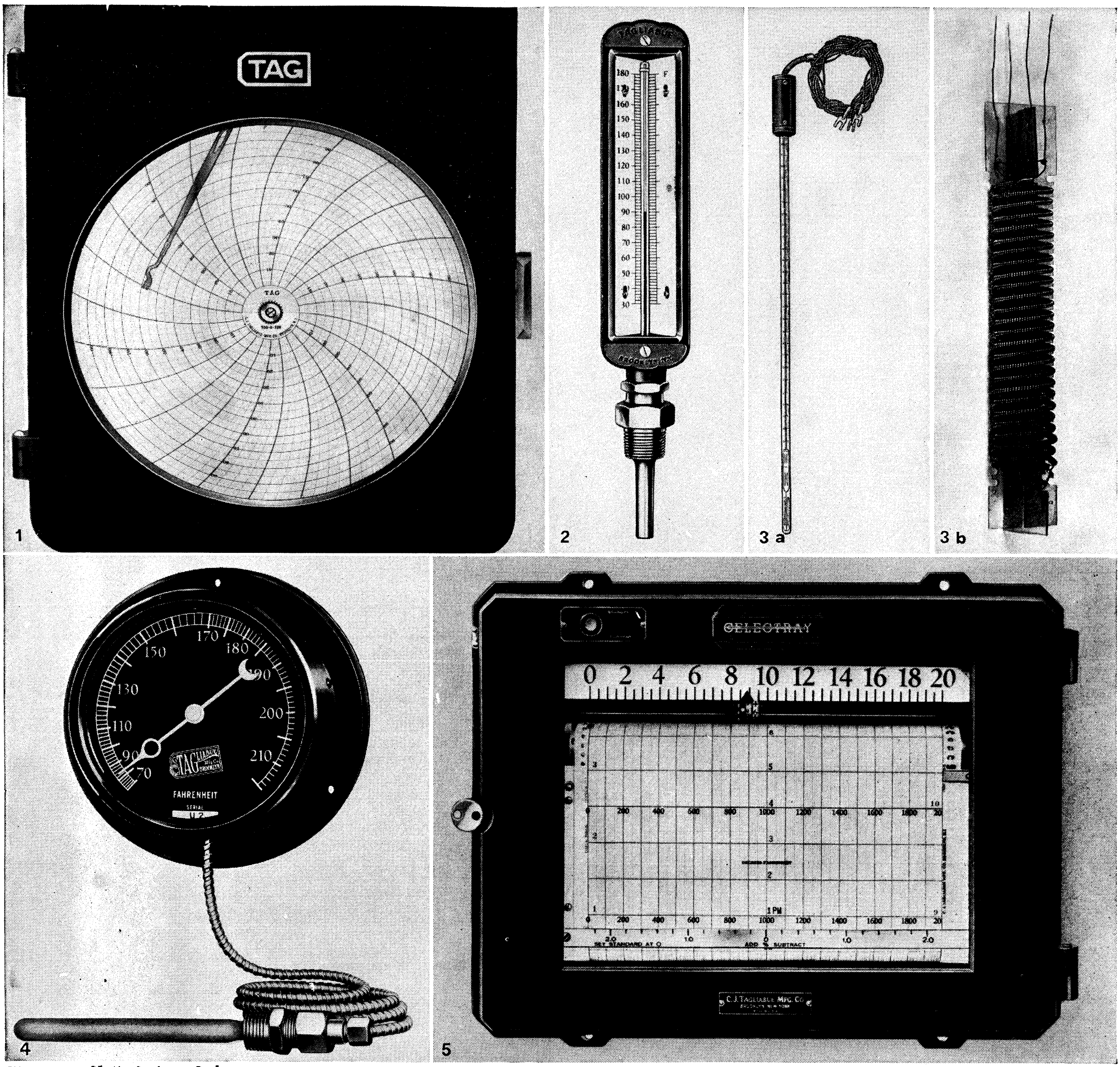
$$t = \frac{R_t - R_0}{R_{100} - R_0}(100) + \delta\left(\frac{t}{100} - 1\right)\frac{t}{100}$$

both formulas being in the first power of R_t and the first and second power of t. The first expression above requires slightly less calculation. but the Callendar equation is still used in some laboratories. The group at the Massachusetts Institute of Technology proposed the addition of the normal boiling point of mercury to the international temperature scale, because according to their own work a cubic equation is required to fit the experimental data with platinum resistance thermometers to the gas thermometer data, and this in turn requires the addition of the third fixed point above 0° C. This group adds the term in t^3 to the Callendar formula.

These formulas are empirical, set up to fit experimental data, and have no theoretical support; in fact, modern physical theories of atomic and crystalline structure and the conduction of electricity show that theoretical support will require a great deal of data not available on the conductivity of very pure metals free from strain and a tremendous amount of mathematical calculation. It is highly probable that the precise information on pure platinum will be used to support theory, rather than the reverse.

Modern methods of measuring resistance are fundamentally the same as those described above in the paragraphs on precise thermometry. The Mueller bridge has been improved in convenience by including all the accessories in one case: including a thermostat and a dry-insulation box enclosing the resistor coils of larger values. The new gold-chromium alloy described by T. B. Godfrey in *Journal* of *Research*, national bureau of standards (1939), provides a material having a coefficient so small that (according to Mueller) the resistances of the coils will not change by more than 1 or 2 parts in 1,000,000 within the ordinary range of room temperatures. Resistors of this alloy can be made of very fine wire and are especially suited for standards of reference. It is problematical that they will replace thermostated manganin in the resistance-measuring bridges. However, since an entire bridge can be rechecked with a single reference standard, this alloy will improve the reliability of measurements from many laboratories.

In 1939 at the second temperature symposium more than ten papers directly concerned with thermocouples were presented. In 1954 at the third temperature symposium not one paper on thermocouples was given. The probable reason for this is the feeling that, except possibly at temperatures above 1,500° C., very little more could be done to significantly improve thermocouples or their use. Nevertheless, thermocouples continue to be used in science and industry. They offer such advantages as simplicity, low cost, a wide range, ease of installation and small size. The major limitation is the effect on the temperature determination when any physical or chemical inhomogeneity in the thermocouple leads exists in a temperature gradient. With the purest platinum and



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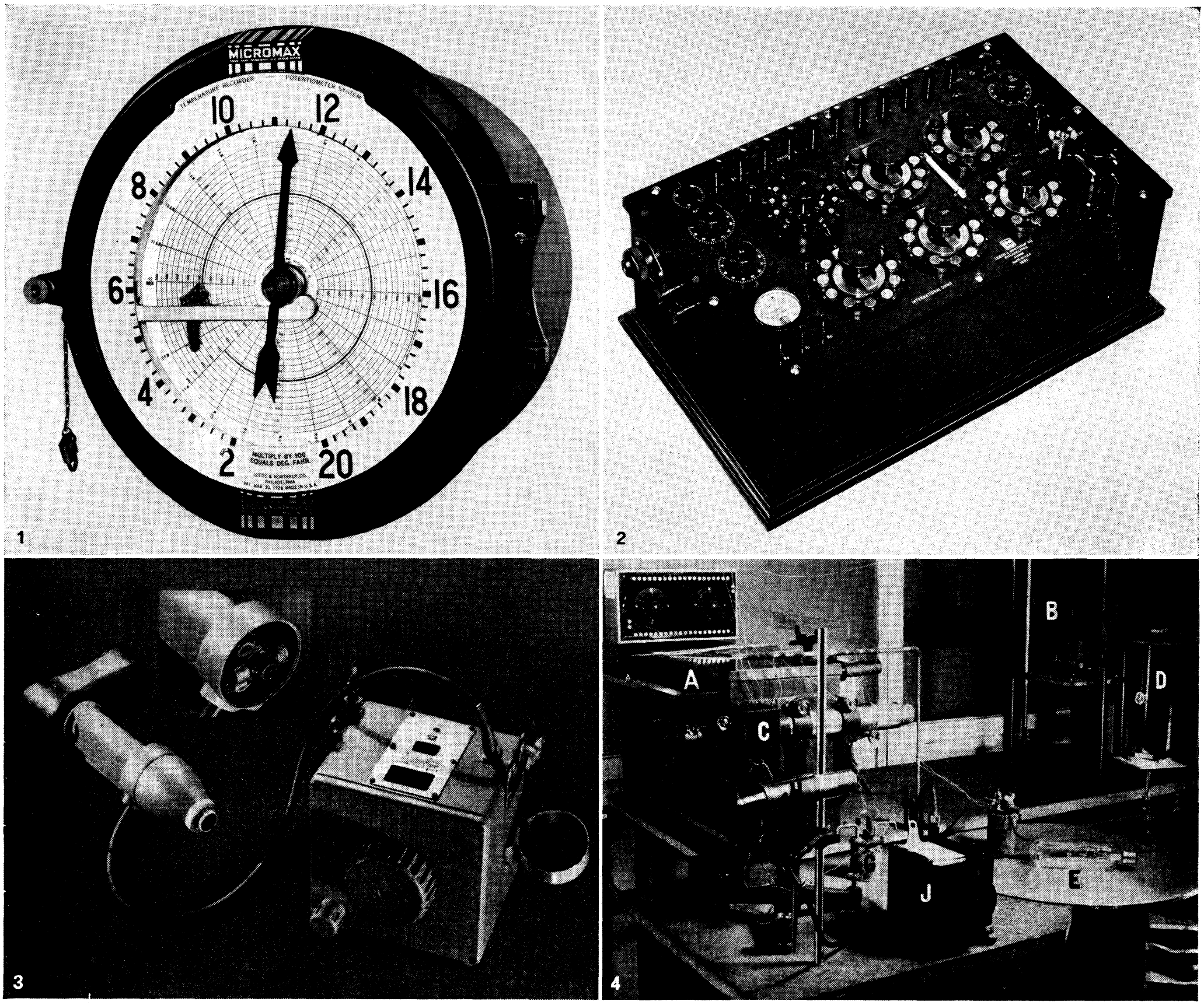
INSTRUMENTS USED IN THERMOMETRY

1. Recording thermometer alike in principle to the dial thermometer illustrated, but having a circular paper chart driven by a clock
2. Industrial thermometer of glass filled with mercury or oiner liquid and having a sheathed bulb, windowed frame and threaded member for holding pressure
3. (a) Platinum resistance thermometer in a pyrex glass tube, and (b) a view of the double-helix coil of fine platinum wire wound on crossed mica strips to keep the wire clean and unstrained
4. So-called dial thermometer of industry having a fluid-filled system of bulb, armoured metal capillary connecting tube and hidden pressure-spring for turning the pointer
5. A potentiometer for recording the voltages of a number of thermocouples in rapid succession on a paper roll-chart, graduated in degrees of temperature. The automatic mechanism is photoelectrically baldnced



BY COURTESY OF (1, 2, 3) LEEDS AND NORTHRUP CO , (4) OR ROBERT B SOSMAN AND AMERICAN SOCIETY FOR METALS

INSTRUMENTS USED IN THERMOMETRY

1. A potentiometer for recording the voltages of one or two thermocouples on a circular chart graduated in degrees of temperature. The bold hand and large circular scale are useful where frequent observation from a distance is essential in controlling a manufacturing plant or process. Also used for automatic control and signalling

2. An electrical bridge for platinum-resistance thermometry. Used in research laboratories for high precision measurements in a narrow range of 0 to 111 ohms

3. An optical pyrometer with which temperature is measured by matching the brightness of an incandescent object with that of the tungsten filament of a lamp mounted inside of the telescope shown on the left. The instrument on the right is a potentiometer for measuring the current in the lamp and is calibrated in degrees of temperature. The special flat-windowed lamp is visible in the opened telescope

4. Apparatus for calibration of optical pyrometers in the research laboratory of the U.S. Steel Corp. A is a precision potentiometer; B, a galvanometer; C, Fairchild optical pyrometer; D, jacket of tungsten-ribbon lamp; E, extra lamp; F, standard 0.001-ohm resistor for source-lamp current; G, standard 0.1-ohm resistor for current in lamp of Fairchild pyrometer; H, telescope of mill pyrometer, and J, milliammeter of mill pyrometer

platinum-rhodium available in the late 1950s, an accuracy of $\pm 0.1°$ was difficult to achieve. However, whenever $\pm 0.1°$ is adequate below 500° C. and $\pm 0.3°$ above 500° C., the thermocouple is an excellent temperature-measuring instrument; and of course, between 630° and 1,063° C., it is the standard thermometer on the international temperature scale.

The thermocouples in common use are limited to those made of a relatively few combinations of metals and alloys which have been found to be suitable for the purpose. The required characteristics include: (1) a thermal e.m.f. large enough to he readily measured; (2) an e.m.f. increasing continuously with rising temperature over a considerable range; (3) freedom from significant change of e.m.f. by changes of crystalline structure or other internal phenomena; (4) resistance to oxidation, corrosion or contamination; (5) homogeneity and reproducibility to fit an established standard relation between temperature and e.m.f. The combinations that have been found to meet these requirements best are: (1) platinum with platinum–10% rhodium (also 13%); (2) copper with constantan; (3) iron with constantan; and (4) chromel P with alumel. The combination of chromel P with constantan is occasionally used because of a relatively large e.m.f. Metals and alloys having high melting points such as molybdenum (2,625° C.) and tungsten (3,410°), but which are easily oxidized at a few hundred degrees, are sometimes used successfully above 2,000° C. in an atmosphere of hydrogen. The so-called rare-metal couples (no. 1 above) are useful from 0° to nearly 1,500° for extended exposures and occasionally to 1,700° or higher. Corresponding temperatures for copper-constantan are $-200°$ to 350° (max. 1,000°); for iron-constantan, $-200°$ to 750° (max. 1,000°); for chromel-alumel, $-200°$ to 1,200° (max. 1,350°). The nominal composition of constantan, which is also used in larger quantities for resistor wire, is 55% copper and 45% nickel. Chromel, identified as chromel P to distinguish it from electrical heating wire, has retained its original composition of 90% nickel with 10% chromium, but alumel is 95% nickel with aluminum, silicon and manganese added.

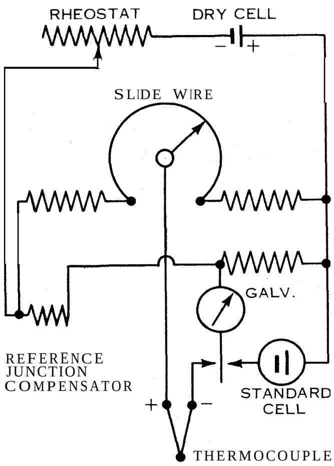
The platinum, platinum-rhodium thermocouple invented by Le Chatelier is noted for its stability and freedom from internal changes. It is usually used carefully protected in a refractory porcelain insulator and tube. It is most interesting to observe that the metals of which this couple is made have a purity of the highest order, spectroscopic analysis revealing scarcely the slightest trace of impurity. This cannot be said of any of the other metals employed for thermocouples although the copper generally used is so pure as to require the spectroscope to detect slight traces of iron, silicon and dissolved oxygen. While platinum of the purity found in resistance thermometer and thermocouple wire is the primary thermoelectric reference standard, the best grade of commercial copper wire makes an excellent standard which can be relied upon to a few microvolts for a 200° C. interval.

The copper-constantan thermocouple is noted for its well-established temperature-e.m.f. relation from about $-260°$ to 350° C., its low cost, and the not inconsiderable adaptability to the use of long extension leads of the same composition and relatively low resistance. Also, as compared with iron, copper oxidizes very slowly at ordinary temperatures at which iron must be protected from rusting.

The iron-constantan couple is the most widely used of any in industrial applications because it is inexpensive and has a useful range well above that of copper. The iron is selected not for its high purity but for its reproduction of established standard tables of temperature versus e.m.f. This iron has about 0.1% of impurities, principally carbon, manganese, silicon and oxygen.

The chromel-alumel couple is well known for its outstanding resistance to oxidation at high temperatures, especially in the range from 750° to 1,200° C., where it is most often used. It suffers the peculiar limitation that it must not be exposed to reducing gases because the oxides of chromium which form in an oxidizing atmosphere are not readily reducible, such that oxidized chromel exposed to hydrogen, for example, develops a conducting coating of nickel mixed with chromium oxides. The widespread employment of controlled atmospheres in heat-treating furnaces of the metals industries accentuates this limitation on the chromium alloy couple.

The relations between temperatures and e.m.f. for various thermocouples are all based entirely on experimental data, not on any general law or relation of theoretical physics. In a simple thermoelectric circuit of two metals joined into a closed loop, there are, supposedly, four sources of e.m.f., one at each junction and one in each leg of the couple where it passes through the temperature gradient. J. C. A. Peltier discovered in 1834 that when an electric current is passed through the junction of two dissimilar metals the junction is heated or cooled depending on the direction of flow. This means that an e.m.f. exists at the junction. In 1851, applying the second law of thermodynamics, W. Thomson (later Lord Kelvin) showed that if only the Peltier e.m.f. supplied the Seebeck current, the relation between temperature and e.m.f. should be linear. This was known experimentally not to be the case, so Thomson concluded that there must be another source of e.m.f. In 1854 he showed that when an electric current flows in a homogeneous conductor through a temperature gradient, a transference of heat generally takes place along the conductor depending on the relative directions of current and gradient, and the material or substance (metal). This strongly implies the existence of an e.m.f. developed along the conductor, and this is called the Thomson e.m.f. It has never been separately detected or measured in a manner generally acceptable as conclusive, although it is conceded that the existence is reasonable. Thomson's reasoning leads to the conclusion that an e.m.f. is developed along the conductor, and all experimental data show that this is independent of the form of the temperature gradient and depends only on the temperatures of the junctions. Thus it is reasonable to conclude further that in the use of a thermocouple the reality of the Thomson e.m.f. is inconsequential, since the total e.m.f. which is all that can be measured directly, is dependent only on the temperatures of the junctions. This statement does not apply to an inhomogeneous thermocouple, as was already indicated.



BY COURTESY OF LEEDS AND NORTHRUP CO

FIG. 5.—A SIMPLIFIED DIAGRAM OF THE ELECTRICAL CIRCUIT OF A POTENTIOMETER FOR USE WITH A THERMOCOUPLE

Analytical expressions have been set up for the platinum, platinum–10% rhodium thermocouple and the copper-constantan couple but these are applicable over limited ranges. For example, the expression $E = a + bt + ct^2$ is used in the specifications for reproducing the international temperature scale between 660° and 1,063° C. with the former couple: and L. H. Adams used the equation $E = at + b(1 - e^{ct})$ between 0° and 350° C. for the latter couple. Adams used the same form of equation with different constants for the range 0° to $-218°$ C. The expressions are primarily useful for the calculation and construction of tables for reference, from which deviation curves or tables can be constructed for particular calibrated couples. The temperature-e.m.f. tables for iron-constantan and chromel-alumel couples reveal that no expression as simple as those given above would suffice even as a rough approximation.

The calibration of thermocouples can be accomplished by many methods depending upon the accuracy desired, the range of temperature, the type of couple and the means available. It is apparent from the definition of the international temperature scale that if a couple is expected to furnish accurate measurements agreeing with this scale, it must be compared with a platinum resistance thermometer from $-190°$ to 660° C., with a platinum, platinum–10% rhodium couple from 660° to 1,063° C. and with a proper optical pyrometer above 1,063° C. The most accurate calibrations are made in a stirred liquid bath by direct comparison with a resistance thermometer from $-190°$ to about $350°$ C.. and from this temperature to $660°$ C. by testing at established freezing points of pure substances. Between $660°$ and $1{,}063°$ C. direct comparison with a standard platinum couple is preferred, and this method and direct comparison with an optical pyrometer are both used above the latter temperature, the comparison with the couple being the more convenient up to about $1{,}450°$ C. Excellent calibrations are also obtained by testing at fixed points below $350°$ C. In all cases the data should be reduced to deviations from the standard tables of temperature versus e.m.f. identified with the couple undergoing calibration. The electrical instruments (potentiometer and galvanometer) needed are determined by the thermoelectric powers of the various couples. For example, copper-constantan has an electromotive force of nearly 17 microvolts (0.000017 volt) per degree at $-190°$ C., increasing to 32 at $0°$ and 60 microvolts at $350°$. The standard platinum–10% rhodium couple gives only 5.j microvolts per degree at 00, increasing to 10 at $500°$ and to 12 at $1{,}200°$ C. Iron-constantan gives 25 microvolts at $-190°$, increasing to 52 at $0°$, 56 at $500°$ and 60 at $1{,}000°$ C. Chromel-alumel gives 40 microvolts at $0°$, increasing to 43 at $500°$, and decreasing to 36 at $1{,}200°$ C. The range of the potentiometer need not exceed 60 millivolts (0.06 volt), but an accuracy of a small fraction of one microvolt may be needed.

Modern electrical instruments for use with thermocouples can be classified as millivoltmeters and potentiometers or as precision instruments for the laboratory and industrial instruments, or as indicators, recorders and recorder-controllers. There is an intermediate class of semiprecision portable potentiometers for general use. These and the industrial potentiometers are all built around the so-called slide-wire, that is, a resistor with sliding contact, while the precision potentiometers have three or more dial switches for connecting betneen fixed resistors, after the manner of the precision bridge. The art of manufacturing potentiometers of many forms is highly developed and, in the classes for industrial applications, has been making extensive use of photoelectric and electronic devices for rapid recording and better controlling. The developments from many other arts have been incorporated, particularly from electronics, also small motors, mass production of small parts and the vast array of new materials of construction, the light alloys and stainless steels. the synthetic molding materials and other plastics for insulation. In a few directions, practice has become standardized to some extent. Industrial instruments are provided with automatic reference-junction compensation, employing the bimetallic spring in millivoltmeters, and the Wunsch branch circuit aith its nickel or copper compensating resistor in potentiometers. Laboratory instruments are more often designed for immersion of the reference junctions in an ice bath, because of the greater accuracy intended. Recording potentiometers almost completely removed recording millivoltmeters from the industrial scene. Industrial instruments had obtained extraordinary precision considering the severe requirements for ruggedness and reliability. Industrial recording to $1°$ F. was not uncommon, and automatic control of some processes to $\frac{1}{4}°$ or even $0.1°$ had been attained.

6. Modern Optical Pyrometry consists for the most part of that of the disappearing-filament pyrometer, because this has been found to afford the greatest precision and accuracy for research work and in addition the greatest convenience for practical applications. The form of the precision instrument found at the national bureau of standards remains that developed by Fairchild and Hoover, and duplicates or similar instruments are found in many other laboratories including some of the national laboratories. The principal commercial form is that made by the Leeds and Northrup company in the United States, the optics of this instrument being similar to that of the laboratory type. It is equipped, however, as a portable instrument. with a unique type of slide-wire potentiometer, designed for rapid use. The specially constructed lamps used in these instruments are highly evacuated so that the tungsten filament of wire or ribbon form will withstand heating to $1{,}500°$ C. for hundreds of hours without serious change. While gas filling would reduce the rate of evaporation of tungsten from the surface of the filament, it would render the lamp subject to changes in ambient temperature, and introduce great lag in its response to adjustments in the heating current. Fairly high temperatures can be measured without heating the lamp much above $1{,}400°$ C. by the use of properly selected absorption screens, under which circumstance the lamp will retain its original calibration remarkably well for many years.

Such pyrometers, which are extensively used, are calibrated at the national laboratories, either by comparison with the standard instrument or by sighting them on large tungsten-strip lamps which have been calibrated for the particular purpose at the national laboratory. Primary calibrations at the gold point are made by sighting the pyrometer at a black body immersed in highly pure freezing gold. Calibrations below or above the gold point are made by sighting at a convenient source (this need not be a black body) with a calibrated screen interposed. This screen may be either a sectored rotating disk, whose open sector has been mechanically measured on a circular dividing engine, or an absorbing coloured glass whose transmission has been measured by comparison nith a sectored disk or with the interval between two fixed points. Primary calibrations above the gold point are of course all based upon this one point ($1{,}063°$ C.) and the constant c_2 in the Planck equation. A complete table of temperature-current values is tediously built up by smoothing the deviations from a reference table or curve based on an equation such as $i(\text{current}) = a + bt + ct^2 + dt^3$, the four constants of which are determined from four selected calibration points. The interval from the copper point to the palladium point is so large that it is preferable to establish at least two points in between by the use of sectored disks or absorption screens to step down from the upper point. The most accurate measurements above the gold point are obtained by keeping the pyrometer lamp at a current value nearly corresponding with that determined for the gold point, and choosing an absorption device to nearly fit the extrapolation desired, for example, from gold to the platinum point ($1{,}773.5°$ C.). However, for much higher temperatures the pyrometer lamp has to be raised toward the palladium point in order to make use of screens of accurately measurable transmission.

The equations employed in the calculations of temperatures measured with absorption screens or sector disks are derived from Planck's law:

$$J(\lambda,\theta) = c_1\lambda^{-5}/e^{\frac{c_2}{\lambda\theta}} - 1$$

where λ denotes the wave length in cm., θ the absolute temperature of a black body, $J(\lambda,\theta)$ the intensity in the wave band $\lambda - d\lambda$, c_2 a constant $= 1.438$ cm. degrees and c_1 a constant the value of which has no significance in pyrometry since it disappears in working equations. The primary working equation is found as follows. If J_1 is the intensity of radiation at θ_1, J_2 that at θ_2 and R is the ratio of J_2 to J_1, then

$$R = \frac{e^{\frac{c_2}{\lambda\theta_1}} - 1}{e^{\frac{c_2}{\lambda\theta_2}} - 1}$$

The wave length λ in the last equation is usually written λ_e to signify the mean effective wave length for the interval θ_1 to θ_2, taking into account the transmission of the red glass filter and the luminosity function of the observer's eye. When observing a non-black body, the wave length to which the brightness temperature corresponds is the mean effective wave length for the interval between the brightness temperature and the colour temperature of the source. Details of calculating mean effective wave lengths can be obtained from Forsythe's paper in *Temperature* I. Laboratory pyrometers of the Fairchild type can be calibrated with an accuracy (with respect to the international temperature scale) of about $\frac{1}{2}°$ C. at the gold point and about $3°$ C. at $2{,}300°$ C. High temperatures are readily measured with the disappearing-filament pyrometer without overheating the pyrometer lamp simply by using tno absorbing screens or one combined with a sector disk. For brightness temperatures up to about $2{,}500°$ C. tungsten strip lamps can be calibrated and used as transfer standards with an accuracy from about $\pm 3°$ at the gold point to $10°$ at $2{,}500°$ C. An interesting fixed point for high-temperature work is that of the positive crater of the carbon arc. Using a properly operated electric arc and a positive electrode of purest carbon, the apparent temperature, usually called brightness temperature, is 3,820° K.; readings can be repeated to a few degrees. The uncertainty in this value is of the order of 15°. (See *Temperature* **I**, p. 1148)

In the practical application of the above optical pyrometer. in many cases black-body conditions are not met and cannot be achieved. Here corrections can be made for the emissivity of the incandescent object, such as a stream or crucible of molten metal, a tungsten filament of an electric lamp, or the hot cathode of an electronic tube. Many values are known and published, one extensive list being furnished by A. G. Worthing in an authoritative article which includes a thorough discussion of the theories of emission (see *Temperature* **I**, p. 1164).

Some success was attained by the late 1950s in the employment of photoelectric devices to take the place of the optical pyrometer. **A** photoelectric pyrometer was being developed by C. P. Johnson, Jr., at the national bureau of standards ahich used a photomultiplier tube as a detector, a multilayer interference filter to restrict the spectral band and a block of optical glass which, when rotated, makes possible the comparison of the pyrometer lamp and unknown source by alternately projecting them on the detector. The instrument appeared to have sufficient signal to noise to improve pyrometer measurements above the gold point by at least a factor of 10. In addition, it afforded a potential means for automatic recording and making brightness measurements of sources having a short time duration.

Many different forms of so-called colour pyrometers have been invented from time to time. In these intriguing instruments the intensities of radiation of two bands of wave lengths are compared and interpreted by calibration, as corresponding to some temperature. Some designs have been highly commendatory for their simplicity, but by the late 1950s none had met marked acceptance.

7. Modern Radiation **Pyrometry.**—This is pyrometry in which heat radiation of all wave lengths is used as a measure of temperature, is generally confined to the field of industrial applications and is seldom employed in research work. Relatively useful designs have been perfected for the ceramic and steel industries but they lack the amazing precision of the optical pyrometer, and are generally set up to remain in a fixed position where they can be checked with an optical instrument and ***in situ*** corrections be determined. These pyrometers are constructed of a receiver of heat radiation consisting of a thermocouple junction or small group of junctions, mounted in a housing which can be water-cooled if necessary, and in which reference junctions of the couples are so disposed as to give the least errors from variations in the temperature of the whole receiver. Such instruments are especially valuable in those applications where recorded temperatures are essential, and where immersed thermocouples cannot withstand the heat. or corrosive vapours of gases. The practice of attaching the receiver of these instruments to the open end of a tube nhich is closed at the other end and inserted into a furnace has promoted the successful application of these instruments because it not only protects the receiver from flame and smoke but also permits sighting it through an atmosphere free from carbon dioxide and water vapour, gases which are not transparent to infrared radiation. The thermal lag that is introduced by the thick-walled tube is not a deterrent to this practice where the lag of the furnace itself is large.

Attempts to design a radiation pyrometer in which the radiation from a standard source is compared with that from the source to be measured had not been notably successful. Victory in this direction would solve the major difficulty of radiation pyrometry in which the total radiation received must always give the same response of the receiver, which means in turn that the heat lost from the receiver with a particular value of the incident radiation must always be the same. An attempt to improve the characteristics of practical radiation pyrometers is that of T. R. Harrison and W. H. Wannamaker, who described their analysis of the problem and its solution in Temperature **I**.

8. Flame Thermometry. — The measurement of temperatures in flames or hot gases, particularly above 1,500° K., requires equipment or techniques somewhat different from those already considered in this article. Thermocouples or resistance thermometers are generally not used in flames above 1,500° K. because of serious problems concerning radiation losses, disturbance of the combustion process. mechanical rigidity of the thermometer, and of course, at sufficiently high temperatures. melting of the thermometer itself. An optical pyrometcr or two-colour pyrometer can sometimes be used, but usually the emissivity is unknown or changing rapidly with wave length, producing large uncertainties in their application. Temperature **I** and *Temperature II* contain papers by B. Lewis and G. von Elbe, G. H. Dieke and H. P. Broida describing various methods of measuring flame temperatures and giving excellent bibliographies on the subject. This article will limit itself to two of the more widely used methods, the line reversal and intensity distribution in spectral lines.

In the line reversal method. the brightness of a source of radiation, such as a tungsten strip lamp, is adjusted until at a wave length corresponding to some spectrum line in the flame, the source appears equally bright when viewed directly or through the flame. The flame temperature is the temperature of a black body having this brightness; *i.e.*, the brightness temperature of the source at the same wave length. This method is based on Kirchhoff's law, which states that the fractional amount of radiation absorbed by a body is equal to the fraction it emits relative to a black body at the same temperature. Thus when the black body and the flame are at the same temperature, the amount of radiation absorbed by the flame is just equal to that which it emits and the black body appears equally bright when viewed directly or through the flame. Usually a spectrograph or a monochromator equipped with a suitable detector such as a photomultiplier is used to isolate and measure the radiation at the spectrum line. An element not found in the flame may be added in order to obtain a strong spectrum line in a convenient spectral region. Sodium, which emits strong yellow lines at 5.890 Å and 5,896 Å, has been used frequently. It is possible to obtain reversal temperatures at 2,500° K. that are reproducible to a few degrees. However, it is very questionable that the temperature measurement is this accurate. Great care must be taken with the optical path, the solid angles subtended and corrections for optical elements utilized with the tungsten source only. In addition, the brightness temperature of the tungsten source will be uncertain by at least 7° at 2,500° K. and greater at higher temperatures. Nevertheless, the reversal method is probably more reproducible than any other method known in 1957 for measuring flame temperatures; and in many cases: the measured temperature agrees reasonably well with that which can be calculated from known equilibrium concentrations.

The second method to be considered in this article for determining flame temperatures is based on measurements of the relative amount of energy emitted by a source per unit time (relative intensity) in two or more spectral lines. According to quantum theory (see PHYSICS: GENERAL SURVEY; QUANTUM MECHANICS) an atom or molecule can have only certain definite energies which are referred to as energy levels. An atom possessing an "excess" amount of energy (for example an atom in a flame) can lose this energy by making a transition to a lower energy level. There is a definite probability that this lost energy will appear in the form of radiation. This radiation will have a particular wave length (spectral line) which is inversely proportional to the lost energy. For a source containing many atoms, the intensity of a spectral line is the product of the energy from one transition, the number of atoms in the initial energy level and the probability of the transition. The relative number of atoms in two or more known energy levels for a system in thermal equilibrium depends only on the temperature; and therefore the temperature can be calculated if the relative number of atoms is known. Thus if the energy levels and the relative transition probabilities can be calculated or determined in an independent experiment, the relative intensity of two or more spectral lines emitted by a source in thermal equilibrium can be used to obtain the temperature of the source. Spectroscopists have determined many energy levels for a great number of atoms and molecules. Unfortunately, as of the late 1950s only a few relative transition probabilities had been determined experimentally or could be calculated accurately. This has been one of the major limitations of this method of measuring flame temperatures. It has the advantage over the reversal method in that another source is not viewed through the flame, thereby making the optical setup less critical.

9. Thermometry Below the Oxygen Point. — This field was still in a state of flux in the late 1950s. The international temperature scale was not defined below the boiling point of oxygen. None of the thermometers available for low temperature measurements had all the desirable characteristics of a practical standard—sensitivity, reproducibility, convenience and a simple interpolation equation. The thermometers widely used below 90° K. will be described with particular emphasis on their virtues and foibles.

From 90° to 20° K.. the platinum resistance thermometer is still the most precise thermometer available. Below 50° K. its sensitivity begins to decrease rapidly but at 17° K. it still has sufficient sensitivity to determine differences of 0.001° or less. At 11° K. the sensitivity has decreased further by a factor of about 4 relative to that at 17° K. The major limitation of using the platinum resistance thermometer below the oxygen point is that no simple mathematical relationship has been found between temperature and resistance. It has been suggested that an empirical table be substituted for the interpolation equation. The table could be adjusted for each thermometer utilizing the calibration data at several fixed points. The national laboratories are investigating this possibility.

The national bureau of standards calibrated (in 1957) platinum resistance thermometers down to 11° K. The calibration is performed by comparison with a set of six platinum resistance thermometers which were calibrated by Hoge and Brickwedde in 1939 using a helium gas thermometer. They claimed an accuracy of $\pm$0.02°. Xloessen. Xston and Ascah at Pennsylvania State university completed in 1955 a similar calibration of .resistance thermometers estimated to agree with the thermodynamic scale within $\pm$0.005°. They compared their new scale with the NBS scale of 1939 by including one of Hoge's and Brickwedde's thermometers. The agreement was well within the $\pm$0.02-degree accuracy claimed.

When considerably less precision than that available with a platinum resistance thermometer is required, a copper-constantan thermocouple can be used down to about 15° K. Another thermometer that often is useful in this region is the saturation vapour pressure of hydrogen. The vapour pressure-temperature relationship has been determined from the critical point, 33° K., where the pressure is about 9,700 mm. Hg, to the triple point, 13.8° K., where the pressure is about 53 mm. Hg. The use of the hydrogen saturation vapour pressure as a thermometer is somewhat complicated. however, by the para-ortho conversion phenomena.

Below 11° K. platinum resistance thermometers are of little value because of their small sensitivity. However, resistance thermometers made of semiconducting materials have ample sensitivity by virtue of their negative temperature coefficient; *i.e.*, the resistance increases with a decrease in temperature. By 1957 the major limitation of the semiconducting thermometers was their lack of stability. However, S. A. Friedberg at the Carnegie Institute of Technology, Pittsburgh, Pa.. has investigated germanium alloy thermometers containing extremely small amounts of indium and found them to be reproducible to 0.001° between 1° and 5° K., even after repeated warming and cooling.

Commercial carbon resistors; though not strictly semiconductors, also have negative temperature coefficients and have proved very promising between 20° and 1° K. J. R. Clement and E. H. Quinnell of the Naval Research laboratory. Washington. D.C.. found resistors that had a reproducibility of better than $\pm$.1% in the above range. Moreover, they found a convenient scheme for relating resistance to temperature. They used the equation

$$\left[\frac{\log R}{T}\right]^{\frac{1}{2}} = a + b \log R$$

where b is a constant and *a* is allowed to vary, being determined from a smoothed curve of *a* versus R constructed from actual calibration data. If these results are readily confirmed by other laboratories, the carbon resistor could well be considered as a standard thermometer between about 15° and 5° K.

Since in most low-temperature experiments, the basic cooling is produced by a bath of liquid helium. the saturation vapour pressure of helium is a convenient thermometer. Its useful range extends from the critical point (5.2° K. and 1,718 mm. Hg) to the lowest pressure conveniently measured (0.1 mm. Hg and 1° K.). The relationship between the vapour pressure of helium and its temperature has been the source of many investigations since the original measurements of Kammerlingh-Onnes at the University of Leiden in 1911. In 1948 an informal international agreement was reached establishing a tentative vapour-pressure scale. By 1955, however, measurements with various thermometers (gas, carbon resistor, magnetic) showed that this scale was in error by as much as 0.012° at 2.2° K. and 0.007° at 3.6" K. Analyzing all the thermometer measurements available in 1955, Clement, Logan and Gaffney derived a new scale by making a best fit to all the data. H. Van Dijk and M. Durieux at Leiden also derived a scale but in a different manner. They used a theoretical vapour-pressure equation and incorporated in this all the empirical thermodynamic and P-V-T data available for helium. The two scales became known as the 55E and L55 scales respectively. Between 1° and 5° K. these two scales agree within about 0.003°. Experimental attempts to decide between them were not successful due to the small differences and contemporary techniques of vapour-pressure measurement. Thus, for many practical purposes the two scales are identical, and thermometry between 1° and 5° K. is in reasonably good shape. However, it must be emphasized that accurate vapour-pressure measurements in this temperature range. particularly above 2.2° K. where thermal conductivity of the liquid is small, are extremely difficult, and highly developed techniques must be utilized. For details, *see* a publication by E. Ambler and R. P. Hudson in *Journal of Research,* NBS, vol. 56 (1956).

Below 1° K. it is extremely difficult to make precise temperature measurements. One of the chief reasons for this is the difficulty in establishing thermal equilibrium. The magnetic thermometer is one of the few thermometers that can be used. It is based on the fact that the magnetic susceptibility of a paramagnetic salt is a function of temperature. Therefore, if such a salt is placed in the magnetic field of an inductor, the inductance which depends on the susceptibility of the salt can be used as a temperature indicator. Often at temperatures below 1° K.. paramagnetic salts themselves are being investigated. Thus the unusual but convenient situation is encountered where the material under study, the coolant, cold bath and thermometer are one and the same. Another feature of the magnetic thermometer is that it is in the class of absolute instruments such as the gas thermometer. With proper corrections, it can be used to determine the ratio of thermodynamic temperatures, but the precision is not very great.

10. Special Methods and **Devices** for the measurement of temperatures are legion, but few remained in use after their faults were discovered. It has not been possible in this article to cover these or even all the thermometric methods still in existence. The interested individual should consult the references cited in the text and the bibliography. Where the measurement oi temperature is incidental to the primary purpose of measuring something else, reference should be made to the major topic. Also, reference may be made to many of the sciences in which temperature is particularly significant, such as meteorology, biology, geophysics and astronomy, heating and power, refrigeration, ceramic and metals industries and the thermal processes of the food, oil and chemical industries. *See* also HEAT; THERMODYNAMICS.

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THERMOPYLAE, a Greek pass leading from Locris into Thessaly between Mt. Oeta and the Maliac gulf; chiefly famous for the heroic defense by the Spartan king, Leonidas, with 300 soldiers against the Persian army of Xerxes advancing upon Greece in 480. (See LEONIDAS.) Two other battles here are famous. In 279 B.C. Brennus and the Gauls were checked for several months by a Greek army under the Athenian Calippus; and in 191 Antiochus of Syria vainly attempted to hold the pass against the Romans under M. Acilius Glabrio. In the time of Leonidas the pass was a narrow track (probably about 14 yd. wide) under the cliff. In modern times the deposits of the Spercheius have widened it to a breadth of $1\frac{1}{2}$ to 3 mi. The hot springs from which the pass derived its name still exist close to the foot of the hill. There is one large spring used as a bath and four smaller ones, and the water, which is of a bluish-green colour and contains lime. salt. carbonic acid and sulfur. is said to produce good effects in scrofula, sciatica and rheumatism.

THERMOSTAT. A device to regulate automatically the supply of heat to, and consequently to control the temperature of, the air in a space, or of liquids or materials involved in a process.

Basically the thermostat consists of two elements, a sensing element, and an actuating or control element. The sensing element is sensitive to temperature changes that produce proportional changes in its physical dimensions, volume or electrical resistance. The actuating element translates the action of the sensing element to a proportional movement of the controlling air damper, valve or electric switch.

The principle of thermal expansion of metals, liquids and gases with temperature increase is the basis of the sensing element design for all thermostats except the electronic instrument. The range of temperature change during which the linear expansion bears a constant ratio to the temperature change is limited to approximately 250° F. The following table lists the coefficients of lineal expansion for the metals commonly used for thermostatic sensing elements.

Linear Coefficients of Thermal Expansion per Degree Fahrenheit

Metal	Coefficient
Aluminum	0.0000123
Brass	0.0000106
Graphite	0.0000044
Copper	0.0000093
Quartz	0.0000003
Wrought iron	0.0000063
Invar steel	0.0000005
Silver	0.0000105

Sensing Elements.— Four types of sensing element are commonly used in commercially produced thermostats. The bi-metal strip consists of two strips of metal having widely different linear coefficients of thermal expansion (see table). These strips are fused together and as the temperature increases, the strip bends away from the side having the greater coefficient of linear expansion. In application, one end of the strip is anchored, leaving the other end free to move. The strip may be straight, bent to a radius perpendicular to the long axis of the strip into a U shape or a helical shape, or it may be wound in a spiral whose axis is parallel to the long axis. Selection of shape is governed by the magnitude of movement desired at the free end of the strip. In some types of thermostats the bi-metal sensing element produces enough force to actuate the control directly.

The tube and rod sensing element also is designed to take advantage of the difference in the linear thermal expansion of two metals. It is composed of a tube of metal that has a high coefficient of expansion and a rod of metal that has a low coefficient of expansion. The rod is inserted into the tube and anchored at its closed end. The open end of the tube is anchored and as the length of the tube changes with a change in temperature there is a relative movement of the free end of the rod, the length of which has remained unchanged.

The bellows type of sensing element consists of a volume confined by a diaphragm of cup-shaped, very light metal, or a cylindrical vessel with a corrugated wall spun out of light weight metal. The volume is completely filled with a liquid, a vapour or a gas. In any case, an increase in temperature results in an increase in volume and an increase in axial length of the vessel.

The remote bulb type of sensing element is actually an adaption of the bellows type. It consists of a bulb attached to the diaphragm, or bellows, by a capillary tube of any desired length, all of which is completely filled with liquid, vapour or gas. The bulb is placed in the region to be controlled and any change in pressure due to a temperature change at the bulb is transferred through the capillary tube to the bellows.

The electronic sensing element consists of a small coil of wire whose resistance changes in a constant ratio with temperature changes.

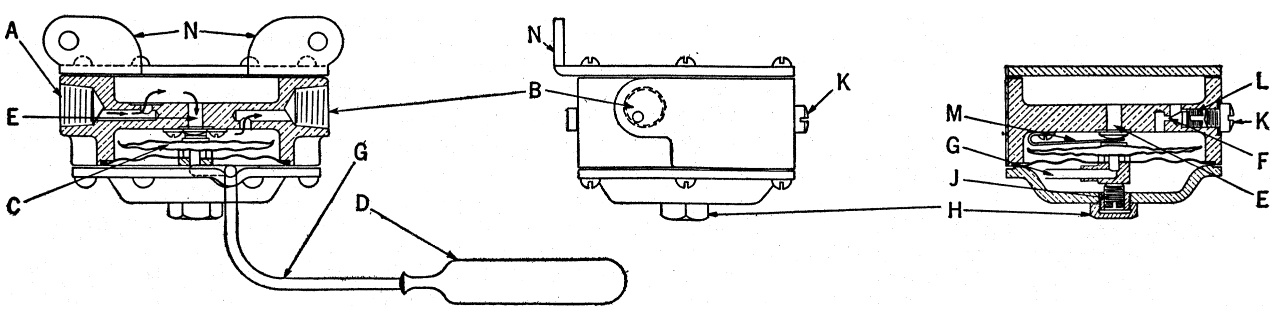
Actuating or Control Elements.— In some types of thermostats using a bi-metal sensing element, the sensing element itself functions as the control element and operates directly an air damper or valve. In other types, the sensing element acts as a pilot to the control element that regulates a supply of external energy in the form of pneumatic energy or electrical energy necessary to operate the air dampers, valves or switches.

The type of control element selected depends upon the type of action. To start or stop a burner or fan, to open or close a damper. a two-position control element is used that simply makes or breaks an electric circuit. The so-called floating control is similar to the two-position control element except that there is a neutral zone midway between the two contacts and that the action is at a constant rate toward either of the on or off positions. When the neutral zone is reached, the action stops until the sensing element makes one contact or the other at which time the action is resumed in the proper direction.

The modulating or proportional control element is piloted by the sensing element pushing a sliding contact over a potentiometer coil that controls the position of a reversible valve or damper motor, there being a motor position for each turn of wire on the potentiometer coil.

The pneumatic powered control element action controls the compressed air pressure in pneumatic air motors attached to dampers and valves. The air pressure causes movement in one direction only and a spring powers the return stroke. The position of the motor is fixed by the air pressure in the control line that is regulated by the control element. The pneumatic thermostats have modulating action that also satisfies a two position requirement.

Types of Thermostats.— There are five classified types of thermostats. (1) The room thermostat is mounted in the room that is to be controlled. It may have a sensing element of either



THERMOSTAT IN WHICH EXPANDING MEDIUM IS VOLATILE FLUID

(A) From gas supply line; (B) Gas to burner; (C) Diaphragm; (D) Bulb; (E) Main valve; (F) By-pass valve (needle type); (G) Capillary, connecting bulb to diaphragm; (H) Hexagonal cap screw; (J) Adjusting screw for lower or higher temperature; (K) Sealing cap sorew; (L) Adjusting sorew for by-pass valve; (M) Spring for opening main valve; (N) Mounting bracket

the bi-metal, bellows or electronic type, and its control element may be powered by electric or pneumatic energy. (2) An insertion thermostat is mounted on a duct with the control element in the room and the sensing element in the duct. (3) The immersion thermostat is used for the control of high pressure fluids or gases. A pressure tight bushing permits the sensing element to be immersed in the fluid and the control element to be accessible. Immersion and insertion thermostats use the bi-metal control element, either the spiral wound or the tube and rod type. The self contained direct acting tube and rod thermostat is often used to control the water temperature in gas fired water heaters. The rod is linked directly to the gas valve operating mechanism. (4) The surface type thermostat has its sensing element clamped to the surface of a tank or pipe and is an expedient substitute for an insertion or immersion thermostat. (5) The remote bulb thermostat is applied when it is desired to have the control element located at a distance from the sensing element.

Action of Thermostats in the Control of Residential Heating.—The action starts with the room thermostat, usually located in the living room. The secondary circuit is normally open and closes the circuit on a falling temperature, causes the relay to close and energize the primary (line voltage) circuit that starts the burner. When the temperature at the room thermostat rises to the desired degree at which it has been set, the secondary circuit is opened, the relay opens the primary circuit and the burner stops. Thus the room thermostat controls the operation of the burner and the source of heat. The point at which the burner starts is usually $1\frac{1}{2}°$ to 2° below the point at which it stops. As a safety measure, a limit switch is connected in series with the secondary circuit to prevent overheating. The limit switch when used with a warm air heating system, is an insertion thermostat that is reverse acting, *i.e.,* opens on a rising temperature and closes on a falling temperature, and has its sensing element in the warm air bonnet of the furnace. Its opening point is usually set about 5" above the minimum air temperature required to heat the house. Its opening point is fixed at 15° below its opening point. In case the bonnet air temperature reaches the limit, the switch opens the secondary circuit and the burner stops independently of the room thermostat. After the bonnet air cools 15° the limit closes and the burner starts again providing the room thermostat has not been satisfied in the meantime. The warm air circulating fan is controlled by an insertion thermostat in the warm air bonnet of the furnace and is set to start the fan 5° above the lowest temperature that will avoid the sensation of drafts in the living room, and to stop the fan 5° below the starting point.

With hot water systems, the room thermostat controls the operation of the circulating pump and the burner is controlled by a direct acting immersion thermostat set to open the secondary circuit at the minimum water temperature necessary to heat the house, and to close at about 10° to 15" below the opening point. When used with hot water heating systems, the limit switch is a direct acting double throw immersion thermostat with one pole in series with the primary circuit to the burner and the other in the primary circuit to the circulating pump. The circuit to the burner is normally closed+, and the circuit to the circulator is normally open. When the water temperature rises to the set point, the highest temperature for safe operation, the primary circuit to the burner opens and the burner stops; at the same time the primary circuit to the circulating pump closes and it starts independently of any controls on the secondary circuit. See also Index references under "Thermostat" in the Index volume.

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(W. T. Mr.)

THÉROIGNE DE MERICOURT, ANNE JOSÈPHE (1762–1817), a Frenchwoman who was a striking figure in the Revolution, was born at Marcourt (from a corruption of which name she took her usual designation), Luxembourg, on Aug. 13, 1762. She was the daughter of a farmer, Peter Théroigne. She was educated in the convent of Robermont. She was quick-witted, handsome, passionate in temper and had a vigorous eloquence, which she used with great effect upon the mobs of Paris during the few years of her life (1789–93) which are of historical interest. She left her home because of a quarrel with her stepmother. As a courtesan she visited London (1782), and Genoa as a singer (1788).

In Paris on the outbreak of the Revolution, she was surrounded by a coterie of well-known men, chief of whom were Jerôme Pétion de Villeneuve and Camille Desmoulins.

She was again in Paris in Jan. 1792, where she often spoke in the clubs. Even in the national assembly she would violently interrupt the expression of moderatist views. Known as "la belle Liégoise," she wore a riding habit, a plume in her hat, a pistol in her belt and a sword at her side, and excited the mob by violent harangues. Associated with the Girondists and the enemies of Maximilien Robespierre, she became in fact the "Fury of the Gironde." She commanded in person the 3rd corps of the so-called army of the faubourgs on June 20, 1792, and shares a heavy responsibility for the riots of Aug. 10. She took no part in the September massacres, and, moderating her conduct, became less popular from 1793. Toward the end of May the Jacobin women seized her, stripped her naked and flogged her in the public garden of the Tuileries. The following year she became mad; she died at La Salpetrière on June 9, 1817.

See E. and J. de Goncourt, *Portraits intimes* du *XVIIIe siècle* (2 vols., 1857–58); M. Pellet, *Étude historique et biographique sur Thtroigne de Mtricourt* (1886); L. Lacour, *Les Origines du ftminisme contemporain. Trois femmes de la Révolution* (1900); Vicomte de Reiset, *La Vraie Théroigne de Méricourt* (1903); and the play *Théroigne de Mtricourt* of *M.* Paul Hervieu, produced at the Théâtre Sarah Bernhardt in 1902.

THERSITES, the ugliest man in the Greek camp before Troy, a railing demagogue (see Homer, *Iliad* ii, 212), was a relative of Diomedes (*q.v.*).

THESEUS was the great hero of Attic legends and the son of Aegeus, king of Athens, and Aethra, daughter of Pittheus. king of Troezen, or of Poseidon and Aethra. The legend relates that Aegeus, being childless, went to Pittheus, who contrived that Aegeus should have intercourse with Aethra, who in due time brought forth Theseus. On reaching manhood Theseus was sent by his mother to Athens. He encountered many adventures on the way. First he met and slew Periphetes, surnamed Corynetes (Clubman). At the isthmus of Corinth dwelt Sinis, called the Pine Bender, because he killed his victims by tearing them asunder between two pine trees. Theseus hoisted the Pine Bender on his own pine tree. Next Theseus despatched the Crommyonian sow (or boar). Then over a cliff he flung the wicked Sciron, who used to kick his guests into the sea, while perforce they washed his feet. In Eleusis Theseus wrestled with Cercyon and killed him. Later he slew Procrustes, who fitted all comers to his only bed by lopping or racking them to the right length. He found his father married to Medea, who had fled from Corinth. Being a witch, she knew Theseus before his father did, and tried to persuade Aegeus to poison his son; but Aegeus recognized him. Theseus was now declared heir to the throne, and the Pallantids[1], who had hoped to succeed the childless king, conspired against him, but he crushed the conspiracy. He then attacked the fire-breathing bull of Marathon and brought it alive to Athens, where he sacrificed it to Apollo Delphinius. Next came the adventure of the Cretan Minotaur (*q.v.*).

While Theseus was on his way to Crete, Minos, wishing to see whether Theseus was really the son of Poseidon, flung his ring into the sea. Theseus dived and brought it up, together with a golden crown, the gift of Amphitrite. He landed on the return voyage at Delos, and there he and his comrades danced the crane dance, whose complicated movements were meant to imitate the windings of the Labyrinth. In historical times, this dance was still danced by the Delians round the Altar of Horns. Theseus had promised Aegeus that, if he returned successful, the black sail with which the fatal ship always put to sea should be exchanged for a white one. But he forgot his promise; and when Aegeus, from the Acropolis at Athens, descried the black sail out at sea,

[1]The sons of Pallas, the brother of Aegeus. Aegeus and Poseidon are quite possibly one and the same.

he flung himself from the rock and died. Hence, at the festival which commemorated the return of Theseus there was always weeping and lamentation. Theseus now carried out the union of the various Attic communities into a single State. He extended the territory of Attica to the isthmus of Corinth.

He transformed the Isthmian ceremony in honour of Melicertes by adding games in honour of Poseidon. Alone, or with Heracles, he captured the Amazon princess Antiope. Thereafter

BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM
THESEUS (ON RIGHT) AND PEIRITHOUS RESCUING LAODAMEIA (HIPPODAMEIA) FROM VIOLATION BY THE CENTAURS. FROM A GREEK VASE FOUND AT ANZI (BASILICATA) NOW IN THE BRITISH MUSEUM

the Amazons attacked Athens. Antiope fell fighting on the side of Theseus.

By her he had a son. Hippolytus (*q.v.*). Theseus is also said to have taken part in the Xrgonautic expedition and the Calydonian boar-hunt He compelled the Thebans to give up the unburied bodies of the Seven (see OEDIPUS).

The famous friendship between Theseus and Peirithous. king of the Lapiths. originated when Peirithous heard of the strength and courage of Theseus. and desired to put them to the test. Accordingly. he drove away from Marathon some cows which belonged to Theseus. The latter pursued. but nhen he came up with the robber the two heroes were so filled with admiration of each other that they snore brotherhood. At the marriage of Peirithous, a fight broke out between the Lapiths and Centaurs (*q.v.*).

Theseus and Peirithous now carried off Helen (*q.v.*). Theseus now descended to the lower world with Peirithous, to help his friend to carry off Persephone. But the two were caught and confined in Hades till Heracles came and released Theseus. \\'hen Theseus returned to Athens, he found that a sedition had been stirred up by Menestheus, a descendant of Erechtheus, one of the old kings of Athens.

Failing to quell the outbreak. Theseus in despair sent his children to Euboea. and after solemnly cursing the Athenians sailed away to the island of Scyros. where he had ancestral estates. But Lycomedes. king of Scyros. took him up to a high place, and killed him by casting him into the sea. His ghost was said to have appeared in the Athenian ranks at Marathon. When the Persian war was over, the Delphic oracle bade the Athenians fetch the bones of Theseus from Scyros and lay them in Attic earth. This was done, in *369,* by Cimon.

Theseus' chief festival. called Theseia, was on the 8th of the month Pyanepsion (Oct. 21), but the 8th day of every month was sacred to him.

The well-preserved Doric temple to the north of the Acropolis at Athens. commonly known as the Theseum, is certainly not his shrine. There were several (according to Philochorus, four) temples or shrines of Theseus at Athens.

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THESMOPHORIA, a very ancient festival. celebrated by women in many parts of the Greek world (as Attica, many places in the Peloponnesus. Boeotia. several islands, the coast of Asia Minor, Cyrene, Italy and Sicily, but not generally among the Dorians) in honour of Demeter Thesmophoros.

The name does not mean, as the ancients usually supposed, *legifera* Ceres, since the festival can in no way be connected with the bringing or establishing of laws or customs (*thesmoi*). It is possibly "bringer of treasure or wealth," an obsolete sense of thesmos, of which a few traces remain; or. perhaps better. the name Thesmophoria is the primary one, from which the epithet of the goddess is derived, and it means "the carrying of things laid down," the radical meaning of thesmos referring to the fertility charms described below. As no men were admitted to the rites, and in any case they were largely secret, nothing like a full description is available.

The celebrants were women who seem to have been at least generally married, and who must be free. They observed chastity for several days (nine. according to Ovid, a likely number considering its magical connotations). and abstained from certain foods; thus, they must not eat pomegranate seeds. The festival lasted three days. although in Attica it was lengthened by the addition of other celebrations of a similar character. the Stenia and the Halamusian Thesmophoria. making five days in all. Pyanopsion 10–14. But the original days were Pyanopsion 12–14 only (*i.e.,* about the beginning of October) and shortly after the Pyanopsia (*q.v.*). The days were called respectively Anodos (or *Kathodos*), *Nesteia,* Knlligenein.

Anodos (ascent) is often taken to mean the "going up" of the women to the Thesmophorion, or precinct of Demeter; but this does not explain why the day should also be called Kathodos, or descent. As the name of the second day. which signifies "fasting." describes what the celebrants then did, it is plausible to take the first day as having been called Ascent and Descent. and to connect it with the rite known to have been performed at some time in the festival. Pigs were thrown into an underground chamber. called a megaron; they were probably alive! but the text is corrupt and uncertain. At all events they mere left there until such parts of them as were not eaten by the guardian snakes of these underground sanctuaries had had time to rot. The remains were then brought up by certain women who had observed chastity for three days and were called antletrini or "drawers up"—the verb antlein means to pump or draw off water. These women also carried, or some of the celebrants did, certain well-known symbols of fertility. including pine cones and "figures made of flour of wheat, in imitation of the shapes of serpents and of men." The remains of the pigs were laid on an altar, and if taken and mixed with seed were believed to ensure a good crop. Apparently the figures, like the pigs. were thrown into the chasms; but the authority here (a scholiast on Lucian) is both confused and manifestly corrupt; he seems to be confusing the Thesmophoria with a quite different festival, the Arrhephoria.

If, however, pigs, pine cones, figures and all were thrown into the megara and "pumped" out again, it is very intelligible magic. These objects are all. in their nature, connected with fertility—a fertile beast. a seed vessel, a preparation of grain shaped like a creature supposed to be full of earth magic (the serpent) and like a man. perhaps a phallic figure. They are then put into a holy place, left there to acquire additional mana from the sacred surroundings and the touch of the sacred serpents, real or imaginary, who live there, and finally taken out again by pure agents, whose chastity has, so to speak. insulated them. Finally, they are laid on a holy altar, whence they are taken, heavily charged now with potency, and used to bring the blessing of fertility. To mix all manner of magical things with seeds to make them sprout better is a widespread primitive custom.

The ancients tried to explain all these matters as commemorations of the abduction of Kore; but it is rather the legends that grew out of the ritual. now no longer understood. In modern times it has been found possible to conjecture a reason for them; but it is to be remembered that, because of the fragmentary state of available knowledge. the above is offered as a conjecture only, especially as regards the date of the rite.

The *Nesteia* is easily enough explained; it is known that the women fasted. sitting upon the ground Fasting is a common piece of agricultural magic, and contact with the ground is also common. The third day, *Kalligeneia,* is "the fair birth." We need not take it as originally referring to anyone so definite as Kore; it rather indicates the happy issue of all this magic, and doubtless of much more that is not known, in the fertility of the ground and doubtless of men and beasts as well. It remains only to add that the Thesmophoria, or at least a great part of it, was carried out at night by torchlight, and that it was accompanied by ceremonial coarse abuse among the women; again a common means of promoting fertility. The festival formed a setting for Aristophanes' comedy *The Thesmophoriazusae.* *See* also FEAST AND FESTIVAL.

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THESPIAE, an ancient Greek city of Boeotia, on level ground commanded by the low eastward spurs of Mt. Helicon. The deity most worshipped at Thespiae was Eros, whose primitive image was an unwrought stone.

The town contained many works of art, among them the Eros of Praxiteles. dedicated by Phryne in her native place, one of the most famous statues in the ancient world. It was carried off to Rome by Caligula, restored by Claudius, and again carried off by Nero. There was also a bronze statue of Eros by Lysippus. The Thespians also worshipped the Muses. and celebrated a festival in their honour in the sacred grove on Mt. Helicon. Remains of the ancient citadel are still to be seen, solidly and regularly built. To east and south foundations show the extent of the ancient city.

The neighbouring village Eremokastro. on higher ground. was thought by Ulrichs to be probably the site of ancient Ceressus. In 1882 there were discovered, about 1,200 yd. east of Eremokastro. on the road to Arkopodi (Leuctra), the remains of a tomb of the 5th century B.C., with a colossal stone lion, probably that of the Thespians who fell at Plataea.

History.—Thespiae figures chiefly as an enemy of Thebes, whose centralizing policy it had all the more reason to fear because of the proximity of the two towns. During the Persian invasion of 480 *B.C.* Thespiae stood almost alone among Boeotian cities in serving the national cause. Seven hundred Thespians accompanied Leonidas to Thermopylae and of their own free will shared his fate.

The remaining inhabitants, though their city was burned by Xerxes, furnished 1.800 men to the Greek army at Plataea. In 424 B.C. the Thespian contingent at Delium sustained heavy losses, and in the next year the Thebans took advantage of this to accuse Thespiae of friendship toward Athens and to dismantle its walls. In 414 the Thebans interfered again to suppress a democratic rising. In the Corinthian war Thespiae sided with Sparta, and between 379 and 372 it repeatedly served the Spartans as a base against Thebes.

In the latter year the Thespians were reduced by the Thebans and compelled to send a contingent to Leuctra (371). It was probably shortly after this battle that the Thebans destroyed Thespiae and drove its people into exile. Later the town was rebuilt and in 171 B.C., true to its policy of opposing Thebes, sought the friendship of Rome.

BIBLIOGRAPHY.—*See* Herodotus, v. 79, vii. 132–ix. 30; Thucydides, iv. 93, 133, vi. 95; Xenophon, *Hellenica,* iv., vi.; Pausanias, ix. 13, 8–14, a, 26–27; Strabo, ix. pp. 409–10.

THESPIS, Greek poet, of Icaria, in Attica (6th cent. B.C.), generally considered the inventor of tragedy, flourished in the time of Peisistratidae. According to Diogenes Laertius (iii. 56), he introduced for the first time in the old dithyrambic choruses a person distinct from the chorus, who conversed with the leader, and was hence called ὑποκριτής ("answerer"). His claim to be regarded as the inventor of tragedy in the true sense of the term depends upon the extent to which this person was really an "actor." (*See* DRAMA.) Suïdas gives the titles (of doubtful authenticity) of several of his plays (not confined to the legends of Dionysus, but embracing the whole body of heroic legends), but the fragments quoted in various writers as from Thespis (*see* Nauck, *Tragic Fragments)* are probably forgeries by Heracleides of Pontus. The statement of Horace *(Ars Poetica,* 276) that Thespis went round Attica with a cart, on which his plays were acted, is due to confusion between the origin of tragedy and comedy, and a reminiscence of the scurrilous jests which it was customary to utter from a waggon (σκώμματα ἐξ ἁμάξης) at certain religious festivals. A, and M. Croiset *(History of Greek Literature,* Eng. tr., 1904), who attach more importance to the part played by Thespis in the development of tragedy, accept the testimony of Horace. According to them, Thespis, actor and manager, transported his apparatus on a cart to the deme in which he intended to produce his drama, formed and trained a chorus, and gave a representation in public. *(See* also DRAMA.)

THESSALONIANS, EPISTLES TO THE, two books of the New Testament. These earliest extant letters of Paul mark the beginnings of Christian literature. Fortunately we can date them as written from Corinth early in A.D. 50, under the circumstances of the life of Paul (*q.v.*) related in Acts xvii. The designation "Missionary Epistles" is sometimes applied to the pair because they stand apart from the "Major" four addressed to Galatia, Corinth, and Rome, being as yet unaffected by the Judaizing reaction. They thus afford a simpler view of the normal type of gospel preached by Paul in Gentile territory, with the reactions it encountered. The designation "Eschatological" would be more distinctive, because doctrinally they chiefly reflect the difficulties raised among Greek converts by the proclamation of "Christ and the resurrection" (Acts xvii. 22–32; *cf.* I., i. 9–10). The drama of a return of the glorified Jesus to judgment and renewal of the world, represented in such books of "Prophecy" as the Revelation of John *(see* REVELATION. BOOK OF; JOHN. SAINT [the Apostle]), was taken over by the primitive Church from contemporary Jewish Apocalypse, but in Paul's letters and in Greek Christianity generally is gradually modified and pruned of its crudities. We should not fail to note that in Acts xv. 32 Silas, or Silvanus. whom Paul here associates with himself as joint author, is specifically called a "prophet."

First Epistle.—Both Thessalonian epistles are replies to communications from that newly founded church, probably not in oral form alone. I., i.–iii. reviews Paul's whole relation to it by way of defence against insinuations from outsiders ascribing his missionary activities to selfish motives. Paul reminds his converts that, when among them, he had not even called for the respect and support which were his due, but had depended for support on his own labour, supplemented by voluntary gifts from churches previously founded, showing toward them only the care and solicitude of a parent. He had been driven out by the jealous hostility of the Jews, who here showed that bitter antagonism shown against the prophets of old, against Jesus, and the mother church in Jerusalem; but he still hopes to return. If his prayers and hopes are frustrated it will be due only to the machinations of Satan, not any failure on his part. A practical section follows in iv. 1–12 urging increased efforts against sexual impurity (a besetting sin of the Greek churches), greater brotherly love, and a life of orderly industry forestalling possible charges from outsiders of idle fanaticism. Practical advice leads over to doctrinal instruction. Individuals have been disturbed in their faith by the death of some members of the brotherhood before the expected Coming. Paul re-assures them by citing a "word of the Lord." This is not, as sometimes imagined, a transmitted report of some saying of the earthly Jesus, whose authentic teachings are of very different stamp, but a message from the glorified "Lord" in "the Spirit," that is, through the type of "prophecy" illustrated in the messages of Jesus "in the Spirit" to the churches of Asia (Rev. i. 1 *ff.*). In I., iv. 13–18 Paul applies such parts of this primitive apocalypse as will serve to "comfort" those in danger of losing their Christian hope, and passes at once in v. 1–11 to further practical exhortation to watch and be sober as children of the light about to dawn, not overtaken like the sinful world by the Coming of the Lord to judgment. After direction to leaders and laity alike to co-operate toward a blameless and orderly communal life, with instructions that the letter be read in public assembly, Paul pronounces his apostolic benediction.

Second Epistle.—The second epistle continues the correspondence after an interval so brief that outward conditions appear unchanged, while leading features of the preceding letter are continued and accentuated. In particular the unfamiliar Jewish eschatology is explained and developed. Chapter i. repeats with further detail the proclamation of the Coming of Christ to judgment of I., i. 10, and justifies the doctrine of "wrath" against persecuting unbelievers in contrast with "rest" and "glory" for the saints. But in ch. ii. a new factor appears. Before the hoped-for Advent the "mystery of lawlessness" now at work in the world must culminate in a counter-manifestation of Satan's power. An Antichrist (*q.v.*) will appear "in the temple of God" claiming divine honours there after the manner of the desecration of Antiochus, self-styled "God-manifest," predicted in Daniel The programme of redemption will begin by the slaying of Antichrist by the breath of the Lord's mouth at his Coming. Momentarily Satan is held in check by Roman power. The closing chapter (iii.) resumes the admonitions of I., v. 12–28, re-enforcing disciplinary measures to be taken against the "disorderly."

Authenticity.–abjections once urged against the authenticity of I. have lapsed, but some still question II Slight changes of diction, usually toward more emphatic form in II., need not detain us. Doubts aroused by the suspicions expressed in II., ii. 2 and iii. 17, are not warranted. Actual circulation of spurious letters during the lifetime of the reputed author is indeed improbable. But this is not implied. Paul has heard of misrepresentations of his teaching and wishes to remove all conceivable excuse for it. The strong language of II., ii. 2 against an alleged Pauline doctrine of the Day of the Lord as "now present" no more presupposes actual utterance by "spirit" (*i.e.*, "prophecy"), or by "word" (of Jesus), or "by letter purporting to be from us" than the stronger language of Gal. i. 8 presupposes actual anti-Pauline preaching by "an angel from heaven." However, spurious epistles were common enough in Paul's time. It is interesting to see how he already guards himself against this possibility by the device later exemplified in Gal. vi. 11–18 and illustrated by many actual documents among the Oxyrhynchus papyri, by attaching to the dictated letter an autographed farewell "in mine own hand."

Serious objections to the authenticity of II. are of two kinds, (1) from its similarity to I. both in formal arrangement of material and in language; (2) from its unexpected attachment of the Antichrist doctrine to Paul's eschatology.

The similarity of material and structure is probably sufficient to prove dependence, possibly even literary dependence. But why not? Intrinsic probability as well as the known practice of the ancients suggests that a copy of I. would be available at Corinth for Paul's use in continuing the correspondence. There remains thus, as the only serious objection to the authenticity of II. its belated supplement to Pauline eschatology. The Antichrist doctrine, if not actually opposed to his teaching elsewhere, is almost unmentioned (but *cf.* I. Cor. xv. 24–28 and "Belial" in II. Cor. vi. 1j). Did Paul forget to mention this preliminary crisis when seeking in I., v. 1–11 to allay excitement at Thessalonica over the expected immediate Coming and to restore orderly industry? Was the working of the "mystery of iniquity" an afterthought?

For answer we must consider the occasion for his introducing the (apocalyptic) "word of the Lord" cited in I., iv. 15–17. It was to restore the hope of certain converts grieved by recent bereavement, and professedly contains but a part of the teaching. Paul purposely limited himself to the single lesson in I., v. 1–11 of watchfulness in view of the uncertainty of the hour. But his readers, reminded of the revelation, seem now to feel that a little more definite information concerning the "times and seasons" would greatly help. If the Antichrist paragraph of II. be read as in reply to an intimation of this kind, probably by letter, while the fact is kept in mind that in both letters the subject is repeatedly declared to be no new doctrine but something preached from the beginning by Paul and his fellow-missionaries, it will be easier to realize that it is not an afterthought with which we are here dealing, but rather something earlier and primitive, brought now to the surface by further development of the subject.

Bibliography.—The most careful study of I. and II. Thess., with full bibliography will be found in the *International Critical Commentary* by *J. E.* Frame, 1912. Similar ground is taken by E. von Dobschütz in Meyer's Commentary (1909) and by M. Dibelius in Lietzmann's *Handbuch* (1911), also by Geo. Milligan (1908) and J. Moffatt (in *Expositor's Gr. Test.*, 1910). Against the authenticity of II. *see* H. J. Holtzmann (*Einl.* 1892 and *Zeitschr. f. ntl. Wiss.*, 1901), Pfleiderer, *Urchristentkum* (1902), and Wrede, *Echtheit des zweiten Thessalonicherbriefes* (1903). On the relation to Synoptic apocalypse *see* Bacon, *The Gospel of Mark* (1925). (B. W. Ba.)

THESSALY, a district of northern Greece, between Macedonia and the Hellenic countries towards the south, and between upland Epirus and the Aegean. It forms an irregular square of about 60 mi. in each direction, for the most part level, but with well-marked boundaries, the Cambunian mountains on the north, Othrys on the south, the massive chain of Pindus, the backbone of this part of Greece, on the west; while at the north-eastern angle is Olympus, separated by the gorge of Tempe (*q.v.*) from the coast range of Ossa and Pelion, standing in a continuous line to the south-east. Three peaks of Pindus are over 5,000 ft., and Olympus, Ossa and Pelion reach respectively 9,570, 6,489 and 5,253 ft. The country within these limits is drained by numerous confluents, which pass into the sea through the gorge of Tempe.

Through Thessaly, therefore, lie all land routes between peninsular Greece and the north. An important pass from Petra in Pieria debouches west of Olympus on the plain north of Larissa. By this Xerxes entered (Herodotus vii. 173), and when the Greeks heard of this passage, they gave up their defence of Tempe. The main communication with Epirus passed over Mount Lacmon by the upper Peneius to Aeginium in the north-west angle. By this route Julius Caesar arrived before the battle of Pharsalia. Another pass, farther south by Gomphi, leads to the Ambracian gulf. The great southern pass of Coela crosses Mount Othrys nearly north of Thermopylae.

Though Thessaly is the most level district of Greece, it is composed of sections, divided by ranges of hills; Upper Thessaly, to the west and south-west, contains the higher course of the Peneius and all tributaries from the south—Enipeus, Apidanus, Onochonus and Pamisus. Lower Thessaly, from the central ridge west of Larissa to the foot of Ossa and Pelion, is inundated by the Peneius, the flood-water forming the Lake Nessonis, and, when that is full, pouring into Lake Boebe. The chief city of the lower Thessaly was Larissa; in the south at the pass of Coela is another plain, containing a small lake, formerly called Xynias, and low hills separate this from the town of Thaumaki, which overlooks the main upper plain "like a vast sea" (Livy xxxii. 4). The Plain of Pharsalia, intersected by the Enipeus, lies north-east of this, and still farther another battlefield, Cynoscephalae. The political divisions follow the physical, Pelasgiotis being the lower plain of the Peneius, Hestiaeotis and Thessaliotis respectively the north and the south portions of the upper; the fourth, Phthiotis, towards the south-east, was geographically separated by the watershed of Mt. Othrys and its north-east spurs. The landlocked Pagasaeus Sinus (Gulf of Volo), extends from Pagasae at its head to Aphetae at its narrow outlet, where the chain of Pelion turns at right angles to south-west in broken ridges, while on the opposite side rise the heights of Othrys. In the heroic age Phthiotis was the legendary birthplace of Greek navigation in the story of the Argonauts. Hence Achilles came and, according to Thucydides (i. 3), it was the cradle of the Hellenes. Iolcus, the centre of many legends, is near the modern Volo. Near Iolcus, later, Demetrius Poliorcetes founded Demetrias, called by Philip V. of Macedon one of the "fetters of Greece," Chalcis and Corinth being the others.

The history of Thessaly is closely connected with its geography. From the earliest times Thessaly has had a separate history controlled by its situation, The fertility of the land offered a temptation to invaders, and was thus the primary cause of early migrations. Its first Neolithic culture combined Danubian characters with elements from the "Tripolje" culture of Ukraine; a second phase reinforces the latter elements, at Dimini near Volo. Then long decadence resulted from the spread, first of "Helladic," then of "Minyan" culture from the south. Finally, just as Mycenaean exploitation was beginning in the 12th century, fresh northern invaders from Macedonia wrecked all. At this point language and legend supplement archaeology. Thessalian Greek is of the Aeolie group, akin to Boeotian; but between lie the "West Greek" dialects of Phthiotis, Malis and Doris, subsequently intruded Aeolic genealogies go back to the early part of the 14th century, whereas the Doric and West Greek expansion is referred to the 12th. Tradition brought both Thessalians and Boeotians from Arne in the northwest, imposing powerful aristocracies on the older inhabitants, who retained political coherence only among the marginal hills in Perrhaebia, Magnesia and the like. The rich lowlands were the natural home of powerful families such as the Aleuadae of Larissa and the Scopadae of Crannon; and the absence of elevated positions was unfavourable to the foundation of cities, which might have fostered freedom and democracy. The plains, also, were suited to the breeding of horses, and consequently the force in which the Thessalians were strong was cavalry, a kind of troops usually associated with oligarchy. The wealth and the semi-Hellenic character of the people (for, in race, as in geographical position, the Thessalians held an intermediate place between the Macedonians and the southern Greeks) held them aloof from national sentiment, and at the time of the Persian Wars the Aleuadae joined the enemy. United, as under Alexander and Jason of Pherae in the 4th century, the Thessalians were formidable, but they seldom combined for long and had little influence in Greece. From the 4th to the 2nd century they were usually Macedonian vassals

For several centuries during the middle ages Rumanian immigrants formed so large a part of the population of Thessaly that that district was called by the Byzantine writers Great Wallachia (Μεγάλη Βλαχία); the Jewish traveller, Benjamin of Tudela, so describes it in the latter half of the 12th century. Only a few Vlach (Ruman) colonies remained, however, principally on the west of Olympus and in some gorges of Pindus. The Turkish conquerors settled in the larger towns and in great ranches. The Greeks form so large a majority that, even while the country belonged to the Ottomans, Greek was the official language. Thessaly was ceded to the Greek kingdom by the Porte in 1881. The whole area was a battlefield in World War II. The port of Volo, almost the only outlet of trade, has a steamer service to Athens. Railways run: (1) from Volo by way of Velestino (ancient Pherae) to Larissa (*q.v.*); (2) from Velestino to the west by Phersala (Pharsala), Domokos (Thaumaki), Karditsa and Trikkala (Trika) to Kalabaka (Aeginium) in the upper valley of the Salambria (Peneios); (3) the main line from Athens to Salonika enters Thessaly by the Coela pass west of Othrys, reaches Larissa and proceeds by the gorge of Tempe and the sea front of Olympus. Thessaly is essentially an agricultural and pastoral district.

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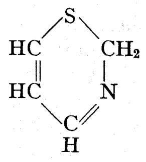
THETFORD, a municipal borough in the South Norfolk parliamentary division of Norfolk, Eng.. 29½ mi. W.S.W. of Norwich by road. It is the centre for the Breckland and is on the edge of Thetford Chase forest. Pop. (1961) 5.398. Area 11.1 sq.mi. In the time of Edward III there were 20 churches and 8 religious houses, but now there are only 3 parish churches and the remains of a Cluniac priory (excavated by the ministry of works) and a Benedictine nunnery. Castle hill, a large medieval motte, is 80 ft. high. Excavations have revealed traces of a Saxon town of some 4,000 inhabitants with considerable industry and a mint. The grammar school has a record of headmasters from 1114, and may be that mentioned in the Anglo-Saxon Chronicle as existing in 631. It mas refounded in 1567 by Sir Richard Fulmerstone. King's house, used by Elizabeth I and James I and reputed to stand on the site of the palace of the Conqueror's son-in-law, was bequeathed to the corporation in 1946 and serves as municipal offices. There have been mayors since 1272 and the town is now governed under a charter of 1573 The borough regalia is fine and interesting. Thomas Paine, the reformer, was born there in 1737 and attended the grammar school. Industries include paper-pulp manufacturing, canning, coffee milling and light engineering.

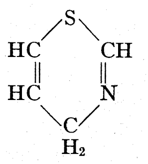
See T. Martin, *The History of the Town of Thetford* (London, 1779); A. L. Hunt, *The Capital of the Ancient Kingdom of East Anglia* (London, 1870).

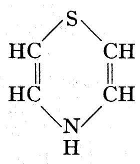
THETIS, in Greek mythology, daughter of Nereus, wife of Peleus and mother of Achilles. The chief of the 50 Nereids, she dwelt in the depths of the sea with her father and sisters. When Dionysus leaped into the sea to escape from the pursuit of Lycurgus, king of the Thracian Edones, and Hephaestus was flung out of heaven by Zeus, both were kindly received by Thetis. Again, when Hera, Athena and Poseidon threatened to bind Zeus in chains, she sent the giant Aegaeon, who delivered him out of their hands. She was married against her will to Peleus (*q.v.; see* also ACHILLES). Thetis is used by Latin poets simply for the sea.

THEURIET, CLAUDE ADHÉMAR ANDRÉ (1833–1907), French poet and novelist, was born at Marly-le-Roi. The best of his novels are: *Le mariage de Gérard* (1875); *Raymonde* (1877); Le *fils Maugars* (1879); *La maison des deux Barbeaux* (1879); *Sauvageonne* (1880); *Reine des bois* (1890); *Villa tranquille* (1899). Theuriet died on April 23, 1907.

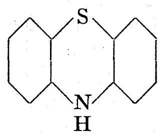
THIAZINES are organic compounds. of which some of the more complex derivatives are of importance in the manufacture of dyestuffs. They have the molecular formula C_4H_5NS, to which six-membered heterocyclic ring structures have been assigned.


1,3,2-Thiazine

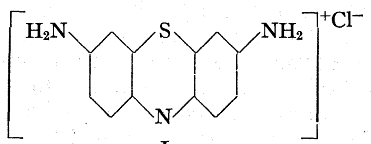

1,3,4-Thiazine


1,4-Thiazine

The thiazines themselves and their simpler derivatives are of little practical importance or theoretical interest. The so-called thiazine dyes are phenazothionium salts and may, therefore, be regarded as derivatives of phenothiazine (2,3,5,6-dibenzo-1,4-thiazine).



The simplest of the thiazine dyes is Lauth's violet (I); probably the most important is methylene blue (II).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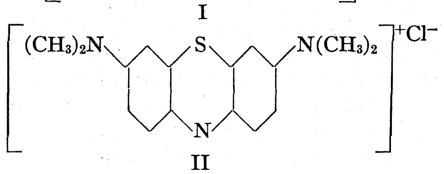
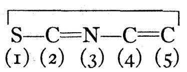

II

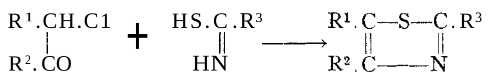
The skeletal structure of the thiazine dyes was elucidated by August Bernthsen in 1887, although methylene blue was discovered in 1876 by Heinrich Caro. (P. H. O. R.; X.)

THIAZOLES, in organic chemistry, consist of compounds containing a five-membered ring of one nitrogen. one sulfur and three carbon atoms connected by three single and two double bonds in the order:



The earliest synthesis of a compound of this type was effected in 1874, by the action of hydrogen sulfide on potassium cyanide; however, the constitution of this product remained long in doubt and was rigorously established. as 5-amino-2-thiocarbamylthiazole, only in 1947.

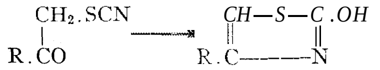
Thiazoles, as a class, were discovered in 1887 by Artur Hantzsch, who then systematically explored their chemical characteristics. They are most conveniently prepared by the condensation of α-halogenated aldehydes or ketones with thioamides:



The parent thiazole, in which R^1, R^2 and R^3 represent hydrogen atoms, is a colourless liquid that boils at 117° C. and exhibits weakly basic properties like those of pyridine; the homologous thiazoles display similar properties.

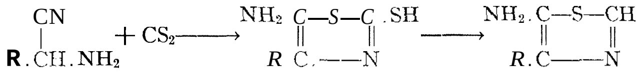
The 2-aminothiazoles, in which R^3 represents the amino group. are formed in an analogous reaction from thiourea; the sulfanilyl derivative, in which $R^1 = R^2 = H$ and $R^3 = NH.SO_2.C_6H_4.NH_2$, is the synthetic antibiotic drug sulfathiazole.

The 2-hydroxythiazoles. in which $R^3 = OH$, are produced by the action of alkali upon a-thiocyanoketones:



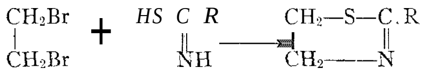
The corresponding 2-mercaptothiazoles ($R^3 = SH$), formed by the interaction of a-halogenated ketones with ammonium dithiocarbamate, find industrial use as accelerators in the vulcanization of rubber.

The 5-aminothiazolcs ($R^1 = NH_2$) have been prepared by treating a-amino nitriles with carbon disulfide and then removing the sulfydryl group (at position 2) from the product by the action of Raney nickel catalyst:



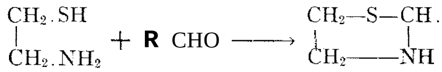
For the versatility of these compounds in synthetic reactions *see* Sir Ian Heilbron's presidential address to the Chemical society of London in the bibliography.

Dihydrothiazoles, or thiazolines. have been prepared by the action of ethylene dibromide upon thioamides:



or, less conveniently, from acid chlorides or anhydrides and β-amino thiols.

Tetrahydrothiazoles. or thiazolidines, are formed by the interaction of aldehydes or ketones with β-amino thiols:



In 1935 and the subsequent two decades the thiazole group and its hydro analogues were shown to occur in natural products: thiamine (vitamin B_1) contains a thiazole nucleus, the penicillins are derivatives of thiazolidine and there are indications that the thiazoline ring may be present in the antibiotic bacitracin. Synthetic thiazole dyes are used in dyeing cotton.

See Sir Ian Heilbron. *J. Chem. Soc.*, 2099 (1949): Roger Adams *et al.* (eds.), *Organic Reactions*, vol. 6, ch. 8 (1949–51). (H. T. C.)

THIBAUT (Theobald) **IV** (1201–1253), count of Champagne and Brie and king. as Theobald I. of Navarre. French poet, was born at Troyes in 1201. His father. Thihaut III of Champagne, died before his son's birth, and his mother. Blanche of Navarre, was compelled to resign the guardianship of the young prince to Philip II Augustus of France: but there is little doubt that the child was acquainted with Chrétien de Troyes and the other trouvères who found patronage at the court of Champagne. Thibaut's verses belong to what is called "courtly" poetry, but they have a personal note that distinguishes them from mere exercises. It has been supposed, apparently without much justification. that they were addressed to Blanche of Castile, the wife of Louis VIII of France. and Thibaut's relations with her have been the subject of much controversy. The count took part with Louis in the crusade against the Albigenses, but in 1226 suddenly left the king and returned to Champagne. Three months later, Louis died under doubtful circumstances, and Thihaut was accused by his enemies of poisoning him. The real reason for Thibaut's desertion appears to have been a desire to consolidate his position as heir apparent of Navarre by an alliance with the disaffected nobility of the south of France, but from this confederation Blanche was skillful enough to detach him. The resentment of the League involved him in a war in which Champagne was laid waste and his capital saved only by the royal intervention. In 1234 he succeeded his uncle. Sancho VII the Strong, as king of Navarre. and from this period date his most fervent songs in praise of his lady. An obligation to go as a crusader to Palestine turned Thibaut's thoughts to religion, and he announced his intention of singing henceforth only in honour of the Virgin. The years 1239 and 1240 were spent in Palestine, and from the time of his return Thibaut devoted himself to efforts for the improvement of his dominions that won for him the title of *le Bon*. He died at Pamplona on July 7, 1253. Thibaut was the most popular of the 13th-century trouvères, and his work is marked by a grace and sweetness which he owed perhaps in part to his association with the trouhadours of the south. As many as 53 poems, including 36 love songs and 9 *jeux-partis* (elaborate discussions between two interlocutors, usually on the subject of love), can be certainly attributed to him.

Thibaut's works were published first by L. A. Lévesque de La Ravalière (1742) and then by P. Tarbé (1851). The critical edition, with introduction and commentary, was edited by A. Wallensköld for the Société des anciens textes français (1925).

THIBAUT, ANTON FRIEDRICH JUSTUS (1774–1840), German jurist. was born at Hameln. in Hanover. on Jan. 4, 1774. the son of an officer in the Hanoverian army. He studied jurisprudence at Göttingen, Königsberg and Kiel. There in 1798 he was appointed extraordinary professor of civil law, and published his earlier works, including the important treatise *Theorie der logischen Auslegung des romischen Rechts* (1799). In 1802 Thibaut was called to Jena. where he wrote his chief work. *System des Pandektenrechts* (1803). This work is. in effect, a codification of the Roman law as it then obtained in Germany. modified by canon law and the practice of the courts into a comprehensive system of pandect law. In 1805 he went to Heidelberg where he stayed till his death on March 29. 1840. His influence was great and. except Gustav Hugo and Savigny, no civilian of his time was so well known. In 1814 appeared his *Civilistische Abhandlungen,* of which the principal was his famous essay advocating a national code for Germany. This essay was inspired by the War of Liberation.

Sre Baumstark, *Thihaut, Blätter der Erinnerung* (1841); Karl Hagemann, *Aus dem Leben A. F. J. Thibaut, mit Correspondenz* in *die Preuss. Jahrbücher* (1880); Teichmann in *Holtzendorff's Rechtslexikon;* E. Landsberg in *Allgemeine Deutsche Biographie,* vol. 37.

THIELMANN, JOHANN ADOLF, Freiherr von (1765–1824), Prussian cavalry soldier, was born at Dresden. Entering the Saxon cavalry in 1782, he saw service against the French in the Revolutionary Wars and in the Jena campaign and, after Jena, at the siege of Danzig and at Friedland. In 1809, as colonel of a free corps, he opposed the advance of the Austrians into Saxony and was promoted major general. becoming lieutenant general in 1810. As commander of the Saxon heavy cavalry brigade he took part in the advance on Moscow (1812), and at Borodino attracted the attention of Napoleon, who took him into his own suite. His own sovereign at the same time made him freiherr. In the War of Liberation Thielmann took a prominent part. When ordered to surrender the fortress of Torgan, of which he was governor, to the French, he resigned his command and joined the allies. As a Russian general he reorganized the Saxon army after Leipzig, and in 1814 he commanded the Saxon corps operating in the Low Countries. Early in 1815 he became a lieutenant general in the Prussian service, and in command of the 3rd army corps he took part in the Waterloo campaign, in which he fought the spirited action of Wavre (June 18–19). He was later a corps commander at Münster and at Coblenz, where he died in 1824.

See Von Petersdori, *General Johann Adolf Freiherr von Thielmann* (1894).

THIERRY, JACQUES NICOLAS AUGUSTIN (1795–1856), French historian. who was horn at Blois on May 10, 1795. He was educated at the Blois grammar school, and at the Ecole Normale Supérieure. He embraced the ideas of the Revolution and became fired with Saint-Simon's ideal society of the future. He became the secretary, and. as he would say himself, the "adopted son" oi the visionary (1814–17); but, while most of Saint-Sinion's followers turned their attention to the affairs of life, devoting themselves to the problems of political economy, Thierry turned his to history. His imagination had been powerfully impressed by reading *Les Martyrs,* in which Châteaubriand had contrasted the two civilizations and the two races from which the modern world has sprung. His romantic ardour was later still further nourished by the works of

Sir Walter Scott. Thierry's main ideas on the Germanic invasions, the Norman Conquest, the formation of the communes, the gradual ascent of the nations towards free government and parliamentary institutions are already observable in the articles contributed by him to the *Censeur européen* (1817–20), and later in his *Lettres sur l'histoire de France* (1820). By the aid of the Latin chronicles and the collection of the Anglo-Saxon laws, he composed his *Histoire de la Conquête de l'Angleterre par les Normands* (1825). Thierry's eyesight began to fail and in 1830 he became quite blind. Nevertheless he republished (1827) his *Lettres sur l'histoire de France,* with the addition of 15 new ones, in which he described some of the more striking episodes in the history of the rise of the mediaeval communes.

Thierry was ardent in his applause of the July Revolution and the triumph of liberal ideas. He re-edited, under the title of *Dix ans d'e'tudes historiques,* his first essays in the *Censeur européen* and the *Courrier français* (1834), and composed his *Récits des temps mérovingiens,* in which he reproduced in a vivid and dramatic form some of the most characteristic stories of Gregory of Tours. These *Rtcits* appeared first in the *Revue des deux mondes;* when collected in volume form, they were preceded by long and interesting *Considrations sur l'histoire de France.* In 1841, the French academy awarded him the first *Prix Gobert,* which was renewed in his favour 15 years in succession. By the aid of zealous collaborators (including Bourquelot and Louandre) he compiled, in four volumes, a valuable *Recueil des monuments inédits de l'histoire du Tiers État* (1850–70), which, however, bear only on the northern part of France. He died in Paris on May 22, 1856.

THIERRY OF CHARTRES (d. c. 1150), in Latin called THEODORICUS or TERRICUS CARNOTENSIS, French encyclopaedist, philosopher and theologian, was a brother of Bernard of Chartres. He taught in Paris and at Chartres, where he became chancellor in 1141, having among his pupils John of Salisbury and possibly Abelard. His unpublished *Heptateuchon* (preserved in microfilms at Oxford, at Toronto, at Chartres. etc.) contains the "classics" of the seven liberal arts (works by Aelius Donatus and Priscian for grammar, by Cicero and Martianus Capella for rhetoric, by Aristotle and Porphyry for logic, etc.). His cosmology, mainly expounded in his commentary on *Genesis,* attempts to harmonize Scripture with Platonic and other physical or metaphysical doctrines. He was among the first to promote in the Latin west the knowledge of science as professed by the Arabians.

See A. Clerval, *Les Écoles de Chartres au moyen âge* (Paris, 1895); and W. Janssen, *Der Kommentar des Clarembaldus zu Boethius De Trinitate* (Breslau, 1926). (*L.* M.-Po.)

THIERS, LOUIS ADOLPHE (1797–1877), French statesman and historian, was born at Marseilles on April 16, 1797. He was educated, first at the lycée of Marseilles, and then in the faculty of law at Aix. There he began his lifelong friendship with Mignet, and was called to the bar. In 1821 Thiers went to Paris, and became a contributor to the *Comtitutionnel.* Cotta, the well-known Stuttgart publisher, who was part-proprietor of the *Constitutionnel,* made over to Thiers a share of his dividends and he was thus relieved of any money anxiety.

Meanwhile Thiers became very well known in Liberal society, and he had begun the celebrated *History of the French Revolution,* 10 vol. (1823–27; Eng. trans. 5 vol., 1895), which founded his literary and helped his political fame. Coming as the book did just when the reaction against the revolution was about to turn into another reaction in its favour, it was assured of success. In 1830 Thiers, with Armand Carrel, Mignet, and others started the *National,* a new opposition newspaper. Thiers himself took a leading part in the actual revolution. He ranked as one of the Radical supporters of the new dynasty. At first Thiers, though elected deputy for Aix, obtained only subordinate places in the ministry of finance. After the overthrow of his patron Laffitte, he became much less radical and, after the troubles of June 1832, was appointed to the ministry of the interior. He repeatedly changed his portfolio, but remained in office for four years, became president of the council and in effect prime minister; and began his series of quarrels and jealousies with Guizot. At the time of his resignation in 1836 Thiers was foreign minister, and, as usual, wished for a spirited policy in Spain, which he could not carry out. He travelled in Italy for some time, and it was not till 1838 that he began a regular campaign of parliamentary opposition, which in March 1840 made him president of the council and foreign minister for the second time. But he held the position barely six months, and resigned on Oct. 29. He now worked on his *History of the Consulate and the Empire* (1840–55; Eng. trans.. 1845–62). Though he was still a member of the chamber he spoke rarely, till after the beginning of 1846, when he was evidently bidding once more for power. When the revolution of February broke out he and Odilon Barrot were summoned by the king; but it was too late.

Under the republic he took up the position of conservative republican. The inconsistency of his conduct, especially in voting for Prince Louis Napoleon as president. was often and sharply criticized, one of the criticisms leading to a duel with a fellow-deputy, Bixio. He was arrested at the *coup d'état,* was sent to Mazas, and then escorted out of France. But in the following summer he was allowed to return. For the next decade his time was occupied for the most part on *The History of the Consulate and the Empire.* It was not till 1863 that he re-entered political life, as deputy for a division of Paris. For the next seven years he was leader of the anti-Imperialists in the French chamber. While nominally protesting against its foreign enterprises, he perpetually harped on French loss of prestige, and so contributed more than anyone to stir up the spirit which brought on the war of 1870.

After the collapse of the empire Thiers visited in the autumn the different courts of Europe in the hope of obtaining some intervention, or at least some good offices. The mission failed; but the negotiator was immediately charged with another — that of obtaining, if possible, an armistice directly from Prince Bismarck. Thiers was chosen deputy to the national assembly by more than 20 constituencies (of which he preferred Paris), and was at once elected by the assembly itself practically president. nominally *chef du pouvoir exdcutif.* He succeeded in convincing the deputies that the peace was necessary, and it was (March 1, 1871) voted by more than five to one. Thiers held office for two years after the peace. He had at first to meet and crush at once the Paris commune, and on Aug. 30 he became president of the republic.

His strong personal will and inflexible opinions had much to do with the resurrection of France; they also made it inevitable that he should excite violent opposition. In Jan. 1872 he formally tendered his resignation; and, though it was refused, almost all parties disliked him, while his chief supporters — men like Rémusat, Barthélemy Saint-Hilaire and Jules Simon — were men rather of the past than of the present. In 1873 regulations were proposed, and on April 13, were carried, which were intended to restrict the executive and especially the parliamentary powers of the president. The government was further weakened by a dissolution and reconstitution of the cabinet on May 19. Immediately afterwards the question was brought to a head by an interpellation moved by the duc de Broglie. The president declared that he should take this as a vote of want of confidence; a vote of this character (though on a different formal issue, and proposed by M. Ernoul) was carried by 16 votes in a house of 704. Thiers at once resigned (May 24). He survived his fall four years, continuing to sit in the .Assembly, and, after 1876, the chamber of deputies. He died on Sept. 3, 1877.

Thiers was by far the most gifted and interesting of the group of literary statesmen which formed a unique feature in the French political history of the 19th century. There are only two who were at all comparable to him — Guizot and Lamartine; and as a statesman, he stands far above both. Nor was this eminence merely the result of his great opportunity in 1870; for Guizot might under Louis Philippe have almost made himself a French Walpole, at least a French Palmerston, and Lamartine's opportunities after 1848 were, for a man of political genius, illimitable. But both failed — Lamartine almost ludicrously — while Thiers in hard conditions made a striking if not a brilliant success. But he only showed well when he was practically supreme. Even as the minister of a constitutional monarch his intolerance of interference or joint authority, his temper at once imperious and intriguing, his inveterate inclination towards *brigue,* that is to say, underhand rivalry and caballing for power and place, showed themselves unfavourably; and his constant tendency to inflame the aggressive and chauvinist spirit of his country neglected fact, was not based on any just estimate of the relative power and interests of France, and led his country more than once to the verge of a great calamity. In opposition. both under Louis Philippe and under the empire, and even to some extent in the last four years of his life, his worst qualities were always manifested. But with all these drawbacks he conquered and will retain a place in what is perhaps the highest, as it is certainly the smallest, class of statesmen — the class of those to whom their country has had recourse in a great disaster, who have shown in bringing it through that disaster the utmost constancy, courage, devotion and skill. and who have been rewarded by as much success as the occasion permitted.

As a man of letters Thiers was very much smaller. He had not only the fault of diffuseness, which is common to so many of the best-known historians of his century, but others as serious or more so. The charge of dishonesty is one never to be lightly made against men of such distinction as his, especially when their evident confidence in their own infallibility, their faculty of ingenious casuistry, and the strength of will which made them (unconsciously, no doubt) close and keep closed the eyes of their mind to all inconvenient facts and inferences, supply a more charitable explanation. But it is certain that from Thier's dealings with the men of the first revolution to his dealings with the battle of Waterloo, constant, angry and well-supported protests against his unfairness were not lacking. (G. SA.; X.)

THIETMAR (DIETMAR or DITHMAR) OF MERSEBURG (975–1018), German chronicler, was a son of Siegfried, count of Walbeck, and was related to the family of the emperor Otto the Great. Born on July 25, 975, he was educated at Quedlinburg and at Magdeburg and became provost of Walbeck in 1002 and bishop of Merseburg seven years later. He took some part in the political events of the time; in 994 he was a hostage in the hands of the Northmen. He died on Dec. 1, 1018.

Thietmar wrote a *Chronicon* in eight books, which deals with the period between 908 and 1018. For the earlier part he used Widukind's *Res gestae Saxonicae,* the *Annales Quedlinburgenses* and other sources; the latter part is the result of personal knowledge. It has been edited by J. M. Lappenberg in vol. iii of the *Monumenta Germaniae historica, Scriptores;* and by F. Kurze (1889); and has been translated into German by J. Laurent (new ed. revised by W. Wattenbach [1892]).

See F. Kurze, *Bischof Thietmar von Merseburg und seine Chronik* (1880) ; W. Wattenbach, *Deutschlands Geschichtsquellen,* vol. ii (1904).

THINKING AND PROBLEM SOLVING, PSYCHOLOGY OF. Problem solving is one kind of thinking, the kind that has been most thoroughly studied. But there are other important kinds of thinking, and the term itself has many definitions; no one of which is satisfactory to everyone. A useful one for those who attempt to study it scientifically defines thinking as that aspect of human (and animal?) activity that primarily involves processing of information.

When a person thinks, he processes information: he takes certain information that he possesses and by carrying out appropriate operations obtains information that in some sense is new. Suppose, for example, he is asked, "What is the numerical value of the seventh power of five?" After a minute or so, he map reply, "78,125," having multiplied $5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5$ in order to get the answer. This would be a simple example of processing of information and hence of thinking. An appropriate operation —in this case, multiplying five by itself the required number of times—was carried out in order to obtain information not previously possessed. Of course, it is possible that some person when asked this question would reply almost immediately, "78,125," recalling a result he had obtained on some previous occasion. In this case, he would be said to be remembering rather than thinking.

It is not easy to distinguish between behaviour involving learning or remembering and that involving thinking. Indeed, many insist that thinking involves nothing more than learning or remembering. But the view taken here is that one learns items of information, one learns the operations employed in processing information, and one may learn the information obtained from such processing; but the processing of information itself, or thinking, involves primarily implicit performance, not learning, from which it should be distinguished at least provisionally. In thinking, one deals with or processes much information that one does not necessarily learn and remember. For example, one does not in the process of obtaining the seventh power of five ordinarily learn and remember the fifth power.

The operations or processes involved in thinking are many and varied in kind and complexity. They include the simpler logical operations such as matching two items or substituting one for another, and also many more complex ones. They include the simpler mathematical operations such as addition and multiplication, and also more complex ones such as differentiation and integration. And they include many less logical processes. These processes are themselves the result of learning and hence vary from one thinker to another. Consider the differences that must exist among the processes involved in choosing moves in chess, in composing a piece of music and in diagnosing a case of appendicitis.

Thinking, as here defined: includes problem solving, decision making, creative thinking, fantasy and even dreaming. But since more is known about problem solving than about any of the other types of thinking, it will be the primary subject of this discussion. A problem exists whenever an individual has a goal, the route to which is unknown. In solving the problem, he thinks; in other words, he processes information which he already possesses or, in some cases, which he can obtain from the environment in order to produce the information that will enable him to achieve the goal. Of course, if the necessary information is obtained from the environment with no further processing required, then no thinking can be said to be involved. The kinds of goals sought in problem solving may be as varied as trapping a wild animal, finding a route by which wagons can cross a mountain range, locating the source of trouble in a television set, disassembling a mechanical puzzle, proving a theorem in geometry, identifying the killer in a murder mystery or determining the speed and direction necessary for a rocket to hit the moon when fired from the earth.

The experiments carried out by psychologists in studying problem solving are of two types: (1) One is concerned primarily with investigating the processes of problem solving; that is, what goes on when an individual solves a problem. (2) The other is concerned primarily with determining how achievement in problem solving varies as a function of a variety of experimental variables; *e.g.,* an experiment designed to determine how the number of problems solved by a group in a given length of time varies with the size of the group. There are also correlational studies concerned with achievement in problem solving as a function of other variables; since these variables; however, cannot be varied for a given individual in an experiment, such studies are said to be nonexperimental. An example of such a variable would be general intelligence. It is not possible to change the intelligence of a subject experimentally to determine how achievement in solving a given kind of problem varies with intelligence; it is possible, however. to determine how differences in such achievement are correlated among a group of subjects with differences in intelligence. Historically, the experiments concerned with the processes involved in thinking and particularly in problem solving have been of most interest and the subject of the most controversy. Accordingly, they will be given primary attention here.

Introspection. — The first systematic experiments on thinking, carried out during the first decade of the 20th century, were of this type. In the psychology then prevalent. still new as an experimental science, thinking was conceived as essentially a conscious process! directly open to the introspection (*q.v.*) of the thinker. The experimental method, therefore, was that of presenting brief thought-provoking tasks to persons and asking them to describe their experience promptly as each task was completed.

The results of this straightforward and apparently obvious procedure were such as to cast doubt on some of the basic presuppositions of psychology as it was then widely understood. Among the most thoroughgoing of the early experimental psychologists, it was commonly assumed that consciousness is a composition of elementary processes — specifically simple sensations, images and feelings — and that it is the special task of a scientific psychology to describe consciousness exhaustively in terms of these constituents, as determined by experimentally controlled introspection.

It was precisely this assumption concerning the nature of consciousness that the data from the thought experiments called into question. The subjects' reports, to be sure, mentioned sensory, affective and imaginal contents; but they referred far more prominently to conscious events which most subjects described as being unanalyzable into the expected elementary constituents. Among these were conscious attitudes such as doubt, hesitation or sudden illumination and "thoughts," noted simply as thoughts *of* or thoughts about, reported as having little or no sensory or imaginal content. Furthermore, such contentless or relatively contentless occurrences seemed to the subjects to mark critical turning points in their thinking, crucial stages in the solution of a problem.

These results were especially convincing because they were obtained independently in investigations conducted by a group of men inspired largely by O. Kiilpe at the University of Würzburg in Germany (1901–07), by A. Binet in France (1903) and by R. S. Woodworth in the U.S. (1906). They were important because they indicated that the course of thought is neither completely nor faithfully mirrored in consciousness — that important determinants of thought, as a matter of fact, are not registered in consciousness and, therefore, are outside the range of introspective observation. Moreover, in the controversy that rose over these unexpected findings, highly trained introspectionists disagreed not only concerning the interpretation of introspective data but even concerning the very nature of some of the data. This disagreement, which could not be settled by an appeal to facts—introspectively observed facts — strongly suggested that introspection is incapable of giving results sufficiently free from ambiguity to be acceptable in scientific research. To some psychologists, it seemed necessary to discard introspection altogether, not only in studying thinking, but in all psychological research. But to others. perhaps to most, the conclusion was that the possibilities of introspection had been greatly overestimated; that, like other modes of observation, it has limitations that must be recognized; but that within these limits it may be useful if properly safeguarded, especially when combined with other methods.

Implicit Muscular Activities. — John B. Watson, the founder of U.S. behaviourism, was chief among those who proposed (1914) to discard from psychology not only the introspective method but all reference to consciousness. Watson treated thinking as consisting of slight muscular movements, especially though not exclusively speech movements. His view that thought is implicit speech led to a number of attempts by others to record such movements by means of mechanical lever systems. These attempts, however, were largely inconclusive, partly because the recording systems employed were not sensitive enough or sufficiently quick acting, and partly for other reasons.

Electrical rather than mechanical recording systems subsequently were used to provide much more sensitive indication of slight muscular activity. Electrodes appropriately placed near a muscle will pick up minute changes in potential and cause deflections of a string galvanometer. By employing a vacuum tube amplifier, potential changes as small as one millionth of a volt have been recorded on photographic film. The work of L. E. Jacobson (1929–32) and of L. W. Max (1934–37) involved the most extensive applications of this technique. Jacobson's general procedure was to have subjects carry out various tasks involving thinking while recording changes in potential. or action currents, from appropriate muscles. In one experiment, for example, subjects were instructed to imagine bending the right arm. Action currents were obtained from the right arm while the subjects were imagining this act, but not while they were imagining bending the left arm or nhile they were relaxing. In another experiment. electrodes were attached to the tongue and lips while subjects imagined counting, telling the date and so forth. The records of action currents were similar in general, but not in detail, to those obtained when subjects were faintly speaking the same words or numbers. Max employed as subjects deaf-mutes, persons who normally use gesture language. When they were given various problems to solve, action currents were obtained from the muscles controlling the fingers that were much larger and more frequent than those obtained from normal control subjects under the same conditions. During sleep, occasional bursts of activity of about two or three minutes in length were recorded from the same muscles in deaf-mutes. When awakened during such bursts. these subjects usually, but not always, reported that they had been dreaming; when awakened in the absence of such bursts, they usually. but not always, reported that they had not been dreaming.

Peripheral v. Central Theory. — These results have been interpreted by some to support the peripheral as opposed to the central theory of thinking. According to the latter, all activities necessary and sufficient for thought occur in the brain. The peripheral theory, however, holds that these implicit muscular activities together with the perceptual changes to which they give rise form the necessary and sufficient condition for thinking; according to this view, the brain serves as a relay station transmitting impulses from receptors to effectors: and as the locus of awareness of thought, such awareness arising from the perception of implicit movements,

Most psychologists accept one of two other interpretations of the significance of these data on implicit muscular activity; both are consistent with the central theory of thinking. According to one view, such implicit muscular movements result from an overflow of central nervous activity; that is, they are simply a by-product of the real processes of thinking. The other view is that these movements provide a necessary neural substratum for particular thought processes, that they in some way provide reinforcement for central neural activity.

A comment may be inserted at this point concerning the possible use of the electroencephalogram as an index of the course of thinking. Brain waves are recorded by placing electrodes at appropriate points on the surface of the scalp and by greatly amplifying the rhythmic changes in potential that are picked up. Gross distortions in the frequency or form of these waves may be useful in diagnosing epilepsy, locating a brain tumour or for other purposes. But using such waves as an indicator of what a person is thinking would be, as one psychologist put it, like trying to measure the width of the edge of a razor blade with a yardstick.

Trial and Error. — Another approach to the understanding of the processes of problem solving grew originally out of investigations of animal behaviour. On the basis of observations of his dog and of other animals, C. Lloyd Morgan (1894) questioned the then widely accepted view that animals can reason. Such behaviour as that of his fox terrier learning to open a gate by raising the latch with his muzzle could best be explained, Morgan held, in terms of trial and error — that is, in terms of a gradual elimination of errors and a gradual strengthening of the correct response through repetition. E. L. Thorndike (1898, 1911) carried out more formal experiments employing specially constructed laboratory apparatus and using as subjects primarily young cats, but also dogs, chicks and monkeys. In a typical experiment, a hungry cat was placed in a barred box from which it might escape by making a certain response; the correct response varied from one experiment to another and included pressing a lever, pulling a string, licking itself, etc. His results led Thorndike to conclude that the animals showed no "seeing through the situation" but only behaviour involving trial and error.

Thorndike's methods were extended by H. A. Ruger (1910) to inquiries into the psychology of solving complex problems. Using human subjects, most of whom were intelligent and educated adults, and substituting complicated mechanical puzzles for Thorndike's maze and puzzle boxes, he followed essentially the same procedures as Thorndike, supplementing them, however, with introspective reports from his subjects. In presenting his findings, Ruger emphasized the large amount of typically "animal" trial and error in the activities of his subjects. He noted that many kinds of nonrational behaviour regularly occurred; for example, that unsuccessful reactions were often retained after they have proved to be useless; that successful variations in procedure often made their first appearance not' through foresight but even without attracting the subject's notice; that a puzzle was often solved with little or no comprehension of the principles involved. But he also presented data that in his opinion pointed to distinctively human as contrasted with animal procedures. Among the learning curves of his human subjects were some that showed sudden drops in performance time, and these drops coincided in most cases with introspective reports that the subject had seen the point of the puzzle—sometimes that it had flashed upon him suddenly, sometimes that he had worked it out deliberately.

Insight.—Thorndike's emphasis upon trial and error not only in animal but also in human problem solving was sharply criticized by Gestalt psychologists, who emphasized instead the role of insight. This concept of insight first aroused widespread interest when W. Kohler published (1925) his study of the mentality of anthropoid apes. Kohler contended that the problems Thorndike had employed artificially produced trial and error because they required for solution responses that were unnatural for the animal and because the elements necessary for solution were hidden. The cats, for example, were required to push levers, a response not a part of their natural repertory and hence one that could be hit on only by blind chance; moreover, the mechanism connecting the lever to the door was hidden and in any case would be beyond the cat's understanding. Kohler presented to his apes problems in which the elements necessary for solution were available to the animals and the solution of which required natural responses. Though he reported considerable behaviour classifiable as trial and error, Kohler stressed the point that the critical moment in the animal's solution of a problem occurred when he grasped the appropriate relational pattern—when, for example, he saw a box, upon which he could climb, as a means of making a norkable connection bet een himself and the fruit suspended beyond his farthest reach. Another example of insightful behaviour was that of an ape that was confined in a cage with food visible at some distance outside the cage and with bamboo sticks available but too short to reach the food; eventually, after signs of considerable difficulty and frustration, the ape inserted one stick into another, thus fashioning a tool by means of which the food was obtained.

The concept of insight has been used by Gestalt psychologists in dealing with human thinking. Max Wertheimer used it (1945) in giving account of so exceptional a course of thought as that which led Albert Einstein to his theory of relativity. The account mas based on a series of leisurely conversations during which Einstein described, in response to Wertheimer's questions. the course and manner of his thinking. According to Wertheimer, the successive stages reported by Einstein—among them, his first glimmerings of the problem, his preoccupation nith the Maxwell equations, his lack of surprise at the results of the Michelson experiment. his incomplete satisfaction with the Lorentz transformations—were successive configurations and reconfigurations which, being partial insights, did not give a closed relational pattern until he conceived of treating the velocity of light as an invariant, thus achieving an insight which, when elaborated, transformed classical physics and brought all the terms of the problem into a single system.

Modern **Behaviourist** Approach.—The terms "trial and error" and "insight," properly understood, are both useful in describing behaviour and experience in human problem solving. But neither concept is adequate as an explanation of the processes involved. Thorndike's early conceptions of "stamping in" of correct responses and "stamping out" of incorrect responses led many to think of trial and error as a blind process in which the responses made to a problem were determined purely by chance. This is rarely, if ever, the case. Much that may be called trial and error does occur even in the thinking of highly intelligent and educated adults. But a more adequate explanation of the underlying processes is required.

Modern behaviourism (*q.v.*), stemming from the work of Clark L. Hull (1943), provides one such explanation. The conceptual system employed in this approach is complex, and its nature can only be suggested here. Among the important concepts are habit family hierarchy, goal gradient and generalization. (1) The concept of habit family hierarchy involves the view that any given stimulus situation will be associated with a number of different responses. These responses differ in their probability of occurrence and hence form a hierarchy. The position of a given response in the hierarchy will vary with the degree to which it has been reinforced previously in similar situations. Given a new problem, the hierarchy will determine the responses that occur and the order of their occurrence. (2) The concept of goal gradient includes. but is not fully represented by, the notion that the closer (in distance or time) an organism is to the goal, the stronger its motivation will be. A direct deduction is that organisms will tend to choose the shorter of two paths to the same goal. Problem situations arise when such direct paths are blocked. Other important deductions follow from this concept singly and in combination with others in the system. For example, combining the idea of goal gradient and of habit family hierarchy yields the deduction that the probability of a roundabout path being taken in solving a problem will vary inversely with the angle between the direct and roundabout paths. (3) The concept of generalization is employed to account for the fact that rewarding an organism for making a given response to a particular situation will increase the probability that it will make that response not only to that situation but also to other similar situations, the increase in probability varying directly with the similarity of the new to the original stimulus situation. Thus, a person confronted with a need to tighten a screw but with no screwdriver may readily use a fingernail file. But a person with a need to pound a nail and with no hammer may exhibit much more trial and error before using the leather heel of his shoe to solve his problem.

Modern Gestalt Approach.—Modern Gestalt theory is not so well worked out in detail with respect to problem solving and thinking as is modern behaviourism. Its concepts need to be clarified, its implications to be much more fully explored. Gestalt theory is so named because of its emphasis upon the importance of the organized whole or *gestalt;* central to the theory is the concept of the psychological field, a concept developed by Kohler (1929) and by Kurt Koffka (1935). This field may be thought of either in terms of conscious experience or in terms of underlying brain processes because according to Gestalt theory isomorphic relations exist between the two such that the same principles apply to both. In either case, the processes involved dynamically distribute and regulate themselves, determined by the actual situation in the whole field. When a person is confronted with a problem, perceptual processes occur in the brain (and in consciousness) which by dynamic interaction with each other and with memory traces result initially in "seeing the problem." Seeing the problem sets up stresses in the psychological field that determine the subsequent course of thinking. These stresses lead to reorganization or restructuring of the field enabling the person to perceive the interrelations that form the solution to the problem. Such reörganization tends to occur suddenly, but a problem may require for solution not one but a series of progressive reorganizations, thus giving the appearance of gradual solution.

The concept of insight, which mas given a central role in Köhler's early work, received less emphasis in subsequent treatments of thinking by Gestalt theorists. Moreover, it has been employed with more than one meaning. On the one hand, it has been used as a descriptive term referring to a kind of experience that occurs in problem solving; this use seems entirely defensible. On the other hand, it has been used as an explanatory concept and more or less equated nith reorganization. Neither insight nor reorganization is adequate as an explanatory concept, even taken together with the concept of the psychological field. A more adequate account is needed of the development and nature of the processes that result in the occurrence of insight.

From Trial and Error to Insight.—An important contribution toward understanding of the development of these processes was made by Harry F. Harlow (1949). Working primarily with monkeys, he undertook to determine whether the animals could with experience progress from solving a given kind of problem by trial and error to solving the same kind of problem by insight. In one of the first experiments, each monkey was confronted with a small board on which lay two objects different in colour, size and shape. If the monkey picked up the correct object, it was rewarded by finding raisins or a peanut underneath. The position of the correct object was varied randomly from trial to trial, and the trials continued until the monkey learned to choose the correct object. The unusual feature of the experiment was that when the monkey had learned to choose correctly for a given pair of objects, it was then confronted mith a new pair, this procedure being repeated many times. The monkey solved the first such problems by slow trial and error. But the important finding was that as the monkey solved problem after problem of the same kind, each new problem was solved nith greater efficiency until eventually the monkey showed perfect insight when given a new problem of the same type, solving the problem in one trial. If it chose the correct object on the first trial, it continued to do so on subsequent trials; if it chose the incorrect object on the first trial. it immediately changed to the correct object on the second trial and subsequently continued to choose it. Similar results were obtained in other experiments mith monkeys involving more complex types of problems and also in experiments with young children.

It appears that trial and error and insight are but aspects of the same underlying processes. Harlow's data indicate that in a very real sense animals, both human and at least some subhuman, learn to think.

Information Processing.—A theory of problem solving quite different from those thus far described was advanced by Allan Newell, J. C. Shaw and Herbert A. Simon (1958). This theory explains behaviour in problem solving in terms of what are called information processes. The thinking human being is regarded as an information processing system. Such a system involves memories that contain symbolized information and are interconnected by various ordering relations. The system also includes a number of primitive information processes, which operate on the information in the memories, together with a perfectly definite set of rules for combining these processes into whole programs of processing. It is possible to deduce unequivocally from a given program what behaviour will be generated. Explanation of observed behaviour, in terms of this theory, consists in constructing the program of primitive information processes which will generate that behaviour. The writing of a program requires a precise language, and special so-called information processing languages have been created for this purpose.

Modern high-speed electronic computers work in terms of what are called machine languages. They can, however, be provided with interpretive programs that enable them to understand these special information processing languages. The important consequence is that a program written in an information processing language can be run on a computer to determine precisely what behaviour it will generate. The consequences of a program also can be determined by hand simulation. but the time required would often be excessive. It should be emphasized that this approach does not depend upon any crude analogy between the structure of a computer and that of the human brain. The only function of a computer is as a tool to determine quickly whether the consequences of a program are in fact consistent with the observed behaviour it is supposed to explain.

If a program is to be more than an *ex post facto* explanation, it must, of course, not only generate the behaviour it was written to account for, but also predict the effect on behaviour of changing conditions.

For some kinds of problems, processes are known which have the very valuable property that if the problem has a solution, the process will, sooner or later, produce it. Such a process is called an algorithm. A simple example of an algorithm would be the process of opening a safe by trying all possible combinations, testing each one in turn to see if it unlocks the safe. For some problems, algorithms are knoan but require far too much time to be practically useful. No one is able to choose his moves in chess, for example, by exploring all possible continuations of the game to termination, a procedure that would be algorithmic.

A process that may solve a particular kind of problem, but that offers no guarantee of doing so, is called a heuristic. In an algebraic problem. for example, introduction of an auxiliary unknown may lead to the solution but offers no guarantee that it will do so. For most problems, only heuristic processes are available. Even with problems for which both an algorithm and a heuristic are knoan, the heuristic process may be preferable because it requires much less time. Programs written to account for observed behaviour in problem solving involve both algorithms and heuristics, but make much more use of the latter than the former. These processes which are important in problem solving are themselves the result of learning, presumably similar to that observed by Harlow in his studies.

An example of a program that will solve problems is the Logic Theorist, a program written by Newell, Shaw and Simon and capable of discovering proofs for theorems in symbolic logic, or more precisely, in the sentential calculus. By using an appropriate interpretive program, the Logic Theorist was run repeatedly upon a high-speed digital computer. In one experiment. the Logic Theorist, employing the same axioms, definitions and rules used in the Pvincipia *Mathematica* of Alfred North Whitehead and Bertrand Russell, was presented with the problem of constructing in turn a valid proof of each of the 52 theorems in Chapter 2 of the Pvincipia in the order in which they appear there. Whenever a theorem mas proved, it was stored in memory and was available for use together with the five original axioms for use in proving subsequent theorems. The Logic Theorist succeeded in proving 38 of the 52 theorems, the time required to construct a proof varying from less than a minute to more than 15 minutes. The success of the Logic Theorist depends upon the effective use of heuristics. Heuristics are important in human problem solving, but much remains to be done to clarify their nature, variety and role.

(See also INFORMATION THEORY.)

Thinking in Relation to Other Psychological Processes.—Attempts have been made to understand thinking by considering it in relation to other psychological processes, especially those representing the basic needs, desires and urges of the organism.

Freud.—The strongest single influence in making this problem focal was that exerted by Sigmund Freud (1920, 1933). According to Freud, the function of thinking and indeed of all cognitive processes is to procure satisfactions for the primal organic needs, especially those represented by sexual desires that repression has rendered unconscious. In his early teachings, he strongly emphasized the point that all human motives spring from these primitive desires, and that by comparison the intellectual processes not only play a minor and subsidiary role in human life but are so weak as to be subject, under the influence of their powerful masters, to perversions such as rationalization, fantasy and other forms of wishful thinking. In his later writings, Freud considered the cognitive processes more directly. Here he treated perception as a device the organism develops to gain a true representation of external reality, the source of all the means to real, not merely fantasied, satisfactions; in this connection he treated thinking as a set of elaborative operations between perception and action, occasioned by inevitable difficulties and delays in obtaining such satisfactions. As means of coping with real situations, including the desires themselves, the cognitive processes were accorded a more important role than that formerly assigned them, but Freud still regarded them as secondary in function and power to the instinctual drives, a view that is highly questionable.

Genetic Approach.—The wider context of thinking includes not only its psychological setting but also its genetic and phylogenetic history and the social field in which it operates. The genetic approach to the problem of thinking is illustrated by the extensive work of Jean Piaget (1920, 1950, 1951). By systematically questioning children of different ages and by conducting experiments, Piaget and his co-workers undertook to chart the course of human intellectual development, tracing through the successive stages of childhood characteristic changes in children's concepts of the physical world and also of the social world.

Social and *Cultural* Approach.—Thinking has also been studied in its social and cultural setting. The social sciences, especially cultural anthropology, have insistently maintained that thinking is so strongly conditioned by cultural factors that very different ways of thinking develop in different cultural milieus. To take a single illustration, B. Malinowski (1938) showed that a language is largely determined by the ways of life of a given culture, and it has become increasingly evident through logical, psychological and sociological investigations that a person's language is a powerful determinant of the way in which he apprehends his physical and social environment, and hence of many of the deeply rooted, unconscious assumptions upon which his thinking operates.

See also LEARNING.

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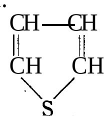
THIOPHENE is an organic sulfur compound that resembles benzene physically in that it is a colourless, water-insoluble liquid boiling at 84° C. (benzene boils at 80°). It resembles benzene also in such chemical reactions as bromination, nitration and sulfonation, but differs in being more reactive. It has the chemical formula C_4H_4S (I).

Although originally isolated from coal-tar benzene by V. Meyer (1883), thiophene is prepared more easily in other ways. A convenient laboratory synthesis is dry distillation of an intimate mixture of sodium succinate and phosphorus sulfide (P_4S_7). Similarly, by heating a mixture of acetonylacetone (CH_3COCH_2-CH_2COCH_3) and phosphorus sulfide, 2,5-dimethylthiophene (II) is obtained.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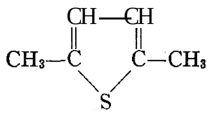
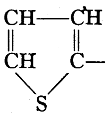

II

In the industrial manufacture of thiophene, mixtures of butane or butene and sulfur or sulfur dioxide are heated at 600° C. for short periods. Similarly, 2-methylthiophene and 3-methylthiophene are formed when pentane and isopentane, respectively, are treated in this way. The important radicals in the thiophene series are 2-thienyl (III), 2-thenyl (IV) and 2-thenoyl (V).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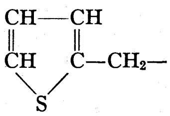
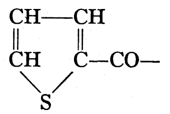

IV


V

A delicate test for thiophene is afforded by reaction with isatin and sulfuric acid. If thiophene is present, as in coal-tar benzene, an intensely blue solution of indophenin results. This reaction is not encountered with benzene. Others in this category are the reactions of thiophene with cyanogen bromide to yield bromothiophene and with acetyl chloride in the presence of titanium tetrachloride to yield acetothienone, the thiophene analogue of acetophenone. The thiophene analogue of phenol, 2-thienol, cannot be prepared by methods that are industrially successful for phenol but can be made from 2-thienyl-magnesium bromide by reaction with oxygen at 0° C. In contrast to phenol, thienol is quite unstable.

Although dyes, plastics, solvents, explosives and the like can be made from thiophene, they frequently are inferior to those made from benzene. Hence, uses have been slow in developing. One application is in the manufacture of pharmaceuticals such as the antihistaminic drug thenylene (or Histadyl), of the structure

$$\left.\begin{array}{r}\text{2-pyridyl}\\ \text{2-thenyl}\end{array}\right\rangle \text{N-}CH_2CH_2N(CH_3)_2$$

Certain thiophene derivatives occur in nature, one being "terthienyl" or dithienyl-thiophene, a blue solid found in the petals of marigolds. Another more complex derivative is biotin, the growth-promoting factor in yeast, liver or eggs.

See H. D. Hartough, *Thiophene and Its Derivatives* (1952). (C. D. HD.)

THIRD DEGREE. Originally a U.S. slang or cant term, but now in common use in the United States and coming into such use in Great Britain, to designate the employment of brutal methods by police or prosecuting authorities to extort information or confessions from persons in custody. The phrase is believed to have been suggested by the third Masonic degree, that of master Mason, which is conferred with considerable ceremony.

The phrase as often employed includes not only the use of physical violence, but also such forms of torture as depriving a prisoner of food, drink, sleep and toilet facilities and the prolonged and uninterrupted interrogation of him when exhausted, suffering and broken down by such deprivations. It is more commonly applied to those forms of physical assault (such as beating with a rubber hose) which produce pain but leave no traces.

Since admissions and confessions of guilt have great probative weight when made voluntarily, it is obvious that unscrupulous officials interested in procuring convictions may be tempted to force unwilling confessions by improper means, and falsely to represent such confessions as voluntary. In several U.S. states, assertions that such methods were used to extort confessions or to elicit information were for some time so common as seriously to disturb the courts. Similar charges have been made in some criminal trials in England. (C. A. P.; X.)

THIRD (COMMUNIST) INTERNATIONAL: *see* INTERNATIONAL, THE.

THIRLWALL, CONNOP (1797–1875), English bishop and historian, was born at Stepney, London, on Jan. 11, 1797. He was educated at Charterhouse and at Trinity college, Cambridge. In Oct. 1818 he was elected to a fellowship, and went for a year's travel on the continent. On his return he settled down to study law, but without much zeal, and in 1827 he definitely abandoned law, and was ordained deacon. At Rome in 1819 he had fallen in with Christian C. J. Bunsen, and since that time had been interested in German literature. He now joined with Julius C. Hare in translating Barthold G. Niebuhr's *History* of Rome (1828). On Hare's departure from Cambridge in 1832, Thirlwall became assistant college tutor and was involved in the controversy upon the admission of Dissenters which arose in 1834. Thirlwall, in replying to objections by Thomas Turton, pointed out that no provision for theological instruction was in fact made by the colleges except compulsory attendance at chapel, and that this was mischievous. After this outburst he had to resign his position. Nevertheless he received from Lord Brougham the living of Kirby-under-Dale in Yorkshire and began his *History* of Greece (1835–44), which remained a standard work.

In 1840 Thirlwall was raised by Lord Melbourne to the see of St. David's. The great monument of his episcopate is the 11 famous charges in which he from time to time reviewed the position of the English Church with reference to pressing questions of the day—addresses at once judicial and statesmanlike, full of charitable wisdom and massive sense. Thirlwall was one of the four prelates who refused to inhibit Bishop John Colenso from preaching in their dioceses. and the only one who withheld his signature from the addresses calling upon Colenso to resign his see. He took the liberal side in the questions of Maynooth, of the admission of Jews to parliament, of the Gorham case, and of the educational conscience clause. He was the only bishop who voted for the disestablishment of the Irish Church.

During his latter years Thirlwall took great interest in the revision of the Authorized Version of the Bible, and was chairman of the revisers of the Old Testament. He resigned his see in May 1874, and retired to Bath, where he died on July 27, 1875. He lies in Westminster Abbey in the same grave as Grote.

Thirlwall's *History of Greece* (new ed. 1845–52) remains a standard book. *See* his *Remains, Literary and Theological,* ed. J. J. S. Perowne in three volumes (1877–80), two of which are occupied by his charges; *Letters, Literary and Theological,* with a connecting memoir, ed. J. J. S. Perowne and L. Stokes (1881), and *Letters to a Friend* (Miss Johnes of Dolaucothy), ed. Dean Stanley (1881). They were originally published by Dean Stanley, and there is a revised and corrected edition. For a general view of Thirlwall's life and character, *see* the *Edinburgh Review,* vol. cxliii.; for a picture of him in his diocese, *Temple Bar,* vol. lxxvi.

THIRSK, an old market town in the North Riding of Yorkshire, Eng., 23 mi. N.N.W. of York by road, on the Cod Beck, a tributary of the Swale river. Pop. (1951) 2,670. The district is known as the Vale of Mowbray. Thirsk is first mentioned as a borough in a charter granted by Roger de Mowbray to Newburgh priory in the reign of Henry II. The Perpendicular church of St. Mary with its 80-ft. tower is one of the most beautiful churches in the Riding. Thirsk was represented in parliament from 1552–53 until 1885. There is a racecourse.

THIRTY YEARS' WAR (1618–1648), the general name of a series of wars in Germany which began formally with the claim of Frederick, the elector palatine, to the throne of Bohemia and ended with the treaty of Westphalia. It was primarily a religious war and was waged with the bitterness characteristic of such wars, but at the same time political quarrels were interwoven with the religious question: with the consequence that the armies, considering themselves as their masters' retainers rather than champions of a cause, plundered and burned everywhere, military violence being in no way restrained by expediency.

Formation of the "Union" and the "League."—Fifty years before the outbreak of the war the Convention of Passau had compromised the burning questions of the Reformation, but had left other equally important points as to the secularization of church lands and the consecration of Protestant bishops to the future. Each such case, then, came before the normal government machine—a Diet so constituted that even though at least half of the secular princes and nine-tenths of their subjects were Protestants, the voting majority was Catholic. Moreover, the Jesuits had rallied and disciplined the forces of Catholicism, while Protestantism, however firm its hold on the peoples, had dissipated itself in doctrinal wrangles. The strongest side was that which represented conservatism, peace and Catholicism. Realizing this from the preliminary mutterings of the storm, the Protestant princes formed a "Union," which was promptly answered by the Catholic League. This group was headed by the wise and able Maximilian of Bavaria and supported by his army, which he placed under a soldier of long experience and conspicuous ability, Count Tilly.

The Bohemian Movement.—The war arose in Bohemia, where the Protestant magnates refused to elect Ferdinand of Austria to the vacant throne, offering it instead to Frederick, the elector palatine. But the aggrandizement of this elector's power was entirely unacceptable to most of the Protestant princes—to John George of Saxony above all. They declared themselves neutral, and Frederick found himself an isolated rebel against the Emperor Ferdinand.

Even thus early the struggle showed itself in the double aspect of a religious and a political war. Just as the Bohemians and their nominee found themselves looked upon askance by the other Protestants, so the emperor himself was unable to call upon Maximilian's Army of the League without promising to aggrandize Bavaria. Only the incoherence of the rebels saved Ferdinand. They ordered taxes and levies of soldiers, but the taxes were not collected, and the soldiers, unpaid and unfed. plundered the country-side. The only coherent force was the mercenary corps of Ernst von Mansfeld, which, thrown out of employment by the termination of a war in Italy, had entered the service of Frederick. Nevertheless, the Bohemians were conspicuously successful at the outset: they won several engagements, and appeared before Vienna itself. Moravia and Silesia supported the Bohemians, and the Austrian nobles attempted, in a stormy conference, to wrest from Ferdinand not only religious liberty but also political rights that would have made Austria and Bohemia a loose confederation of powerful nobles. Ferdinand firmly refused, though the deputation threatened him to his face, and the tide ebbed as rapidly as it had flowed. No sooner had Frederick accepted the crown than Maximilian let loose the Army of the League. Spanish aid arrived. Spinola with 20,000 men from the Low Countries and Franche Comté invaded the Palatinate, and Tilly, with a combined army of Austrians and Bavarians crushed the Bohemians at the battle of the Weisser Berg near Prague (Nov. 8–18, 1620). With this the Bohemian war ended. Some of the nobles were executed, and Frederick, the "Winter King," was put to the ban of the empire. But the emperor's revenge alarmed the Union princes. They were Protestants, and neither in religion nor in politics could they suffer an all-powerful Catholic emperor. Moreover, the alternative to a powerful emperor was a powerful Bavaria, and this they liked almost as little.

Predatory Armies.—There still remained for the army of Tilly the reduction of the smaller garrisons in Bohemia, which when finally expelled rallied under Mansfeld, the last general of a lost cause. Then there began the wolf-strategy that was the distinguishing mark of the Thirty Years' War. An army even of ruffians could be controlled, as Tilly controlled that of the League, if it were paid. But Mansfeld, the servant of a shadow king, could not pay. Therefore "he must of necessity plunder where he was. His movements would be governed neither by political nor by military considerations. As soon as his men had eaten up one part of the country they must go on to another." These movements were for preference made upon hostile territory, and Mansfeld was so far successful in them that the situation in 1621 became distinctly unfavourable to the emperor. Tilly and the League Army fought warily and did not risk a decision. Thus even the proffered English mediation in the German war might have been accepted but for the fact that in the Lower Palatinate a corps of English volunteers, raised by Sir Horace Vere for the service of the English princess Elizabeth, the fair queen of Bohemia, found itself compelled, for want of pay and rations, to live, as Mansfeld lived, on the country along the Rhine. This brought about a fresh intervention of Spinola's Spaniards who had been destined to the interminable Dutch war. Moreover Mansfeld, having thoroughly eaten up the Palatinate, decamped into Alsace, where he seized Hagenau and wintered in safety.

The winter of 1621–22 passed in a series of negotiations which failed because too many interests, inside and outside Germany, were bound up with Protestantism to allow the Catholics to speak as conquerors, and because the cause of Protestantism was too much involved with the cause of the elector palatine to be taken in hand with energy by all Protestant princes. But Frederick and Mansfeld found two allies. One was Christian of Brunswick, the gallant young knight-errant, titular bishop of Halberstadt, queen Elizabeth's champion, and withal, though he called himself Gottes Freund, der *Pfaffen Feind,* a plunderer of peasants as well as of priests. The other was the margrave George Frederick of Baden-Durlach, reputed to be of all German princes the most skilful sequestrator of ecclesiastical lands. In April 1622, while Vere garrisoned the central fortresses of the Palatinate, Mansfeld, Christian and George Frederick took the field against Tilly, who at once demanded assistance from Spinola. The latter, though engaged with the Dutch, sent a corps under his subordinate Cordova. Mansfeld and the margrave of Baden defeated Tilly at Wiesloch (April 17–27, 1622). But soon the allies had to separate to find food. Then Cordova came up, and Tilly and the Spaniards combined defeated George Frederick at Wimpfen on the Neckar (April 26–May 6). Cordova chased Mansfeld back into Alsace, while Tilly went north to oppose Christian of Brunswick on the

Main. On June 10–20 the latter's army was almost destroyed by the League Army at Höchst. Mansfeld, and with him Frederick, had already set out from Alsace to join Christian, but when that leader arrived with only a handful of beaten men, the war was practically at an end. Frederick took Mansfeld and Christian back to Alsace, and after dismissing their troops, retired to Sedan. Henceforth he was a picturesque but powerless exile, and his lands and his electoral dignity, forfeited by the ban, went to the prudent Maximilian, who was created by the Emperor elector of Bavaria.

Mansfeld and Christian of **Brunswick.**—The next act in the drama, however, had already begun with the adventures of the outlaw army of Mansfeld and Christian. After Hochst, had it not been for them, the war might have ended in compromise. James I. of England was busy as always with mediation schemes. Spain, being then in close connection with him, and the Protestant princes of North Germany being neutral, a diplomatic struggle over the fate of the Palatinate might have ended in a new convention of Passau that would have regulated the present troubles and left the future to settle its own problems. The struggle would only have been deferred, it is true, but meanwhile the North German Protestants remained powerless and inactive, while Tilly's army was kept in hand to deal with the adventurers.

These, after eating up Alsace, moved on to Lorraine, whereupon the French Government "warned them off." But ere long they found a new employment. The Dutch were losing ground before Spinola, who was besieging Bergen-op-Zoom, and the States-General invited Mansfeld to relieve it. The adventurers moved straight across Luxemburg and the Spanish Netherlands to the rescue. Cordova barred the route at Fleurus near the Sambre, but the desperate invaders, held together by the sheer force of character of their leaders, thrust him out of their way (Aug. 19–29, 1622) and relieved Bergen-op-Zoom. But ere long, finding Dutch discipline intolerable, they marched off to the rich country of East Friesland.

Their presence raised fresh anxieties for the neutral princes of North Germany. In 1623 Mansfeld issued from his Frisian stronghold, and the threat of a visitation from his army induced many princes of the Lower Saxon Circle to join him. Christian was himself a member of the Circle, and although he resigned his bishopric, he was taken, with many of his men, into the service of his brother, the duke of Brunswick-Wolfenbüttel. Around the mercenary nucleus gathered many thousands of volunteers, for the towns and the nobles' castles alike were alarmed at the progress of the Catholics, who were reclaiming Protestant bishoprics. But this movement was nipped in the bud by the misconduct of the mercenaries. The authorities of the Circle ordered Christian to depart. He returned to Holland, therefore, but Tilly started in pursuit and caught him at Stadtlohn, where on July 28–Aug. 6, 1623 his army was almost destroyed. Thereupon the Lower Saxon Circle, which, like the Bohemians, had ordered collectively taxes and levies of troops that the members individually furnished either not at all or unwillingly, disbanded their army to prevent brigandage. Mansfeld, too, having eaten up East Friesland, returned to Holland in 1624.

Foreign Intervention — The only material factor was now Tilly's ever-victorious Army of the League, but for the present it was suspended inactive in the midst of a spider's web of European and German diplomacy. Spain and England had quarrelled. The latter became the ally of France, over whose policy Richelieu now ruled, and the United Provinces and (later) Denmark joined them. Thus the war was extended beyond the borders of the empire, and the way opened for ceaseless foreign interventions. From the battle of Stadtlohn to the pitiful end 20 years later, the decision of German quarrels lay in the hands of foreign powers. France was concerned chiefly with Spain, whose military possessions all along her frontier suggested that a new Austrasia, more powerful than Charles the Bold's, might arise. James, in concert with France, re-equipped Mansfeld and allowed him to raise an army in England, but Richelieu was unwilling to allow Mansfeld's men to traverse France, and they ultimately went to the Low Countries, where, being raw pressed-men for the most part, and having neither pay (James having been afraid to summon parliament) nor experience in plundering, they perished in the winter of 1625. At the same time a Huguenot rising paralysed Richelieu's foreign policy. Holland after the collapse of Mansfeld's expedition was anxious for her own safety owing to the steady advance of Spinola. The only member of the alliance who intervened in Germany itself was Christian IV. of Denmark, who as duke of Holstein was a member of the Lower Saxon Circle, and as king of Denmark was anxious to extend his influence over the North sea ports. Gustavus Adolphus of Sweden, judging better than any the difficulties of affronting the empire and Spain, contented himself with carrying on a war with Poland.

Intervention of Christian of Denmark. — Christian IV. raised an army in his own lands and in the Lower Saxon Circle in the spring of 1625. Tilly at once advanced to meet him. But he had only the Army of the League, the Emperor's troops being occupied in a war on Gabriel Bethlen of Transylvania. Then, like a *deus ex machina,* Wallenstein, duke of Friedland, came forward and offered to raise and maintain an army in the emperor's service. It was an army like Mansfeld's in that it lived on the country, but its exactions were systematic and the products economically used, so that it was possible to feed 50,000 men instead of 20,000. This method, the high wages which he paid, and his own princely habits and commanding personality gave it a cohesion that neither a free company nor an army of mere Lower Saxon contingents could ever hope to attain.

In 1625, Wallenstein kept his new army well away from the risks of battle until he could trust it to conquer. It was fortunate for Ferdinand that he did so. Christian IV., who had been joined by Mansfeld and Christian of Brunswick, had, in 1626, 60,000 men. Wallenstein and Tilly together had only a very slight numerical superiority, and behind them was nothing. Even the hereditary provinces of Austria were threatening revolt and Gabriel Bethlen was again giving trouble. But on the other side the English subsidies failed, and the Protestant armies soon began to suffer in consequence. Tilly opposed Christian IV.; Wallenstein, Mansfeld. The latter advanced upon Wallenstein, attacked him in an entrenched position at the Bridge of Dessau and was thoroughly defeated (April 15–25, 1626). He then wandered across Germany into Silesia and joined Bethlen. Wallenstein followed up, and by taking up strong positions, compelled Mansfeld and Bethlen to choose between attacking him and starving. So, without a battle, he brought about a truce, whereby Bethlen was disarmed and Mansfeld was required to leave Hungary. Mansfeld and Christian of Brunswick died soon afterwards, the one in Hungary, the other in Westphalia. King Christian, left alone and unable without English subsidies to carry on the war methodically, took the offensive, as Mansfeld had done, in order to live on the Thuringian countryside. But Tilly, with whom Wallenstein had left a part of his army, moved as quickly as the king, brought him to action at Liitter-am-Barenberge in Brunswick and totally defeated him (Aug. 17–27).

With this, armed opposition to Tilly and Wallenstein in the field practically ceased, but their armies continued to live on the country. Christian of Denmark slowly gave up fortress after fortress to Tilly. Wallenstein, returning from the campaign against Gabriel Bethlen, drove Christian's army through Jutland and into the sea (1627). But Wallenstein, with his dreams of a united Germany free in conscience and absolutely obedient to the emperor, drifted farther and farther away from the League. Ferdinand thought that he could fulfil the secular portion of Wallenstein's policy while giving satisfaction to the Catholics. The princes and bishops of the League continued to oppose any aggrandizement of the emperor's power at their expense and to insist upon the resumption of church lands. In this equilibrium the North German Protestant cities were strong enough to refuse to admit Wallenstein's garrisons. In 1628 Wallenstein, who had received the duchy of Mecklenburg on its rightful lord being put to the ban fcr his share in the Danish war, began to occupy his new towns, and also to spread along the coasts. But the Hanse towns rejected his overtures, and Stralsund, second-rate seaport though it was, absolutely refused to admit a garrison of his wild soldiery. The result was the famous siege of Stralsund (Feb. to Aug. 1628), in which the citizens compelled the hitherto unconquered Wallenstein army to retire. The siege was, as the result proved, a turning-point in German history. The emperor's policy of restoring order had practically universal support. But the instrument of the restoration was a plundering army. Even this might have been borne had Wallenstein been able to give Germany, as he wished, not only peace but religious freedom. When the Edict of Restitution (1629) gave back 150 northern ecclesiastical foundations to the Catholics, men were convinced that one ruler meant one religion.

Gustavus **Adolphus** of Sweden.—Rather than endure this the North Germans called in Gustavus Adolphus of Sweden and, just as Gustavus landed, the resentment of the princes of the League against Wallenstein's policy and Wallenstein's soldiers came to a head, and the emperor was forced to dismiss him. His soldiers were taken over by Tilly, and for the moment he disappeared from the scene. On Gustavus's side, a thoroughly trained army, recruited from good yeomen and stout soldiers of fortune, paid good wages, and led by a great captain, was a novelty in war that more than compensated for Tilly's numerical superiority. Gustavus, however, after landing at Peenemünde in June, spent the rest of the year in establishing himself firmly in Mecklenburg and Pomerania, in order to secure the active support of the more important Protestant princes, so as to appear as an auxiliary rather than a principal in the German conflict. First the old duke Bogislav of Pomerania, then George William of Brandenburg joined him, very unwillingly. He was soon afterwards allied with France, by the treaty of Barwalde (Jan. 1631). John George of Saxony, still attempting to stifle the war by a policy of neutrality, sent a last appeal to Vienna, praying for the revocation of the Edict of Restitution. Meanwhile Tilly had marched into north-eastern Germany, where his lieutenant Pappenheim was besieging Magdeburg. This city had twice defied Wallenstein's attempts to introduce a garrison, and it was now in arms against the League. Gustavus, as yet without active allies, thought it impossible to go forward alone, and could only hope that his sudden and brilliant storm (April 3–13) of Frankfurt-on-Oder would distract Tilly from the siege.

Sack of **Magdeburg.**—But the hope was vain and when, realizing this, he moved directly to Magdeburg's relief, his passage through the territories of the Electors of Brandenburg and Saxony was delayed by the objections of the Protestant princes. While he was negotiating with them in turn, Magdeburg, although the citizens fought desperately, was stormed, sacked and burned on the night of May 10, 1631, amidst horrors that neither of the imperialist generals was able to check. The Catholics rejoiced as though for another St. Bartholomew's day, the Protestants were paralysed, and Gustavus, accused on all hands of having allowed the Magdeburgers to perish, sorrowfully withdrew into Pomerania. But Tilly, in spite of Pappenheim's remonstrances, turned westward against Hesse-Cassel and other minor principalities whose rulers had declared for Gustavus. The king of Sweden, thereupon, advanced to Werben (at the junction of the Elbe and the Havel), where his army entrenched itself, and, in spite of sickness and famine, stoically awaited the attack. The desired result was achieved. At the end of July Tilly, returning from the west, made his appearance and was twice repulsed (July 13–23 and 18–28), losing 6,000 men out of 22,000. Thereupon, turning away from Gustavus's entrenchments, Tilly invaded Saxony, being reinforced *en route* by 20,000 men from Italy. The elector John George at once made an alliance with the Swedes.

Battle of **Breitenfeld.**—Then Gustavus advanced in earnest. He crossed the Elbe at Wittenberg. 16,000 Saxons joined his 26,000 Swedes at Düben, and some of the western Germans had already come in. Tilly had just captured Leipzig, and outside that place, carried away by Pappenheim's enthusiasm, he gave battle on Sept. 7–17 to the now superior allies. The first battle of Breitenfeld (*q.v.*) was a triumphant success for Gustavus and for the new Swedish system of war. Though the raw Saxons were routed at the outset by Tilly's men, the Swedes on the other wing drove the veterans of the League off the field in disorder, leaving 6,000 dead. Tilly himself was thrice wounded and barely escaped.

All Protestant Germany hailed Gustavus as the liberator. John George, the Swedish general Horn and the Swedish chancellor Oxenstierna united in advising Gustavus to march straight upon Vienna. Richelieu was of the same mind. But Gustavus deliberately chose to move into South Germany, there to organize the cities and the princes in a new and stronger Protestant Union, the *Corpus Evangelicorum*, and to place himself in a country full of resources whence he could strike out against the emperor, Tilly and the Rhine Spaniards in turn. The Swedish army pushed on to Mainz, where it wintered in luxury. The Palatinate was reorganized under Swedish officials and the reformed religion established again. In March 1632 the campaign was resumed. Nuremberg and Donauworth welcomed Gustavus. Tilly's army, reorganized for the defence of Bavaria, stood to fight on the Lech, but the passage was forced (April 4–14) and Tilly himself was mortally wounded. Augsburg, Munich and all the country south of the Danube were occupied without resistance. At the same time John George's Saxons, advancing into Bohemia, entered Prague without firing a shot.

Wallenstein Returns.—The emperor had now either to submit or to reinstate Wallenstein. Wallenstein demanded as the price of his services the reversal of the Edict, and power to dethrone every prince who adhered to the Swedes. His terms were accepted, and in April 1632 he took the field as the emperor's *alter ego* with a new army that his recruiters had gathered in a few weeks. He soon expelled the Saxons from Bohemia and offered John George amnesty and the rescinding of the Edict as the basis of peace. The elector, bound by his alliance with Gustavus, informed the Swedish king of this offer, and a series of negotiations began between the three leaders. But John George had too much in common with each to follow either Wallenstein or Gustavus unreservedly, and the war recommenced. The Swedish king had now to meet Wallenstein's new army of 60,000, composed of the men immortalized by Schiller's play, excellent in war and in plundering, destitute of all home and national ties, and owning allegiance to its general alone. While Gustavus in Franconia was endeavouring with little success to consolidate his *Corpus Evangelicorum* Wallenstein came upon the scene. Gustavus offered him battle. But as in 1625 Wallenstein would risk no battle until his army had gained confidence. He entrenched himself near Fürth, while Gustavus camped his army about Nuremberg and a contest of endurance ensued. Wallenstein, aided by his superiority in irregular cavalry, was able to starve for three days longer than the king, and at last Gustavus furiously attacked the entrenchments (battle of the Alte Veste, Aug. 24–Sept. 3, 1632) and was repulsed with heavy losses. Thereupon he retired, endeavouring in vain to tempt Wallenstein out of his stronghold by making his retreat openly and within striking distance of the imperialists. Wallenstein had other views than simple military success. Instead of following Gustavus he marched into Saxony, his army plundering and burning even more thoroughly than usual in order to force the Saxons into peace. Gustavus followed with the swiftness that was peculiar to the Swedish system, and concentrated at Erfurt when Wallenstein had scarcely mastered Leipzig. But it was now late in the season, and Wallenstein hoped to spin out the few remaining weeks of the campaign in an entrenched position. Gustavus, without waiting for Arnim's Saxons to join him, suddenly moved forward, and on Nov. 6–16 the battle of Lutzen (*q.v.*) was fought, a battle as fierce even as Breitenfeld. Gustavus was slain, but Wallenstein's army was driven from the field.

The League of **Heilbronn.**—The fall of Gustavus practically determined the intervention of France, for Richelieu supported all electors, Catholic or Protestant, against the central power at Vienna as part of his anti-Spanish policy, and French assistance was now indispensable to the Protestants. For although Lützen was a victory and the Protestant circles formed the League of Heilbronn in April 1633, the emperor was really in the ascendant. John George of Saxony needed but little inducement to make peace. But the tragedy of Lützen was soon to be followed by the tragedy of Eger. Wallenstein, gradually forming the resolve of forcing peace on Germany with his army, relaxed his pressure on Saxony, and flung himself upon the Swedish garrisons in Silesia.

Winning a victory at Steinau (Oct. 11, 1633) and capturing one town after another, he penetrated almost to the Baltic. But he was recalled to the south-west before his operations had had any effect. The Swedish army, now under Bernhard of Saxe-Weimar, Horn and Banér, had returned to the South, and took Regensburg from Maximilian's army. But it was now late in the year and Wallenstein was intent upon peace. With this object he endeavoured to secure the higher officers of the army, but these were gradually won over by Spanish emissaries; the emperor, having decided to continue the war in alliance with Spain, dismissed his general for the second time. Wallenstein then openly attempted to unite the Swedish, Saxon and other Protestant armies with his own, so as to compel all parties to make peace. But his officers would not follow, the *coup d'état* failed, and Wallenstein was murdered at Eger by his own lieutenants, with the full sanction of the Emperor (Feb. 15–25, 1634).

All idea of German unity died with him, and for the next 14 years Germany was simply the battle-ground of French, Spanish, Austrian and Swedish armies, which, having learned the impunity and advantages of plunder in the school of Mansfeld and Wallenstein, reduced the country to a state of misery that no historian has been able to describe, save by detailing the horrors of one or other village among the thousands that were ruined. Germany remained for a century in the stillness of exhaustion.

Battle of **Nordlingen.**—Success was for the present with the emperor and Spain. Under the leadership nominally of the king of Hungary, Ferdinand's heir, but really of Gallas, the army recaptured Regensburg and Donauworth, and when the Spanish Cardinal Infante joined them with 15,000 men on his way from Italy to the Netherlands, they were invincible. Bernhard of Weimar and the Swedes attacked them in an entrenched position at Nordlingen (Aug. 27/Sept. 6, 1634) and was beaten with absolutely ruinous loss. The model army of Gustavus perished there, and for the rest of the war a Swedish army, except for some advantages of organization and technical form, was intrinsically no better than another. John George, having obtained from Ferdinand a compromise on the question of the Edict, agreed to the peace of Prague (May 20–30, 1635), wherein all that was Protestant in 1627 was to remain so, or if since resumed by the Roman Church to be returned to the Lutherans. A certain number of princes followed John George's example on the same terms. There was now no ideal, no objective, common even to two or three parties. Gustavus's *Corpus Evangelicorum* as a German institution was moribund since Nordlingen, and Richelieu and the Spaniards stepped forward as the protagonists.

The **Policy** of **Richelieu.**—The centre of gravity was now the Rhine valley, the highroad between Spanish Italy and the Spanish Netherlands. Richelieu had, as the price of his assistance after Nordlingen, taken over the Alsatian fortresses held by the Swedes, and in May, just before the treaty of Prague was signed, he declared war on Spain. The French army numbered 130,000 men in 1635, and 200,000 in the year after. One army assembled in Upper Alsace for the attack of the Spaniards in Franche Comté; another occupied Lorraine, which had been conquered in 1633; a corps under Henri de Rohan was despatched from the same quarter across Switzerland, to expel the enemy from the Valtelline, Another force, co-operating with the duke of Savoy, was to attack the Milanese. Bernhard was to operate in the Rhine and Main country. Having thus arranged to isolate the Spanish Netherlands, Richelieu sent his main army, about 30,000 strong, thither to join Frederick Henry of Orange and so to crush the Cardinal Infante. This was strategy on a scale hitherto unknown in the war. Richelieu had unified France under the single authority of the king, and his strategy, like his policy, was masterful and clear. But the event proved that his scheme was too comprehensive. Richelieu proposed to strike at each of the two halves of his enemy's power at the same time as he separated them. His forces were not sufficient for these tasks and he was therefore compelled to eke them out, both in Italy and the Netherlands, by working with allies whose interests were not his. Popular outbreaks among the Brabanters and Flemings led Frederick Henry to withdraw to his own country and in 1636 the French northern army had to face the whole of the Cardinal Infante's forces. In Italy the Franco-Piedmontese army achieved practically nothing. In Alsace and Lorraine neither side was strong enough to prevail. Bernhard waged a desultory campaign in Germany, and later, when supplies gave out he and his army were taken into the French service. In eastern Germany the consequences of the peace of Prague were that Saxony, Brandenburg and other States, signatories to the treaty, were *ipso facto* the enemies of those who continued the war. Thus John George turned his arms against the Swedes in his neighbourhood. But their commander Banér was as superior in generalship as he was inferior in numbers, and held the field until a truce between Sweden and Poland set free a fresh Swedish corps that had been held ready for eventualities in that country. This corps, under Torstensson, joined Banér in October, and on Nov. 1 they won an action at Domitz on the Elbe.

Thus Richelieu's great scheme was only very partially executed. The only important military events of the year took place outside Germany; within Germany men were chiefly occupied in considering whether to accept the terms of the peace of Prague. But the land had no rest, for the armies were not disbanded. In 1636 the movements foreshadowed in 1635 were carried out with energy. John George, aided by an imperialist army, threatened to interpose between Banér and the Baltic. But Banér was too quick for them. Before the Brandenburg contingent could join John George, he brought on a general action at Wittstock (Sept. 24–Oct. 4, 1636). The elector had 30,000 men against 22,000 and sought to attack both in front and rear. But while his entrenchments defied the frontal attack Banér threw most of his army upon the enveloping force and crushed it. The Swedes lost 5,000 killed and wounded, the combined army 11,000 killed and wounded and 8,000 prisoners. The prestige of so brilliant a victory repaired even Nordlingen, and many North German princes who were about to make peace took fresh heart.

Invasion **of** France. — In the west, though there were no such battles as Wittstock, the campaign of 1636 was one of the most remarkable of the whole war. The Cardinal Infante was not only relieved by the retreat of the Dutch, but also reinforced by a fresh army[1] under a famous cavalry officer, Johann von Weert. He prepared, therefore, to invade France from the northwest. The French were too much scattered to offer an effective resistance, and the Cardinal Infante's generals took Corbie, passed the Somme and advanced on Compikgne. For a moment Paris was terror-stricken, but the Cardinal Infante missed his opportunity. Louis XIII. and Richelieu turned the Parisians from panic to enthusiasm. The burghers armed and drilled, money, too, was willingly given, and some 12,000 volunteers went to Compikgne, where all levies and reinforcements were concentrated. Thus the army at Compiègne was soon 50,000 strong. It was only half mobile owing to its rawness and its "trained-band" character, but the Spaniards and Bavarians retired unmolested to oppose Frederick Henry in the Low Countries.

During the episode before Compiègne another storm burst on the eastern frontier of France. This was the inroad into Burgundy of Gallas with the main imperialist army. He took a few small towns, but Dijon and the entrenchments of Bernhard's army there defied him, and his offensive dwindled down to an attempt, soon abandoned, to establish his army in winter quarters in Burgundy.

War in Italy. — In Italy the duke of Savoy with his own army and a French corps under Créqui advanced to the Ticino, and an action in which both sides lost several thousand men was fought at Tornavento, a few miles from the future battlefield of Magenta, to which in its details this affair bears a singular resemblance (June 22, 1636). But the victory of the French was nullified by the refusal of Victor Amadeus, for political reasons, to advance on Milan.

The campaign of 1637, on the French and Spanish side, was not productive of any marked advantage to either party. From Catalonia a Spanish army invaded Languedoc, but was brought to a standstill in front of the rocky fortress of Leucate and defeated with heavy losses by the French relieving army under Schom-

[1]Composed partly of Bavarians, partly of Cologne troops.

berg. On the Low Countries frontier the cardinal de La Valette captured Câteau Cambrésis, Landrecies and Maubeuge.

War on the Rhine.—On the Rhine and in the adjacent countries Johann von Weert, returning from Belgium with his Bavarians, captured Ehrenbreitstein, the citadel of Coblenz, and expelled small French detachments from the electorate of Trier, whose ruler, the archbishop, had been put to the ban by the emperor. Then, passing into the Main valley, he took Hanau. The main imperialist army, still under Gallas, had departed from Alsace to the east in order to repair the disaster of Wittstock, and Charles of Lorraine was defeated by Bernhard on the Saône in June, after which Bernhard advanced vigorously against Piccolomini, the imperialist commander in Alsace. But soon Piccolomini was joined by Johann von Weert, and Bernhard retired again.

In the north-east the effect of Wittstock proved but transient. In 1638 Banér found himself the target of several opponents. The Saxons did no more than defend their own country, but the imperialists and Bavarians uniting under Gen. Geleen manoeuvred Banér out of his strongholds on the Elbe. He retreated on the Oder, but there found, not the expected assistance of Wrangel's Pomeranian army, but Gallas with the main imperial army which had hurried over from the west. Banér escaped only by a stratagem. Deluding Gallas with an appearance of retreat into Poland, he slipped northwards, joined Wrangel, and established himself for a time in Pomerania. Gallas ruined his army by exposing it to an open winter in this desolate country, and at last retired to the Elbe.

Fighting in the Netherlands and Alsace.—In 1638 the French operations in Italy, Belgium and Spain were in the main unsuccessful. In Italy the Spanish advanced to the Sesia and took Vercelli. In the Low Countries Prince Thomas and Piccolomini repulsed in turn the Dutch and the French. In the south the Prince of Condé led from Bayonne an invading army that was to dictate terms at Madrid, but failed ignominiously before the small frontier fortress of Fontarabia. But the case was different in Alsace. There Richelieu was more than ever determined to strike at the Spanish power, and there too was Bernhard, who hoped that Alsace was to be his future principality, with the survivors of Breitenfeld and Nordlingen, now in French pay under the name of the "Weimar Army." Bernhard had wintered about Basle, and began operations by taking a few towns in the Black Forest. Johann von Weert, however, fell upon him by surprise and drove him away (Feb. 28). But Bernhard reassembled his adventurers and invited them to return and beat the imperialists at once. The outcome was the battle of Rheinfelden, in which the redoubtable Weert, who had terrified Paris in 1636, was taken prisoner and nis army dissipated (March 3). Bernhard later invested Breisach and received its surrender when the garrison had eaten the cats, dogs and rats in the place, on Dec. 17.

In the course of 1638 peace negotiations were carried on at Cologne and Hamburg, but the war still dragged on. In the east, 1639 began with Banér's pursuit of the retreating Gallas. Thanks to his skill the Swedish star was again in the ascendant. Banér crossed the Elbe, inflicted a severe defeat on the imperialists at Chemnitz (April 14, 1638), and then after overrunning western Saxony advanced into Bohemia. But he contented himself, after an unsuccessful attempt upon Prague, with thoroughly eating up the country and, as winter came on, he retired into the Saxon mountains.

France and Spain.—In 1639, as before, Richelieu's attacks on Spain, other than those directed upon Alsace and Baden, were unsuccessful. In the north the French devoted this year, as they had devoted 1637 and 1638, to a methodical conquest of walled towns in view of a future *frontière de fer*. The two objectives selected, Hesdin and Thionville, were far apart, and Piccolomini, by a forced march from Liège and Huy through the Ardennes, flung himself upon the besiegers of Thionville before their "circumvallation" was completed, and being greatly superior in numbers he almost annihilated them (June 7, 1639). But on the Flemish-flank Hesdin was driven to surrender. On the side of the Pyrenees Condé as usual showed himself both unlucky and incapable. In Italy Cardinal de La Valette died after allowing Prince Thomas to win over Savoy to the emperor's side and seeing almost every French post lost.

His successor was the duc d'Harcourt, called by his men "Cadet-la-Perle" on account of his earrings, but a bold and exceedingly competent soldier. Under him served Turenne, hitherto known only as a younger brother of the duke of Bouillon. Harcourt successfully revictualled Casale, and beat the Savoyards and Imperialists in the Route de Quiers (Nov. 29).

In Alsace Bernhard was carried off by a fever just as he was preparing to fight his way to a junction with Baner. Nevertheless he was fortunate in the opportunity of his death, for his dream of a duchy of Alsace had already brought him into conflict with Richelieu, and their conflict could only have ended in one way. Another event of importance in this year was the episode of the Spanish fleet in the Downs. Now that the land route was imperilled the sea communications of Spain and Belgium were brought into use. A squadron sailed from Spain for the Netherlands, and, though it evaded the now powerful French navy, it was driven into English territorial waters by the Dutch. Charles I. of England offered France free access to the victim if France would restore the Elector Palatine, offered Spain protection if she would furnish him with funds for his army. But the Dutch, contemptuous of his neutrality, sailed in and destroyed the fleet at anchor.

In 1640 the French still kept up their four wars in Belgium, Germany, Italy and Spain. But the Belgian and Spanish frontiers were no longer directly attacked. The Catalans turned their arms against the old enemy Castile and Portugal declared herself independent under a king of the house of Braganza. In the Low Countries Louis XIII. himself presided over the siege of the important fortress of Arras, which surrendered on Aug. 8.

Casale and Turin.—In Italy, however, Cadet-la-Perle kept the moral ascendancy he had won in the brave action of the *Route de Quiers*. In April with 10,000 men he advanced from Carignan against the 20,000 Spaniards who were besieging Casale and attacked their line of circumvallation boldly and openly on April 29. Half of Leganez's army was killed or captured. After this, Harcourt promptly turned upon Prince Thomas, and then followed one of the most curious episodes in military history. Thomas, himself defending Turin, was besieging the French who still held the citadel, while Harcourt, at once besieging the town and attempting to relieve the citadel, had, externally, to protect himself against Leganez's army which was reorganized and reinforced from Naples and the Papal States. Harcourt's courage and the disunion of his opponents settled the problem. Their general attack of July 11 on the French lines was made not simultaneously but successively, and Harcourt repulsed each in turn with heavy losses. Soon afterwards the French received fresh troops: the citadel was relieved and the town surrendered. Leganez retired to Milan.

In Germany Banér's course was temporarily checked and when at last Bernhard's old army, under the duc de Longueville, crossed the Rhine and joined Banér in Thuringia, the country could not support the combined army. The Weimar army retired to the Rhine valley and Banér to Waldeck. A fresh opportunity came to Banér in the winter months of 1640–41. Negotiations for peace were constantly in progress, but no result seemed to come out of them. The Diet was assembled at Regensburg. Banér suddenly moved south to surprise the Diet, for the defence of which all available troops were hurried up by the emperor. The Weimar army under Gubbriant joined the Swedes *en route*, and the combined army reached the objective. But a thaw hindered them and gave the emperor time to concentrate his forces, and the raid failed. On May 20 Banér, worn out by fatigue, died, and Torstensson succeeded to the command. The war had now receded far from Alsace, which was firmly held by France, but Marcourt's continued success in Piedmont and the trouble to Spain caused by the Catalan and Portuguese insurrection was partly balanced by France's own difficulties in the abortive conspiracy against Richelieu.

In Dec. 1641 there began at Miinster and Osnabrück in Westphalia the peace negotiations which, after eight more years of spasmodic fighting, were to close this ruinous war. In 1642 Tors-

tensson crossed the Elbe and besieged Leipzig. The imperialist army, which was joined by the Saxons when their country was again the theatre of war, marched to the rescue. But Torstensson defeated them with enormous loss in the second battle of Breitenfeld (Nov. 2, 1642). But, although the Austrians feared an advance on Vienna itself, the victors waited for the fall of Leipzig and then took up winter quarters. The Bavarians had advanced into the lower Rhine region in order to support, in concert with the Belgian army of Spain, a fresh outbreak in France (Cinq-Mars' conspiracy). But the Spanish were attacked and defeated before the Bavarians came up, at Hulst (Jan. 17), whereupon the Bavarians took shelter under the guns of the fortress of Julich.

On the northern frontier of France, Harcourt, the brilliant commander of the Italian army, failed to prevent the Spaniards from capturing Lens and La Bassée, and another army was defeated and routed at Honnecourt (May 26). The Spaniards in the Milanese lost fresh ground. Louis XIII. himself conquered Roussillon. Richelieu crushed the conspiracy of Cinq-Mars by executing its leaders, and Marshal de la Motte-Houdencourt held Catalonia and defeated Leganez at Lerida (Oct. 7th).

The **Duc d'Enghien.**—Before the next campaign opened, Louis and Richelieu were dead. One of the last acts of the king was to designate the young duc d'Enghien, son of the incapable Condé, general of his northern army. It was no small matter to put in command a youth of 21, who might prove not merely inexperienced but also incompetent. But Enghien's victory was destined to be the beginning for the French army of a long hegemony of military Europe. Mello, the Spanish general, had selected the Meuse route for his advance on Paris. On it he would meet only the places of Rocroi and Rethel. The young duke learned at the same moment that Louis XIII was dead and that the Spaniards had invested Rocroi. With the resolution and swiftness which was to mark his whole career, he marched at once to offer them battle, though all the generals of the old school were for delay. The battle took place on May 19, 1643, in a plain before Rocroi. Mello's cavalry was routed, and nearly all the infantry, the best regiments in the Spanish army, stood their ground and were annihilated.

But even Rocroi, under the existing conditions of warfare, was decisive only in so far as, by the destruction of Spain's superiority in Belgium, it saved France from further danger from the north. The thorough establishment of the French on the Rhine and the need of co-operating with the Swedes were considered by the young general to be more important than fighting Mello in front of Brussels, and in spite of the protests of the Regent and Mazarin, he decided to attack Thionville. Taking a leaf out of Mello's book, he threatened Brussels in order to draw all the defenders thither, and then suddenly turned eastward. Enghien arrived on June 18, and on Aug. 8, Thionville surrendered.

Beyond the Rhine Guébriant was mortally wounded in the siege of Rottweil, and Rantzau, taking over the command, allowed himself to be surprised in the act of dispersing into winter-quarters, and was defeated at Tuttlingen on the headwaters of the Danube (Nov. 24).

In the East the campaign had as usual turned more upon subsistence than upon military operations. Torstensson swept through Bohemia and Moravia, his steps dogged through the devastated country by Gallas, until he reached Brunn. Thence, however, he suddenly retreated to the shores of the Baltic. For Christian of Denmark had declared war on Sweden, and threatened to isolate the Swedish forces in Germany. Torstensson, therefore, wintered in Holstein. In Italy and Spain there was no event of any importance.

In 1644 Gaston of Orleans began the conquest of the Dunkirk region in July, and Mello. having no army to oppose him, remained inactive. In Italy there happened nothing serious, while in Spain La Motte-Houdencourt lost Lerida, and was imprisoned by Mazarin in consequence. But the Rhine campaign is memorable for the first appearance of Turenne at the head of an army and for the terrible battle of Freiburg.

Freiburg.—In Suabia Mercy's Bavarians were left to oppose Turenne, who spent the first months of the year in restoring discipline and confidence in the shaken Weimar army. But Mercy was still considerably superior in strength, and, repulsing Turenne's first inroad into the Black Forest, besieged Freiburg. Turenne made one cautious attempt at relief, then waited for reinforcements. These came in the shape of Enghien's army, and Enghien as a prince of the blood took over the supreme command. But both armies together numbered hardly 17,000 men when Enghien and Turenne united at Breisach on Aug. 2. On the 3rd they crossed the Rhine and attacked Mercy's position, which was of great natural and artificial strength, in front and flank. Three separate battles, which cost the Bavarians one-third of their force and the French no less than half of theirs, ended in Mercy's retreat (*see* FREIBURG IM BREISGAU) on Aug. 10. Enghien did not follow him into the mountains, but proceeded to the methodical conquest of the middle Rhine fortresses, leaving Turenne and the Weimar army at Spire.

In the east, or rather in the north, a desultory campaign was carried on during 1644 between Torstensson and the younger Wrangel, on the one side, the Danes and Gallas on the other, and in the end Gallas retreated to Austrian territory, so completely demoralized that his army dwindled on the way from 20,000 men to 2,000. Torstensson followed him, having little to fear from the Danes. Meanwhile the prince of Transylvania, George Rakóczy, playing the part of Gabriel Bethlen his predecessor, made war upon the emperor, who not being able on that account to send fresh troops against Torstensson called for help to Maximilian of Bavaria. The Elector sent most of his own troops under Weert on the same errand—hence Mercy's defeat at Freiburg. But Torstensson pressed on towards Vienna, and on Feb. 24–March 6, 1645 he inflicted a crushing defeat on the Bavarians and Imperialists at Jankau near Tabor. In his extremity Ferdinand offered part of Bohemia and Silesia to Maximilian in return for soldiers. But the Bavarian ruler had no more soldiers to give, for Turenne was advancing again from the Rhine.

At the end of March the Weimar army marched to Heilbronn, and Rothenburg-on-Tauber, when Turenne resolved to go northward in search of supplies and recruits in the territories of his ally and cousin the landgravine of Hesse-Cassel. But at this point the army, headed by Bernhard's old colonels, demanded to be put into rest-quarters, and Turenne allowing them to disperse as they wished, was surprised by Mercy and Weert—who brought his courage, if nothing else, back from the field of Jankau—and lost two-thirds of his forces. But Turenne, instead of retreating to the Rhine, installed himself in the landgravine's country, while Enghien hurried up from the Moselle to his aid. The "Army of Weimar" and the "Army of France" joined forces, as in 1644, almost under the eyes of the enemy. Enghien at once pushed forward from Ladenburg, by Heidelberg and Dinkelsbiihl, and found the Austro-Bavarians under Mercy entrenched in a strong position at Allerheim near Nordlingen, directly barring the way to the Danube. The second battle of Nordlingen (Aug. 3, 1645) was as desperately fought as the first, and had not Mercy been killed at the crisis of the day Enghien would probably have been disastrously defeated. As it was, the young duke was victorious, but he had only 1,500 infantry left in rank and file out of 7,000 at the end. Soon afterwards Enghien fell ill, and his army returned to France. Turenne, left with a few thousand men, attempted in vain to hold his ground in Germany and had to make a hasty retreat to Philippsburg on the Rhine, almost the only remaining conquest of these two brilliant but costly campaigns. In Flanders Gaston of Orleans conquered a number of fortresses, and his army united with that of the Dutch. But the allies separated again almost at once, each to undertake the sieges which suited its own purposes best.

From Silesia Wrangel, who had succeeded Torstensson, passed into Bohemia, where he remained until the forces employed against Rakóczy and Turenne could send help to the imperialists opposed to him. He then drew away into Hesse, the Archduke Leopold and the Bavarians following suit.

Turenne's Strategy.—The campaign of 1646 in Hesse up to August was as usual uneventful, each army being chiefly concerned with its food. But at last the archduke retired a little, leaving Turenne and Wrangel free to join their forces. Turenne had no intention of repeating the experiences of Freiburg and Nordlingen. It was more profitable to attain the small objects that were sought by manoeuvre than by battle, and the choice of means practically lay between manoeuvring the enemy's army into poor districts and so breaking it up by starvation, and pushing one's own army into rich districts regardless of the enemy's army. The usual practice was the first method. Turenne chose the second.

Delayed at the opening of the year by orders from Mazarin —Turenne found it impossible to reach Hesse by the short and direct route, and he therefore made a rapid and secret march down the Rhine as far as Wesel, whence, crossing unopposed, he joined Wrangel on the upper Lahn (Xug. 10). The united armies were only 19,000 strong. But the imperialists, fearing to be hemmed in and starved between Turenne and the Rhine, fell back to Fulda, leaving the Munich road clear. The interior of Bavaria had not been fought over for 11 years, and was thus almost the only prosperous land in desolated Germany. Turenne and Wrangel marched straight forward on a broad front, and for the rest of the year they devastated the country about Munich in order to force Maximilian to make terms. An armistice was concluded in the winter, Maximilian having been finally brought to consent by an ill-judged attempt of the emperor to seduce his army. The French and Swedes wintered in southern Wiirttemberg.

In Flanders, Gaston of Orleans and Enghien took Dunkirk and other fortresses. In Italy, where the Tuscan fortresses were attacked, the French were completely checked at first, until Mazarin sent a fresh corps thither and restored the balance. In Catalonia Harcourt underwent a serious reverse in front of Lerida at the hands of his old opponent Leganez, and Mazarin sent Enghien, now prince of Condé, to replace him.

1647 was a barren year. In the Low Countries the war dissipated itself in sieges. In Italy Plessis-Praslin won an unprofitable victory over the viceroy of the Milanese on the Oglio (July 4). In Spain Condé, resuming the siege of Lerida, was repulsed and had to retire. In Germany Turenne and Wrangel parted company. The latter returned to Hesse, whence he raided into Bohemia, but was driven back by the imperialists. As the few obtainable supply areas gave out one by one, the Swedes gradually retired almost to the coast, but the imperialists did not follow, swerving into Hesse instead. Turenne meanwhile had had to send all his French troops to Luxemburg to help in the defence of northern France against the Spaniards. The Weimar army had refused to follow him to the Meuse, and mutinied for its arrears of pay. Turenne, however, promptly seized the ringleaders and after a sharp fight disarmed the rest. Thus ignominiously Bernhard's old army vanished from the scene.

In the autumn the elector of Bavaria was reconciled to the emperor and his army re-entered the field. Turenne was therefore sent back to Germany to assist the Swedes. But winter came on before any further inroads could be made into south Germany.

The campaign of 1648 brought the decision at last. Turenne and Wrangel, having refitted their forces and united in Hesse as in 1646, steadily drove back the imperialists and Bavarians, whose 30,000 combatants were accompanied by a horde of nearly 130,000 hangers-on—men, women and children—to the Danube. At Zusmarshausen (May 1;) catching the enemy in the act of manoeuvring, they destroyed his rear-guard. The victors advanced as far as the Inn, but Piccolomini, reorganizing the débris of the Austro-Bavarian army, checked their further progress and even drove them back to the line of the Isar. Meantime, however, the Swedish general Konigsmarck, had entered Bohemia and was besieging Prague. This caused the recall of Piccolomini's army, and Turenne and Wrangel invested Munich. But Mazarin ordered the French to retire into Suabia so as not to compromise the peace negotiations at the critical moment, and Wrangel followed suit. Before Königsmarck was in a position to assault Prague news came of peace. Meanwhile in Artois Condé had repulsed the Spanish invasion by his brilliant victory of Lens (Aug 5), which was a second Rocroi. After the thanksgiving service for the victory at Nôtre Dame, Mazarin arrested the leaders of the *parlement* of Paris. and in a few hours the streets were barricaded and a civil war was in progress. This was the Fronde (*q.v.*), which went on for another 11 years.

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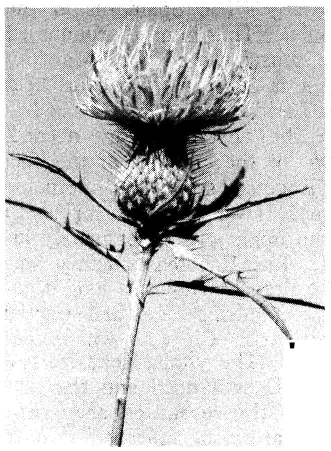
THISTLE, a name of vague application. given to almost any herbaceous plant that has spines. More strictly. it is applied to certain herbs possessing very spiny leaves. and similar bracts surrounding a head of purplish-white, tubular. five-parted flowers seated on a pitted and hairy receptacle, belonging to the Compositae family. The fruit is surmounted by a tuft of silky hairs. The species, chiefly natives of Europe, western Asia and North America, are numerous, and some are of great beauty. The blessed thistle is *Cnicus benedictus;* lady's thistle, the leaves of which are spotted uith white, is *Silybum marianum.* The common bull thistle *Cirsium lanceolatum,* seems to be the most suitable prototype for the Scots thistle, though that honour is also conferred on *Onopordon acanthium,* the cotton thistle, remarkable for its covering of white down. a doubtful native of Great Britain, and on other species.



JOHN H. GERARD

FIELD THISTLE (CIRSIUM DISCOLOR)

The great objection to thistles from an agricultural point of view resides in the freedom with which their seeds are spread and in the vigour of their underground growth, which makes their eradication difficult. Among the so-called thistles the following, all introduced from Eurasia, are well-known noxious weeds of farmlands in the northern Cnited States and Canada. The blue thistle *(Echium vulgare)* is a biennial member of the Borage family. The Russian thistle *(Salsola kali),* so common on the Great Plains of western North America, is an introduced annual tumbleweed belonging to the pigweed family. The perennial sow thistle *(Sonchus arvensis),* a milky-juiced member of the family Compositae, because of its freely creeping root system, is one of the most persistent weeds of arable lands. *See* CANADA THISTLE. (W. C. M.)

THISTLEWOOD, ARTHUR (1770–1820), principal instigator of the Cato street conspiracy, a plot to murder the British cabinet in 1820. A son of William Thistlewood. and born at Tupholme in Lincolnshire, young Thistlewood became a soldier and visited France and America. He developed republican sympathies and joined the Spencean society, a revolutionary body; associated himself with James Watson (d 1838) and other agitators; and in Dec. 1816 helped to arrange a meeting in Spa Fields. London, which was to be followed by the seizure of the Tower of London and the Bank of England and by a general revolution. The proposed rising failed, but the Habeas Corpus act was suspended and Thistlewood and Watson were tried but acquitted. Thistlewood was sentenced to a year's imprisonment for challenging the home secretary, Lord Sidmouth, to a duel. After his release in May 1819 he prepared a new and comprehensive plot. On Feb. 23, 1820, at a time of great distress and unrest caused by the death of George III, the cabinet ministers had arranged to dine at the earl of Harrowby's house in Grosvenor square. With some associates Thistlewood hired a room in the neighbouring Cato street, collected arms and made ready to fall upon Harrowby's guests. The authorities had been informed of the plot, probably by a conspirator named George Edwards, officers appeared and arrested some of the conspirators; and although Thistlewood escaped he was seized the following day. Tried for high treason, Thistlewood and four others were sentenced to death, and were hanged hlay 1, 1820.

See Sir S. Walpole, *History of England,* vol. i (1890).

THOKOLY, IMRE (EMERICH), PRINCE (1657–1705), Hungarian statesman, was born at Kesmark on Sept. 25, 1657. He lost both parents while still a child. In 1670, fleeing from the dangers of upper Hungary where the Protestants and imperialists were constantly in arms against each other, he took refuge with his kinsman Michael Teleki, the chief minister of Michael Xpafy, prince of Transylvania. There he came into contact with the Magyar refugees. who had great hopes of the high-born, high-gifted youth who was also a fellow sufferer, a large portion of his immense estates having been confiscated by the emperor. The discontent reached its height when Leopold (Feb. 27, 1673) suspended the Hungarian constitution, appointed Johan Gaspar Ampringen dictator, deprived 450 Protestant clergy of their livings and condemned 67 more to the galleys. Encouraged by promises of help from Louis XIV. the Magyars now rose for liberty and justice. and chose the youthful Thokoly as their leader. The war began in 1679. Upper Hungary and the mining towns were soon in Thokoly's possession. In 1681, reinforced by 10,000 Transylvanians and a Turkish army under the pasha of Nagyvarad, he compelled the emperor to grant an armistice. Thokoly's distrust of the emperor induced him to turn for help to the sultan. In the same year Thokoly captured fortress after fortress from the emperor and extended his dominions to the Waag. He refused the title of king ofiered to him by the Turks.

Thokoly was buried at Nicomedia but in 1906 his relics were transferred to Hungary.

See *Correspondence of Thokoly* (Hungarian), ed. by Kalman Thaly (1896); V. Fraknbi, *Papst Innocenz XI. und Cngarn's Befreiung von der Türkenherrschaft* (1902); *Memoirs of Emeric Count Teckely (1693)*; *Correspondence* of *Michael Teleki* (Hungarian), ed. by S. Gergely (1905–06).

THOLOS, in architecture, a circular building with or without a peristyle. The earliest examples are the beehive tombs at Mycenae and in other parts of Greece, which were covered by domes built in horizontal courses of masonry. The tholos at Epidaurus, built by Polycleitus (*c.* 400 B.C.), and the tholos at Olympia, known as the Philippeion, are the most remarkable examples and in both cases were covered with a sloping roof and not with a dome. *See* PRE-HELLENIC ARCHITECTURE; GREEK ARCHITECTURE.

THOLUCK, FRIEDRICH AUGUST GOTTREU (1799–1877), German Protestant theologian, was born at Breslau on March 30, 1799. He studied at Breslau and at Berlin, where he was received into the house of the orientalist H. F. von Diez (1750–1817). He came under the influence of the Pietist Baron Ernst von Kottwitz (1757–1843), who became his "spiritual father:" and of the historian Neander. In 1821 he was *Privatdocent* (official but unpaid lecturer! and in 1823 became professor extraordinarius of theology in Berlin. *Die wahre Weihe des Zweiflers* (1823; 9th ed., with the title *Die Lehre von der Sünde und dem Versöhner,* 1870), the outcome of his own religious history, secured his commanding position as the Pietistic apologist of Evangelical Christianity. In 1825, with the aid of the Prussian government, he visited the libraries of England and Holland, and on his return was appointed (1826) professor ordinarius of theology at Halle, the centre of German rationalism, where he afterward became preacher and member of the supreme consistorial council. There he sought to combine in a higher unity the learning and to some extent the rationalism of J. S. Semler with the devout and active Pietism of A. H. Francke; and, in spite of the opposition of the theological faculty of the university, he succeeded in changing the character of its theology. Tholuck was also one of the prominent members of the Evangelical alliance: and few men were more widely known or more beloved throughout the Protestant world. As a preacher he ranked among the foremost of his time. He died at Halle on June 10, 1877.

After his commentaries (on Romans, the Gospel of John, the Sermon on the Mount and the Epistle to the Hebrews) and several volumes of sermons, his best-known books are *Stunden christlicher Andacht (1839;* 8th ed., 1870).

THOMA, HANS (1839–1924), German painter whose works consist of minutely realistic landscapes, portraits and historical and biblical subjects. was born on Oct. 2. 1839. at Bernau in the Black Forest. He entered the Karlsruhe academy in 1859 and in 1868 went to Paris, where he became a pupil of Courbet. His reputation was established as the result of an exhibition of about 30 of his paintings in Munich. He died at Karlsruhe on Nov. 7, 1924. Thoma's art has little in common with modern ideas and was formed partly by his early impressions of the simple idyllic life of his native district, partly by his sympathy with the early German masters, particularly Xlbrecht Altdorfer and Cranach, and partly by his study under Courbet. In his love of the details of nature, in his precise though by no means faultless drawing of outline and in his predilection for local colouring he has distinct affinities with the Pre-Raphaelites. His works hang chiefly in German museums.

THOMAR: *see* TOMAR.

THOMAS, ST., one of the twelve apostles. The name means "twin" in Aramaic, as is recognized in John xi. 16 ("called Didymus"). Eusebius (H.E. iii. 1, 1) says Thomas was the evangelist of "Parthia," probably because Edessa (*q.v.*), where some of his bones were preserved, is sometimes called "Edessa of the Parthians." These bones were reputed to have been brought to Edessa from India, and a work known as the *Acts of Thomas* relates his missionary labours and martyrdom there. This work was originally composed in Syriac; it is indeed one of the oldest and most idiomatic monuments of Syriac literature, though many have doubted whether it is based on any historical facts. In the 4th century it was translated into Greek, and thence into Latin, almost certainly as part of the Manichaean propaganda. The Manichaean taint was soon recognised (*e.g.*, by Augustine) and the *Acta Thomae* in their original form branded as heretical. The view taken was that the framework, recounting the journeyings of the apostle, was historical, while the speeches and sermons contained the heresy. In consequence most mss., both Greek and Latin, contain very little of the speeches while retaining the framework. Even Wright's Syriac ms. has been occasionally conventionalized, and the original form is only to be found in the ancient (4th or 5th century) palimpsest fragments at Sinai.

The *Acts of Thomas* is a leading authority for the earliest Christianity in the countries east of the Euphrates: it was ascetic, marriage being discountenanced and all preoccupation with the things of this world discouraged. In the Acts Eucharistic prayers are given, but (according to the Sinai fragments and the best Greek) only bread and water were used. The Lord's Prayer is quoted in full. A curious feature is that the name of the apostle is given as Judas Thomas, and it is expressly set forth that he was the twin of Jesus Christ. As a tale the *Acts of Thomas* is remarkable for the real religious emotion that pervades it and for careful delineation of character, but above all for the hymn chanted by the apostle when in prison. This, commonly known as the "Hymn of the Soul" (Wright, pp. 238–245), is a metrical Syriac poem describing, under the parabolic form of the journey of a prince from his Eastern home to Egypt, the descent to earth and the return to its heavenly home of the soul. It is often supposed to be an independent composition inserted into the *Acts,* but for this there is no real evidence. In any case it is the great gem of Syriac literature.

"Christians of St. Thomas" is a name often applied to the ancient Christian churches of southern India; the view taken of their history is so intimately connected with the historicity of the *Acts of Thomas* that it is convenient to treat of them here. According to the tradition, St. Thomas founded the Christian churches in Malabar (south-west coast), and then crossed to Mylapur, now a suburb of Madras, where the shrine of his martyrdom, rebuilt by the Portuguese in 1547, still stands on Mt. St. Thomas, where a cross is shown with a Pahlavi inscription which may be as old as the 7th century. We know from Cosmas Indicopleustes that there were Christians of Persian (East Syrian) origin, and doubtless of Nestorian creed, in Ceylon, in Malabar, and at Caliana (north of Bombay) before 550. In 1490 they sent to the Nestorian patriarch Simeon, who gave them fresh bishops (Assemani, *Bib. Or.* iii, 1,590-f., *J. Theol. Stud.* xxix, 155). Hard pressed by the Moslems they welcomed the Portuguese and, after much controversy, a formal union with Rome was carried through in the Synod of Diamper (1599). Syriac was to remain the ecclesiastical language, but the service books were "purified from error."

Dom R. H. Connolly proved in 1914 that this revision was slight in extent, and that the Malabar liturgy remained essentially a form of the Nestorian rite. After a century and a half of union with Rome a schism took place in 1653, those who thus became independent of Rome organizing themselves under Jacobite (Monophysite) influence. (The ms. of the whole Syriac Bible and the Clementine literature [12th century] then sent to Malabar from Mesopotamia was brought to Europe by Claudius Buchanan [1811] and is now in the Cambridge university library.) Both this Church and the Roman obedience still flourish in Malabar.

From what has been said, the ancient Christian communities of southern India would be naturally regarded as a surviving branch of the extensive Nestorian missions, parallel to those which once flourished in Turkestan and China. But many of the Christians in India in fact regard St. Thomas as their founder and appeal to tradition and to the *Acts of Thomas,* in support. They claim that the *Acts* are historical, and that they refer in part to the apostle's activity in southern India. There are, indeed, objections to this view, such as the absence of compellingly clear allusions to specifically southern usages. As to the meeting of St. Thomas and the Indian King Gundaphar (the historical Gondophares, contemporary with the apostle and ruler in Gandhara, the northwest borderland of India), while a rigorously scientific proof is impossible, yet the substantial agreement of the *Acts* (the sole literary document which mentions this king) with all that is known from other sources, is best explained on the supposition that the *Acts* contain a kernel of historical truth. As to the southern journey and the martyrdom in Mylapur, it should be remarked that the agreement of the south Indian tradition with that of the Church of Edessa lends a high degree of probability to the claim that St. Thomas preached in southern India, suffered martyrdom there, and was there first buried. But difficulties remain, and no strict certainty is claimed for their conclusions by temperate investigators.

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(N. J. T.)

THOMAS, surnamed Magister (*i.e.,* officiorum)[1], also known as a monk by the name Theodulos Monachos, a native of Thessalonica, Byzantine scholar and grammarian and confidential adviser of Andronicus II. (1282–1328). His chief work, 'Εκλογὴ 'Ονομάτων καὶ 'Ρημάτων 'Αττικῶν, is a collection of selected Attic words and phrases, partly arranged in alphabetical order, compiled as a help to Greek composition from the works of Phrynichus, Ammonius, Herodian and Moeris. He also wrote scholia on Aeschylus, Sophocles, Euripides (with life), and three of the comedies of Aristophanes; the scholia on Pindar, attributed to him in two mss., are now assigned to Demetrius Triclinius. His speeches and letters deal with contemporary events.

Editions of the 'Εκλογ. by F. Ritschl (1832), C. Jacobitz (1833) and C. D. Beck (1836); other works in J. P. Migne, *Patrologia graeca,* cxlv.; *see* also C. Krumbacher, *Geschichte der byzantinischen Literatur* (1897).

[1]For the duties of this important office, *see* J. B. Bury (*Later Roman Empire*) (1889), i. 45.

THOMAS (d. 1100), archbishop of York, a native of Bayeux, is usually called Thomas of Bayeux. His father was a priest named Osbert, and Samson, bishop of Worcester (1086–1112), was his brother. Owing largely to the generosity of Odo, bishop of Bayeux, Thomas studied in France, Germany and Spain and then became one of Bishop Odo's officials and after 1066 one of William the Conqueror's chaplains, or secretaries. In 1070 he succeeded Aldred as archbishop of York, but declining to promise obedience to the archbishop of Canterbury, Lanfranc refused to consecrate him. King William, however, induced him to submit and he was consecrated, but his profession of obedience was to Lanfranc personally and not to the archbishops of Canterbury.

In 1071 both archbishops travelled to Rome for their palls and while there Thomas wished Pope Alexander II. to decree the equality of the sees of Canterbury and York. The pope, however, referred the dispute to a council of English prelates which met at Windsor at Whitsuntide in 1072. It was then decided that the archbishop of Canterbury was the superior of the archbishop of York, who had no rights south of Humber, but whose province included Scotland. This decision did not end the dispute which broke out again in 1092 and 1093 when Thomas protested against what he thought infringements of his archiepiscopal rights. The first of these occasions was over the dedication of the cathedral built by Remigius at Lincoln and the second was over the consecration of St. Anselm to the archbishopric of Canterbury. He died at York on Nov. 18, 1100.

THOMAS, ALBERT (1878–1932), French statesman, was born on June 16, 1878, at Champigny-sur-Marne, near Paris. His father was a baker who by great sacrifices enabled his son to receive a college and university education. Scholarships enabled him to travel in Russia and Germany. A sequel to this was his book *Le syndicalisme allemand* (1903) in which his socialist faith was propounded for the first time.

When, in 1904, Jean Jaurès launched *l'Humanité* he appointed Thomas assistant editor. Thomas played an important part as a right-wing leader in the General Confederation of Labour (C.G.T.). He published in 1908 a volume on the Second Empire in Jaurès' great *Histoire socialiste.*

He was elected to the Chamber for his native city in May 1910 and again in 1914, becoming one of the most active and prominent Socialist members.

He joined his regiment in 1914. After he had seen a few weeks of war service, the Government summoned Thomas and two other Socialists, Jules Guesde and Marcel Sembat, to organize the production of munitions. In May 1915 he entered the cabinet as under-secretary for armaments and also joined the Briand Ministry which followed at the end of the year. Towards the end of 1916 he became minister of munitions, retaining this post in the Ribot Ministry which followed. In April 1917 he was sent to Russia, where he remained for several months and succeeded in persuading Kerensky to undertake the ineffectual "great offensive" against the Central Powers.

Meanwhile in France the struggle was becoming very bitter between the majority (pro-war) and the minority (internationalist) sections of the French Socialist party, culminating in the Stockholm Conference. Leader, with Renaudel and Sembat, of the majority party, Albert Thomas was also a strong advocate of the independence of Czechoslovakia and Poland and the creation of a "Great Serbia" and a "Great Rumania." Since this "majority wing" policy was opposed by many Socialists, particularly in the Paris district, Thomas decided not to stand again in the Paris suburbs and resigned the mayoralty of Champigny. At the elections of Nov. 16, 1919, he was returned as a Socialist in the Tarn, Jaurès' former constituency.

During the first session of the International Labour Conference, held at Washington at the end of the year, Thomas was provisionally appointed director of the International Labour Office (League of Nations) by its governing body; the appointment was confirmed at the governing body's second meeting held in Paris in Jan. 1920. Apart from the organization and conduct of the administration and scientific work of the Office, he secured many national ratifications of conventions adopted by the International Labour Conference. In 1921 the claims of his work at Geneva led him to resign his seat in the Chamber of Deputies.

THOMAS, (CHARLES LOUIS) AMBROISE (1811–1896). French composer, was born at Metz Aug. 5, 1811. After studying under his father, a musician, he entered the Paris conservatory in 1828 and four years later won the Prix de Rome with *Herman et Ketty,* a cantata. He was professor of harmony and composition at the conservatory thereafter and in 1871 was named director. He was elected a member of the Académie des Beaux Arts in 1851. Among his compositions are ballets, cantatas and songs; his best known operas are *Mignon* (1866), *Hamlet* (1868) and *Françoise de Rimini* (1882). He died at Paris Feb. 12, 1896

THOMAS, ARTHUR GORING (1850–1892), English composer, was born at Ratton Park, Sussex, on Nov. 20, 1850. and educated at Haileybury College. He studied music in Paris under Durand and at the Royal Academy of Music under Ebenezer Prout and Arthur Sullivan; also under Max Bruch. The performance at the Royal Academy of a selection from *The Light of the Harem* (libretto by Clifford Harrison). induced Carl Rosa to commission him to write *Esmeralda* (libretto by T. Marzials and A. Randegger). which was successfully produced at Drury Lane on March 26, 1883. On April 16, 1885, Rosa produced at Drury Lane Thomas's fourth and best opera. *Nadeshda* (libretto by Julian Sturgis), a German version of which was given at Breslau in 1890. Besides his dramatic works Thomas's chief compositions were a psalm, "Out of the Deep," for soprano solo and chorus (London, 1878), a choral ode, "The Sun Worshippers" (Norwich, 1881), and a suite de ballet for orchestra (Cambridge, 1887). His music, which shows traces of his early French training, reveals a great talent for dramatic composition and a real gift of refined and beautiful melody. He died on March 20, 1892.

THOMAS, AUGUSTUS (1857–1934), U.S. playwright, was born in St. Louis, Mo., Jan. 8. 1857. He was educated in the public schools, served as a page boy in the Missouri legislature and in congress, for several years worked in railway freight offices, and, after serving as writer and illustrator for various newspapers, became in 1886 part editor and proprietor of the Kansas City (Mo.) *Mirror.*

The success in New York and on the road of *The Burglar* (1889), an elaboration of the earlier one-act piece, and of *A Man of the World* (1883) used by Maurice Barrymore, induced A. M. Palmer of the Madison Square theatre to offer the young playwright the post left vacant by the retirement of Dion Boucicault, and under Palmer's management *Alabama* (1891), a play about the reunited U.S., was produced. Thenceforth Thomas was one of the most prolific and successful of American playwrights, writing altogether over 60 plays. Other dramatic successes by him which made use of native materials were *In Mizzoura* (1893), *The Capital* (1895), *Arizona* (1899) and *The Copperhead* (1918). Other outstanding plays, chiefly in the vein of light comedy or romance, were *The Earl of Pawtucket* (1903), *Mrs. Leffingwell's Boots* (1905), and *The Witching Hour* (1907). An autobiographical volume *The Print of My Remembrance* appeared in 1922. He died near Nyack, N.Y., Aug. 12, 1934.

THOMAS, DYLAN MARLAIS (1914–1953), Welsh poet, was born in Swansea, Oct. 27, 1914. At the time of his death he was held to be one of the most remarkable poets of his generation. In 1934 he published his first volume of verse, *Eighteen Poems,* which was immediately recognized by Edith Sitwell and others as the work of an original and individual talent. There followed *Twenty-Five Poems* (1936); *The Map of Love* (1939) and *A Portrait of the Artist as a Young Dog* (1940), a collection of humorous autobiographical sketches. Some of his finest work was in *Deaths and Entrances* (1946) and *In Country Sleep* (1951). The theme of all his poetry is the celebration of the divine purpose which he sees in all human and natural processes. In some of the best of his later poems he seeks, like Henry Vaughan or Thomas Traherne, to recapture the child's innocent vision of the world. His poems are, in a good sense, impersonal. The wit and humour that made him an enchanting companion come out in his sketches and short stories, mainly based on memories of his Swansea childhood. In his last completed work, the radio play *Under Milk Wood,* the vision of the poet and the fun of the entertainer can be seen, for the first time. working together. His gifts as a broadcaster and the legend of his wild conviviality helped to spread his reputation. Thomas led a reckless life, but it never interfered with his sober devotion to his "craft and sullen art." He died, during a poetry-reading tour. in New York on Nov. 9, 1953. (G. S. E.)

THOMAS, GEORGE HENRY (1816–1870), U.S. general, who has been called "The Rock of Chickamauga." was born in Southampton county, Va., on July 31. 1816. He graduated at West Point in 1830, served as an artillery subaltern in the war against the Seminole Indians in Florida (1841), and in the .Mexican War at the battles of Fort Brown, Resaca de la Palma. Monterrey and Buena Vista, receiving three brevets for distinguished gallantry in action. From 1851 to 1854 he was an instructor at West Point. In 1855 he was appointed by Jefferson Davis, then secretary of war, a major of the and cavalry. His regimental superiors were A. S. Johnston, R. E. Lee and Hardee. All three resigned at the outbreak of the Civil War. Thomas finally decided to adhere to the United States. He was promoted in rapid succession to lieutenant colonel, colonel in the regular army. and brigadier general of volunteers.

In command of an independent force in eastern Kentucky, on Jan. 19, 1862, he attacked the Confederate general. Felix Zollicoffer, at Mill Springs, and gained the first important Union victory in the west. He served under Buell and was offered, but refused. the' chief command in the anxious days before the battle of Perryville. Under Rosecrans he was engaged at Stone river and was in charge of the most important part of the maneuvring from Decherd to Chattanooga. At the battle of Chickamauga (*q.v.*) Sept. 19. 1863. he gained the name of "The Rock of Chickamauga," because of his firmness. He succeeded Rosecrans in command of the army of the Cumberland shortly before the great victory of Chattanooga (*q.v.*), in which Thomas and his army played a conspicuous part, his divisions under Sheridan, Wood and Baird carrying Missionary ridge in superb style. When J. B. Hood broke away from Atlanta in the autumn of 1864, menaced Sherman's long line of communications and endeavoured to force Sherman to follow him, Sherman left to Thomas the difficult task of dealing with Hood. At the battle of Franklin, Nov. 30, 1864. Thomas's force, under General Schofield, checked Hood long enough to cover the concentration at Nashville (*q.v.*). Thomas attacked (Dec. 15–16, 1864) and inflicted on Hood the worst defeat sustained in the open field by any army on either side during the war. For this Thomas was made a major general in the regular army and received the thanks of congress. After the Civil War he commanded military departments in Kentucky and Tennessee until 1869, when he was placed over the division of the Pacific with headquarters at San Francisco. He died there March 28, 1870.

THOMAS, ISAIAH (1749–1831), U.S. printer and publisher pre-eminent in his day, was born in Boston, Mass., on Jan. 19, 1749. When he was six he was apprenticed to Zechariah Fowle, a Boston printer. At the age of 16 he ran away and worked as a printer in Halifax, Nova Scotia and Portsmouth, N.H., and later, with Fowle's consent, in Charleston, S.C. In 1770 he formed a partnership with Fowle to publish the *Massachusetts Spy*. Under Thomas' sole ownership it became a weekly publication which eventually espoused the patriots' cause and printed essays advocating independence; the paper's circulation reached a high of 3.500. On April 16. 1775, three days before the battle of Concord, in which he took part, Thomas was forced to take his presses and types from Boston to Worcester, Mass., where he was postmaster for a time. There he published and sold books, built a paper mill and bindery, and continued his paper (with the exception of the years 1776–78 and 1786–88) until about 1802, during which time the *Spy* supported Washington and the Federalist party. Thomas set up printing houses and bookstores in various parts of the country: in Boston he published the *Royal American Magazine,* which contained many engravings by Paul Revere; the New *England Almanac;* the *Massachusetts Magazine,* a monthly, with Ebenezer

T. Andrews; and, in Walpole, N.H., the *Farmer's Museum*. About 1802 he relinquished his business at Worcester, including control of the *Spy*, in favour of his son Isaiah, Jr. In 1812 Thomas founded the American Antiquarian society. He died in Worcester on April 4, 1831.

His accurate and thorough *History of Printing in America, With a Biography of Printers, and an Account of Newspapers* (1810; 2nd ed., 1874), with a memoir by his grandson B. F. Thomas, is the first history of American publishing. "Diary of Isaiah Thomas, 1805–28" was published in *Transactions of the American Antiquarian Society*, vol. ix and x (1909).

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THOMAS, JAMES HENRY (1874–1949), British Labour leader. was born at Newport, Mon., on Oct. 3, 1874 He started work as an errand boy at the age of 9 and was later employed by the Great Western railway as an engine cleaner; he rose rapidly and soon became a power in Swindon (the G.W.R. headquarters) both as a trade unionist and in local government. By 1910 he had become president of the Amalgamated Society of Railway Servants and played a leading part in its reorganization as the National Union of Railwaymen (N.U.R.) of which he mas appointed general secretary after the great railway strike of 1911. Under him the N U.R. became the leader in the policy of "industrial" or "all grades" as against "craft" trade unionism. Thomas became member for Derby in 1910 and a privy councilor in 1917. He was president and chairman of the parliamentary committee of the Trades Union congress (1920–21) and president of the International Federation of Trade Unions (1920–24).

In the Labour government of 1924 Thomas was secretary for the colonies; and in that of 1929 was made lord privy seal and minister of employment, and in 1930 secretary of state for the dominions. He retained this office in the national government of 1931, and consequently resigned his office in the N.U.R. In Nov. 1935 he became colonial secretary. In 1936 it was found that Thomas was, to some extent, responsible for a serious leakage of information concerning the budget before the date of its publication; and in consequence he resigned from the cabinet and from the house of commons. He died Jan. 21. 1949, in London.

THOMAS, PHILIP EDWARD (1878–1917), British author and poet, was born on March 3, 1878, and educated at St. Paul's School and at Lincoln college, Oxford. His first book, a volume of nature studies. *The Woodland Life* (1897), was followed by *Horae Solitariae* (1902), and numerous other works. including his critical studies of *George Borrow* (1912); *Swinburne* (1912); and *Walter Pater* (1913). But his prose work was done to order, and shows signs of constraint as to subject and time. A collection of his prose fragments appeared in 1928, under the title of *The Last Sheaf;* some of these were written under less exacting conditions, and allow more scope to his leisurely and precise genius. It was not till middle age that, under the influence of Robert Frost, the American poet. Thomas discovered himself as a poet. Thomas enlisted in the British army in 191j. and with freedom from routine literary work became extremely fluent. His verse was first written under the name of "Edward Eastaway" and a volume of *Poems* under his own name appeared in 1917. He was killed in France on April 9, 1917. His poetry is not sharply distinguished from his prose, the rhythms are quiet and unstressed. He was preeminently a poet of the country.

THOMAS, SIDNEY GILCHRIST (1850–1885), British inventor, was born on April 16, 1850, at Canonbury. London As a police court clerk he found time to study chemistry at the Birkbeck institute He set himself to solve the problem of separating phosphorus from iron in the Bessemer converter. and by the end of 187j he had discovered a method which was tested by his cousin, Percy C. Gilchrist, at the Blaenavon works, and found effective. In March 1878 the first public announcement of the discovery was made at the meeting of the Iron and Steel institute. A paper was written by Thomas and Gilchrist on the "Elimination of Phosphorus in the Bessemer Converter" for the autumn meeting of the institute, but was not read till May 1879. Thomas interested E. W. Richards. the manager of Bolckow, Vaughan & Co.'s works at Cleveland, Yorkshire, in the process. and from that time its success was assured and domestic and foreign patents were taken out. The "basic process" invented by Thomas was especially valuable on the continent. where the proportion of phosphoric iron is larger, and both in Belgium and in Germany the name of the inventor became more widely known than in his own country. Thomas died in Paris on Feb. 1, 1885.

See R. W. Burnie, Menzoirs *and* Letters of Sidney Gilchrist Thomas, Inventor (1891); L. G Thompson, Sidney Gilchrist Thomas, an Invention and Its Consequences (1940).

THOMAS, THEODORE (1835–1905), U.S. musician and conductor. was born in Esens, Ger.. on Oct. 11, 1835. His first public appearance as a violinist was made at the age of five. He was taken to the United States by his parents in 1845, and became first violin in the orchestra that accompanied Jenny Lind (1850), Sontag (1852) and Grisi and Mario (1854). In 1862 he began to organize his own orchestra, and in 1864 he inaugurated the series of Irving Hall symphony concerts, which for 14 years were regarded as one of the great musical institutions of New York city. To Theodore Thomas is largely due the popularization of Wagner's works in America, and it was he who founded the Wagner Union in 1872. In 1891. Thomas organized the Chicago Symphony orchestra, which has continued to be one of the foremost organizations of its class in the world. He died Jan. 4. 1905, in Chicago.

See biography by George P Upton; Charles Edward Russell, The *American* Orchestra and Theodore *Thomas* (1927).

THOMAS, WILLIAM ISAAC (1863–1947), pioneer U.S. sociologist, who specialized in social psychology as applied to cultural analysis and personality development. was born on Aug 13, 1863. in Russell county, Va. After graduating from the University of Tennessee. Knoxville, in 1884, he taught English there and at Oberlin (O) college for ten years. Turning to sociology, he received his Ph.D. in 1896 at The University of Chicago, where he studied physiology, neurology, philosophy and social psychology. He taught sociology consecutively at The University of Chicago, the New School for Social Research. New York city. and Harvard, and was a consultant at Yale. He died on Dec. 5, 1947, in Berkeley, Calif.

Thomas' *Source-Book for Social Origins* (1909) and *Primitize Behavior* (1937) reflected his interest in ethnography. His *Sex and Society* (1907) was the first fully secular approach to the subject written by an American sociologist His major work, *The Polish Peasant in Europe and America, j* vol (1918–21), prepared with F Znaniecki, illustrated his comparative approach to the study of nationalities and his analysis of social problems by means of personal history. *The Unadjusted Girl* (1923) and *The Child in America* (1928) were outstanding psychological studies of personality. His important methodological contributions mere the technique of personal history, described in the "Methodological Note" to his *Polish Peasant,* and his later "point-by-point procedure," based on the contention that theoretical formulations in sociology must be regarded as tentative until checked and developed by further research.

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(H. E BAR)

THOMAS À KEMPIS (*c.* 1380–1471), the name by which the Augustinian canon and writer Thomas Hammerken (Hammerchen, Malleolus) is commonly known. He was born in 1379 or 1380 in the town of Kempen, near Düsseldorf, in one of the many patches of territory between the Meuse and the Rhine belonging to the archiepiscopal principality of Cologne. His father was a poor hard-worked peasant; his mother kept a dame's school for the younger children of the town. John and Gertrude Hammerken had two sons. John and Thomas, both of nhom found their way to Deventer, and thence to Zwolle and to the convent of Mount St Agnes. Thomas reached Deventer when he was barely 12 years old, mas taught by a dame the beginnings of his learning, and in a few months to his great joy entered the classes of Florentius Radeuyn. After the fashion of the time he was called Thomas from Kempen, and the school title, as was often the case then, pushed aside the family name. Thomas Hammerken was forgotten; Thomas & Kempis has become known to the whole Christian world.

The school at Deventer had become famous long before Thomas à Kempis was admitted to its classes. It had been founded by Gerhard Groot (*q.v.*), a wealthy burgher nho had been won to pious living mainly through the influence of Ruysbroeck, the Flemish mystic. At Deventer, in the midst of this mystical theology and hearty practical benevolence, Thomas à Kempis was trained Gerhard Groot was his saintly ideal. Florentius Radewyn and Gerhard's other early disciples were his heroes; their presence was his atmosphere. the measure of their lives his horizon. But he was not like them; he was not an educational reformer like Radeuyn, nor a man of affairs like Gerhard. He liked books and quiet corners all his days, he says; and so, when conviction of sin and visions of God's grace came to him in the medieval fashion of a dream of the anger and forgiveness of the Virgin, Florentius told him that a monk's life would suit him best, advised him to join the Augustinian order, and sent him to Zwolle to the new convent of Mount St. Agnes, where his brother John was prior. Thomas was received there in 1399, professed the vows in 1407, received priest's orders in 1413, became sub-prior in 1425 and died on Aug. 8, 1471, at the age of ninety-one.

Works. — The convent of Mount St. Agnes was poor, and most of the monks had to earn money to support their household by copying MSS. Thomas was a most laborious copyist; missals, books of devotion and a famous MS. Bible were written by him. He also wrote a large number of original writings, most of them relating to the convent life, which was the only life he knew. He wrote a chronicle of the monastery and several biographies— the life of Gerhard Groot, of Florentius Radewyn, of a Flemish lady St. Louise, of Groot's original disciples; a number of tracts on the monastic life—The Monk's Alphabet, The Discipline of Cloisters, A Dialogue of Novices, The Life of the Good Monk, The Monk's Epitaph, Sermons to Novices, Sermons to *Monks,* The Solitary Life, On Silence, On Poverty, Humility and Patience; two tracts for young people—A Manual of Doctrine for the Young, and *A Manual* for Children; and books for edification— On True Compunction, *The* Garden of Roses, The Valley of Lilies, The Consolation of the Poor and the Sick, The Faithful Dispenser, The Soul's Soliloquy, The Hospital of the Poor. He also left behind him three collections of sermons, a number of letters, some hymns and the famous Imitatio *Christi* (though his authorship of this has been disputed).

Character. — These writings help us to see the man and his surroundings, and contemporary pious records make him something more than a shadow. We see a real man, but a man helpless anywhere save in the study or in the convent—a little fresh-coloured man, with soft brown eyes, who had a habit of stealing away to his cubiculum whenever the conversation became too lively; somewhat bent, for it is on record that he stood upright when the psalms were chanted, and even rose on his tiptoes with his face turned upwards; genial, if shy, and occasionally given to punning, as when he said that he preferred Psalmi to Salmones; a man who perhaps led the most placid uneventful life of all men who ever wrote a book or scribbled letters. His brethren made him oeconomiae prefectus, but he was too "simple in worldly affairs" and too absent-minded for the post, and so they deposed him and made him sub-prior once more. And yet it is this placid kindly fresh-coloured old man who has come down to us as the author of that book the Imitation of Christ, which has been translated into more languages than any other book save the Bible, and which has moved the hearts of so many men.

On the controversy as to the author of the Imitatio, see the article IMITATION OF CHRIST. See also James Williams. Thomas of Kempen (1910). The classical edition of the works of Thomas à Kempis by Sommalius—Thomas Malleoli *à* Kempis opera *omnia* (3 vols. in 1, 1607)—has been many times reprinted. A critical edition in 8 vols. by M. J. Pohl has also been undertaken. The best accounts in English of Thomas à Kempis are those by S. Kettlewell (1882) and F. R. Cruise (1887), written from the Protestant and the Catholic standpoints respectively. A penny tract by F. R. Cruise, entitled Outline of the *Life* of Thomas *à* Kempis (1904), contains substantially all that is known concerning him. (T. M. LI.)

THOMAS OF CELANO, Franciscan friar and disciple and biographer of St. Francis of Assisi. Born at Celano in the Abruzzi, he joined St. Francis probably about 1214, and he appears to have been one of the first band of friars who went into Germany. He was commissioned by Gregory IX. to write the Life of St. Francis, and in 1229 he completed the First Legend; in 1247 at the command of the minister general he composed the Second Legend, and a few years later the Tract on the *Miracles* of *St.* Francis. He also composed in 1255 the Legend of St. Clare; and he is one of those to whom the sequence Dies irae is attributed.

Thomas' of Celano's writings on St. Francis have been critically edited by E. d'Alençon in 1906. An English translation (The Lives of S. Francis of Assisi by Brother Thomas of Celano) by A. G. Ferrers Howell appeared in 1908. See FRANCIS OF ASSISI. (E. C. B.)

THOMAS OF ERCELDOUNE, called also THE RHYMER, and sometimes given the surname of LEARMONT (*fl.* ? 1220– ? 1297), poet and prophet in the legendary literature of Scotland. The historical person of that name figures in two charters of the 13th century, and from these it appears that he owned lands in Erceldoune (now Earlstoun), in Berwickshire, which were made over by his son and heir on Nov. 2, 1294, to the foundation of the Holy Trinity at Soltra (or Soutra) on the borders of the same county. This would imply that Thomas the Rhymer was already dead, but J. A. H. Murray, who edited The Romance and Prophecies (E.E.T.S., 1875), thinks that he was living three years later in a Cluniac priory in Ayrshire. He figures in the works of Barbour and Harry the Minstrel as the sympathizing contemporary of their heroes, and Walter Bower, who continued the *Scotichronicon* of Fordun, tells how he prophesied the death of Alexander III. in 1285.

In the folk-lore of Scotland his name is associated with numerous fragments of verse of a gnomic and prophetic character. The romance of Thomas and the elf-queen was attributed to Erceldoune by Robert Mannyng de Brunne, but the earliest text, in the Auchinleck ms. in the Advocates' library, Edinburgh, is in a dialect showing southern forms, and dates from the beginning of the 14th century. It may be based on a genuine work of Thomas, a version by him of the widely diffused Tristan Saga. The most widely accepted opinion is that it is a translation of a French original.

See J. A. H. Murray's edition of The Romance and Prophecies (E.E.T.S., 1875); Brandl's Thomas of Erceldoune (Berlin, 1880), and Kolbing's *Die nordische und* die *englische* Version der *Tristransage* (Heilbronn, 1882); also McNeill's Sir Tristrem (S.T.S., 1886); Lumby's Early Scottish Prophecies (E.E.T.S., 1870), and the reprint of the Whole Prophesie of Scotland (1603) by the Bannatyne Club (1833); J. Geddie, Thomas the Rymour and his Rhymes (Edinburgh, 1920).

THOMAS OF MARGA, a Nestorian bishop and author of an important monastic history in Syriac, who flourished in the 9th century A.D. He was born early in the century, probably of Persian parents, in the region of Salakh to the north-east of Mosul. As a young man he became in 832 a monk of the famous Nestorian monastery of Beth 'Ābhē, about 25 m. due east of Mosul when he acted as secretary to Abraham, who had been abbot of Beth 'Ābhē, and was catholicus (patriarch) of the Nestorians from 837 to 850. Thomas was promoted by Abraham to be bishop of Margā, and afterwards to be a metropolitan of Beth Garmai. It was during the period of his life at Beth 'Ābhē and his bishopric that he composed The Book of Governors, which is in the main a history of his own monastery, but includes lives of holy men in other parts of Mesopotamia and elsewhere.

The Book of Governors has been edited with an English translation and a copious introduction by E. W. Budge, 2 vol. (1893).

THOMOND, EARL AND MARQUESS OF, Irish titles borne by the great family of O'Brien. the earldom from 1543 to 1741 and the marquessate from 1800 to 1855. Thomond, or Tuaidh-Muin. was one of the three principalities of Munster, forming the northern part of the province. Its earls were descended from Turlough O'Brien (*c.* 1009–1086), king of Munster, and through him from the celebrated king of Ireland. Brian

Boroimhe. Turlough's descendants, Conchobhar O'Brien (d. 1267) and Brian Ruadh O'Brien (d. 1276), kings of Thomond, nere both typical Irish chieftains. Conchobhar's tomb and effigy with a crown are still to be seen in the ruined abbey of Corcomroe, County Clare. His descendant Conor O'Brien (d. 1539), prince of Thomond, took part in the feud between the great families of Fitzgerald and Butler and was the last independent prince of Thomond Conor's brother, MURROUGH O'BRIEN (d. 1551), prince of Thomond, the succeeding chief of the race, gave up his "captainship, title, superiority and country" to Henry VIII in 1543, when he was created earl of Thomond. By special arrangement the earldom descended, not to his son Dermod, but to his nephew. Donough, who became the 2nd earl. Dermod, however, inherited the barony of Inchiquin, which was conferred upon his father at the same time as the earldom.

CONOR O'BRIEN, the 3rd earl (c. 1534–*c.* 1582), was for some years at the outset of his career, harassed by the attacks of his discontented kinsmen. Then in his turn he rose against the English, but was defeated and fled to France; in 1571, however, he was pardoned and formally surrendered his lands.

DONOUGH O'BRIEN, the 4th earl (d. 1624), called the "great earl." mas the son and successor of the 3rd earl. He served England well in warfare with the rebellious Irish during the closing year of Elizabeth I's reign and was made president of Munster in 1605. The 8th earl, Henry (1688–1741), was created an English peer as Viscount Tadcaster. When he died the earldom of Thomond became extinct

The estates of the earldom descended to the last earl's nephew, PERCY WYNDHAM (*c.* 1713–1774), a younger son of Sir William Wyndham, Bart. He took the additional name of O'Brien and was created earl of Thomond in 1756. When he died unmarried the title again became extinct.

In 1800 MURROUGH O'BRIEN, 5th earl of Inchiquin (c. 1724–1808), was created marquess of Thomond. His brother James, the 3rd marquess (*c.* 1768–1855), was an officer in the navy and became an admiral in 1853. When he died the marquessate became extinct.

See John O'Donoghue, *Historical Memoirs of the O'Briens* (1860).

THOMPSON, SIR BENJAMIN (COUNT VON RUMFORD) (1753–1814), British-American scientist particularly noted for his researches on heat, and a founder of the Royal institution, was born at Woburn. Mass., on March 26, 1753. In 1766 he was apprenticed to a storekeeper in Salem, Mass , and became interested in chemical and mechanical experiments and in engraving. On the evacuation of Boston by British troops in 1776 he went to London, where he was appointed to a clerkship in the office of the secretary of state. Within several months he was advanced to the post of secretary of the colony of Georgia and in 1780 became undersecretary of state. During this period he continued his scientific pursuits, however, and 1779 was elected a fellow of the Royal society. Thc explosive force of gunpowder, the construction of firearms and a system of signaling at sea were subjects which particularly interested him. On the resignation of Lord North's administration Thompson left the civil service and went to Austria. At Strasbourg he was introduced to Prince Maximilian, afterward elector of Bavaria, and was invited by him to enter the civil and military service of that state. Having obtained permission from the British government to accept the prince's offer and having received the honor of knighthood from George III, he remained at Munich 11 years as minister of war, minister of police and grand chamberlain to the elector. During his stay in Bavaria he reorganized the Bavarian army, improved the conditions of the industrial classes, did much to suppress mendicancy and also contributed a number of papers to the *Philosophical* Transactions.

In 1791 he was created a count of the Holy Roman empire and chose his title of Rumford from the name of the American township to which his wife's family belonged. In 1795 he visited England. where he lost all his private papers including the materials for an autobiography. In London he investigated methods for curing smoky chimneys and for improving fireplace construction. For a short time he was recalled to service in Bavaria, but in 1798 he returned to England. That year he presented to the Royal society his celebrated "Enquiry Concerning the Source of Heat Which is Excited by Friction," in which he regarded heat as a mode of motion, as opposed to the then current view that it was a material substance. In 1799, with Sir Joseph Banks, he projected the establishment of the Royal institution, which received its charter from George III in 1800, and selected Sir Humphrey Davy as scientific lecturer there. Rumford died at Auteuil, near Paris, on Aug. 21, 1814.

He was founder and first recipient of the Rumford medal of the Royal society, founder of the Rumford medal of the American Academy of Arts and Sciences and founder of the Rumford professorship in Harvard university. His complete works, with a memoir by George H. Ellis, were published by the American Academy of Arts and Sciences in 1870–75.

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THOMPSON, SIR D'ARCY WENTWORTH (1860–1948). Scottish biologist and hellenist. was born in Edinburgh on May 2, 1860. After graduating at Trinity college, Cambridge, he became professor of natural history at University college, Dundee, and then at St. Andrews university, holding the chair for 64 years. He was a fellow (1916), vice-president (1931–33) and Darwin medalist (1946) of the Royal society, president of the Classical association (1929), knighted (1937) and honoured by learned institutions the world over. For more than 50 years he was a leading member of national and international bodies investigating sea fisheries. His classic work On Growth and Form (1917; new ed., 1942), written in rich literary style, exemplifies best his great erudition in physical and natural sciences, ancient and modern languages and the humanities. Herein growth and structure in organisms are expressed in mathematical and physical terms and an important "theory of transformation" developed—that one species evolves into another not by successive minor changes in individual body parts but by large-scale transformations involving the body as a whole. He died at St. Andrews on June 21, 1948.

Sir D'Arcy Thompson's works include *A* Glossary of Greek Birds (1895; new ed., 1936). Science and the Classics, etc. (1940) and *A* Glossary *of* Greek Fishes (1947).

See Ruth *D'A.* Thompson, *D'Arcy Wentworth Thompson* (1958).
(*A.* D. P.)

THOMPSON, FRANCIS (1859–1907), English poet, whose best-known poem, "The Hound of Heaven," describes the divine pursuit of the human soul, was born at Preston, Lancashire. on Dec. 18, 1859. He was the son of Charles Thompson, a doctor, and the nephew of Edward Healy Thompson, the friend of Cardinal Manning and professor of English literature at the Catholic university in Dublin. After his father became a convert to Roman Catholicism, Francis was educated in the Catholic faith at Ushaw college. In 1877 he proceeded to Owen's college, Manchester, to study medicine. He took more interest in Aeschylus, Blake and De Quincey's Confessions of an English Opium Eater than in his work, however; and. having failed the examinations three times, he went to London in Nov. 1885 to seek a livelihood. Ill-health drove him to opium, and poverty reduced him to selling matches and newspapers. Eventually he found light work with a Leicester square bootmaker and wrote his first poems. In 1888 Wilfrid Meynell published two poems in Merry England, which aroused the admiration of Browning. Discovering the young author on the verge of starvation, the Meynells induced him to enter a hospital, aided him through his long convalescence and in 1893 arranged for the publication of his first volume, Poems, which was highly praised by Coventry Patmore, among others. Sister Songs (dedicated to the Meynells' children) followed in 1895, and New Poems (dedicated to Patmore) in 1897. From 1893 to 1897, apart from short intervals, Thompson lived near the Franciscan monastery in Pantasaph, North Wales. He died in London on Nov. 13, 1907, of tuberculosis, and was buried in the Catholic cemetery at Kensal Green.

Thompson's language is customarily orotund, ornate and farfetched; too often the reader is aware of the poet's self-conscious posturing. The common comparison with Richard Crashaw is misleading. The older poet, though he has something of Thompson's equivocal sensuousness, displays greater care for the meaning of words and maintains a more consistent dignity. Subject aside, the kinship is rather with the Keats of *Endymion*. Thompson is, undeniably, a poet of the "aesthetic" 1890s. His simpler poems (*e.g.*, about children) are frequently marred by a mawkishness of which the poet seemed perversely proud. It is likely that his place in literature will depend entirely upon "The Hound of Heaven," where language and subject matter are more properly matched, and which, by virtue of its dramatic quality, is in fact nearer in spirit to the religious poetry of the 17th century (*cf.* George Herbert), though in this too the somewhat florid religiosity of the 1890s may occasionally repel the reader.

Thompson also wrote several prose works, including *Health and Holiness* (1905), *Life of St. Ignatius Loyola* (1909), *Life of Blessed John Baptist de la Galle* (1911) and *Essay on Shelley* (1909). His *Literary Criticisms* were edited by T. L. Connolly (1948). Thompson's *Works* were edited by W. Meynell, 3 vol. (1913); *Poems* were reprinted in 1 vol. (1937); *Selected Poems* (1908) includes an obituary by W. Meynell.

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THOMPSON, SIR JOHN SPARROW (1844–1894), Canadian jurist and statesman, was born at Halifax. Nova Scotia, on Nov. 10, 1844. of Irish descent. In 1877 he was elected to the local legislature for Antigonish as a Conservative. and in 1878 became attorney general. In May 1882 he became premier. but in June was defeated at the general election, though retaining his own seat, and in July was made a judge of the provincial supreme court. In Sept 1885 he was appointed minister of justice in the federal cabinet, and soon after was elected member for Antigonish. In 1886 he successfully defended in the federal parliament the hanging of Louis Riel (*q.v*), which had greatly angered the French Roman Catholics: in 1887–88, together with Mr. Joseph Chamberlain and Sir Charles Tupper, he arranged a Fisheries treaty with the U.S. commissioners, which was afterward thrown out by the United States senate. During the following years he defended the government with great skill in various politico-religious disputes, and in Nov. 1892 he became premier of Canada. He died suddenly on Dec. 12, 1894, at Windsor castle, a few minutes after having been sworn in by Queen Victoria as a member of the privy council.

His *Life* has been written by J. C Hopkins (Toronto, 189;).

THOMPSON, WILLIAM TAPPAN (1812–1882), U.S. humorist remembered for his realistic character sketches of Georgia-Florida backwoodsmen, was born Aug. 31, 1812, in Ravenna, O He early moved to Georgia, where as a self-made man whose education came from the printing press, he identified himself with Georgia life and culture. In 1838 he founded the *Augusta Mirror*, a literary magazine. Discovering that the south would not support literary periodicals, he turned in 18jo to newspaper editorship. founded the *Savannah* (Ga.) *Morning News*, and continued as editor until his death in Savannah on March 24. 1882. A Democrat throughout his editorial career, he typified the ideals, attitudes and prejudices of middle-class Georgians.

Influenced by Augustus Baldwin Longstreet, his personal friend, Thompson wrote amusing dialect letters which were collected in 1843 as *Major Jones' Courtship;* the book achieved nation-wide popularity. Other volumes followed. Thompson had a demonstrable influence on Mark Twain. Richard Malcolm Johnston and Joel Chandler Harris, his literary protégé. His popular antebellum humour is accepted as convincing Georgia dialect and as realistic local colour.

See also Walter Blair, *Native American Humor* (1937); Henry Prentice Miller, "The Background and Significance of *Major Jones's Courtship*," *Georgia Historical Quarterly*, xxx, 267–296 (1946). (H. P. M.)

THOMSEN, (HANS PETER JÖRGEN) JULIUS (1826–1909), Danish chemist best known for his work on thermochemistry, was born in Copenhagen on Feb. 16, 1826, and spent his life in that city. From 1847 to 1856 he was engaged in teaching chemistry at the Polytechnique, of which from 1883 to 1892 he acted as director. From 1856 to 1866 he was on the staff of the military high school. He and his brother August founded the important *Journal of Chemistry and Physics*, one of the principal scientific periodicals in Denmark, of which he was editor from 1862–78. In 1866 he was appointed professor of chemistry at the University of Copenhagen and retained that chair until 1891 when he retired. He was awarded the Davy medal in 1883 and elected a foreign member of the Royal society in 1902. He was a member of the municipal council for about 35 years. and the gas, water and sewage systems of Copenhagen mere largely the results of his civic activity. He died on Feb. 13, 1909.

He was attracted to thermochemistry as early as 1852, as his first published paper, entitled "Contributions to a Thermochemical System." shows. But his comprehensive work in this subject was not started until some years later. The results first appeared in 1869, and were published from time to time until 1882. They were collected in *Thermochemische Untersuchungen*, 4 vol (1882–88), and a summary in Danish appeared in 1905. The latter was translated into English as *Tlzermochemistry* by Katherine Burke.

In the course of his thermochemical work Thomsen made about 3,500 calorimetric measurements and he determined the heat evolved or absorbed in a very large number of chemical reactions. Incidentally he verified Kirchoff's equation connecting the change of heat of a reaction with temperature and the specific heats of the reactants and resultants, and also used his measurements to confirm Guldberg and Waage's theory of mass action (1867). Thomsen introduced the term "avidity" to indicate the tendency of an acid to unite with a base and used his results to draw up the first table of relative strengths of acids He also worked on selenic acid, platinum compounds and hydrogen peroxide and made accurate determinations of the atomic weights of oxygen and aluminum In 1853 Thomsen devised a process for manufacturing soda from cryolite, which was first worked on a large scale in 1857 and made him rich. His polarization battery received many awards at international exhibitions and was used in the Denmark telegraphic service. In 1895 he predicted the existence of a group of inactive gases.

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THOMSON, SIR CHARLES WYVILLE (1830–1882), Scottish naturalist especially remembered as a student of the biological conditions of the depths of the sea and as director of the scientific staff in the "Challenger" expedition (*q.v.*), was born at Bonsyde, West Lothian (Linlithgowshire). on March 5, 1830, and was educated at Edinburgh university. At first a botanist by profession, he was lecturer in botany at Aberdeen university from 1851 to 1852, and professor of botany at Marischal college from 1852 to 1853. His leanings, however, were toward zoology, and between 1853 and 1868 he taught natural sciences at Cork and at Belfast. Having been for a short time (1868–70) professor of botany at the Royal College of Science. Dublin. he finally (1870–79) was professor of natural history at Edinburgh. He died at Bonsyde on March 10, 1882. Thomson's interest in crinoids was stimulated by the results of the dredgings of the Norwegian zoologist Michael Sars in the deep sea off the Norwegian coasts. With W. B. Carpenter son of the Unitarian minister Lant Carpenter and brother of the philanthropist Mary Carpenter, he succeeded in obtaining the loan of H.M.S. "Lightning" and "Porcupine" for successive deep-sea dredging expeditions in 1868 and 1869. These operations showed that animal life exists in abundance down to depths of 650 fathoms, that all invertebrate groups are represented (largely by Tertiary forms previously believed to be extinct) and, moreover, that deep-sea temperatures are by no means so constant as was supposed, but vary considerably, indicating an oceanic circulation. The results of these expeditions were described in ***The***

Depths of the Sea (1873). The government realized the value of the work and provided H.M.S. "Challenger" for a circumnavigating expedition. Thomson sailed at the end of 1872 as director of the scientific staff, the cruise lasting three and one half years. On his return he received many academic honours, and was knighted. In 1877 he published two volumes of a preliminary account of the voyage *(The Voyage of the "Challenger"*; and *The Atlantic)* and, with John Murray, superintended the preparation of the full reports until the time of his death.

THOMSON, CHRISTOPHER BIRDWOOD, 1ST BARON, cr. 1924 (1875–1930), British soldier and statesman) was born on April 13, 1875. Educated at Cheltenham and the Royal Military academy, Woolwich, he served in the Mashonaland campaign and in the South African War. From 1902–05 he was instructor at the military engineering school at Chatham. In 1909 he passed on to the Staff college and in 1911 to the war office. During World War I he served as military attach6 and chief of the British military mission in Rumania (1915–16), and in Palestine (1917) and was on the supreme war council in 1918. Having attained the rank of brigadier general, he resigned from the service in 1920 as a protest against Allied intervention in Russia. He joined the Labour party, and accompanied, as military expert, the commissions of enquiry dispatched by that body to Ireland and to the Ruhr; later, he visited Russia. In 1922, and again in 1923, he stood for parliament in the Labour interest, but was unsuccessful. In 1924, he was appointed air minister in the first Labour government, with a seat in the cabinet, and raised to the peerage. A graceful and effective speaker, Lord Thomson also possessed marked literary gifts and published various writings including *Old Europe's Suicide* (1922); *Victors and Vanquished* (1924). He was killed in the crash of the airship R·IOI in 1930.

THOMSON, ELIHU (1853–1937), U.S. inventor, was born in blanchester, England, March 29, 1853, but moved to Philadelphia, Pa., with his parents in 1858. He received a public school education and in 1876–80 was professor of chemistry and mechanics at the Central high school in Philadelphia. In 1880 he went to New Britain, Conn., as electrician for the American Electric company and two years later he united with Edward J. Houston to found the Thomson-Houston Electric company in Lynn, Mass. In 1892 a merger took place between this company and the' Edison General Electric company to form the General Electric company, the largest manufacturer of electrical equipment in the world. Thomson remained as director of the large laboratory in Lynn, renamed after him the Thomson laboratory. Thomson made the first important research into the nature of the laws governing the electric arc, disclosing the fact that the resistance of the arc varies inversely with the current. He invented and constructed an arc light dynamo with a spherical three-coil armature, and the first with an automatic regulator, which went into commercial use in 1880. He was the first to utilize a magnetic field to move an electric arc, a principle which found many uses, notably in the construction of the magnetic blowout switches. In his notable discovery of the so-called alternating current repulsion phenomena he laid the basis for successful alternating current motors. He made the first high-frequency dynamo in 1890 and shortly afterward the first high-frequency transformer, and was a pioneer in the development of other high-frequency apparatus. In 1886 he invented the art of electric welding by the incandescent method which was simpler and less expensive than previous methods and applicable to a wider range of metals.

Thomson also invented the electric watt-hour meter, while the arc lamp, incandescent lamp, alternator, alternating current transformers and railway motors found improvement at his hands. He made many contributions to the field of radiology and was the first to make stereoscopic X-ray pictures. He published many articles in scientific journals, held over 700 patents, and received the Rumford, John Fritz, Kelvin and Faraday medals as well as other honours.

See D. O. Woodbury, *Beloved Scientist: Elihu Thomson, A Guiding Spirit of the Electrical Age* (New York, 1944); *Elihu Thomson, Eightieth Birthday Celebration at the Massachusetts Institute of Technology* (Cambridge, 1933).

THOMSON, SIR GEORGE PAGET (1892–), English physicist, a co-winner of the Nobel prize for physics in 1937 for his work on the diffraction of electrons in crystals, was born in Cambridge, Eng., May 3. 1892, the only son of Sir Joseph John Thomson (*q.v.*), the eminent physicist and Nobel prize winner (1906). After taking his degree at Trinity college, Cambridge, in 1914, he saw service in World War I in France and was later a member of the British war mission in the U.S. At the end of the war he worked in the Cavendish laboratory at Cambridge. In 1922 he was appointed professor of natural philosophy in the University of Aberdeen, and it was there that he did work on the diffraction of electrons in crystals which established the wave properties of moving electrons and also had important practical applications. By means of the electron diffraction camera it is possible to determine the arrangement of the atoms in many solids and liquids, and this threw much light on the question of stress and resistance in metals. From 1930 to 1952 Thomson was professor of physics in the Imperial College of Science and Technology, University of London. During and after World War II he was one of the principal scientific advisers to the British government and to the UN Atomic Energy commission. He was elected a fellow of the Royal society in 1930 and was awarded the Hughes medal in 1939 and the Royal medal in 1949; he was knighted in 1943. In 1952 he became master of Corpus Christi college, Cambridge.

He wrote *Applied Aerodynamics* (1919); *The Atom* (1930; 5th ed., 1955); *Wave Mechanics of Free Electrons* (1930); *Theory and Practice of Electron Diffraction* (with William Cochrane, 1939); and *The Foreseeable Future* (1955); he also helped revise his father's *Conduction of Electricity Through Gases* (3rd ed., 2 vol., 1928–33). (W. J. BP.; X.)

THOMSON, JAMES (1700–1748), English poet, author of *The Seasons*, was born at Ednam, in Roxburghshire, on Sept. 11, 1700—the third son and fourth child of Thomas Thomson, minister of that place. About 1701 Thomas Thomson removed to Southdean near Jedburgh. Here James was educated at first by Robert Riccaltoun, to whose verses on winter he owed the idea of his own poem, and then at a school at Jedburgh. In 1715 he went to Edinburgh university. He became a divinity student, and it was partly to make a reputation as a preacher that he went to London in March 1725. He had already friends in London in Lady Grizel Baillie and Duncan Forbes of Culloden, and he was introduced by them to literary society in London, where he supported himself partly by acting as tutor.

The Seasons.——Thomson's *Winter* appeared in March 1726. It was dedicated to Sir Spencer Compton. the speaker, uho rewarded the poet. to his great disgust, with a bare 20 guineas. *Summer* appeared in 1727, dedicated to Bubb Dodington. In the same year Thomson published his *Poem to the Memory of Sir Isaac Newton. Spring* appeared in 1728, published by Andrew Millar. In 1729 he produced *Sophonisba*, a tragedy now only remembered by the line "O Sophonisba, Sophonisba, 0," and the parody "O Jemmy Thomson, Jemmy Thomson, O." A poem, anonymous but unquestionably Thomson's, to the memory of Congreve appeared in the same year. In 1730 *Autumn* was first published in a collected edition of *The Seasons.* It was dedicated to the speaker, Onslow. In this year, he accompanied the son of Sir Charles Talbot, solicitor-general, upon his travels. In the course of these he projected his *Liberty* as "a poetical landscape of countries, mixed with moral observations on their government and people." In Dec. 1731 he returned with his pupil to London. His pupil died soon after, and Talbot, who became chancellor, gave Thomson a sinecure in chancery. The first part of *Liberty* appeared in 1734–35, and it was completed in five parts in 1736. The poem was a failure; its execution did not correspond with its design; in a sense indeed it is a survey of countries and might have anticipated Goldsmith's *Traveller.* The truth is that Thomson's poetical gift was for many years perverted by the zeal of partisanship.

His patron died in Feb. 1737 and he lost his sinecure. His tragedy *Agamemnon* appeared in April 1738, not before he had been arrested for a debt of £70, from which, according to a story which has been discredited on quite insufficient grounds, Quin relieved him in the most generous and tactful manner. The incident took place probably a little before the production of *Agarnemnon,* in which Quin played the leading part. The play is of course modelled upon Aeschylus and owes whatever of dignity it possesses to that fact; the part of Cassandra, for instance, retains something of its original force. But most of the other characters exist only for the purpose of political innuendo. Agamemnon is George, absent in Germany; Aegisthus is Walpole, and so on. As a result his next tragedy, *Edward and Eleanora,* was banned. This event sufficiently accounts for the poet's next experiment, a preface to Milton's *Areopagitica.* He joined Mallet in composing the masque of *Alfred,* represented at Clieveden on the Thames before the prince of Wales, on Aug. 1, 1740. There can be little question that "Rule Britannia," a song in this drama, was the production of Thomson. The music of the song, as of the whole masque, was composed by Arne. In 1744 Thomson was appointed surveyor-general of the Leeward Islands by Lyttelton with an income of £300 a year; this improved his circumstances considerably, and whilst completing at his leisure *The Castle of Indolence,* he produced *Tancred and Sigismunda* at Drury Lane in 1745.

Eventually *The Castle of Indolence,* after a gestation of 15 years, appeared in May 1748. It is in the Spenserian stanza with the Spenserian archaism, and is the first and last long effort of Thomson in rhyme. The great and varied interest of the poem might well rescue it from the neglect into which even *The Seasons* has fallen. It was worthy of an age which was fertile in character-sketches, and excels in the lifelike presentation of a noteworthy circle. It is the last work by Thomson which appeared in his lifetime. In walking from London to his house at Richmond he became heated and took a boat at Hammersmith; he thus caught a chill and died on Aug. 27, 1748. He was buried in Richmond churchyard. His tragedy *Coriolanus* was acted for the first time in Jan. 1749. In itself a feeble performance, it is noteworthy for the prologue which his friend Lyttelton wrote, two lines of which—

> He loved his friends—forgive the gushing tear!
> Alas! I feel I am no actor here—

were recited by Quin with no simulated emotion.

Precursor of Romanticism.—It may be questioned whether Thomson himself ever quite realized the distinctive significance of his own achievement in *The Seasons,* or the place which criticism assigns him as the pioneer of a special literary movement and the precursor of Cowper and Wordsworth. His avowed preference was for great and worthy themes of which the world of nature was but one, but fortunately his readers were wiser than himself. And though he recalled the minds of his contemporaries from the town to the country, in his feeling for nature, he is a true man of his age; his descriptions are general, and purely objective. There is no hint yet of the emotional reactions of the Romantic school. He has many audacities and many felicities of expression, and enriched the vocabulary even of the poets who have disparaged him. Yet it is difficult to believe that he was not the better for that training in refinement of style which he partly owed to Pope.

The first collected editions of *The Seasons* bear dates 1730, 1738, 1744, 1746. Lyttelton tampered both with *The Seasons* and with *Liberty* in editions after his friend's death. Among the numerous lives of the poet may be mentioned those by his friend Patrick Murdoch, by Dr. Johnson in *Lives of the Poets,* by Sir Harris Nicolas (Ald. ed., 1860), by M. Morel, *James Thomson, sa vie et ses oeuvres* (Paris, 1895), and *James Thomson,* in the English Men of Letters Series, by G. C. Macaulay (1908). *See* also Dr. G. Schmeding's *Jacob Thomson, ein vergessener Dichter des achtzehnten Jahrhunderts;* the life prefixed to the Aldine edition of his works in 1897; and an excellent edition of *The Seasons* in the Clarendon Press Series by J Logie Robertson. Also A. H. Thompson in *Cambrzdge History of English Lzterature,* vol. 10 (1913). (D. C. To.; X.)

THOMSON, JAMES (1834–1882), British poet, best known by his signature "B.V.", was born at Port-Glasgow, in Renfrewshire, on Nov. 23, 1834, the eldest child of a mate in the merchant shipping service. His mother was a deeply religious woman of the Irvingite sect. On her death, James, then in his seventh year, was procured admission into the Caledonian Orphan asylum. In 1850 he entered the model school of the Military asylum, Chelsea. As assistant army schoolmaster at Ballincollig, near Cork, he encountered the one brief happiness of his life: he fell passionately in love with, and was in turn as ardently loved by, the daughter of the armourer-sergeant of a regiment in the garrison, a girl of very exceptional beauty and cultivated mind. Two years later he suddenly received news of her fatal illness and death. The blow prostrated him in mind and body. Henceforth his life was one of gloom, misery and poverty, rarely alleviated.

While in Ireland he had made the acquaintance of Charles Bradlaugh, then a soldier stationed at Ballincollig. In 1860 was established the paper with which Bradlaugh was so long identified, the *National Reformer,* in which, among other productions by James Thomson, there appeared (1861) the powerful and sonorous verses "To our Ladies of Death," and (1874) his chief work, the sombre and imaginative *City of Dreadful Night.* In Oct. 1862 Thomson was dismissed from the army, in company with other teachers, for some slight breach of discipline. Through Bradlaugh, with whom he lived for some years, he gained employment as a solicitor's clerk. From 1866 to the end of his life, except for two short absences from England, Thomson lived in a single room, first in Pimlico and then in Bloomsbury. He was intemperate in his habits, and made few friends. In 1869 his long poem, "Sunday up the River," appeared in *Fraser's Magazine.* In 1872 Thomson went to the western states of the U.S., as the agent of the shareholders in what he ascertained to be a fraudulent silver mine; and in 1873 he received a commission from the New York *World* to go to Spain as its special correspondent.

On his return to England he continued to write in the *Secularist* and the *National Reformer,* under the initials "B.V."[1] In 1875 he severed his connection with the *National Reformer,* owing to a disagreement with its editor; henceforth his chief source of income (1875–81) was from the monthly periodical known as *Cope's Tobacco Plant.* Chiefly through the exertions of his friend and admirer, Bertram Dobell, Thomson's best-known book, *The City of Dreadful Night, and other Poems,* was published in April 1880, and at once attracted attention; it was succeeded in the autumn by *Vane's Story, and other Poems,* and in the following year by *Essays and Phantasies.* All his best work was produced between 1855 and 1875 ("The Doom of a City," 1857; "To our Ladies of Death," 1861; *Weddah and Om-el-Bonuin,* "The Naked Goddess," 1866–67; *The City of Dreadful Night,* 1870–74). He died at University College Hospital, in Gower Street, London, on June 3, 1882, and was buried at Highgate cemetery, in the same grave, in unconsecrated ground, as his friend Austin Holyoake.

To the productions of James Thomson already mentioned may be added the posthumous volume entitled *A Voice from the Nile, and other Poems* (1884), to which was prefixed a memoir by Bertram Dobell. If James Thomson has distinct affinity to any writer it is to De Quincey. The merits of Thomson's poetry are its imaginative power, its sombre intensity, its sonorous music; to these characteristics may be added, in his lighter pieces, a Heine-like admixture of strange gaiety, pathos and caustic irony. The same may be said of his best prose. His faults are a monotony of epithet, the not infrequent use of mere rhetoric and verbiage.

See the *Life, by* H. S. Salt (1905 edition).

THOMSON, SIR JOHN ARTHUR (1861–1933), British naturalist known chiefly for his popular books and writings on biology, was born at East Lothian, Scot., on July 8, 1861, and was educated at the universities of Edinburgh, Jena and Berlin. He was, for a time. lecturer on zoology and biology at the school of medicine in Edinburgh, and in 1899 he became regius professor of natural history at Aberdeen university. Apart from his purely zoological work, chiefly on alcyonarians, Thomson did much, both by his lectures and his numerous attractive books and writings, to popularize biological science, and he was indefatigable in his efforts to correlate science and religion. He was knighted in 1930 and died Feb. 12, 1933.

His publications include: *Outlines of Zoology,* 9th ed. (1944); *The Wonder of Life* (1914); *The System of Animate Nature,* Gifford Lectures (1920); *Science, Old and New* (1924); *The New Natural History* (1925); *Science and Religion* (1925).

[1]Bysshe Vanolis: "Bysshe," as the commonly used Christian name of Shelley, Thomson's favourite writer; and "Vanolis," an anagram of Novalis (F. von Hardenberg).

THOMSON, JOSEPH (1858–1895), Scottish explorer and the last who, during the late 18th and part of the 19th centuries revealed the interior of Africa, was also the first who served the chartered companies developing the new discoveries. Born on Feb. 14, 1858, at Penpont, Dumfriesshire, he studied geology at Edinburgh university under Archibald Geikie, and in 1878 was appointed geologist and naturalist to the Royal Geographical society's expedition to east central Africa, under Keith Johnston. Johnston's early death left Thomson in command and, with David Livingstone's Chuma as his headman, he led the expedition to the north end of Lake Nyasa and thence to Lake Tanganyika. An attempt to reach the Congo was thwarted by the hostile Warua, and he returned to the coast by Tabora, discovering Lake Rukwa on the way. He investigated some spurious coal mines on the Rovuma for the sultan of Zanzibar in 1881.

In 1882 the Royal Geographical society launched an expedition led by Thomson to probe the shortest route from the sea to the Nile headwaters, a may hitherto barred by the warlike Masai. Thomson traveled from Mombasa by way of Mounts Kilimanjaro and Kenya, discovered Lake Baringo and, surviving numerous encounters with the Masai, reached Lake Victoria on Dec. 10, 1883.

Thomson received the Royal Geographical society's founder's gold medal for 1885. In 1885 he undertook a mission for the National African (afterward the Royal Niger) company, securing trade treaties with the sultans of Sokoto and Gando, in 1888 he traveled privately in Morocco and in 1890 he entered the service of Cecil Rhodes' South Africa company, on whose behalf he made trade and mining agreements in what is now Northern Rhodesia. Thomson's splendid constitution at last gave way, and he returned to Gatelawbridge in 1891 in permanently impaired health. He died in London on Aug. 2, 1895.

Thomson's maxim when traveling was the Italian saying: "Who goes slowly, goes safely; who goes safely, goes far," and he was notable for his abhorrence of force. He wrote *To tlze Central African Lakes and Back* (1881), *Through Masui Land* (1884), *Travels in the Atlas and Southern Morocco* (1889).

See J. B. Thomson, *Joseph Thomson, African Explorer* (1896), which contains a full list of his writings. (D. Mn.)

THOMSON, SIR JOSEPH JOHN (1856–1940), English physicist, the discoverer of electrons and the recipient of the 1906 Nobel prize in physics for his work on the conduction of electricity through gases, was born at Cheetham Hill, near Manchester, on Dec. 18, 1856. At the age of 14 he enrolled at Owens college, Manchester. In 1876 he went to Cambridge and entered Trinity college as a minor scholar; he remained a member of this college, in one capacity after another, during the rest of his life. In 1884 he was elected a fellow of the Royal society and upon the resignation of Lord Rayleigh that same year was chosen his successor in the Cavendish professorship at Cambridge, a chair which he held until 1919.

Thomson's treatise on vortex rings, which won him the Adams prize and which may be taken as an indication of his early interest in atomic structure, appeared in 1883. Ten years later, in 1893, his *Notes on Recent Researches in Electricity and Magnetism* appeared. This book covers results obtained after the appearance of James Clerk Maxwell's great *Treatise* in 1873, and is often alluded to as "the third volume of Maxwell." *A Textbook of Physics,* in four volumes, was the joint work of Thomson and John H. Poynting. These books had a wide use, as did Thomson's *Elements of the Mathematical Theory of Electricity and Magnetism* (1895; 5th ed., 1921).

In 1896, Thomson gave a course of four lectures at Princeton university. These summarized his researches on the *Discharge of Electricity Through Gases.* Several years later, at Yale university, he gave a series of six lectures on *Electricity and Matter* (1904) in which some keen suggestions looking toward atomic structure were offered. It was, however, between these two series of C.S. lectures that he accomplished the most brilliant work of his life. This was the highly original study of cathode rays, in which he measured the ratio $\frac{m}{e}$ (where m is mass and e the charge of an ion) and discovered that its value is nearly 1,000 times less than in the electrolysis of liquids. He immediately proceeded to measure the charge of electricity, e, carried by various negative ions and found it to be the same in the gaseous discharge as in electrolysis. In this manner the fact was established that the particles which constitute cathode rays are much smaller than the smallest atoms known. They are the particles now called "electrons." This discovery of a body smaller than the hydrogen atom was first announced in his Friday evening lecture at the Royal institution on April 30, 1897.

In 1903 he published his most remarkable book, *Conduction of Electricity Through Gases,* described by Lord Rayleigh as a summary of "the work of Thomson's great days at the Cavendish laboratory." A later edition, in two volumes, was published in collaboration with his son, George P. Thomson (*q.v.*) in 1928 and 1933.

Thomson's later researches led to an exceedingly important discovery, namely, a new method of separating different kinds of atoms and molecules. This consists in the use of "positive rays," the deflection of which in a magnetic or electric field varies, other things being equal, with the atomic weight. This idea, in the hands of Francis W. Aston, A. J. Dempster and others, led to the discovery of many isotopes (*q.v.*).

Thomson was president of the Royal society from 1915 to 1920 and master of Trinity college from 1918 to 1940. He died in Cambridge on Aug. 30, 1940; his ashes were buried in Westminster abbey. His autobiographical *Recollections and Reflections* was published in 1936.

For a complete chronological list of Thomson's 231 scientific papers and of his 13 books, see *Obituary Notices of Fellows of the Royal Society,* vol. 3, pp. 598–609 (1931); *see* also Lord Rayleigh, *Life of Sir J. J. Thomson* (1943). (H. Cm.; X.)

THONBURI, a city and province in central Thailand on the west bank of the Chao Phraya river across from Bangkok. Area of province 174 sq.mi., pop. (1956 est.) 445,093. Approximately 28% of the city's population (1957 est., 319,909) is of immediate Chinese descent, 16% being China-born. Connected by three bridges with Bangkok, the city has in effect become a suburb of the capital.

Thonburi is a centre for sawmilling, rice milling and light manufacturing industry. Many of its people live on *khlongs* or canals, on which "floating markets" can be seen. The most prominent landmark is Rat Arun, the Temple of Dawn. During the reign of King Taksin (1767–82), Thonburi was the national capital. Paddy production for the province averages about 40,000 metric tons annually. (G. W. Sk.)

THONET, MICHAEL, (1796–1871), Austrian manufacturer, originator of bentwood furniture, was born July 2, 1796, at Boppard in the Rhineland. A humble artisan, Thonet by the age of 40 developed a system of steam-bent veneers, glued four or five together, from which he made complete chairs, light and curvilinear. Similar techniques were simultaneously used, but less freely, by the German-born Henry Belter in New York city, and bent plywood had even been used by the ancient Egyptians for mummy cases. Thonet's inventiveness attracted Prince Metternich, another native Rhinelander, who in 1842 invited Thonet to settle in Vienna, where for the next five years he worked on the masterly neorococo interiors of the Liechtenstein palace.

Some of Thonet's work there included bent, solid wood, formed by methods familiar to wheelwrights; these pieces were subcontracted through the important firm, Carl Leistler and Son, decorating the palace.

By 1856 Thonet had perfected the bending of solid wood and was ready for mass production. From then on, success attended Thonet's enterprises. He died on March 3, 1871, in Vienna where his firm was producing furniture in hitherto unheard-of quantities, around 400,000 pieces annually. Solid bentwood furniture, never out of production, was again made fashionable by Le Corbusier in the 1920s. In 1953 the centenary of Thonet's firm was celebrated internationally. (Er. K.)

THONGA (properly Tsonga), a group of Bantu-speaking peoples inhabiting the southern part of Mozambique and stretching into neighbouring territories. Culturally and linguistically the Thonga are related to other Mozambique peoples such as the Chopi, Lenge and Inhambane Tonga.

The Thonga group comprises a number of formerly independent tribes, each of which occupied its own territory which was under the domination of a powerful patrilineage, whose name was also the name of the territory. During the 19th century they were conquered by Nguni-speaking raiders from the south, who formed the Shangaan and other kingdoms.

The people dwell in scattered homesteads, each inhabited by a group of males. related by agnatic descent, with wives and children. The Thonga have patrilineal succession and inheritance. They allow polygamy and husbands give bride wealth for their brides. A man's cattle herd is apportioned among the households of his wives for their support and for ultimate inheritance by the children of the household. The principal heir is the senior son of the chief wife. Children are also closely linked to their mother's lineage. They have a joking relationship with their mother's brother and may make free with his property. Divorce is rare. On the death of a man, his wives are usually inherited by other males of his lineage.

They are agriculturalists and pastoralists, much of the agricultural work falling upon the women, but also practice some fishing and hunting. For a cash income they are dependent upon wage labour. At any one time a large proportion of the able-bodied men are away at work in the Union of South Africa or in the cities of Mozambique. They have a highly developed set of ritual systems. Males are initiated into adult life through an initiation school and circumcision.

There is a strong cult associated with ancestral spirits who may be approached only by members of their own lineage. Illness and other misfortune are usually attributed to the breaking of a taboo, to the anger of the ancestors or to sorcery. Detection of the agent is done through divination. Sorcery accusations are most commonly leveled at women married into the lineage, rarely at lineage mates.

See H. A. Junod, *The Life of a South African Tribe,* 2 vol. (1927); A. M. Duggan-Cronin, *The Bantu Tribes of South Africa,* vol. iv, *The Vathonga* (1936). (E. Co.)

THOR, a mythological deity of the Scandinavians, is represented as a middle-aged man of enormous strength, an implacable foe to the harmful race of giants (demons), but benevolent toward mankind. His figure is somewhat secondary to that of Odin, represented as his father. But in Iceland and indeed, perhaps, in all northern countries except among the royal families, he was apparently worshiped more than any other god. There is evidence that a corresponding deity named Thunor or Thonar was worshiped in England and on the continent, but little is known about him beyond his identification with the Roman Jupiter. His name is the Teutonic word for thunder. Outside the Teutonic area he has close affinities with Jupiter or Zeus, and still more with the Lithuanian god Perkunas, whose name (which likewise means "thunder") appears to be connected with that of Thor's mother (Fiorgyn). (H. M. C.)

THORAX, the anatomical term for the chest, in man and other mammals that part of the body between the neck and abdomen. The bony framework consists of the 12 thoracic vertebrae, 12 pairs of ribs and the sternum or breastbone. It contains the chief organs of respiration and circulation; namely, the lungs, some air passages, the heart and great vessels. Below, it is bounded by the diaphragm. The bony framework is encased with muscles, fat and cutaneous tissues. (See SKELETON, VERTEBRATE.)

In insects the thorax is the middle of the three major divisions of the body. It is composed of three parts, each of which commonly bears a pair of legs; the rearward two parts usually bear each a pair of wings. (F. L. A.; X.)

THORBECKE, JAN RUDOLF (1798–1872), Dutch statesman, was born at Zwolle, in the province of Overijssel, on Jan. 14, 1798. He studied at Leiden, and, on the completion of his course, visited the principal German universities. At Giessen he lectured as an extraordinary professor, and at Göttingen, in 1824, published his treatise, Ueber *das Wesen* der Geschichte. After his return to Amsterdam in 1824 Thorbecke wrote his Bedenkingen *aangaande* het Recht en den Staat ("Objections Anent Law and the State"), which procured him in 1825 a chair as professor in Ghent university. The Belgian revolt of that year drove him from Ghent to Leiden, where he became professor of jurisprudence and political science. His standard work. *Aanteekeningen op* de *Grondwet* ("Annotations on the Constitution," 1839; 2nd ed., 1841–43), became the textbook and the groundwork for the new reform party in the Netherlands, as whose leader Thorbecke mas definitely recognized.

Thorbecke's political career until his death, which occurred at The Hague on June 4, 1872, is sketched under HOLLAND: History.

See biographies *by* Buys (Tiel, 1876) and J A. Levy (1876). There are two collections of his *Speeches,* 6 vol. (1867–70; 1900). His *Correspondence With Groen van Prinsterer* appeared in 1873.

THOREAU, HENRY DAVID (1817–1862), U.S. writer, poet and philosopher who invested his life in his native village to the end of enacting the doctrines of New England Transcendentalism as expressed by his friend and associate Ralph Waldo Emerson (*q.v.*), among others. A naturalist chiefly in the sense that nature was his field of action and contemplation, Thoreau was concerned primarily with the possibilities for human culture provided by the American natural environment. He believed that "All things invite this earth's inhabitants/To rear their lives to an unheard-of height"; to meet this "expectation of the land" (Collected *Poems* of Henry Thoreau, edited by Carl Bode, p. 135, Packard and Co., Chicago, 1943), he domesticated ideas garnered from classical, oriental, English and the then current romantic literatures in order to extend U.S. libertarianism and individualism beyond the political and religious spheres to those of social and personal life. In a society which Henry James said was "not fertile in variations" (F. O. Matthiessen, The *James Family,* p. 441, Alfred A. Knopf, Inc., New York, 1947), Thoreau pioneered the life of an artist and like Emerson opened vistas to new vocations and intrinsic successes. "The life which men praise and regard as successful is but one kind. Why," he asked in Walden, where his example was the answer, "should we exaggerate any one kind at the expense of the others?" (This and all following quotations from the prose works of Thoreau — the standard Walden edition, The Writings of Henry David Thoreau, 1906— are by permission of Houghton Mifflin Company, Boston.) In a commercial, conservative, expedient society rapidly becoming urban and industrial, he upheld the right to self-culture, to an individual life shaped by inner principle. An artist whose life was his material, he demanded for all men the freedom to follow unique life styles, to make poems of their lives and living itself an art. Wholeness and being were his aims, not the limited fulfillment of specialization; the artisan was to become an artist, the partial man "spheral," the factitious man authentic. In a restless, expanding society dedicated to practical action, he demonstrated the uses and values of leisure, contemplation and rootedness.

Thoreau's writing not only enriched the New England landscape with human associations, but taught men how to take up the land without despoiling it — with .their imaginations. He established the tradition of nature writing developed by John Burroughs and John Muir, and his pioneer study of the human uses of nature profoundly influenced such conservationists and regional planners as Benton MacKaye and Lewis Mumford. More important, his life, so fully expressed in his writing, has had a pervasive influence because it was an example of moral heroism and an example of the continuing search for a spiritual America. One of the classic U.S. writers, he became a culture hero because he had shown that "the intransigence of the spiritual unit . . . alone gives edge to democracy" (The Seven Arts, II, July, 1917, p. 385).

Early Life. — Although Thoreau playfully linked his genealogy with that of the first discoverers of America, the Viking descendants of Thor, and characterized himself as a follower of the "trade of heroism," Thoreau's outward life offered little adventure for the annalist. The son of John Thoreau, whose father had emigrated from the Channel Islands, and of Cynthia Dunbar, daughter of a Congregational minister, he was born July 12, 1817, in the rural village of Concord, where his unsuccessful father finally settled and set up a small graphite pencil factory. This home industry, which Thoreau dutifully served all of his life, and his mother's boardinghouse, where he lived except for the intervals at the Emersons' and at Walden pond, were his permanent background.

Thoreau prepared at the Concord academy, and, at great sacrifice to his family, entered Harvard college in 1833. There he came abreast of his age, encountering both the intellectual heritage of the 18th century. which he would soon abandon, and the new thought that provided the philosophical basis for his experiment in life. Jones Very, a minor Transcendentalist poet, was his tutor in Greek; Orestes Brownson (*q.v.*), soon to become a Transcendentalist publicist, helped him with German during a schoolteaching vacation; Edward Tyrel Channing, professor of rhetoric, assigned compositions in which Thoreau sketched his conception of the superior man and recorded the increasing Transcendental tendency of his thought. A good student but indifferent to the rank system and preferring to use the library to his own ends, he graduated midway in the class of 1837. But, as he announced in his commencement piece on "The Commercial Spirit," with its scorn for getting and spending, with its plea for cultivating "the moral affections" and the powers to enjoy and admire the "wonderful" world, he was eager to follow a vocation for which few of his classmates had the inclination, preparation or heart.

Emerson called Thoreau to that vocation. During commencement week he delivered his challenging Phi Beta Kappa address, "The American Scholar." In it he summoned the younger generation to follow his own calling—that of the independent intellectual at the service of the republic—and to fulfill in action the program for nurturing American genius and culture that he had outlined in *Nature* (1836). "He shall see," he promised the self-reliant truth seeker, "that nature is the opposite of the soul, answering to it part for part. . . . Its beauty is the beauty of his own mind. Its laws are the laws of his own mind. Nature then becomes to him the measure of his attainments. So much of nature as he is ignorant of, so much of his own mind does he not yet possess. . . . in fine, the ancient precept, 'Know thyself,' and the modern precept, 'Study nature,' become at last one maxim." This "correspondence" between the subjective and the objective, the inner and the outer, the indwelling spirit in man and the immanent spirit in nature, were at the core of the Transcendentalist faith. To discover the identities between man and nature, to translate the external world into consciousness, to humanize science by making fact flower into truth. was now the work of the scholar. Thoreau undertook this exploration of "whole new continents and worlds within" when, on his return to Concord, Emerson suggested that he keep a journal; eventually running to 39 manuscript volumes, the journal became the principal archive of Thoreau's arduous experience of assimilating nature to himself.

After Haward.—Immediately following his graduation Thoreau kept a school; privately he continued his apprenticeship to his chosen craft by writing poems and literary essays. He began his long service as lecturer and curator for the Concord Lyceum and published his first poem in the newly launched magazine the *Dial*, edited by Margaret Fuller (*q.v.*) and Emerson. He fell in love with Ellen Sewall of Scituate and was rejected. Unwilling to postpone his life and already lamenting that he was an Apollo enslaved to Admetus, he gave up teaching; on Emerson's request, he went to live with his mentor, exchanging his skills as handy man and editorial assistant on the *Dial* for the freedom to pursue his own work.

Emerson turned Thoreau to nature writing by prompting Thoreau's first major essay, "Natural History of Massachusetts"; he severely pruned Thoreau's poems; and he tried to bring his protégé to market by sending him as tutor to the William Emersons of Staten Island, where he might find it easier to sell his wares in New York. Thoreau, however, was unsuccessful. As he put it, his essays were not "companionable"; "Paradise (To Be) Regained" destroyed the popular assumptions of utilitarian progress, and "A Winter Walk," one of the best of his early spiritual excursions, was better fitted for the *Dial*. Confirmed in his distaste for city life, disappointed by his failure, and in debt, he returned home and with Yankee brevity noted in his autobiographical record. "Made pencils in 1844."

The Walden Years.—In 1845, Emerson provided the few acres Thoreau needed for his Walden experiment, which was to make good his losses and permit him at last to have his life while living it; but Emerson did not approve what seemed to him a withdrawal into solitude and an abdication of the "Napoleonic" leadership he expected of his "brave Henry." For Thc eau. however. going to nearby Walden pond was an act of independence, the act of precipitating his fate (in *Walden* he began the account of his residence there on Independence day). Not only did he aish to solve by simplicity and subsistence farming his economic problems as a writer, he wished by means of his intimacy with nature to meet "the great facts of his existence" and to live an uncommitted life open to spirit. To him the landscape of his new life bordered the "Elysian fields"; measured by his ecstatic communion with nature, the two years at Walden were the great occasion of his life.

Thoreau left the pond in September 1847 in order to manage the Emerson household during Emerson's absence on a lecture tour in Great Britain and because, with *A Week on the Concord and Merrimack Rivers* completed, he felt ready to retrieve his early failure. He was unable to find a publisher, however, and the publication of this, his first book, was delayed until 1849, when Thoreau issued it at his own expense. It mas so poorly received that Thoreau resisted the appeals to publish *Walden* until the debt he had incurred mas paid. Just as poorly received were his attempts as a lecturer to find a public. Having "not made it worth any one's while" to buy his delicately woven wares, as he explained in *Walden*, he tried to "avoid the necessity of selling them." He no longer tried to maintain himself by writing; he returned to the pencil factory and to surveying, his occupations for the rest of his life.

The Fruits of **Walden.**—Thoreau's greatest books, *A Week* and *Walden*, were indebted to the Walden years. Companion volumes, the first covers Thoreau's spiritual history from 1839 to 1849, the second the years from 1845 to 1854 *A Week* takes its joyousness from the vacation mood and spiritual communion of these early years and the years at Walden where it was nritten. An excursion in thought, its narrative framework is the boat trip Thoreau had made with his beloved brother John in 1839; the literal adventure carried with it his thoughts on religion, friendship, politics, reform, art and nature—the experience of a decade of exploration. The book enacts Thoreau's belief that "the order of things should be somewhat reversed; the seventh day should be man's day of toil . . . and the other six his Sabbath of the affections and the soul,—in which to range this widespread garden, and drink in the soft influences and sublime revelations of Nature. . . ." A meandering, meditative book, successfully uniting action and contemplation; a series of days on the stream of consciousness; a voyage into America, to the headwaters of inspiration: *A Week* covers Thoreau's life from youth to maturity, from the easy availability of inspiration to the more conscious use of inspiration in the creation of art.

Thoreau's relation to nature in *A Week* was "one and continuous everywhere"; inspired, his life was "constantly as fresh as this river." He was "a long-lived child/As yet uninjured by all worldly taint/. . . whose whole life is play." In *Walden*, he was the "mature soul of lesser innocence" who, "from the sad experience of his fate," had consciously earned "the ripe bloom of a self-wrought content" (Bode, p. 225).

Walden was begun in 1846–47, but was considerably modified and amplified in six revisions, material being incorporated almost until the time of publication in 1854. The book therefore did not literally record the Walden experience, for this experience was refracted by what Thoreau felt was the "decay" of the following years during which it was brought to completion. A symbolic book, then, treating his experience not so much retrospectively as prospectively, to the end of self-therapy and hope, *Walden* affirmed Thoreau's faith in "the unquestionable ability of man to elevate his life by conscious endeavor." By his definition, the book was a scripture, the sacred testament of a man living through the process of revelation; its myth, secured by the seasonal movement of the narrative from summer to spring, was that of a return to the springs of life—a fable of spiritual renewal.

Later Writings — Thoreau's actual life in these and the remaining years did not bring renewal. Now his problem was a more difficult one than that of living by writing. His inspirational relation to nature itself had been broken by the deterioration of his friendship with Emerson, by his involvement in the antislavery movement, by the impurity that he felt was due to the coarse life required of the surveyor, and by the intense strain of the outdoor life and the scientific studies he imposed on himself. The goal of self-culture, he found, could not be fully realized in nature; personal and social relations were also necessary. The inevitable awareness of manhood had destroyed the unconsciousness of youth and, with it, the communion with nature he now desperately tried to regain by discipline.

Though his sense of losing his innocence and purity was great, his powers as a writer were increased by his more objective investigation of nature and by his social concerns. "Civil Disobedience," his most famous essay (it influenced Gandhi, among others), was his defense of the private conscience against majority expediency; published in 1849, it announced the moral intransigence of later essays such as "Slavery in hfassachusetts" and "Life Without Principle." and those essays written in behalf of John Brown, who carried the political faith of the Transcendentalists to the conclusion of bloody action.

The finest essays, however, like his travel books *(The Maine Woods, A Yankee in Canada* and *Cape Cod)*, were the fruit of a more strenuous undertaking, that of rediscovering and repossessing the aboriginal environment of America which had sustained his own spirit. Composed of his accounts of his three trips to Maine, in 1846, 1853 and 1857, *The Maine Woods* presents at its finest Thoreau's zest for outdoor adventure. Less symbolic than his other works (the essays were intended to be of practical help to campers), the book does however indicate his retreat from primitivism to the more human pastoralism of Concord. *A Yankee in Canada* took Thoreau into the country explored by the French discoverers whom he admired, but the old world institutions there provoked him to praise of the freer institutions of New England. *Cape Cod* introduced him to the first frontier, the sea, and enabled him to recount the history of the new world from the time of the Northmen, Cabot and Columbus to that of his own excursions; and the incidents of shipwreck made it possible for him to transform death into a passage to the last frontier, the spiritual west. At home, in Concord, with failing strength (the signs of fatal tuberculosis appeared as early as 1852) he laboured on his "Kalendar." His most grandiose project, it was to put on record all of his knowledge of nature's year as this knowledge had been mixed with human aspiration, growth and fruition—his, his countrymen's, and man's throughout history. He completed only "Autumnal Tints" and "Wild Apples"; appropriately they were essays on the values of maturity, an autumnal victory over the tragic loss of his springtime. The first is a pean to the flaming, courageous leaves that taught him how to die; the latter is a transparent parable of his own life and his desire to grow wild that he might, in Emerson's words, "yield that peculiar fruit which each man was created to bear." These travels, in New England at large and in his own backyard, provided the inspiration for his final testament, "Walking." Walking had been his spiritual exercise; his holy land was the west. The west was the freedom, the "mild" that nurtured civilizations and men. This ecology of man and his environment was Thoreau's largest gift to America.

Thoreau did not relinquish civilization for primitivism; in the interests of human culture, he wished only to keep civilization open on one side that others, as he had, might bear their peculiar fruits. For health as well as because of his devotion to the west, Thoreau went to Minnesota in 1861. He died in Concord on May 6, 1862.

Editions. — The standard edition is *The Writings of Henry David Thoreau*, in 20 volumes (1906); vol. vi, *Familiar Letters*, was edited by F. B. Sanborn; vol. vii–xx, the *Journals*, were edited by Bradford Torrey and Francis Allen. *Consciousness in Concord*, edited by Perry Miller (1958), contains the "lost" journal of 1840–41. Other primary sources are *Collected Poems of Henry Thoreau*, edited by Carl Bode (1943), and *The Correspondence of Henry David Thoreau*, edited by Walter Harding and Carl Bode (1958).

Bibliography.—*Biographical and Critical Studies:* H. S. Canby, *Thoreau* (1939); J W Krutch, *Henry David Thoreau* (1948); F. O. Matthiessen, *American Renaissance* (1941); Leo Stoller, *After Walden: Thoreau's Changing Views on Economic Man* (1957); Sherman Paul, *The Shores of America: Thoreau's Inward Exploration* (1958). Walter Harding (ed.), *Thoreau: A Century of Criticism* (1954), is a collection of critical essays. A bibliography compiled by T. H. Johnson can be found in *Literary History of the United States, ed.* by Robert E. Spiller *et al.*, vol. iii, pp. 742–746 (1948). *See* also Floyd Stovall (ed), *Eight American Authors: a Review of Research and Criticism* (1956); Walter Harding, *A Thoreau Handbook* (1959). (S. Pl.)

THORFINN KARLSEFNI (fl. 1002–07), Scandinavian leader of the first medieval expedition for the colonization of North America, was born in Iceland around 980. He must have been given his nickname at an early age, for *karlsefni* means "promising boy." His grandfather, Snorri Bjarnason, is a historical figure as one of the aristocrats who, about the year 900, led the westward-swarming Norwegians to Iceland. Many of them felt so pressed for stock-farming land by 986 that they followed the lead of Eric the Red and migrated to Greenland. By the year 1000 there were probably more than 1,000 Scandinavian stock farmers in what is now the Julianehaab district of Greenland. Karlsefni, finally caught up in the westward sweep from Iceland, reached what was known as the eastern settlement of Greenland during the autumn 1003 with two ships and about 80 colonists. No doubt the ships would have continued to or beyond the western settlement had not Eric invited all hands to spend the winter with him at his farm, Brattahlid. From the *Saga of Eric the Red* it appears that there may have been a motive behind the hospitality. The saga tells of banquets, jollity and glowing talk of a country to the southwest, beyond the sea, that had been discovered three years before by one of Eric's sons, Leif *(see* Leif Ericsson), and named by him Vinland (*q.v.*). The impression one gets from the saga is that both father and son were persuasive, trying to divert the two Icelandic vessels from prosecuting a further northwestward colonization along the shore of Greenland, directing them instead toward Vinland, perhaps in part because the previous year Eric's son Thorstein had died in the western settlement, and his widow Gudrid had come to stay at Brattahlid. Eric now married her off to Thorfinn; and it was arranged that a Greenland ship would join the Icelandic ones and they would pick up Gudrid's property on their way to Vinland.

In the spring of 1004 about 130 men and women, in three vessels, with livestock and household goods, sailed northwest from the eastern to the western settlement, picked up Gudrid's property, and crossed from the Greenland coast at Bear Island (Disko) toward Baffin Island, apparently striking that shore near Cape Dyer. They named the coast Helluland, meaning "Land of Flat Stones" (Flagstoneland) and continued to use this name as long as they saw no trees while coasting in a southerly direction. After crossing Hudson strait they saw trees and then called the shore Markland, meaning "Forest Land."

Farther south they came to a section which they took for Leif's Vinland district and which sounds in the narrative as if it probably was some part of the Gulf of St. Lawrence, perhaps the south shore. Reaching the heavily wooded region, the colonists built houses, made hay and spent the winter hunting and fishing, much as if they were still in Greenland; but they noted that the meadows were grassier and that the winter was shorter.

The first winter the Scandinavians met no people but the next summer they were visited by friendly natives with whom they traded and who, from the description, were Eskimos. After wintering in a different place, or perhaps scattered in several wintering places, they were again visited by natives, this time more numerous and no longer friendly. A battle ensued; the Europeans won it, but at the cost of some lives. Following still another winter, during which the colonists evidently thought things over, Thorfinn decided to return to Greenland. There was no longer unity among the colonists. Although all decided to abandon Vinland, they did not all head for Greenland and some. perhaps intending to reach Iceland, were shipwrecked on a western coast of Europe.

With his wife, and a son who had been born to them in Vinland, Thorfinn spent the winter of 1006–07 in Greenland. Later they returned to Iceland, where Thorfinn's was already a powerful family.

Snorri, the Vinland-born son whom Thorfinn had named after his Norwegian grandfather, became the progenitor of a line of clergy. The clergy were not celibate in those days and their numerous descendants came to include two bishops during the first few generations — and bishops were nobility in both Greenland and Iceland under the new dispensation. In a genealogically minded modern Iceland, many people of consequence trace their descent, through Karlsefni, to the U.S. or to Canada; for though the Vinland of the 1004–05 wintering almost certainly was in Canada, some argue that one or both of the other winterings may have been in New England.

Among the persisting results of the Karlsefni voyage was a North American activity of the Roman Catholic Church in the Markland-Vinland region. There resulted, too, commerce between Greenland (*q.v.*) and Labrador (Markland) that is mentioned in both Icelandic and Norwegian records as late as 1347. The seafarers of northwestern Europe never lost memory of coasts west of Greenland that stretch to the south. A theory developed that these coasts would curve eastward in the far south to connect with northern Africa. But in the period between the 13th and 15th centuries nobody seems to have been much interested in this knowledge until after Columbus had the idea that these lands beyond the Atlantic might be a northward extension of Marco Polo's rich Cathay.

BIBLIOGRAPHY.—Excellent scholarship on the Vinland voyages is found in the following three volumes by Halldór Hermannsson in the series, *Islandica, The Northmen in America* (1909), *The Problem of Wineland* (1936) and *The Vinland Sagas* (1944). On the historicity of the Greenland-Vinland sagas *see* Sir William A. Craigie, *The Icelandic Sagas* (1913). *See* also for history, Vilhjalmur Stefansson, *Greenland* (1942). (V. S.)

THORIANITE, a strongly radioactive mineral with the idealized composition thorium dioxide, ThO_2. It ordinarily contains more or less uranium in solid solution and is then transitional to the structurally related mineral uraninite (*q.v.*), UO_2. Rare earths and radiogenic lead and helium also are present. Thorianite forms hard, black to brown isometric crystals of high specific gravity, 9.7–10. The mineral was originally found as waterworn grains and crystals in the gem gravels of Ceylon. It also has been found sparingly in the black sands of rivers and beaches in Alaska and other parts of the United States, Madagascar and Siberia. Varieties containing much uranium occur in pegmatites in Quebec and Ontario, and in serpentine at Easton, Pa. The refractory nature and the small supply of thorianite has restricted its commercial use as a source of thorium (*see* also MONAZITE). (CL. F.)

THORILD, THOMAS (1759–1808), Swedish poet and critic who led the revolt against the influence of French classicism. Born, April 18, 1759, at Svarteborg, Bohuslan, he studied at Lund and Uppsala. He visited England (1788–90). In 1793 he mas banished from Sweden as a result of a political libel after the assassination of Gustav III. He went to Germany and in 1795 was appointed professor and librarian at Greifsmald where he died, Oct. 1, 1808. A born fighter, Thorild attacked the taste for French culture, writing unrhymed verse inspired by Ossian, Shakespeare, Klopstock and Goethe. Among his best works is *Passionerna* (1785), a philosophical poem expressing a pantheistic feeling for nature. The powerful style of his prose essays resembles that of the old Swedish laws. His famous *En critik ofver critiker* ("A Critique of Critiques," 1791–92) is a plea for positive literary evaluations. After his banishment he continued to write essays of which Om *qvinnokonets naturliga hoghet* ("The Natural Greatness of Womankind," 1793) is one of his best.

Thorild's collected works were first published in 4 vol. (1819–35). A critical edition by Stellan Arvidson was begun in 1932; vol. iv appeared in 1946.

See A. Nilsson, *Thomas Thorild. En studie over hans livsaskadning* (1915); E. Cassirer, *Thorilds Stellung in der Geistergeschichte* (1941). (S. E.)

THORITE, a mineral consisting of thorium silicate, is one of the most important thorium minerals. The theoretical formula, $ThSiO_4$, requires 81.5% of thoria, but analyses show only 50%–70%. there being also some uranium, cerium, etc. The mineral is almost always altered by hydration and is then optically isotropic and amorphous. Because of alteration and differences in composition. the specific gravity varies from 4.4 to 5.4. The colour is usually light brown, but in the gem variety known as orangite it is orange-yellow. It crystallizes in the tetragonal system and is isomorphous with zircon (*q.v.*). The mineral occurs as isolated crystals and small masses in the augite-syenite near Brevik in south Norway; also at Arendal. and in the gem gravels of Ceylon. Good crystals are found on Stove mountain, El Paso county. Colo. Thorite is mined commercially at Cripple Creek, Colo., and at Hall mountain, Idaho. (L. J. S.; W. F. FG.; X.)

THORIUM. The metal thorium and its oxide are comparatively rare materials. In spite of this fact, they have played an important role in technology for many years and have been the foundation of at least one large industry, the manufacture of gas mantles. The oxide is also important as an additive to metallic tungsten filaments for controlling metallurgical properties. In electronic devices thorium oxide is widely used as a source of primary electron emission.

The advent of atomic energy, jet turbines and rockets brought an unusual demand for new metals and alloys. Important alloys containing thorium mere developed for improving the high-temperature strength of metals, in particular the magnesium base alloys.

Thorium has great potential use in nuclear reactors. Its abundance in the earth's crust is at least three times that of uranium. The particular advantage of the use of thorium in the field of atomic energy is as a "breeder" material. It functions in an atomic pile in such a way as to yield a net increase in atomic fuel; see *Industrial Applications,* below. *(See* ATOMIC ENERGY: *Peacetime Applications.)*

ELEMENTAL THORIUM

Thorium was identified as an element by J. J. Berzelius in 1828. The element is named after Thor, Scandinavian god of war.

Freshly cut massive thorium is silvery white in colour but turns gray or black on exposure to air. The stability of the surface is a function of the oxide content and surface potential. A cold rolled sheet processed to a high finish remains remarkably stable, retaining a high metallic lustre for years.

The metal may be extruded, rolled, forged, swaged and spun. Drawing is a difficult operation because of its low tensile strength. Most of the operations with the exception of extruding and spinning may be performed cold. Work hardening is moderate, and annealing is usually *in vacuo* at 800°–1,000° *C*. The major embrittling element is carbon, which dissolves in thorium with resulting lattice expansion. Thorium powder is relatively stable in air, but spontaneous combustion has occurred and the storage of large quantities is hazardous. The solid metal is not readily oxidized in air at high temperatures. High-temperature steam is more effective.

Thorium metal is practically nonreactive to acetic acid (0%–50%) and also to sodium hydroxide in all concentrations. It is attacked by hydrochloric acid (0.1%–36%) but only slightly by nitric acid in all concentrations, provided traces of fluorides are absent.

OCCURRENCE AND PRODUCTION

Mineral Deposits. — Minerals in which thorium is the major constituent are silicate, thorite and orangite, auerlite, calciothorite, mackintoshite and thorianite. Deposits of these minerals are usually too small to be of industrial importance.

The major source of thorium is monazite (*q.v.*), essentially a phosphate of the rare earths. Important deposits are found in Travancore-Cochin, former Indian state, and Brazil. Significant deposits have been found in the Scandinavian peninsula, Ceylon, Tasmania (Australia) and the Ural mountains (U.S.S.R.). U.S. deposits are in Idaho, Colorado, North Carolina, Virginia and Florida. Monazite sands usually contain 2%–10% thoria (ThO_2). The poorer ores are concentrated to an oxide content of 5%–10% prior to refining. Domestic sources of thorium rarely exceed 4% ThO_2.

Extraction. — The recovery of thorium compounds, in particular the oxide (ThO_2) from monazite concentrates depends upon the separation of this element from cerium and other rare-earth phosphates and substantial amounts of silica, calcium oxide and iron oxide.

In some monazites the cerium content (CeO_2) is 40%–50% and the phosphorus content (P_2O_5), 20%–25%. The separation is accomplished by a variety of methods, including precipitation after digestion with an acid or base, direct reaction with chlorine, separation by an organic liquid, reduction with calcium and electroylsis.

Precipitation. — Commercial extractive processes in use for many years involve the digestion of pulverized monazite in hot concentrated sulfuric acid to dissolve the thorium and rare earths. If the solution is diluted or partially neutralized with ammonia, thorium phosphate separates, and the ratio of ThO_2 to rare earths is increased.

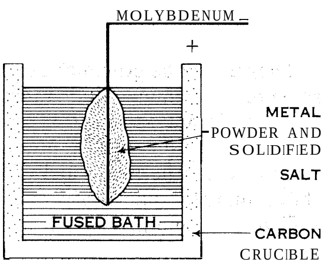
For the complete removal of phosphors and the remaining rare earths several operations have been used. The important ones are sulfate separations, carbonate extractions, oxalate separations and iodate separations.

The sulfate separation procedure depends upon the low solubility of thorium sulfate, $Th(SO_4)_2{\cdot}8\ H_2O$, compared with the sulfates of cerium, neodymium, praseodymium and lanthanum. In carbonate extraction. thorium forms a soluble double carbonate, and cerium precipitates. The precipitation of thorium as the oxalate from dilute acid solutions is commonly used to separate small amounts of the rare earths and some common metals. It is also used as a final step prior to conversion to oxide which is obtained by ignition.

Some monazites yield to sodium hydroxide extraction, with thorium and the rare earths precipitating. It is used as a means of separating thorium from phosphorus.

The precipitation of thorium iodate from strong nitric acid solution affords an excellent separation of thorium from the rare earths and common metals, but it is too expensive for commercial practice.

In spite of the complicated procedures involved in precipitation, thorium oxide of over 99% purity is produced. The major contaminants are small amounts of cerium, rare-earth oxides, silica, calcium and magnesium. None of these impurities is present in amounts exceeding 0.1%, and many are of the order of 0.04% or less.



FROM RARE METALS HANDBOOK REINHOLD PUBLISHING CORPORATION

FIG. 1 — ELECTROLYTIC CELL FOR THORIUM DEPOSITION

Reaction With Chlorine. — Production processes have been suggested which involve the extraction of thorium chloride by the direct reaction of the ore. the oxide or the oxalate nith chlorine. Efficiency of chlorination is increased by mixing the materials with carbon. Chlorine gas saturated with sulfur chloride or carbon tetrachloride may also be used. The direct formation of the chloride affords the preparation of a soluble compound of thorium which may be easily purified or if sufficiently pure may be used directly for metal production.

Extraction by Organic Liquid. — Processes have been developed for separating thorium from the rare-earth nitrates. Calcium nitrate and nitric acid are added to a solution of the nitrates and thorium nitrate extracted into an organic liquid phase (alcohol or ketone). The extraction is accomplished by mixing the two fluids by passage in opposite directions through a vertically packed column. The rare earths and other impurities remain in the water phase. The organic phase containing the thorium nitrate is then back-extracted, the thorium nitrate entering the water phase from which the oxide may be recovered by evaporation and ignition. Oxide with a purity of 99.7% has been produced.

Reduction With Calcium. — Several processes have been proposed which include reduction of the fluoride (ThF_4) and oxide (ThO_2) with calcium. These reactions are carried out on a large, scale in closed metal containers usually referred to as "bombs." The reactants are heated to initiate the reaction. The thorium as a metal powder is recovered by leaching the charge with suitable acids which dissolve the by-products of the reaction. A method of preparation is to add metallic zinc to the charge to form a zinc alloy with the thorium, which fuses. Thorium is recovered by vacuum distillation of the zinc followed by vacuum casting of the thorium. A particular advantage is the elimination of a powder step in the process.

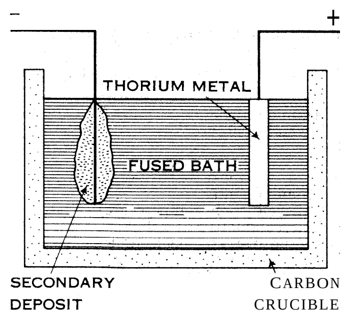


FIG. 2. — ELECTROLYTIC CELL FOR THORIUM REFINING

Electrolytic *Methods.*—Electrolysis of thorium compounds such as the chloride ($ThCl_4$) from alkali metal baths have shown promise of replacing the "bomb" type of reaction. Such processes may be continuous, requiring only the insertion of electrodes with occasional bath replacement. Thorium is deposited on a metal cathode (molybdenum), and the crucible containing the charge serves as the anode. The deposit upon withdrawal from the bath contains thorium powder plus solidified salts and is recovered by grinding and acid leaching.

. Metal of very high purity is obtained by subjecting the primary deposition product to an electrolytic refining operation in which the compressed deposit acts as the anode in a fused salt bath and the thorium is redeposited on a metallic cathode. Lowering occurs in the concentrations of many contaminants, including boron, beryllium, copper, chromium, iron, nickel and silicon. The basic principles of the electrolysis and refining operations are shown in fig. 1 and 2.

Thorium is also refined by the thermal decomposition of the iodide (ThI_4) on a hot wire. The process is similar to that used for zirconium production in which iodine and chips of metal are placed in a closed evacuated container that is heated to form thorium iodide vapour. As the vapour comes into contact with a heated filament in the same vessel, thorium of a very high purity is deposited with the liberation of iodine.

Billets for rolling are produced from the powder by standard powder metallurgy (*q.v.*) practice or by direct arc casting. The former practice is to press the powder in steel dies under 20–30 tons per square inch; the resulting green compacts are vacuum sintered. Casting of powder compacts is sometimes made in beryllia crucibles.

Thorium is also cast in a water-cooled copper cup. The powder may be compressed into a rod which acts as a consumable electrode, and the arc is struck between the electrode and solid thorium with the formation of a liquid pool. Melting takes place under a partial pressure of helium or argon gas.

GENERAL CHEMISTRY

Thorium is an electropositive element. It lies between beryllium and magnesium in reducing strength and is more electropositive than zirconium and cerium. In solution. thorium shons only the +4 oxidation state. The standard electrode potential is +1.77 v. Salts of thorium are white although thorium solutions are colourless. The hydrolysis of thorium in solution is less than that of zirconium. Because of its high charge. the thorium ion is strongly adsorbed from solution by an ion exchanger. Thorium forms complex ions and double salts. The nitrate is soluble in organic liquids and can be extracted from water solutions by alcohols, ketones, ethers and esters. Thorium compounds are not generally volatile with the exception of the acetylacetonate,

$Th(C_5H_7O_2)_4$, thorium borohydride, $Th(BH_4)_4$, and a group of organic compounds of the general formula Th(OCRR′R″) R, R′ and R are radicals.

The dioxide, thoria (ThO_2), is very refractory. Thoria may be prepared by ignition of the peroxide (ThO_4), nitrate. $Th(NO_3)_4$, hydroxide, $Th(OH)_4$, sulfate, $Th(SO_4)_2$, or of an organic thorium compound. Compounds such as thorium fluoride (ThF_4) may be converted to oxide by treatment with superheated steam. Thorium peroxide is precipitated from acid solutions with hydrogren peroxide. Ignition yields thorium oxide. The alkalies and ammonia precipitate thorium hydroxide.

TABLE—*Physical Constants (Metallic Thorium)*

Atomic number	90
Crystalstructure	Face-centred cubic up to 1,400" C. Body-centred cubic 1,400° C. to melting point
Atomic weight	232 05
Unit cell 'room temperature)	5:09∓0 004 A
Superconductive at 1.2" K.	—
Tensile strength, p.s.i. (annealed)	27,000
Heat of fusion, kg. cal./mol.	<4.6
Electrical resistivity, microhm/cm. '(annealed)	8
Density, g./cc.	11.7
Melting point	1,750' C.
Boiling point	*c.* 3,500" C.
Young's modulus, p.s.i.	10.3×10^6
Shear modulus, p.s.i.	4.1×10^6
Heat of vapourization, kg.cal./mol.	130–140
Periodic table	Actinide series

The common commercial salt of thorium is the nitrate. which is tetrahydrated. Double nitrates of thorium are known with sodium and potassium and also with some bivalent ions such as magnesium. zinc, cobalt and manganese.

Hydrogen gas reacts with thorium metal to produce thorium hydride of composition ThH_2 and ThH_4. Thorium hydride is used as a substitute for thorium powder in some applications. A particular advantage is its greater resistance to atmospheric oxidation. Fluorine reacts with thorium hydride or thorium to form thorium fluoride. Thorium fluoride may be separated from solutions by addition of the fluoride ion, but it is hydrated and must be treated with hydrogen fluoride gas to yield the anhydrous fluoride.

Chlorine or hydrogen chloride reacts with thorium hydride or metal to form thorium chloride ($ThCl_4$), which sublimes at temperatures in excess of 750° C., in *vacuo*. Bromine or hydrogen bromide converts the hydride or metal to bromide, and a corresponding reaction occurs nith iodine. The chlorides. bromides and iodides are soluble in mater but hydrolyze. Thorium iodate, $Th(IO_3)_4$, is formed upon addition of an iodate to thorium solutions. The salt may be dried to the anhydrous state.

Normal thorium sulfide (ThS_2) is yellow and may be prepared by the action of hydrogen sulfide on thorium hydride. This sulfide is stable up to 1,900° C., above which sulfur is evolved and Th_2S_3 or ThS formed. These compounds resemble metals and may be machined. filed and polished.

Thorium sulfate, $Th(SO_4)_2$, crystallizes from aqueous solutions in several hydrates depending upon temperatures. Heating in *vacuo* produces the normal salt and ignition yields the oxide. Double sulfates are also known. Chromates, phosphates and molybdates may be recovered from water solutions.

Thorium carbides, both ThC and ThC_2, have been identified and are prepared by heating the metal or oxide with carbon at high temperatures. These react with water to yield hydrocarbons. Thorium carbonate, $ThOCO_3$, is difficult to prepare from solution, but double carbonates are easily prepared. Thorium salts with organic acids are usually insoluble. The formate and the acetate are exceptions. Examples of insoluble salts are the oxalate, picrolonate and the sebacate. Thorium acetylacetonate. $Th(C_5H_7O_2)_4$, is formed by the reaction of thorium salts and acetylacetone. It is one of the few volatile salts of thorium. Several volatile compounds of thorium have been prepared by synthesis with tertiary alcohols Borides of the formula ThB_4 and ThB_6 are knonn and also the borohydride $Th(BH_4)_4$.

Two thorium nitrides have been identified. ThN and ThN_4. The nitrides are unstable at high temperatures in the presence of nater vapour with the elimination of ammonia.

INDUSTRIAL APPLICATIONS

Nonnuclear.— The earliest use of thorium oxide was in the incandescent gas-mantle industry. In 1885 Carl Auer von Welsbach patented a mixture of 99% thoria and 1% ceria which was impregnated into a combustitile fabric (cotton or ramie) as nitrates. Ignition resulted in oxide formation which when heated in a gas flame emitted white light for illumination. The use of gas mantles has declined, having been replaced by electrical lighting. (See LIGHTING: Historical Development.)

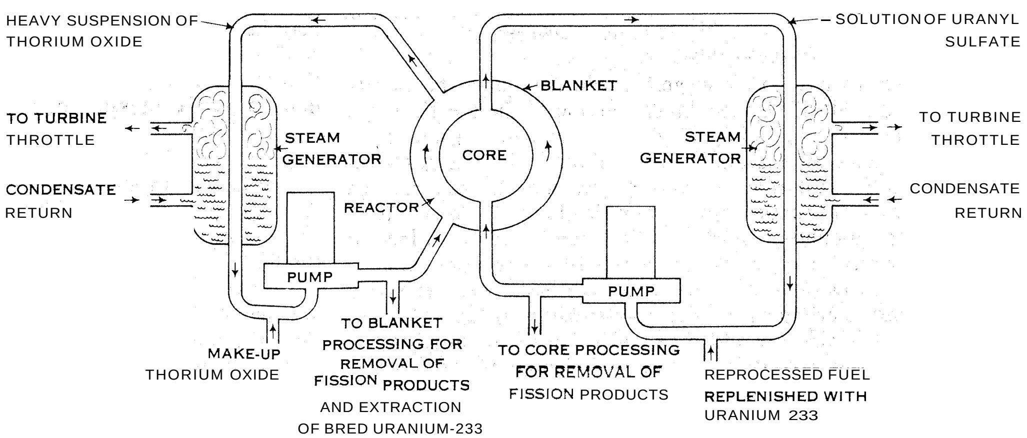
Thorium oxide is used in the electrical lighting industry for controlling the grain size of tungsten filaments used in lamps as a radiant source of energy. Pure tungsten is unsatisfactory because the metallic grains continue to grow when the filament is heated. causing some grains to slip along grain boundaries. The addition of 0.8%–1.0% ThO_2 to the tungsten produces a stable structure. Such filaments also exhibit increased vibrational strength.

Thorium oxide-metal systems have been used for years in electronics as a source of primary electron emission. The thorium oxide content is usually 1%–2%. So-called "cermets" which are oxide-metal compositions, in particular Mo-ThO_2 have been used as an emission source. A desirable property of these latter combinations is that the electrical resistance may be easily controlled by changes in composition. (See THERMIONICS: Reduction in Electron *Affinity*.)

The oxide has gained wide use as a component of electrodes for arc welding. The addition of 1%–2% ThO_2 to tungsten results in improvement in arc stability over that exhibited by pure tungsten. A practice embodying the same principle is the incorporation of the oxide in tungsten electrodes used in arc-casting metals. The addition of thorium oxide lowers the work function of the metal, that is, the ease with which electrons may be emitted thermionically.

Thorium oxide crucibles are used to a limited extent for melting some of the common and transition metals. Its use is quite selective. It is not satisfactory for melting oxygen-sensitive metals such as zirconium and titanium. Its relatively high cost and poor resistance to thermal shock limit its use to operations where it shons marked superiority over other competing ceramics.

Thorium sulfide crucibles have been investigated and show promise up to 1,800° C. The monosulfide (ThS) is the more stable compound.



FROM S GLASSTONE SOURCEBOOK ON ATOMIC ENERGY D VAN NOSTRAND CO INC

FIG. 3.— TWO-REGION AQUEOUS BREEDER REACTOR

Thorium oxide, as well as the oxides of beryllium, zirconium and aluminum, is of importance as a current-carrying compound in high-temperature furnace design and insulation. These oxides have negative temperature characteristics, and the limiting factor in their use is excessive conductivity. Thorium oxide compositions have been used experimentally where the resistor element is composed of 85%–95% ThO_2 and 5%–15% yttrium oxide (Y_2O_3) or lanthanum oxide (La_2O_3).

Thorium oxide is an efficient catalyst in reactions involving oxidation, hydrogenation and cracking of hydrocarbons. In many cases it is used as a mixture with aluminum oxide.

A very important alloy application of thorium is its addition to magnesium and magnesium alloys for improving their high-temperature strength. The addition of 1%–5% thorium to these alloys permits their use in temperatures up to 650° F., in compressor housings.

Thorium metal has been used as a deoxidant in molybdenum. It is also used in electronic tubes and lamps for lowering the starting voltages and maintaining stability in such lamps over their useful life.

Thorium is used in photoelectric cells for measurement of a wide band of the ultraviolet spectrum. The response of commercial tubes extends from 2,000 A–3,750 Å.

Nuclear Applications.—*Isotopes.*—Ordinary thorium consists almost entirely of the isotope Th^{232}, which has a half life of radioactive decay by emission of alpha particles of 13,900,000,000 years. This activity is the start of the 4N, or thorium, series. Another alpha-emitting isotope of thorium, Th^{228} (radiothorium), occurs in this series and because of its much shorter half life (1.89 years) constitutes only about one part in 1,000,000,000 of ordinary thorium. Thorium isotopes are found also in the actinium (4N + 3) decay chain: Th^{227} (radioactinium) with a half life for alpha emission of 18.9 days, and Th^{231} (uranium-Y), which emits beta particles at a half life of 25.6 hours. Th^{234} (uranium-X_1, emitting beta particles with a half life of 24.1 days) and Th^{230} (ionium, with a half life of 81,000 years) are members of the uranium (4N + 2) decay series. Although ionium occurs in a concentration of less than two parts per million in uranium ores it has been recovered. (See RADIOACTIVITY, NATURAL: *Ionium.*)

A number of synthetic thorium isotopes have been prepared by transmutation reactions or through the further decay of transmutation products. The most important is Th^{233}, produced by neutron reaction on ordinary thorium, since this decays to U^{233}, which is fissionable with the liberation of energy similar to that produced from U^{235}. The synthetic isotope Th^{229} has a very long life with a half life of 7,340 years and is a member of the wholly artificially produced neptunium (4N + 1) radioactive decay series. Other synthetic shorter-lived thorium isotopes are Th^{223}, Th^{224}, Th^{226}. (See RADIOACTIVITY, NATURAL: Transformations *of Thorium.*)

Nuclear Reactors.—As discussed under isotopes, Th^{232} is not capable of sustaining a nuclear chain reaction. Thorium will, however, absorb a thermal neutron coming from the controlled fission of U^{235} to become Th^{233}, which in turn transmutes to U^{233}, which is fissionable.

The nuclear reaction, from thorium to protactinium to uranium follows:

$$Th^{232}_{90} + n \rightarrow Th^{233}_{90} + \beta^- \rightarrow Pa^{233}_{91} + \beta^- \rightarrow U^{233}_{92}$$

Thorium is referred to as a "fertile material" and its transformation into U^{233} as the "breeding cycle." When the efficiency of this cycle is unity. the amount of U^{233} produced in an atomic pile will equal the U^{235} consumed. There are a number of calculated breeding ratios for various combinations of fuels. For example, for Pu^{239} (plutonium) the ratio is 1.03, and for U^{233} obtained from the Th^{232} the ratio is 1.25.

Major solid-fuel reactors utilize either U^{235} alloyed with zirconium and thorium or zirconium-clad thorium using deuterium as a moderator. Water or liquid sodium is used as a coolant. (See NUCLEUS: *Utilization* of the Energy of the *Nucleus.*)

Reactors employing liquid fuels utilize, for example, UO_2SO_4 (uranium sulfate) with deuterium (heavy water) as a moderator. The breeding ratio for one such reactor is 1.13. The slurry-type reactor employing thorium oxide in slurry form appears to have considerable merit over the solid-fuel type. In addition to an excellent breeding ratio the slurry type permits partial withdrawal of the slurry for chemical processing during operation of the reactor and also addition of reprocessed fuel. See fig. 3 for illustration of the basic principles involved in the use of thorium in reactors.

See also ATOMIC ENERGY; NUCLEAR ENGINEERING; see also Index references under "Thorium" in the Index volume.

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THORN (Polish TORUN), a town of Poland, in Bydgoszcz province situated on the right bank of the Vistula, 85 mi. N.E. of Poznan by rail, and 92 mi. S. of Gdansk (Danzig). Pop. (1950) 80,600. Torun has always been important because of its position in Poland proper between the former German Pomerania and East Prussia and because of its strategical location commanding the passage of the Vistula. The old town and the new tow-n, founded in the 13th century, were united in the 15th; both retain interesting buildings dating from the 14th, 15th and 16th centuries when Torun was a flourishing member of the Hanseatic league. The ruined castle of the Teutonic knights, part of the old walls, the town hall, the churches of St. John, of the Virgin and of St. James are the most interesting edifices. There is a monument to Kopernik (Copernicus), who was born in Torun. The old wooden bridge has been succeeded by a massive iron railway viaduct 3,300 ft. long. Torun carries on trade in grain, timber and foodstuffs and has ironworks, sawmills and other manufactures. Torun was founded in 1231 by the Teutonic Order, which was given land and invited to help the Poles against the heathen Prussians. It became a subject city of the order and an important member of the Hanseatic league, but political and commercial interests bound it to Poland. In 1454 the city revolted against the order and was annexed to Poland in 1466 at the peace concluded there. A religious riot in 1724, terminating in a brutal execution, made a great stir in Europe. The town was seized by Prussia at the second partition, was returned to the grand duchy oi Warszawa, and again granted. in 1815, to Prussia, in which it remained until 1918. Germany seized Torun in 1939; it was returned to Poland in 1945.

THORN, in botany, a hard pointed structure, also termed a spine. It may be an attenuated branch, leaf or root, but generally represents a small branch, as in hawthorn, where a normal branch arising in the axil of a leaf is replaced by a sharply pointed thorn. Accessory buds on either side of the thorn and developed in the same leaf axil will grow in the next season into ordinary branches. The similarly developed thorns of the honey locust (Gleditsia) are branched. In other cases, as the sloe or the wild pear. branches become spiny at the apex tapering into a stiff leafless point. On a cultivated tree these branches disappear as a result of their more vigorous growth. Leaves may be modified into spines, as in barberry, the leaves of which show every gradation between a leaf with a spiny-toothed edge and those which have been reduced to simple or multiple spines. In some species of *Astragalus* the petiole or supporting stalk of the pinnately compound or bisymmetrical leaf persists after the fall of the leaflets as a sharp spine. In the false acacia (Robinia) the stipules are represented by spines. The thorns of desert cacti protect the succulent plant body from animal predators; and, unlike leaves: they do not give off precious water to the air. (See also CACTUS.)

Thorn is also a common name for the species of the genus *Crataegus* or hawthorn (*q.v.*), and when combined with other words is applied to many other plants such as blackthorn (*Prunus spinosa*), Christ's-thorn (*Paliurus spina-christi*), Jerusalem thorn (Parkinsonia *aculeata*) and others.

THORNABY-ON-TEES, a municipal borough in the North Riding of Yorkshire, England, 3 mi. S.W. of Middlesbrough by road, in the hliddlesbrough West parliamentary division. Pop. (1951) 23,416. Area 3 sq.mi. It lies on the Tees river. opposite Stockton-on-Tees. with which it is connected by a bridge. In the 8th century the Danes called it Thormodby; in Domesday Book it appears as Tormozby. The parish church on the village green is Norman. Thornaby's industrial development dates from the 19th century. It was incorporated as a separate borough in 1892. The population is employed chiefly in bridge building, heavy engineering, foundries. wire ropemaking, shipbreaking, flour milling, the production of sugar and preserves.

THORNDIKE, EDWARD LEE (1874–1949), U.S. psychologist. whose most significant contributions to world thought perhaps were made in the science of behaviour. was born at Williamsburg, Mass., Aug. 31. 1874. His professional career. save for one year at Western Reserve university, Cleveland. O., was spent at Teachers college, Columbia university. An unusually creative and productive scholar. he, or he and collaborators, published more than 500 books and articles. His influence upon psychological and educational thought has been world-wide.

Thorndike's pioneer nork on animal intelligence. in the late 1890s, established animal psychology as a natural science and introduced a new concept of the nature of mind. His laws of learning, an outgrowth of his experiments on animal intelligence, and subsequent modification and elaboration of them, hold a central place in learning theory.

Almost immediately after joining the faculty of Columbia he turned his energies to learning in school situations. He was largely responsible for the early development in the United States of the field of psychology, including applications of psychology to such fields as arithmetic, algebra. reading, handwriting and language. Other major contributions to education include works on the theory of mental measurement, educational and psychological tests, compilations of the words occurring most frequently in English reading matter and a series of dictionaries designed for school use.

Best knoan is his three-volume work *Educational Psychology* (1913–14). Additional works of special interest treat mental life of monkeys; prediction of vocational success; wants. interests and attitudes: and principles of education. Thorndike died at Montrose. N.Y.. on Aug. 9, 1949. (J. B. SD)

THORNDIKE, ISRAEL (1755–1832), U.S. merchant. financier and politician, was born in Beverly, Mass.. on April 30, 1755. He became a sea captain at the age of 21 and then a merchant shipowner in partnership with Moses Brown of Waltham. He was a Revolutionary War privateer owner and master. In 1810 his interests outgrew Beverly and he moved to Boston. His customary title of "colonel" derived from a brief tour of duty with the Massachusetts militia. With money made in foreign trade he engaged in unprofitable speculation in Western Reserve (Ohio) and Maine lands, in highly successful investment in Boston real estate and in the early cotton textile manufacture with Francis C. Loaell and Nathan Appleton.

Thorndike was an ardent Federalist in politics and served in the Massachusetts legislature for 12 years. He gave the Ebeling library of Americana of Hamburg, Germany, to Harvard college. His estate was valued at more than $1,100,000. He died May 8, 1832, in Boston.

See J. D. Forbes, ***Israel Thorndike, Federalist Financier (1953).*** (J. D. Fo.)

THORNDIKE, DAME SYBIL (1882–), British actress, whose unusual versatility enabled her to build up a reputation in tragedy, melodrama and comedy. was born at Gainsborough, Lincolnshire, on Oct. 24, 1882, and was educated at the high school in Rochester, where her father was a canon of the cathedral. After experience on tour in the U.S. with Ben Greet in Shakespearean repertory (1903–07) and with Miss A. E. Horniman's company in Manchester (1908–09 and 1911–13), she joined the Old Vic company in London (1914–18) and helped to establish not only the theatre's name as a home of Shakespeare but also her own as the most promising English tragic actress of the day.

Having set the seal on this reputation in 1919–20 with performances as Hecuba in *The Trojan Women* and as Medea. she went on to prove her versatility in a multiplicity of parts, modern as well as classical, comic as well as tragic. In 1924 she created the name part in Shaw's *Saint Joan;* and though many admired actresses followed her, none realized the character more completely.

Her superb health and vigour did not desert her as she grew older! and she was able to tour the world in exacting classical parts at an age when many of her contemporaries had been content to retire. Also. in her 60s, she broke new ground, giving, in such plays as *The Linden Tree* (1947), *The Foolish Gentlewoman* (1949), *Treasure Hunt* (1949), *Waters of the Moon* (1951) and *A Day* By *The Sea* (1953), a whole gallery of portraits of elderly ladies having in common nothing but the meticulous and humorous observation which the actress had brought to their creation. She married Lewis Casson in 1908. She was created a dame of the British empire in 1931. (W. A. DN.)

THORNHILL, SIR JAMES (1675–1734), English painter, the first to excel in historical painting, whose style was in the Italian baroque tradition, was born at Melcombe Regis, Dorset. He became the history painter and sergeant painter to George I and George II, master of the Painters' company in 1720, fellow of the Royal society in 1723, member of parliament from 1722 to 1734, and was knighted in 1720.

He was one of the original directors of Kneller's Academy of Painting, and when this closed, and he had failed to establish a "royal academy." he opened his own drawing school, which also proved unsuccessful. Thornhill died at Thornhill, Dorset, on May 13, 1734.

The eight scenes in the dome of St. Paul's cathedral (1715–19) and the allegories in the Painted hall, Greenwich hospital (1708–27), are his two most considerable works. His paintings were largely executed, on the ceilings and stairs of such country houses and palaces as Hampton Court, Blenheim and Chatsworth. Among Thornhill's few canvases are the altarpiece for St. Mary's parish church, Weymouth, and a group portrait of the members of the house of commons in which he was assisted by William Hogarth, his son-in-law. Thornhill also did portraits (his sitters including Isaac Newton and Richard Steele), book illustrations, theatre scenery and the rose window of the north transept of Westminster abbey (1721). (WM. O.;X.)

THORNHILL, a village in the civil parish of Morton, Nithsdale, Dumfriesshire, Scot., 14 mi. N.N.W. of Dumfries by road. Pop. (1951) 1.262. Its broad village street is lined with lime trees. planted in 1861. Thornhill, in the valley of the Nith, near wooded country, stands on the site of a Roman signal camp. Morton parish church is in the village, and there is a museum, containing some relics of Robert Burns. Sales of livestock are held every Thursday and an agricultural show occurs annually in July. Agriculture and forestry employ most of the inhabitants. but there is also a bacon and sausage factory. Morton castle, 2½ mi. N.E. and now ruined. was built *c.* 1080. Drumlanrig castle (3 mi. N.N.W.) is a seat of the duke of Buccleuch and Queensberry (the two dukedoms were united in 1810), whose family had much influence in the district and actually possesses the village land. Drumlanrig was built in the latter half of the 17th century, and the retreating Jacobites spent a night there in 1745. The ancient Dalgarnock churchyard contains many Covenanters' tombs and a cross commemorating 57 of the martyrs.

THORNTON, WILLIAM (1759–1828), British-U.S. architect. inventor and public official who created the original design for the Capitol at Washington, D.C., was born May 20, 1759, at Tortola, V.I. He studied medicine at the University of Edinburgh (1781–84) and received his M.D. from Aberdeen university (1784). After travel on the continent he returned to Tortola and went to the United States in 1787. In the following year he became a United States citizen and settled in Philadelphia. The Library company of Philadelphia promoted a competition (1789) for its new building that Thornton won without formally having studied architecture. As inventors he and John Fitch (*q.v.*) early experimented with paddle steamboats.

From 1790–92 he was again at Tortola, where he first heard of the important competition for the Capitol at Washington. He submitted designs that were received months after the competition closed; yet the judges, not satisfied with those previously submitted, selected Thornton's. His revised Georgian design of 1795 was executed as the exterior of the north and south wings adjacent to the central rotunda, though B. H. Latrobe (*q.v.*) completely redesigned the interiors. From 1794–1802 Thornton was a commissioner of the city of Washington. He designed the Octagon, Washington (1798–1800), a residence for John Tayloe. From 1802–28 he served as first superintendent of the patent office. He died in Washington on March 28, 1828, and was buried in the congressional cemetery. (P. F. N.)

THORNYCROFT, SIR (WILLIAM) HAMO (1850–1925), English sculptor, was born in London on March 9, 1850, and studied under his father, Thomas Thornycroft, at the British museum, at the Royal Academy schools and in Italy, where he was particularly interested in Michelangelo. In 1872 he contributed the figures of Shakespeare. Fame and Comedy to the Poets' fountain, Park lane (later removed), designed by his father. His independent success began with "Artemis" (exhibited 1880), and in 1881 he showed the bronze "Teucer" (Tate gallery. London) at the Royal Academy, of which he was then elected associate. He executed many public monuments, including those to Gen. Charles George Gordon (1888, formerly Trafalgar square), Oliver Cromwell (1899, Westminster), Dean John Colet (1902, St. Paul's school, Hammersmith), William Gladstone (1905, Strand) and the architect Richard Norman Shaw (bas-relief, 1914, New Scotland Yard). His style, at first an enlivened classicism, was affected in the mid-1880s (in "The Mower," 1884, Walker art gallery, Liverpool; "A Sower," 1886) by J. F. Millet's peasant realism and later (*e.g.,* "The Kiss," 1916, Tate gallery) was influenced slightly by Auguste Rodin. Thornycroft was elected Royal academician in 1888 and knighted in 1917.

Thornycroft died at Oxford on Dec. 18, 1925. He was the brother of Sir John Thornycroft (*q.v.*).

THORNYCROFT, SIR JOHN ISAAC (1843–1928), British naval architect and engineer who was responsible for the introduction of special designs of ships' hulls and improvements in machinery was born in Rome on Feb. 1, 1843. He was sent by his father, Thomas Thornycroft. a sculptor, who was also an amateur engineer, to Glasgow university, after nhich he worked for a short time in John Elder and Palmer's shipyards. In 1866 he started his own launch-building and engineering works at Chiswick, London. Gaining a high reputation for his boats. he was given the order for H.M.S. "Lightning," the first torpedo boat of the Royal Navy. Later he took into partnership his brother-in-law, John Donaldson. Thornycroft took a leading part in introducing water tube boilers into the British and into other navies and was granted a number of patents, including one of the earliest for ship stabilizers. He served as a member of Lord Fisher's committee. which produced the design for the battleship "Dreadnought" and introduced oil fuel for the Royal Navy. He was knighted in 1902 and died on June 28, 1928, at Bembridge, Isle of Wight. (J. E. Tt.)

THÓRODDSEN, THORVALDUR (1855–1921), Icelandic geographer who specialized in exploration of the interior of Iceland, was born on the island of Flatey in Breidi fiord. Iceland, on June 6, 1855. Having studied at the University of Copenhagen, he began his long series of Icelandic explorations by joining J. F. Johnstrup in a study of the volcanic districts of Iceland in 1876. Thóroddsen held teaching posts at Mddruvellir in northern Iceland (1880) and at Reykjavik (1885–95), but his journeys in Iceland continued almost annually. diversified only by brief visits to England and the continent of Europe. From 1895 to 1898 he made his expeditions from Copenhagen. where he had settled. and he died there on Sept. 28, 1921. Thóroddsen wrote several books on the volcanoes of Iceland.

THOROUGH BASS, in music, a system of accompaniment (*q.v.*) customary during the 17th and 18th centuries, whereby the bass line is written out all "through" the composition, but its harmonization is left to the accompanist to provide more or less impromptu. Usually. though not invariably, he is kept generally informed as to the harmony resulting from the melodic part or parts which he is accompanying, so as not to conflict with it in his own harmonization. This information is conveyed by figures added to the bass line, which is then more specifically described as figured bass.

The accompanist is said to "realize" the bass. He may do this impromptu, *i.e.,* reading it strictly at sight in course of performance: a very skilled achievement to which not many modern performers are trained. But it was always customary to look through the music in advance if opportunity occurred. This allows the performer to improve on his first thoughts, and, in music suited to an elaborate accompaniment, is normally the best course. It hardly matters whether his preparations are memorized or written out in whole or part, but it does matter that the result shall sound free, flexible and spontaneous, as if it had been improvised. Modern editors who provide printed realizations usually bear this in mind. keeping their parts on the light side.

The information conveyed by the figures is never complete and is often so sketchy, not to say inaccurate, that the performer, when no preparation has been possible, has to rely on his own grasp of where the music is going. This came more easily to a contemporary performer than it does to present-day musicians, but the faculty can be cultivated. Indeed it is one of the most enjoyable parlour games. According to J. F. Daube's *General-Bass* (1756), the style of improvised accompaniment was brought to its height by J. S. Bach: "He knew how to introduce a point of imitation so ingeniously in either right or left hand and how to bring in so unexpected a counter-theme, that the listener would have sworn that it had all been composed in that form with the most careful preparation . . ." The true reason for thorough bass is the freshness of the invention. Thorough bass was thus not merely a convenient shorthand for saving the composer's time; it was a means of giving zest to the accompaniment by inviting the performer to draw on his capacity for spontaneous enjoyment.

The figures themselves are numerals set one above the other to indicate the intervals, as counted up from the bass note, of the harmonies required. In realizing these intervals, the performer can invert them in any order of notes; *i.e.,* he can manipulate the spacing of the chord, though he will not normally go above the solo part for long at a time, if at all. The figures are kept to the minimum necessary to determine the harmony by indicating its most characteristic intervals, the remainder of the chord being taken as understood. Necessary accidentals are shown. Only the main harmonies, and not the passing harmonies, are normally shown. There is great scope for varying and enriching the indicated harmony by introducing passing notes, especially accented passing notes. The same recourse is invaluable for contriving an interesting and convincing melodic outline to the accompaniment.

The elaboration given to the realization will vary from the simplest harmonization in plain part-writing to an exploitation of all the harmonic and contrapuntal possibilities. Four-part harmony is standard, though the nature of the music to be accompanied sometimes requires only three or two parts and occasionally the unharmonized bass line. Alternatively, a "full accompaniment" requires as many notes to each hand as the fingers can accommodate and in such realizations all rules forbidding consecutive fifths, etc., may be waived except as between the two outside (bottom and top) parts.

Good figured-bass accompaniment, taking into account not only the character of the piece but, as C. P. E. Bach specified, the remaining performers, the soloist, the auditorium and the audience, thus made almost as heavy a demand on the performer's judgment as on his imagination.

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THORPE, JIM (James Francis Thorpe) (1888–1953), U.S. athlete, recognized as the greatest all-around athlete of the first half of the 20th century, was born May 28, 1888, near Prague, Okla., of American Indian descent. A star in both college and professional football, he was twice named halfback on Walter Camp's -411-America teams (1911, 1912); in 1912 he scored 25 touchdowns and 198 points for Carlyle (Pa.) institute.

Standing 6 ft. tall and weighing 190 lb., Thorpe was a standout in the 1912 Olympic games at Stockholm, where he won the pentathlon and decathlon. Later, however, when it was discovered that he had played semiprofessional baseball in the summer of

1911, his gold medals and trophy were taken from him and his Olympic records erased from the books.

Signed by John J. McGraw of the New York Giants for $4,500 in 1913, Thorpe spent most of the time on the bench. He finished his six-year major-league baseball career in 1919 with the Boston Braves, where he played in 60 games and hit .327. He died in Lomita, Calif., March 28, 1953. (J. D. McC.)

THORPE (Thorp). **THOMAS BANGS** (1815–1878), U.S. humorist. was one of the most effective portrayers of frontier life and character before Mark Twain; he is the author of "The Big Bear of Arkansas," a tall tale so outstanding that some historians have named certain southwestern contemporaries of Thorpe the Big Bear school of humorists.

Born at Westfield, Mass., on March 1, 1815, and educated in New York schools, Thorpe studied painting under John Quidor and at the age of 18 exhibited his "Ichabod Crane" at the American Academy of Fine Arts, New York city. In 1836, after two years' study at Wesleyan university, Middletown, Conn., he moved to Louisiana. An active Union Whig, he published successively five newspapers, chiefly in New Orleans and Baton Rouge.

It was during this period that Thorpe wrote "The Big Bear of Arkansas," published in 1841 in the New York magazine *Spirit of the Times*.

Following a political defeat, Thorpe moved in 1854 to New York city and published his finest sketches as *The Hive of the Bee Hunter*. During the Civil War he saw service in New Orleans; afterward he returned to New York and spent his remaining years painting. working at the customhouse and writing for *Harper's*, *Appleton's* and other journals.

He died at New York, on Sept. 20, 1878.

Thorpe's painting and writing show the influence of Washington Irving and of sporting literature, a love of romantic scenery and a continuing attempt to define the distinctively American character, which, he believed, the western frontier was producing.

See Walter Blair, *Native American Humor* (1937); Milton Rickels, "A Bibliography of the Writings of Thomas Bangs Thorpe," *American Literature*, 29:171–179 (1957). (M. H. R.)

THORPE, SIR THOMAS EDWARD (1845–1925), British chemist. was born at Harpurhey. Manchester, on Dec. 8, 1845. Thorpe is perhaps best known for his work as an organizer in connection with his direction of the British government laboratories and as a brilliant lecturer and writer. He studied at Owens college. Manchester, and then under Robert W. von Bunsen at Heidelberg, where he obtained his doctorate (1869). In 1870 he became professor of chemistry at Anderson college. Glasgow, and four years later at the Uorkshire college, Leeds. In 1885 he obtained the chair at the Normal School of Science (later the Imperial College of Science), London, and remained there until appointed director of the government laboratories in 1894. On his retirement, he returned to the Imperial college (1909–12). He was elected to the Royal society in 1876, was made a companion of the Bath in 1900 and knighted in 1909. He died at Salcombe, South Devon, on Feb. 23, 1925. He brought out, with the cooperation of a number of specialists, the well-known *Dictionary of Applied Chemistry* (1890; rev. ed., 1927). He was also the author of *Essays in Historical Chemistry* (1894) and a biography of Joseph Priestley (1906). His contributions to chemical knowledge include an accurate series of measurements of the specific volumes of chemical substances of related composition. With A E. H. Tutton, he studied the oxides of phosphorus (*q.v.*) (1886 *et seq*); they discovered phosphorus tetroxide (P_2O_4) and investigated this and phosphorus trioxide (P_4O_6). From 1884 to 1886 he made a long series of measurements (with J. W. Rodger) of the viscosities of organic substances and attempted to correlate fluidity and composition.

With Sir Arthur Rucker, Thorpe carried out (1884–88) a magnetic survey of the British Isles.

See *Proc. Roy. Soc.* (192;).

THORVALDSEN (Thorwaldsen), **BERTEL** (1768–1844), Danish sculptor, who was the most successful of the neoclassical sculptors, was born in Copenhagen on Nov. 19, 1768. His father was an Icelander who had settled in Denmark and there carried on the trade of a wood carver. Thorvaldsen entered the Copenhagen school of art, where he won the highest prize, the traveling studentship. In 1797 he went to Rome, where Antonio Canova was at the height of his popularity. Thorvaldsen's first success was the model for a statue of Jason, highly praised by Canova, which he was commissioned to execute in marble by the English author and connoisseur Thomas Hope. From that time Thorvaldsen's success was assured, and he did not leave Italy for 23 years. In 1819 he returned to Denmark. where he was commissioned to make the colossal series of statues of Christ and the 12 apostles that are now in the Vor Frue Kirke in Copenhagen. These were executed after his return to Rome and were not completed till 1838, when Thorvaldsen again returned to Denmark. He died in Copenhagen on March 24, 1844, bequeathing a great part of his fortune for the building and endowment of a museum in that city. His collection of works of art and the models for all his sculpture went to furnish the museum, in the courtyard of which he was buried under a bed of roses, by his own wish.

Many of Thorvaldsen's statues of pagan deities are modeled with much of the antique feeling for breadth and purity of design. For Christian sculpture he had no real feeling, and the tomb of Pius VII in St. Peter's and the "Christ and Apostles" at Copenhagen are less successful. One of his best-known works is his statue of a lion, at Lucerne, Switz. He worked sometimes with feverish eagerness; at other times he was idle for months.

THOTH, Greek form of the name of the Egyptian god Djhowtey, whose cult was centred in the town of Khmun (Lat. Hermopolis Magna; mod. El Ashmunein) in upper Egypt. At first he was probably the moon-god and, as such, was called "reckoner of time" and his name was given to the first month of the Egyptian year. In consequence he became the god of reckoning and of learning in general, and was held to be the inventor of writing, the founder of social order, the creator of languages, the scribe. interpreter and adviser of the gods and the representative of the sun-god Ra (Re) on earth. He was also the patron of scribes and officials. Thoth played an important part in the myth of Osiris, protecting Isis during her pregnancy and healing the injury inflicted on her son Horus by Osiris' adversary, the god Set. Thoth weighed the hearts of the deceased at their judgment, and reported the result to the presiding god Osiris and his fellow judges.

Thoth's sacred animals, for reasons which are not quite clear, were the bird ibis (*Threskiornis ethiopica*) and the baboon (*Cynocephalus hamadryas*); numerous mummified bodies of these two animals were found in cemeteries near Hermopolis and Thebes. Thoth himself was sometimes represented as an ibis or as a baboon, but more usually in human form with an ibis' head. The Greeks identified Thoth with their god Hermes and traced back to "Thoth, the thrice great" (Hermes Trismegistos; *q.v.*) the authorship of powerful magical books.

See P. Boylan, *Thoth, the Hermes of Egypt* (1922). (J. Cy.)

THOU (Thuanus), **JACQUES AUGUSTE DE** (1553–1617), French historian, was the grandson of Augustin de Thou, president of the *parlement* of Paris (d. 1544). He studied law at Orléans, at Bourges and finally at Valence. He was at first intended for the church; he received the minor orders, and on the appointment of his uncle Nicolas to the episcopate succeeded him as a canon of Notre Dame. As *conseiller d'état* he served faithfully both the effeminate, bigoted and cruel Henry III and Henry IV, a skeptic, because they were both the representatives of legitimate authority. He succeeded his uncle Augustin as *président à mortier* (1595), and used his new authority in the interests of religious peace, negotiating, on the one hand, the Edict of Nantes with the Protestants, while in the name of the principals of the Gallican church he opposed the recognition of the Council of Trent. This attitude exposed him to the animosity of the League party and of the Holy See, and to their persecution when the first edition of his history appeared.

The history mas the work of his whole life. His materials for writing it were drawn from his rich library, which he established in the Rue des Poitevins in the year 1587, with the two brothers, Pierre and Jacques Dupuy, as librarians. His object was to produce a purely scientific and unbiased work, and for this reason he wrote it in Latin. giving it as title *Historia sui temporis.* The first 18 books, embracing the period from 1545–60, appeared in 1604 (1 vol. folio), and the work was at once attacked by those whom the author himself calls les *envieux* et les *factieux.* The second part, dealing with the first wars of religion (1560–72), was put on the Index *librorum prohibitorum.* The third part (to 1574). and the fourth (to 1584), which appeared in 1607 and 1608, caused a similar outcry, in spite of de Thou's efforts to remain impartial. In answer to his detractors. he wrote his *Mémoires,* which are a useful complement to the History of His Own *Times.* After the death of Henry IV, the queen regent refused him the position of first president of the *parlement,* appointing him instead as a member of the *Conseil* des finances. He continued to serve under Marie de Nedicis, and took part in the negotiations of the treaties concluded at Ste. Menehould (1614) and Loudun (1616). He died at Paris on May 7, 1617. Three years after the death of de Thou, Pierre Dupuy and Nicolas Rigault brought out, nith part 5, the first complete edition of the *Historia sui* temporis, comprising 138 books; they appended to it the *Mémoires,* also given in Latin (1620). A hundred years later, an Englishman, Samuel Buckley, published a critical edition, the material for which had been collected in France itself by Thomas Carte (1733). De Thou's history is a model of exact research, drawn from the best sources. and presented in a style both elegant and animated. The standard translation is *Histoire* universelle, by Le Beau. Le Mascrier, the Abbé Des Fontaines (1734). The *Mémoires* had already been translated by Le Petit and Des Ifs (1711); in this form they have been reprinted in the collections of Petitot. Michaud and Buchon. To de Thou we also owe certain other works: a treatise De re *accipitraria* (1784). a Life, in Latin, of Papyre Masson, some *Poemata* sacra, etc.

THOUGHT, LAWS OF. Traditionally, special importance has been attached to three of the simplest laws of logic, the law *of* identity, the law of contradiction, and the law of *excluded middle* (or *tertium non datur*). These were called the "laws of thought," a name which may conveniently be retained even by those who do not accept the implications which the name suggests.

As examples of axioms (see AXIOM) Aristotle cites that, of two contradictories. one must be true, and that it is impossible for anything both to be and not to be. These are the principles which were afterward known as the laws of excluded middle and of contradiction respectively. They occur in Aristotle also in other forms, which are regarded as being expressions of the same laws, *e.g.,* that there is no middle ground between contradictories, and that it is impossible for anything both to be predicated and not to be predicated of the same thing in the same sense. Aristotle partly exempted future contingents from the law of excluded middle, holding that it is not (now) either true or false that there will be a naval battle tomorrow, but that it is (now) true that either there will be a naval battle tomorrow or not; against this, Chrysippus (see LOGIC, HISTORY OF) maintained that all propositions. even about the future, are either true or false.

The law of identity has usually been stated (for example by Leibniz) as: A is A

To render the three laws in modern logical notation (see LOGIC), the best choices would seem to be: $F(x) \supset \cdot F(x)$ (law of identity), $\sim \cdot p \sim p$ (law *of* contradiction), $p \vee \sim p$ (law of excluded middle). However. the law of identity is also often given as $(x)\, x =$ x, a form which differs from the other (on the basis of the definition of $=$ in the article LOGIC) only by the insertion of a quantifier.

The three laws may also be understood in a semantical sense (see SEMANTICS IN LOGIC), the traditional statements of them generally not making a sharp distinction between such metatheoretic principles and principles which are rather to be expressed in the notation of propositional calculus or functional calculus. Thus the law of identity would be that a term must preserve the same denotations in all its occurrences, at least throughout any one context; the law of contradiction, that a sentence and its negation. S and $\sim S$, are not both true; the law of excluded middle, that either S or $\sim S$ is true. In this interpretation the "laws of thought" are to be regarded as being about some particular language—or else as general principles of sound notation, demands which any acceptable language or system of notation is required to satisfy.

That the lans of thought—or even only the laws of identity and contradiction—are a sufficient foundation for the whole of logic, or that all other principles of logic are mere elaborations of them, nas a doctrine common among traditional logicians of the 19th century, and though it appears already in the *Vernunftlehre* (1756) of H S. Reimarus, its widespread adoption is perhaps traceable to Kant's characterization of an analytic judgment (see LOGIC. HISTORY OF) as one for recognition of whose truth the law of contradiction suffices. It is, however, difficult to give this doctrine a precise meaning in such a way as to make it tenable. For example it is not true that the three laws, say in the forms $F(x) \supset_x F(x)$, $\sim \cdot p \sim p$, $p \vee \sim p$, are a sufficient set of axioms for logic, or even for the most elementary branch of logic, the propositional calculus, or for the traditional theory of the categorical syllogism

Criticisms and Rejections of the Laws of Thought.—The law of excluded middle and some related laws of propositional calculus and functional calculus of first order are rejected by L. E. J. Brouwer and the school of mathematical intuitionism (see LOGIC, and MATHEMATICS, FOUNDATIONS OF), not in the sense that the negation of the law is asserted, but in the sense that use of the law is not admitted as a valid method of mathematical proof in cases in which all members of an infinite class are involved. For example, Brouwer would not accept the disjunction that either there occur ten consecutive 7's somenhere in the decimal expansion of the number π or else not (since there is no proof known of either alternative), but he would accept that there occur ten consecutive i's somewhere in the first 10^{100} digits of the decimal expansion of π or else not (since this could in principle be settled by carrying out the computation of the decimal expansion to the required point).

On the basis of Aristotle's doctrine of future contingents, but not without some modification of it, Jan Łukasiewicz was led in 1920 to formulate a propositional calculus which has a third truth-value (for future contingents) in addition to the usual two, and in which the laws of contradiction and excluded middle alike fail. Propositional calculi with n truth-values, $n \geqq 3$, were published independently by E L. Post in 1921 and by Łukasiewicz in 1930. Corresponding many-valued functional calculi of first order were formulated still later by other writers.

Other criticisms or rejections of one or more of the laws of thought—*e.g.,* by Epicurus (*q.v.*), by Hegel (*q.v.*), by Alfred Korzybski (see SEMANTICS, GENERAL)—are in a different category from those of Brouwer and Lukasiewicz, as they offer no precise formulation of a usable logic in which these laws fail or are modified. *See* also Index references under "Thought, Laws of" in the Index volume.

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THOUGHT-READING: see PARAPSYCHOLOGY; PSYCHICAL RESEARCH; SPIRITUALISM.

THOUGHT TRANSFERENCE: see PARAPSYCHOLOGY.

THOUSAND AND ONE NIGHTS (Arabic, ALF LAYLA WA LAYLA), popularly known as the Arabian Nights, a collection of Arabic short stories of uncertain date and authorship. With the possible exception of the Koran, no other work of Arabic literature has been better-known or more influential in the west: indeed, certain stories, such as those about Aladdin, Ali Baba, and Sindbad the Sailor (*q.v.*), have almost become part of the folklore of western Europe. The stories are grouped round a central situation or frame story, in a manner familiar in medieval European literature as, for instance, in Chaucer's Canterbury *Tales* and Boccaccio's Decameron. The scene is in central Asia or, as the text puts it. "in the islands, or peninsulae, of India and China." King Shahryar discovers that his wife has been regularly unfaithful to him during his absences from the palace Killing her, and the other guilty parties, he is filled with a loathing of all womankind. Henceforward he marries, and kills. a new wife every day. Soon no further candidates can be found for the royal hand. The vizier, or prime minister, has two daughters, Shahrazad, the elder, and Dunyazad. Shahrazad insists that her father give her in marriage to the king. having worked out a scheme whereby she can save both herself and her people. Each evening she tells a story to her sister and the king, but does not finish it, promising to do so on the following night, if she survives. The stories are so entertaining, and the king is so eager to hear how each one ends that he puts off the execution of Shahrazad from day to day and ultimately gives up his cruel plan altogether.

Texts and Translations. — Antoine Galland (1646–1715; *q.v.*) produced not only the first translation, but also the first printed edition of the *Nights*. He traveled in the near east first in the French diplomatic service, then as a collector of objects for museums. Returning to France, he made a French translation of the *Nights* from a Syrian manuscript in four volumes. This translation, *Les Mille et Une Nuits, contes arabes traduits en français,* was published in 10 volumes between 1704 and 1712. Volumes xi and xii appeared after his death, in 1717. The later volumes contained many stories from other sources; and there is really no "canonical" text of the *Nights,* in respect to either the stories included or the actual wording of them. Galland translated freely, molding the stories into a form acceptable to Europeans of his day. But he was a born storyteller and his work enjoyed enormous popularity. For over a century it was the standard European version, and parts of it have even been translated back into Arabic.

The Arabic text was first published in Calcutta in an incomplete form in two volumes (1814–18); and again in four volumes (1839–42). However, it mas the Egyptian recension which was the basis of 19th–20th century European translations. The first Bulaq (Cairo) edition dates from 1835, and there have been several Cairo editions since. The text was also printed in Breslau (1825–43) as *Tausend und eine Nacht, Arabisch. Nach einer Handschrift von Tunis,* edited by Maximilian Habicht.

During the 19th century, there were several European translations of varying degrees of accuracy and fullness. The question of expurgation troubled some translators, as certain stories in the original are certainly not for juvenile reading. The translation (1838–40) of E. W. Lane (*q.v.*) is incomplete, but has useful notes. John Payne's, in nine volumes, appeared during 1882–84. There were three supplementary volumes in 1884 and a 13th volume in 1889. The most famous English translation is that of Sir Richard Burton (*q.v.*), which is based on Payne's, from which it sometimes quotes passages verbatim. It was published in ten volumes (1885) with six supplementary volumes (1886–88). It has been reprinted since, both in full and in a shortened form. Lady Burton's edition (1886–88) was ruthlessly expurgated. Smithers' edition in 12 volumes (1894) restored most, but not all, of the omissions. Burton had considerable knowledge of the seamy side of eastern life, and his version is much sought after for its notes and commentary. The French translation of J C. Mardrus, begun in 1899, is well known, but not highly esteemed among scholars Not only is the text inaccurate, but it also includes stories which do not really belong to the *Nights*. Space does not permit the listing of the many translations into various European languages, but an outstanding example is the German translation of E. Littmann first published at Leipzig in six volumes (1921–28) with second and third editions in 1953 and 1954.

Origins and Contents. — European orientalists have been interested in the origins of the nork from the beginning of the 19th century onward. Antoine Isaac Silvestre de Sacy (1758–1838; *q.v.*) realized that it could not be the work of a single writer; though Lane thought otherwise. There is now general recognition that it is a composite work which consists of popular stories, probably originally told orally. it has grown in the course of the centuries, material being added somewhat haphazardly in different periods and places. This is borne out by the style, which is largely unstudied and unaffected, with a number of colloquialisms, and even grammatical errors, such as no self-respecting Arabic author would have permitted himself. The varied character and wide geographical diversity of origin of the material also makes a single authorship unlikely. The component elements can be traced to India, Iran, Iraq, Egypt and Turkey. and Gustave von Grunebaum in *Medieval Islam* (2nd ed., 1953) also postulated Greek elements. The general framework may be Indian, though the names of the chief protagonists are Iranian. There are Indian, Iranian, Turkish and even European proper names, but, as is only to be expected in an Islamic work, the majority of names are Arabic. The stories come under several categories. Some of them may be classed as fairy tales. *Aladdin and the Magic Lamp, Ali Baba and the Forty Thieves*, the *Merchant and the Djinni*, etc. There are also romances and love stories; adventure stories such as *Sindbad;* humorous tales such as *The Sleeper Awakened* and *Khalifa the Fisherman;* fables and parables; and a few Arab legends. But the Arab background portrayed is largely that of the Baghdad of Harun al-Rashid and the Cairo of the Fatimids and Mamelukes.

Nabia Abbott discovered the first known reference to the *Thousand and One Nights (See* "A Ninth-Century Fragment of the 'Thousand Nights ," in *Journal of Near Eastern Studies,* 1949). Next, the work is mentioned by al-Masudi (*q.v*) in his *Muraj al-Dhahab* (947). In discussing legendary stories which have come from Iran, India and Greece, he instances "the book *Hazar Afsana,* nhich in Persian means 'A Thousand Tales' .. "The people," he says, "call this book 'A Thousand Nights,' " and it is the story about the king, the vizier, the latter's daughter and her servant girl. These, two are named Shirazad and Dinazad. The *Fihrist* (987) of Ibn al-Nadim mentions the *Hazar Afsana* and outlines the frame story. It then goes on to describe how a certain Abu Abdullah ibn 'Abdus al-Jashyari (d. 942) began writing a collection of 1,000 stories of the Arabs, Iranians, Greeks and other peoples. At his death, he had only completed 480 of them. The existence of some form of the work in Fatimid Egypt is vouched for by al-Qurti, who wrote a history of Egypt under the last Fatimid ruler (1160–71).

August Müller, in 1887, distinguished several layers in the work, including one belonging to Baghdad, and another, much larger and later, written in Egypt. This idea was worked out in greater detail by T. Noldeke, and especially by J. Oestrup in *Studier over 1001 Nat* (1891). The contents were also discussed by J. Horowitz in his article "Die Entstehung von Tausendundeine Nacht" in the *Review of Nations,* no. 4 (April 1927). Nabia Abbott suggests the following successive forms of the *Nights:* (I) An 8th-century Arabic translation of the *Hazar Afsana,* probably full and literal, and entitled *Alf Khurafa.* (2) An 8th-century Islamized version entitled *Alf Layla.* (3) A 9th-century version based on the above, and augmented by other current stories, such as those about Sindbad. (4) Ibn 'Abdus' work, mentioned above, possibly containing much material from 1, 2, and 3. (5) A 12th-century collection, including Egyptian stories. The title *Alf Layla wa Layla* may date from this period. (6) The final form of the nork, extending into the 16th century. Additional material probably included stories of Islamic counter-crusades and far-eastern tales brought to the middle east by the Mongols.

The original title, *A Thousand Stories* was not meant to be accurate, but merely to indicate a large number Littmann suggests that the change to '1,001" came under Turkish influence, from the Turkish idiomatic expression *bzn bir* ("1,001") for a large number. Later, it was felt necessary to justify this title by adding stories, in order to complete the number.

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THRACE, a name applied at various periods to areas of different extent. Since 1923 'Ihrace has been divided betneen Greece (Western Thrace) and Turkey (Eastern Thrace) The boundaries of the Rornan province of Thrace nere — north, the Haemus; east, the Euxine sea; south, the Propontis, the Hellespont and the Aegean; and west, the Nestus. The distinguishing features of the country were the chain of Rhodope (Despotodagh) and the river Hebrus (Maritza). The greater part of the country is hilly and irregular; besides Rhodope two other tolerably definite chains intersect it, one of which descends from Haemus to Adrianople, while the other follows the coast of the Euxine at no great distance inland. One district in the extreme north-west of Thrace lay beyond the watershed separating the streams that flow into the Aegean from those that reach the Danube: this was the territory of Sardica, the modern Sofia. On the southern shore are found the Greek colonies of Abdera and Mesambria on the Aegean, Perinthus on the Propontis, and, the most famous of all, Byzantium (*q.v.*). Colonies were also planted in the Thracian Chersonese, between the Hellespont and the Bay of Melas; among its cities were Sestos and Callipolis (Gallipoli). In order to prevent the incursions of the Thracians, a wall was built across its isthmus.

History. — The most striking archaeological monuments of the prehistoric period are the sepulchral mounds, which are found especially in the neighbourhood of the ancient towns. Roman implements and ornaments have been found in some of them. The country was overrun several times by Darius and his generals, and the Thracian Greeks contributed 120 ships to the armament of Xerxes (Herod. vii. 185). The most powerful Thracian tribe was the Odrysae, whose king, Teres, extended his dominion so as to include the greater part of Thrace. During the Peloponnesian War his son Sitalces was an ally of the Athenians against the Macedonians. During the early period of the Roman empire the Thracian kings were allowed to maintain an independent sovereignty, while acknowledging the suzerainty of Rome, and it was not until the reign of Vespasian that the country was reduced to the form of a province. It was much exposed to the inroads of barbarian invaders, was overrun by the Goths on several occasions, and subsequently by the Huns; but its proximity to Constantinople caused its fortunes to be closely connected with the capital of the Eastern empire. In the middle ages the northern parts of Thrace were occupied by Bulgarians; in 1361 the Turks made themselves masters of Adrianople, which became the Turkish capital. When Constantinople fell in 1453, the whole country passed into the hands of the Turks, and in their possession it remained until 1878, when the northern portion of it was placed under a separate administration, with the title of Eastern Rumelia; this province has now become a part of Bulgaria.

Ancient **Peoples.**—The name "Thracians," from being used both ethnically and geographically, has led to confusion. There were the indigenous Thracians, and also Celtic tribes, such as the Getae. These were the "red" Thracians of Greek writers, and they differed not merely in complexion, but also in their customs and religion, from the native Thracians. The chief native deities were Dionysus, Ares and Bendis (Artemis). The ancient Dionysiac rites, including a ritual play by "goat-men" carrying a wooden phallus, may still be seen at Bizye, the old residence of the Thracian kings. The true Thracians were a dark-complexioned, long-skulled race, which had been in the Balkan peninsula from the Stone Age, closely akin to the Pelasgians (*q.v.*), to the Ligurians, and to the Iberians. There is no well-defined difference between aboriginal Thracians and Illyrians (*see* ILLYRIA). Thus there was an Illyrian tribe, Brygi; a Thracian tribe, Bryges; and, in Strabo's time, a tribe called Dardanii, then reckoned Illyrian, living next the Thracian Bessi (in whose land was the oldest oracle of Dionysus), was probably as much Thracian as Illyrian. All the Thracian and Illyrian tribes tattooed, thus being distinguished from the Celtic tribes. The Thracians differed only dialectically from the Illyrians, their tongue being allied to Greek. The Thracians from Olympus to the Pangaean district struck coins almost as early as the Greeks. (See NUMISMATICS.) (X.)

THE 20TH CENTURY

Thrace was one of the three theatres of the first Balkan war of 1912, when the Bulgarians entered it and defeated the Turks in the great battle of Lule Burgas, subsequently marching up to the ramparts of Chatalja, where the armistice with the Turks was signed. With the assistance of Serbian troops the Bulgarians took Adrianople, and the Treaty of London of May 30, 1913 put back the frontier of European Turkey to a line drawn from Enos on the Aegean to Midia on the Black Sea. Nearly all Thrace had thus fallen to the share of Bulgaria, but her quarrel with her allies over the spoils in Macedonia led to the second Balkan war of 1913, and the Turks took the opportunity to recapture Adrianople, to reoccupy Western Thrace and create the "independent government of Gumuljina," a mainly Moslem district.

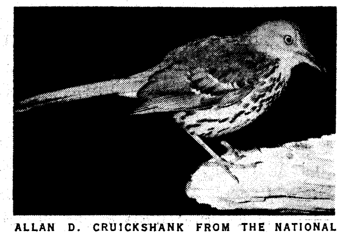
The treaty of Constantinople of Sept. 29, 1913 set back the Turco-Bulgarian frontier in Thrace to the mouth of the river Rezvaya on the Black Sea, considerably to the north of Midia, and, while making the right branch of the Maritsa the frontier on the Aegean, so drew the line between those points as to include Kirk Kilisse and Adrianople within Turkish Thrace. But Giimuljina was restored to Bulgaria, with the result that 14 Moslem deputies of Western Thrace held the balance of power in Bulgaria and, under the influence of their compatriot Talaat, helped to bring Bulgaria over to the Central Empires. Meanwhile the third Treaty of Bucharest fixed the Greco-Bulgarian frontier at the mouth of the Mesta; thus the Thracian coast from the Mesta to the Maritsa gave Bulgaria her coveted outlet on the Aegean. But the frontier cut the latter river and the Mustafa-Pasha (Svilen) Adrianople-Dedeagach railway so that Bulgarian trains had to traverse Turkish territory before reaching their Bulgarian port. The Maritsa was consequently declared free to the transit of both states till they had made fresh lines on their own territories. The cession of this awkward bend in the railway to Bulgaria in 1915 was a further inducement to enter the War on the Turkish side. Thrace was not long left in peace, for the operations at the Dardanelles brought her again within the war zone. The Treaty of Neuilly of 1919 again changed her boundaries. Bulgaria was moved back from the Thracian sea coast in favour of Greece, which by Article 27 of the Treaty of Sèvres of 1920 obtained the lion's share of Thrace as far as "a point near the mouth of the Biyuk Deré" on the Black Sea, and "a point on the sea of Marmora about one kilometre southwest of Kalikratia"—in other words, up to the Chatalja lines.

But the Allies undertook to make the Maritsa an international river and "to ensure the economic outlet of Bulgaria to the Aegean" by Article 48 of the Treaty of Neuilly. This they effected —in theory—by "the Thracian Treaty," signed on the same day as that of Sèvres, which decreed, as a condition of the recognition of Greek sovereignty over the former Bulgarian territories in Thrace, that Bulgaria should have "freedom of transit over the territories and in the ports assigned to Greece in the present Treaty," that "in the port of Dedeagach Bulgaria will be accorded a lease in perpetuity, subject to determination by the League of Nations, of a zone," and that Dedeagach be "declared a port of international concern," free to all members of the League. In practice, Bulgaria did not avail herself of this provision, rejecting Venizelos' offer in 1922 of a lease of the port and preferring a corridor and actual possession. The Greek tenure of Eastern Thrace was brief. After the disaster in Asia Minor, Article 2 of the second Treaty of Lausanne of July 24, 1923 restored Eastern Thrace up to the Maritsa to Turkey, leaving Western Thrace, *minus* the enclave of Karagach, to Greece. By conventions 3 and 6, on either side of these Greco-Turkish and Bulgaro-Turkish frontiers in Thrace demilitarized zones of about 30 km. were established and existing fortifications ordered to be dismantled and the Moslem inhabitants of Western Thrace were exempted from the obligatory exchange of populations. Thus Thrace became divided between Turkey, Greece and Bulgaria.

(W. M.)

THRASEA PAETUS, PUBLIUS CLODIUS, Roman senator and Stoic philosopher, lived during the reign of Nero. At first he was treated with great consideration by Nero, probably because of the influence of Seneca, and became consul in A.D. 56. In 59 Thrasea retired from the senate without voting after the emperor's letter justifying the murder of Agrippina had been read. In 62 he prevented the execution of the praetor Antistius, who had written a libel upon the emperor. From this time (63) until his death in 66 Thrasea retired into private life. Various charges were brought against him, and the senate, awed by the presence of large bodies of troops, condemned him to death. When the news was brought to Thrasea at his house, where he was entertaining a number of friends, he retired to his room and had the veins of his arms opened.

THRASHER, a group of birds belonging to the same American family Mimidae as the mockingbird (*q.v.*). Perhaps the best of these accomplished songsters is Sennett's thrasher (Toxostoma longirostre) of southeast Texas and northeast Mexico, but the brown thrasher (T. rufum) of eastern North America also has a fine song. A third species is the sage thrasher (Oreoscoptes *montanus*) of the southwestern United States. All thrashers are birds of bushy thickets, where they build fairly bulky cup-shaped nests of twigs, in which they lay three to six whitish or pale greenish eggs, heavily speckled with brown. In spite of their arboreal nature, thrashers to a large extent feed on the ground.



ALLAN D. CRUICKSHANK FROM THE NATIONAL AUDUBON SOCIETY

BROWN THRASHER (TOXOSTOMA RUFUM) OF EASTERN NORTH AMERICA

The catbird (*q.v.*) has a cat-like mewing sound as well as a song. Unlike most of its relatives, it lays deep glossy blue-green eggs. Thrashers are beneficial in view of their insect-eating habits. (HT. FN.)

THRASYBULUS, an Athenian general, whose public career began in 411 B.C., when he frustrated the oligarchic rising in Samos (see PELOPONNESIAN WAR). Elected general by the troops, he effected the recall of Alcibiades and assisted him in the ensuing naval campaigns, contributing to the victories of Cynossema (411) and Cyzicus (410). He commanded a ship at Arginusae and was commissioned with Theramenes (*q.v.*) to rescue the men on the wrecks. In 404, when exiled by the Thirty Tyrants, he retired to Thebes. Late that year, with 70 men, he seized Phyle, a hill fort on Mt. Parnes. Thrasybulus then gained the Peiraeus, 1,000 strong, and held Munychia against the oligarchs. Eventually a Spartan expedition under king Pausanias arrived and the democracy was restored. Thrasybulus was now the hero of the people; but a decree by which he secured the franchise for all his followers was rescinded as illegal. In 395 Thrasybulus induced Athens to join the Theban league against Sparta, and in 389 he led a new fleet of 40 ships against the Spartans at Rhodes. Sailing first to the Bosporus he effected a democratic revolution at Byzantium and renewed the corn toll. After a successful descent on Lesbos and the renewal of the 5% import tax at Thasos and Clazomenae he sailed south and was killed at Aspendus.

THREE BODIES, PROBLEM OF, the problem of determining the motion of three heavenly bodies moving under no influence but that of their mutual gravitation. No general solution of this problem is possible. As practically attacked it consists in the problem of determining the perturbations or disturbances in the motion of one of the bodies around the principal or central body that are produced by the attraction of the third. Examples are the motion of the moon around the earth as disturbed by the action of the sun, and of one planet around the sun as disturbed by the action of another planet.

For application of the problem to asteroids, see TROJAN PLANETS.

THREE RIVERS: see TROIS-RIVIÈRES.

THRESHING: see FARM MACHINERY; CROP-PROCESSIKG MACHIKERY.

THRING, EDWARD (1821–1887), who ranks with Thomas Arnold as one of the outstanding English schoolmasters of the 19th century, was born at Alford, Somerset, on Nov. 29, 1821, and educated at Eton and King's college, Cambridge. Ordained in 1846. seven years later he was appointed headmaster of Uppingham school, which he transformed from a small country grammar school into a large public school, in spite of opposition from his governors. Fearing that the independence of the school was threatened by the Endowed Schools commissioners, he formed in 1868 the Headmasters' conference, which thereafter had a great influence in English public school education. Thring remained as headmaster until his death on Oct. 22, 1887. He believed that every boy could do something well and that the business of the master was to discover what this was.

He built the school chapel, opened in 1859 the first school gymnasium in England, started wood and metal workshops, and provided a swimming pool and opportunities for school gardening. At the same time he stressed a sound training in classics, mathematics and English. Thring realized the refining and stimulating power of music in education and built up a strong, musical tradition at Uppingham.

To help young teachers, he wrote Theory and Practice of Teaching (1883).

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THROAT (PHARYNX), in human anatomy, a passageway leading from the oral and nasal cavities to the esophagus (gullet) and larynx (voice box). According to strictest dictionary definition, pharynx is a broader term than throat, the latter being restricted to only part of the pharynx. In medical practice, however, the two terms ordinarily are used interchangeably, and they will be so used in this article.

The throat passes the intake of solids and liquids to the esophagus and conducts air to and from the larynx in inspiration and expiration. The throat also communicates on either side with the cavity of the middle ear by way of the auditory (Eustachian) tube; this provides for equalization of air pressure on the eardrum membrane, which separates the cavity of the middle ear from the external ear canal. (See EAR, ANATOMY OF.)

Anatomy. — The throat has roughly the form of a funnel flattened from front to back, about five inches long and narrowing from a width of about two inches at the base of the skull to one inch at its junction with the esophagus. The wall of the pharynx is attached by its connective tissue and muscles to surrounding structures. The firmest attachments (in addition to continuities with the walls of the oral cavity, Eustachian tubes, esophagus and larynx) are with basal parts of the skull, mandible, tongue, hyoid bone and the thyroid and cricoid cartilages of the larynx. The outermost connective tissue is in most areas loose enough in organization to admit gliding of the pharyngeal wall, in the movements of swallowing, against the surrounding structures.

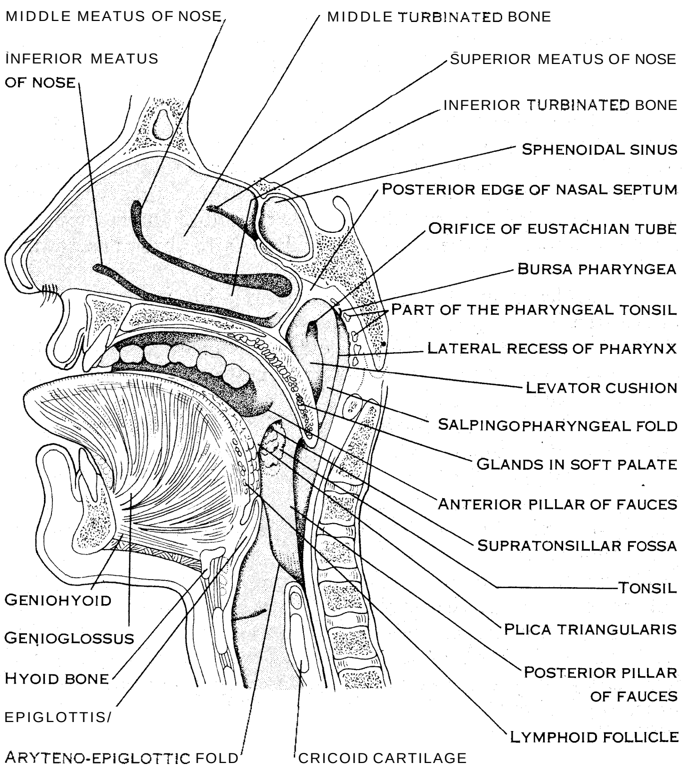
Three main divisions of the throat are distinguished: oral pharynx, nasal pharynx and laryngeal pharynx (see figure). The latter two are airways, whereas the oral pharynx is shared by the respiratory and gastrointestinal tracts. Some of the boundaries of these divisions may be observed in a person whose mouth is held wide open. The limit between mouth cavity and oral pharynx may be approximated by studying the positions of structures appearing in this view. On either side is the palatine tonsil, enlodged between two vertical folds of mucous membrane (in front, the glossopalatine arch; behind, the pharyngopalatine arch). A plane coinciding with the glossopalatine arches on the sides of the throat, and with the junction of the front two-thirds and back one-third of the tongue on its floor, represents the approximate boundary between mouth cavity and oral pharynx. Above, the hard palate separates the oral cavity from the nasal cavities; the soft palate partitions the oral pharynx from the nasal pharynx. The free edge of the soft palate is prolonged in the mid-line as the teatlike uvula. The laryngeal pharynx and the lower part of the oral pharynx are hidden by the bulging of the root of the tongue. An important feature of this obscured region is the epiglottis, a laryngeal flap that guards the glottis as a deflector between the laryngeal pharynx and the lowermost oral pharynx.

The wall of the throat is divisible into principal layers, from within outward: (1) mucous membrane, consisting of epithelium and fibrous connective tissue, of which the outermost part is a tough membrane called the pharyngeal aponeurosis, especially concerned with the upper and lower attachments of the throat; (2)

muscle; (3) connective tissue. The muscle is subject to voluntary control and is concerned in the mechanics of swallowing. The mucous membrane contains numerous minute salivary glands (*q.v.*).

The throat is the seat of the tonsils. The term "tonsil" may suggest only the palatine tonsils, whose position is described above, but these are only components of a series of tonsils encircling the wall of the pharynx. On either side, in addition to the palatine tonsil, is the tubal tonsil, near the orifice of the Eustachian tube. On the roof of the nasopharynx is the pharyngeal tonsil, which is frequently so enlarged in children (adenoids; *q.v.*) as to obstruct the airway. On the floor of the oral pharynx, in the back one third of the tongue, is the lingual tonsil. All these tonsils are masses of lymphoid tissue imbedded in the mucous membrane; this tissue is composed principally of lymphocytes, a variety of white blood cell. Normally, these masses of lymphoid tissue tend to become smaller in adulthood.

Comparative Anatomy.— Broadly defined, the pharynx is the segment of the alimentary tract in direct continuity with the mouth cavity. The invertebrates are widely diversified in degree of complexity, and in the simpler representatives the pharynx does not exist because at this level of structural organization there is no alimentary tract equivalent to that of higher forms. Even in some invertebrates that possess an alimentary tract the pharynx as such is absent, the passage leading from the mouth being termed esophagus or stomach. The invertebrates that have a pharynx exhibit variations of its construction and functions. of which examples are cited. In leeches the pharynx has a robust musculature and serves as a suction pump to extract blood from the prey nhose skin has been pierced by the teeth of the leech. In certain marine worms the wall of the mouth cavity and pharynx may be turned out and protruded for the ingestion of food; the interior of the pharynx



FROM AMBROSE BIRMINGHAM IN "CUNNINGHAM'S TEXT BOOK ANATOMY" (OXFORD MEDICAL PUBLICATIONS)

SAGITTAL SECTION THROUGH MOUTH. TONGUE, LARYNX.' PHARYNX AND NASAL CAVITY. VIEWING THE SECTION SLIGHTLY FROM BELOW

may bear papillae or even horny teeth that aid in the process of ingestion.

The pharynx in invertebrates as a whole is not the strict homologue of the pharynx in vertebrates. The likeness between them is only the analogy of their sequential relations in the alimentary tract. and they are no more homologous than the wings of insects in comparison with the wings of birds. In chordate animals (that is, vertebrates and their immediate kin, illustrated by the lancelet, tunicates and "acorn worms") the pharynx is consistent not only in the fundamentals of structural relationship but also in embryologic derivation, hence homologous throughout.

The classes of vertebrates present wide variation in the character of the pharynx. In all lung-breathing forms (mammals, birds, reptiles and most amphibians in their postlarval stages) the pharynx is constructed in principle like that of man, though varying in anatomical details. Gill-breathing vertebrates reflect the basic pharyngeal pattern that characterizes the chordates as a group. The possession of gills in relation to the pharynx is a primitive feature. Gills are retained throughout life in fishes and in some tailed amphibians (*e.g.*, Necturus, the mud puppy). Gills in some animals (*e.g.*, larval amphibians and the adults of forms such as Necturus) are tufted external appendages. Typically in fishes, however, the gills are internal and in more direct relation with the pharynx. A shark, for example. presents on each side of the "neck" a series of gill slits, usually five in number, exclusive of the front opening known as the spiracle. These slits are communications between the pharynx and the outside, the gills being anchored within the slits where they are bathed with water issuing from the pharynx. A characteristic of bony fishes is the operculum on each side of the "neck." a protective flap overlying the gills and bordering the single gill opening. In all cases the gills are respiratory organs. Their rich capillary beds, fed by pharyngeal blood vessels, provide for the exchange of oxygen and carbon dioxide between blood and the surrounding water, just as the same exchange takes place betneen blood and air within lungs.

In the embryonic history of lung-breathing vertebrates the pharynx is first modeled in the primitive pattern—as if gills were to develop, which they actually do in abortive and transitory fashion in the embryos of some animals that lack gills. As an occasional anomaly in human development, one or more "gill slits" may persist. with or without opening into the pharynx.

For the function of the throat in the process of digestion, see DIGESTION. *Deglutition.* See also MOUTH; RESPIRATORY SYSTEM, ANATOMY OF; TONGUE; see also Index references under "Throat" in the Index volume.

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THROAT, DISEASES OF. Diseases of the throat (*q.v.*) may affect its muscular wall, as in paralysis, or its lining, as in infection by bacteria, viruses or fungi. Infection by streptococci usually produces acute tonsillitis (*q.v.*) with swelling, pain and fever. If the infection reaches the space behind the tonsil, an abscess may form and produce quinsy, with extreme pain, difficulty in swallowing and inability to open the mouth. Scarlet fever (*q.v.*) is a streptococcal throat infection accompanied by a skin rash.

Although streptococcal infections of the throat may produce kidney and heart complications, they are to be less dreaded since the discovery of sulfonamide drugs and penicillin, as these agents, particularly penicillin, control such infections effectively.

Repeated infections usually result in enlarged tonsils and adenoids (*q.v.*), with obstruction to breathing and swallowing. Enlarged adenoids are the commonest cause of deafness in children. Adenoidectomy, usually done with tonsillectomy, restores normal hearing in such cases. These structures, which normally serve a useful purpose, should not be removed unless they are the site of repeated or intractable infection.

Diphtheria (*q.v.*), an acute specific bacterial infection of the throat, is rare where routine immunization is carried out in childhood. It can be cured by antitoxin if recognized early, but untreated it is often fatal. Other throat infections may be caused by viruses (mononucleosis, herpangina) or may occur when the body's resistance is weakened by a scarcity of white blood cells, a condition often due to drug sensitivity and occasionally to prolonged X-ray exposure.

The muscular wall of the throat may be weakened or paralyzed by virus infections of the supplying nerves (poliomyelitis, rabies, etc.), by toxins from diphtheria or infected food, by chemical agents (lead or methyl alcohol) or by circulatory disturbances of the brain, especially in the aged. Spasm of the lowermost constrictor muscle may result from emotional tension, producing the sensation of "lump in the throat."

Cancer of the throat is not common. It may begin as a painless swelling in the region of the tonsil, diagnosable by biopsy. X-ray treatment is often effective in controlling it.

Infections of the larynx or voice box (laryngitis; *q.v.*) may produce hoarseness, and in young children, a difficulty in breathing, known as croup (*q.v.*), which is treated by steam inhalation and antibiotics. A rare but rather severe form of croup, due to diphtheria, may require surgical opening of the windpipe to provide an airway. Tuberculous laryngitis is effectively controlled by streptomycin.

Hoarseness may be due to "singers' node" of the vocal cord, usually associated with overuse of the voice, or to vocal polyp, often found in excessive smokers. Since hoarseness is also an early symptom of cancer involving the larynx, it should be investigated by a physician if it lasts more than two weeks. Laryngeal cancer can be cured in most cases if discovered early. X-ray therapy can cure most small cancers of the vocal cord, whereas surgical removal of the larynx is required for extensive growths.

See A. R. Hollender (ed.), ***The Pharynx*** (1953). (J. A. Ki.)

THROCKMORTON (or THROGMORTON), **FRANCIS** (1554–1584), English conspirator, was the son of Sir John Throckmorton of Feckenham in Worcestershire, and his wife Margery Puttenham. Sir John had been concerned in Wyat's rebellion against Queen Mary Tudor, but was afterward known as a sympathizer with the Roman Catholic party in the reign of Queen Elizabeth, and in 1580 was removed from his office of chief justice of Chester for irregularities in his office, but probably because he was suspected of disloyalty by the government. Francis entered Hart hall. Oxford in 1572, and in 1576 he was enrolled in the Inner Temple.

At Oxford Throckmorton came under the influence of the Roman Catholics, and when Edmund Campion and Robert Parsons (*qq.v.*), the first of the Jesuit missionaries, came to England in 1580 Francis Throckmorton was one of a society of members of the Inner Temple who united to hide and help them. In that year he went abroad. where he consorted with exiled papists, and engaged in treasonable intrigues. In 1583 he returned to act as the confidential agent of a conspiracy which had for its object the invasion of England by a French force for the purpose of releasing Mary Queen of Scots and restoring the papal authority.

Throckmorton occupied a house on Paul's wharf. London, which served as a meeting place for the conspirators. The suspicions of the government being aroused, Throckmorton was arrested in Nov. 1583. He was ciphering a letter to Queen Mary when the constables came upon him, but he found time to send a casket of compromising papers to Mendoza, and a card in cipher in which he promised to reveal nothing. On being threatened with a second application of the torture. however, his strength and courage failed and he made a full confession. His trial took place on May 21, 1584, and he was executed at Tyburn on the 10th of July. The arrest and confession of Throckmorton eventually led to the expulsion of the Spanish ambassador and so to war with Spain.

THROCKMORTON (or THROGMORTON), **SIR NICHOLAS** (1515–1571), English diplomat and politician, was the son of Sir George Throckmorton of Coughton in Warwickshire, and uncle of Francis Throckmorton (*q.v.*). A member of the household of Catherine Parr, the last wife of Henry VIII, he was favourable to the reformers in religion. He sat in parliament from 1545 to 1567. During the reign of Edward VI he was in high favour. When on the death of Edward VI an attempt was made to place Lady Jane Grey on the throne, he contrived to appear the friend of both parties, and secured the favour of Mary Tudor. He was, however, suspected of complicity in Wyat's rebellion in 1554, was brought to trial but was acquitted; though he was detained in the Tower till the following year. But he made his peace with Queen Mary. After the accession of Elizabeth he rose rapidly into favour. He became chamberlain of the exchequer. and from May 1559 to April 1564 he was ambassador in France. During this embassy, in which he was from Sept. 1562 associated with Sir Thomas Smith, Thockmorton was a strong supporter of the Huguenots and uas taken prisoner at the battle of Dreux. He also conducted the negotiations which accompanied Mary Queen of Scots's return to Scotland, and though he supported the reformers on political grounds, he became her personal friend.

On returning to England Throckmorton was sent as ambassador to Scotland in May 1565, to prevent Queen Mary's marriage with Darnley, which however he was unable to do. After the murder of Darnley he mas again sent to Scotland in June 1567 with the still more hopeless task of persuading the Scottish barons who had just imprisoned the queen to restore her to her authority.

Throckmorton's known friendship for Queen Mary, and his constant support of her claim to be recognized as Elizabeth's successor, made him an unwelcome representative of England in that crisis. In Edinburgh Throckmorton could effect little, but he exerted himself to secure the personal safety of the queen. He offended his mistress by showing his instructions to the Scottish barons, and was recalled in August.

In 1569 Throckmorton fell under suspicion during the duke of Norfolk's conspiracy in favour of Mary, and was imprisoned for a time at Windsor, but was not further proceeded against. He died on Feb. 12, 1571.

Sir Nicholas married Anne Carew, and his daughter Elizabeth became the wife of Sir Walter Raleigh.

THROMBOSIS AND EMBOLISM. In health the blood remains fluid in the circulatory system, but under certain conditions a thrombus, or clot within a blood vessel, may form and obstruct the passage of blood. Should part of the clot detach and become free to travel in the circulatory system as an embolus. it will lodge in another part of the vascular system, also interfering with blood flow. The symptoms of thrombosis or embolism, as the processes are called, are determined by the site of the obstruction and may be similar.

Thrombosis tends to occur in an artery, vein, or chamber of the heart (see CIRCULATION OF BLOOD) when the velocity of blood flow is reduced, the lining of the vascular system is roughened, or the clotting tendency of blood is enhanced. Injury, surgery, general or local infection, arterial disease, heart failure. pregnancy and certain disorders of the blood all predispose to thrombus formation.

The incidence of thrombosis increases with age. It occurs most often in the large veins of the pelvis and legs, the small arteries of the heart and the brain, and in the chambers of the left heart, but, under appropriate circumstances, may occur anywhere in the circulatory system.

If the intravascular clotting occurs in a vein, the process is called phlebothrombosis and may produce no symptoms unless productive of embolism. Usually there is also an element of inflammation present which may cause local pain and smelling of the region drained by the affected vein, and then it is designated thrombophlebitis.

While venous thrombosis may sometimes lead to embolism, it is not the threat to life that is met with in arterial thrombosis. The coronary and cerebral arteries to the heart and brain (see CIRCULATION OF BLOOD) are often the site of arteriosclerosis, thickening and irregularity of the vessel lining. which may predispose to clot formation. Should this occur. the mass of heart muscle or brain ordinarily supplied by the thrombosed vessel dies, and. if the victim survives the initial insult, healing follows with scar formation. A favourable course in such an instance will depend upon the extent of involvement and the absence of complicating thromboses, either attached to the lining of the injured heart wall or arising in the veins of the leg, which may give rise to fatal emboli.

Thrombosis depends upon the coagulability of the blood. The blood clot begins as a few blood platelets which adhere to som'e irregular or injured area of vessel wall and form microscopic ridges at right angles to the blood flow. Then, rapidly joined by white blood cells, they initiate precipitation of multitudinous strands of fibrin in which become enmeshed all the formed elements of the blood. The thrombus may then propagate itself, filling the involved vessel and extending back to it's origin. The "tail" of the thrombus thus formed may lie free in a parent vessel and. should it break free, an embolus is born. After its development, the thrombus begins a gradual process of contraction, disintegration and reabsorption, which ultimately may permit some return of blood flow through the clogged vessel.

Emboli are usually composed of coagulated blood but may rarely consist of tumour cells, air, fat particles or bacterial clumps (septic emboli). They are a common cause of sudden death but are by no means always fatal. The embolus arising anywhere in the venous system or in the right side of the heart will lodge in the ramifications of the pulmonary artery. If the embolus is large enough, one of the main pulmonary arteries is obstructed and death occurs. Should it be smaller, the segment of lung dependent upon the obstructed artery dies. In certain types of heart disease an embolus may originate from one of the chambers of the left side of the heart, or from the mitral or aortic valves therein. in which case the blood stream will carry it to one oi the branches of the peripheral arterial tree. Should such an embolus lodge in certain internal organs, pain might be the only consequence; but occlusion of even a small artery to the heart, the eye, the brain, the intestine or one of the extremities will lead also to the death of enough tissue to cause severe disruption, if not cessation, of function of the part. However, tissue death does not occur in all arterial obstructions, for in many locations there are neighbouring collateral arteries which can carry enough blood into the affected area to allow adequate circulation.

In the years after 1940 there were rapid advances in the treatment and prevention of thrombosis and embolism by the use of anticoagulants. Heparin, dicoumarol and related chemicals were shown to greatly reduce the frequency of thrombosis and complicating embolism when administered to postoperative and cardiac patients.

Surgical ligation of the vein proximal to a thrombosis in order to prevent subsequent embolism has been attempted. After embolism has occurred, surgical removal oi the offending clot may frequently save a limb if it can be achieved within six to eight hours after onset.

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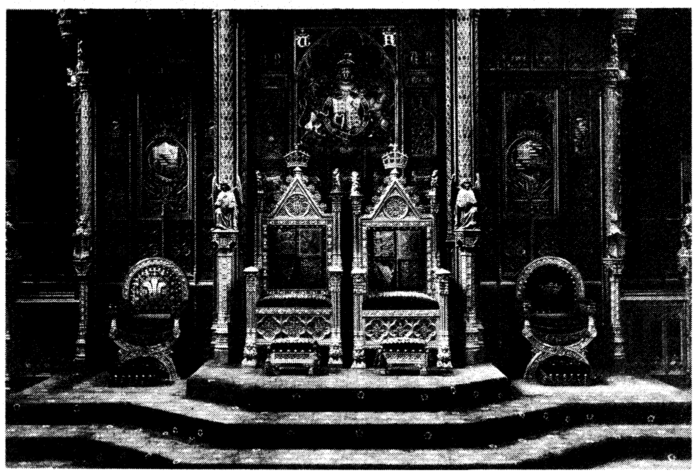
THRONE. A throne is the seat of a sovereign. potentate or dignitary, secular or religious, and a symbol of rule and authority.

Modern usage incorrectly applies the name to the seat alone, but historical evidence shows that not only the seat, but the dais on which it stands and the canopy over it, iorms the throne (Gr. *thronos* "elevated seat"!. Thus. at the end of a papal conclave. the canopies are lowered over the throne of each cardinal except that of the newly elected pope. On occasion the dais alone is referred to as a throne; *e.g.*, that on which two small altars were set at Louis XIII's funeral is described as a *petit trosne*. The throne cannot therefore be the forerunner of chairs. as is often supposed.

In the ancient world, particularly in the east, thrones were almost invariably of a symbolic magnificence: *e.g.*, Solomon's throne of ivory set on a dais approached by six steps flanked by lions. On the throne of the Byzantine emperors. said to be imitated irom it, the lions were mechanical, moving and emitting sounds. In the British museum. London. is a chryselephantine iragment incrusted with gold. ivory, lapis lazuli and cornelian, believed to have come irom the throne of Sargon II oi Assyria (722–705 B.C.).

The "Peacock Throne" of the rulers of Delhi, set with jewels and raised on a dais with silver steps. is of legendary splendour. The oldest surviving throne is probably that (much restored) built-in with the walls at Cnossos (c. 1800 B.C.). The earliest remaining post-Christian throne, the chair of St. Peter, for which Bernini created an elaborate *cathedra* in St. Peter's. Rome, is built of oak and ivory with iron carrying-rings (4th–5th century). The magnificent ivory throne of Archbishop Maximian at Ravenna dates from the following century. The so-called throne of King Dagobert from the treasury of St. Denis (now in the Bibliothèque Nationale, Paris). is a iolding stool of bronze, probably 8th century but with 12th-century additions prescribed by Abbot Suger. Thrones were oiten of silver in the later 17th and early 18th centuries (examples at Hanover and Copenhagen); later thrones nere generally of gilt wood. The English coronation throne in Westminster abbey is more properly a ceremonial chair, and the real throne of Great Britain is the oak chair in the house of lords, used



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THRONE OF GREAT BRITAIN IN THE HOUSE OF LORDS

by the sovereign during the opening and prorogation of parliament. (*See* also CHAIR; CROWN AND REGALIA.)

Thrones is also the name of the third order of angels. See ANGEL.

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THROTTLE is a valve that controls admission of steam to an engine or turbine or of an explosive mixture to an internal-combustion engine or of draught to a boiler furnace. The amount of opening can be regulated by hand, by foot or by a governor in different cases. The butterfly throttle is an established type for large valves, and is a favoured type in the small passages which lead from carburetors in automobile and airplane engines. The turning of the spindle causes the valve gradually to close the passage. An altitude cock is employed in conjunction with the throttle for airplane engines to compensate for the different conditions at various heights. Large throttle valves for steam engines have a piston valve construction with packing rings, and the action is such that opening and closing can be periormed with great ease.

Governor control acts on a throttle to regulate the engine speed; in hoisting engines the safety overwinding apparatus closes the throttle and applies the brakes in case of neglect on the part of the operator to reduce speed or stop at the correct times.

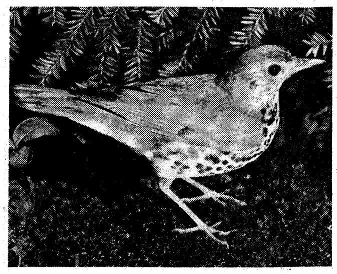
Big rolling-mill engines are throttled and reversed with great precision by a steam servomotor mechanism set in motion by the operator's control lever.

THROWING THE DISCUS: see DISCUS THROWING.

THRUSH, generally, any bird of the family Turdidae, a world-wide group which includes many excellent songsters. Specifically, the name is applied to several species of *Turdus,* old-world thrushes, and to species of *Hylocichla,* American thrushes.

The song thrush or mavis (T. *ericetorum*), one of the finest songsters in Europe, has a brown back and a speckled breast in both sexes. It ieeds very largely on worms and snails, which latter it shells by beating on a stone. It is an early breeder, rearing two broods a year; the nest, a deep cup, is lined with mud, cow dung and rotten wood, formed into a smooth layer by the pressure of the bird's breast. The eggs, iour or five in number, are a bluish green, spotted with black.

The missel thrush (T. *viscivorus*) is also called mistletoe thrush, from its fondness for the berries of that plant, and stormcock, from its habit of singing in squally weather. It is larger than the last species, reaching a length of 11 in. Otherwise it resembles its relative in appearance, but is greyer and has a white edge to the tail. Its song is loud and wild, but less sweet than that of the mavis. The bird boldly attacks marauding crows, jays and even cats, driving them away from its nest. The hermit thrush (*Hylocickla* guttata) of North America is the finest songster of the continent. The rufous tail and whitish eye ring are distinctive features. The wood thrush (H. mustelina), is little inferior to the last as a singer and has spotted sides as well as breast. The olive-backed thrush (H. *ustulata)* has a similar lovely song.



ALLAN D CRUICKSHANK FROM THE NATIONAL AUDUBON SOCIETY

WOOD THRUSH (HYLOCICHLA MU- [illegible] BIRDS THAT ,IN,~ IN CHORDS

The genus *Turdus* includes also the blackbird (*q.v.*), ring-ousel, fieldfare (*q.v.*), redwing (*q.v.*), and others. Included in the Turdidae are the wheatears, stonechats and whinchats (see WHEATEAR), redstarts (*q.v.*), robins (see REDBREAST), and hedge sparrows (see SPARROW). The "ant-thrushes" belong to a different family (see PITTA).

THRUSH is a disease of the mouth and throat, caused by a yeastlike fungus. *Candida (or* Monilia) *albicans.* It brings about the development of grayish-white adherent membranes. Often the fungus is an inhabitant of the birth canal and the mouth of the newborn infant is contaminated from there during delivery. In older children and adults the infection rarely occurs inside the mouth, more frequently in the mouth corners. causing unsightly cracks. Moreover, the same iungus may invade the skin (moniliasis) under special circumstances. In bartenders and housewives whose hands are exposed to moisture over unduly long periods of time, the fungus causes erosions in the webs of the fingers and also may attack the nails.

The skin folds of obese diabetic persons are highly susceptible to moniliasis because of moisture and high sugar content of the skin. All these localized forms can easily be cured by competent medical treatment. In emaciated undernourished persons with decreased resistance, the whole body surface may become involved. An often fatal intestinal disease of infants. acrodermatitis enteropathica. with severe diarrhoea, promotes widespread monilial infection of the skin; this condition can be cured by eradicating the underlying intestinal disease with the drug Diodoquin.

Candida albicans, however, may also invade and attack internal organs. This systemic moniliasis up to the mid-1950s invariably ended fatally. Attempts to find antibiotic materials which kill *Candida albicans* in the body without harming the host were most promising at that time, however. (S. Ros.)

THRUST BLOCK: see BEARINGS.

THUBURBO MAIUS (mod. HENCHIR-KASBAT), an ancient city of Roman North Africa, in the province of Africa proper; 2 mi. N. of the station of Pont-du-Fahs on the railway from Tunis to Kef. Octavian founded it near a native town, which was fused with it under Cornmodus.

The forum and its surroundings have been completely excavated. The Capitolium is well preserved.

THUBURSICU NUMIDORUM (mod. KHAMISSA), some 20 mi. by road S.W. of Souk Ahras. the junction of the railway to Tebessa from the main line from Algiers to Tunis. It was originally a native town, and became a Roman municipality under Trajan. There are extensive Roman remains, including two temples, a large civil basilica. and a well preserved theatre.

THUCYDIDES (fl. second half of the 5th century B.C.), greatest of Greek historians, was the author of the (incomplete) History of *the Peloponnesian War*. All that we know (perhaps all that ancient scholars knew) of his life is what he tells us himself in the course of his narrative. He was an Athenian, old enough when the war began (431 B.C.) to estimate its importance and that it was likely to be a long one, and to determine to write an account of it. observing and making notes from the beginning. He was probably born, therefore. not later than 460 — perhaps a few years earlier since his detailed narrative begins with the events provocative of the war which belong to the years just before 431. He was certainly over 30 when he was elected strategos in 424 (see below). That is, he belongs to the generation younger than Herodotus. His father's name was Oloros. This is not otherwise known as an Athenian name: and Oloros was probably of Thracian descent on his mother's side, and Thucydides related in some way to the great Miltiades, who had married the daughter of a Thracian prince of this name. He himself had property in Thrace. including mining rights in the gold mines opposite the island of Thasos, and was, he tells us, a man of influence there.

He was in Athens when the great pestilence of 430–429 raged there and caught the disease himself and saw others suffer. Later in 424 he was elected one of the ten strategoi of the year, and, because of his connections, given command of the fleet in the Thraceward region which was based at Thasos. He failed to prevent the capture of the important city of Amphipolis by Brasidas (*q.v.*), who launched a sudden attack in the middle of winter. He was recalled and tried and sentenced to exile. This, he says later. gave him greater opportunity for undistracted study for his History and for travel and wider contacts, especially with the Peloponnesian side. He survived the war and his exile of 20 years ended only with the fall of Athens and the peace of 404. The time and manner of his death are uncertain. but that he died shortly after 404 is probable. and that he died by violence in the troubled times following the peace may well be true, for the History stops abruptly long before its appointed end. His tomb. perhaps a cenotaph, and a monument to his memory, were still to be seen in Athens in the 2nd century A.D.

Scope and Plan of **the** History. — The History, which is divided into eight books (probably not Thucydides' own division) stops in the middle of the events of the autumn of 411 B.C., rather more than six and a half years before the end of the war. This much at least is known: that three historians. Cratippus. a younger contemporary. Xenophon a generation later and Theopompus in the last third of the 4th century. began their histories (of Greece as a whole, for a limited period) where he had stopped. Xenophon, one might almost say, beginning the next paragraph — nearly as abruptly as Thucydides ends. From this it is certain that Thucydides' work was well known soon after publication and that no more of it was ever published than the eight books that have survived; and it may reasonably be inferred from the silence of the available sources that no separate section of the work was published in his lifetime. It may also be inferred that parts of the History are defective, in the sense that he would have written at greater length had he known more and that he was trying still to learn more— *e.g.,* of internal Athenian politics in the years of "uneasy truce" (his existing narrative is in parts barely understandable without some imaginative guesswork). A good deal of the last book is defective.

We may assume. then, three fairly definable stages in his work: first. the "notes" he made of events as they occurred. always being supplemented by fresh inquiries; secondly, these notes arranged in their order and rewritten as consecutive narrative, as a "chronicle," but by no means in the final form that Thucydides intended— (*e.g.,* some, but not all, of the story of the "uneasy truce" in book v, and, surely, most of book viii); thirdly. the final, elaborated narrative — of the preliminaries of the war (book i), of the "Ten Years' War," and of the expedition to Sicily. No documentary evidence exists of the note stage but there are passages that are only chronicle embedded in the more finished parts. Many of these, however. Thucydides intended to leave as they are. Even the most elaborated parts of the History may have been added to right up to his death — certainly many additions were made after the war was over.

All this is significant because Thucydides was writing what scarcely another (of eminence) has attempted, a strictly contemporary history, of events which he lived through and which succeeded each other almost throughout his adult life. Sir Winston

Churchill has said of his own *Second World War*, based as it is on a unique collection of documents giving a current account of events, of the day-to-day conduct of the war: "I do not describe it as history, for that belongs to another generation. But . . . it is a contribution to history which will be of service to the future" (Introduction to vol. i, The *Gathering Storm;* Cassell and Company Ltd., 1948). Thucydides too was ariting of events in some of which he took an active part. of all of nhich he nas a direct or indirect spectator; but he attempted the final history, what, it might have been said. was "for another generation" and, as far as a man can, and as no other man has. he succeeded. It will be observed that he did not rush his work: the last of the complete narrative (stage three, above) took him to autumn 413. eight and a half years before the end of the war, the last of stage two to six and a half years before. During these last years he was observing, inquiring, mriting his notes, adding to or modifying nhat he had already written; at no time before the end. during all the 27 years of the war, did he know what that end would be (unlike Churchill in this). nor therefore what would be the length and the final shape of his own *History*. It is evident that he did not long survive the war since he did not leave any connected account, even at stage two, of the last six years. But, in what he lived to complete, he wrote a history, not a contribution to history.

It should however here be stated that in the opinion of some scholars *(see* BIBLIOGRAPHY), Thucydides did wait till after 404 to compose his *History* from his accumulated notes; and that much of the earlier part. especially Pericles' speeches in book ii, is only to be fully understood in the light of the final defeat of Athens. He was of course, as stated, always thinking about and sometimes modifying what he had already written; but the view that he, in any real sense. "began" his work after 404 seems to be untenable.

Diagnosis of the Causes of the **Peloponnesian** War.—The conflict which he set out to describe, in detail. as truthfully as possible, with strict observation of the chronology was, as he saw it, twofold. In its simpler aspect it was caused by the rapid rise of Athens in wealth and political power after the Persian Wars, which was a challenge to the generations-old Spartan leadership in Greece. This leadership was traditional and had been widely accepted—so much so that in 480 Athens, in spite of a sharp conflict with Sparta over its internal affairs 30 years before and its proud consciousness that it had stood alone, and successfully, at Marathon in 490, was ready to accept it, nith all the other Greek states who shared in the resistance to the second Persian invasion *(see* GRAECO-PERSIAN WARS).

In 431 Sparta, though "ever slow in going to war," took up the challenge and declared war. But Athenian power was something more than that of an ambitious rival. To the Greek world, accustomed as it was to the autonomy of cities under democratic rule, and even to the Athenians themselves at times, it appeared "like a tyranny"—moderately used as they asserted, contrary to all Greek custom as their enemies said It had begun in Athens' chosen leadership of the Delian league in which a number of Greek states were bound together for common defense against a further Persian attack. They had taken an oath not to secede from this league; but a few did—some of the larger ones nho were also geographically safer from Persian menaces—and Athens, followed by the rest, reduced them to subjection. One or two others, originally outside, were forced in. Most of the states contributed money for the league. the amount from each being decided by Athens (moderately enough); the common treasury mas transferred to Athens and Athenian officers controlled it. Athens encouraged. and sometimes imposed, the adoption of its onn kind of democracy in recalcitrant cities and made, sensibly enough. or tried to make, its own excellent coinage common for all in the league, to the great advantage of trade. By arranging that delegates conveying the tribute should come there for the most important of the dramatic festivals. and in other ways. Athenians encouraged all to look upon their city as a religious and intellectual centre (the latter it had already, by its own radiant genius, become'). All this attempt at unity under one leadership nas new in Greece and dangerous, both to the influence of Sparta and to Greek political institutions; and Thucydides makes this clear, and why general opinion in Greece favoured the Peloponnesian cause. But he also makes clear that Athenian rule was no "empire" in any ordinary sense (Persian, Roman or modern)—not only were there no "provinces" with Athenian governors to administer them, because each state was individually attached to Athens, but free institutions in them survived and were active, and indeed the commons in most were favourable to Athens, or at least preferred its rule to the risk of seeing their own richer classes put in power by Sparta.

Character Studies of the Leading Participants.—There was another aspect of the conflict which interested Thucydides and which he emphasizes: it was also between the ever-active, innovating, revolutionary, disturbing Athenians and the slower-moving, more cautious Peloponnesians, especially the Spartans. "not excited by success nor despairing in misfortune)" but quietly self-confident. This was a conflict between two types of character; but also it in some degree crossed the conflict between states. Thucydides was not much concerned with individuals, rather with the actions and sufferings, the characters of states ("the Athenians," "the Syracusans," etc.); but he understood the significance of personalities. and besides making clear by their words and deeds the characters of some who influenced events, as Cleon the harsh demagogue of Athens and Hermocrates the would-be moderate leader in Syracuse, the brave Nicostratus and the incompetent Alcidas, he goes out of his way to make clear the characters and influence of four men: Themistocles (in a digression, the Athenian hero of the second Persian War), Pericles. Brasidas and Alcibiades (*qq.v.*). All four of them were of the active. revolutionary type—Pericles indeed was unique for Thucydides in that he combined caution and moderation in action, and great stability of character with a daring imagination and intellect; but he was a leader of the new age. During the war each of them.—Pericles and Alcibiades in Athens. Brasidas in Sparta,—was in conflict with a conservative. quietist opposition; and one expression of this in Thucydides deserves especial notice. Pericles, trying to restore the confidence of the Athenians struck down with the pestilence: told them that risk and labour were unavoidable by an imperial city—"quietism" was only for those who sought security in servitude—and that ex-en in defeat they would leave behind an imperishable name. Nicias the cautious, on the other hand; is described as believing that he could save his name by taking no risks and that to make peace meant to take no risk. In Sparta it was the wise and strong King Archidamus who led at first the cautious and conservative side, Brasidas the other; and Brasidas had his enemies at home. The conflict between the revolutionary and the conservative thus ran across that between the (on the whole) daring Athenians and the (on the whole) cautious Peloponnesians; and it is a great loss that Thucydides did not live to write the story of the last years of the war when Lysander (*q.v.*); the other great revolutionary Spartan. played a larger part than any other single man in the defeat of .Athens. This defeat was in one aspect the defeat of intellectual brilliance and daring by "stupidity" and stability of character (this last the quality most lacking in Alcibiades, the most brilliant Athenian of the second half of the war); but it was largely brought about by the two Spartans who rivaled Athenians in daring and intellect.

Study of the Technical Aspects of the War.—There is another aspect of the war in which Thucydides was much interested—the technical. One problem was the limitations of normal Greek heavy-armed land fighting. conducted mainly by peasant farmers who could not long be away from their fields or the harvest would be ruined, against other peasant farmers who must defend their fields to prevent a destruction of the crops which might mean near starvation. There was the special case of Sparta. which was free of these limitations because it had helots for its agriculture; the citizens also had time for harder training and for longer warfare. A quite different case was that of Athens. which could if necessary bring all the population behind walls. sacrificing the highly developed fields and farms of Attica. Athens could import all the food needed. because it was powerful at sea and rich enough by silver mines, manufacture and trade and by accumulated capital to pay for the import. Other problems concerned the difiiculties and possibilities of war between an all-powerful land force (Sparta and its allies) and an all-powerful navy; many of these were peculiar to the conditions of Greece and the Mediterranean at that time, but some endured to modern times. Thucydides studied the details of siege warfare; the difficulties of the heavy-armed in mountain country or of the Greeks fighting the fierce but unruly barbarians of the north; an army trying to force a landing from ships against troops on shore; the one great night battle, at Syracuse; the skill and the daring maneuvers of the Athenian sailor and the way these were overcome by the Syracusans; the unexpected recovery of the Athenian fleet after the Sicilian disaster. In all these aspects of the war he took a keen professional interest.

This is too the reason why in Thucydides' introductory pages on the early history of Greece he lays so much stress on the development of sea trading and naval power and on the accumulation of capital resources: they help to explain the great war between a land power and a sea power.

Thucydides' **Style.**—Thucydides himself of course was an intellectual of the Athenian kind; markedly individualist as he was, his whole style shows the man brought up in the company of Sophocles and Euripides, with Anaxagoras, Socrates and the contemporary sophists.

Of this style something should be said here and the analysis given by R. C. Jebb in the previous article on THUCYDIDES. in the ninth edition of the *Encyclopaedia Britannica,* cannot be bettered. Jebb begins by contrasting the styles of Antiphon (*q.v.*), said, very improbably, to have been Thucydides' master, and of Thucydides himself:

"Antiphon wrote for hearers, Thucydides for readers; the latter, consequently, can use a degree of condensation and a freedom in the arrangement of words which would hardly have been possible for the iormer. Again, the thought of Thucydides is often more complex than any which Antiphon undertook to interpret; and the greater intricacy oi the historian's style exhibits the endeavour to express each thought. Few things in the history of literary prose are more interesting than to watch that vigorous mind in its struggle to mould a language of magnificent but immature capabilities. The obscurity with which Thucydides has sometimes been reproached often arises irom the very clearness with which a complex idea is present to his mind, and his strenuous effort to present it in its entirety. He never sacrifices thought to language, but he will sometimes sacrifice language to thought. A student of Thucydides may always be consoled by the reflexion that he is not engaged in unravelling a mere rhetorical tangle. Every light on the sense will be a light on the words; and when, as is not seldom the case, Thucydides comes victoriously out of this struggle of thought and language, having achieved perfect expression oi his meaning in a sufficiently lucid form, then his style rises to an intellectual brilliancy—thoroughly manly, and also penetrated with intense feeling—which nothing in Greek prose literature surpasses."

Method, Aims and Authority as an Historian.— Ina prefatory note near the beginning of the *History* Thucydides speaks a little of the nature and difficulties of his task and of his aims. It was difficult, he says, to get at the truth both of the speeches made, whether he heard them himself or got the report from others. and of the actions of the war. For the latter, both for those at which he had been present and for the others, he made as thorough an enquiry as he could—for eyewitnesses did not always say the same things. either from faulty memory or from bias. For the speeches, he says, in order to meet the difficulties, he had written out in his own words what was appropriate to the occasion, keeping as closely as possible to the general sense of what had actually been said. He could not do without speeches, for it is through them that he explains the motives and ambitions whether of leading men or of states; and this, the study of the human mind in time of war, is one of his principal aims. (The omission of speeches from the last book is a great loss and is due, no doubt, to the difficulty he had in getting information about Athens at this period.) They are reported in direct speech though in Thucydides' own words. in his own unique style, partly because he must not pretend that they were exact reports, partly because long passages in indirect speech would be scarcely tolerable and no more "authentic." He avoided, he says, all "storytelling" (this is his one criticism of Herodotus), and his work might be the less attractive in consequence; "but I have written not for immediate applause but for posterity, and I shall be content if the future student of these events, or of other similar events which are likely in human nature to occur in after ages, finds my narrative of them useful." This is all that he expressly tells us of his aim and methods, Moreover in the course of his narrative (except for the pestilence of 430 and his command in 424) he nowhere gives his authority for a statement: neither which speeches he had heard nor the other campaigns he had taken part in, nor what places he had visited, nor what persons he consulted. He insisted, as Gilbert Murray said, in doing all the work himself; and he gives us, for the parts he completed, the finished structure, not the plans and the consultations as well, not the "scaffolding."

His authority is hardly equaled by that of any other historian. He kept to a strict chronological scheme, and where it can be accurately tested, *e.g.,* by the eclipses that he mentions, it fits closely. There are also a fair number of contemporary documents recorded on stone which almost all confirm his account in general and in detail There is the silent testimony of the three historians who began where he left off, not attempting, in spite of much independence of opinion, to revise what he had already done, not even the last book which he clearly did not complete (it is here that occurs the one serious divergence from him in a later writer—Aristotle; *see* below). Another historian, Philistus (*q.v.*), a Syracusan who uas in Syracuse as a boy during the Athenian siege, had, it seems, in his *History of Sicily,* little to alter or to add to Thucydides. Above all there are the contemporary political comedies of Aristophanes (the production dates of which are fortunately known): Aristophanes (*q.v.*) was about 15 years younger than Thucydides and a man of as different a temper and writing with as difierent a purpose as could well be. but his comedy remarkably reinforces the reliability of the historian's serious picture of Athens at war, and as well supplies much to this picture of a kind which Thucydides deliberately did not give. The modern historian of this war is in much the same position as the ancient: he cannot do much more than translate, abridge or enlarge upon Thucydides.

For he kept rigidly to his theme, the history of a war, that is, a story of battles and sieges, and of a truce or a peace and alliance hastily made and soon broken, but also, more important, of the behaviour of peoples as the war lasted longer and longer, and of the inevitable "corrosion of the human spirit." He has vivid narrative of exciting episodes and careful descriptions of tactics on land and sea. He gives a picture, direct in speeches, indirect in the narrative, of the ambitious imperialism of Athens—controlled ambition in Pericles, reckless in Alcibiades, debased in Cleon—ever confident that nothing was impossible for them, resilient after the worst disaster; and the opposing picture of the slow steadiness of Sparta, sometimes so successful, at others so accommodating to the enemy. The speech he records of Pericles on those killed in the first year of the war is the most glowing account of Athens and its democracy as its leading citizen hoped it might prove itself. It is followed (in of course due chronological order) by a minutely accurate account of the symptoms of the pestilence ("so that it may be recognised by medical men if it recurs") and a moving description of the demoralizing despair which took men after so much suffering and such heavy losses—probably more than a quarter of the population, most of it crowded within the walls, died. Equally moving is the account of the last battles in Syracuse harbour, and of the Athenian retreat. In one of his best-known passages he analyzes by a most careful choice of words, almost creating the necessary language as he writes, the effects, moral as well as political, of civil strife within a state in time of war. By a different method, in speeches, he portrays the hard fate of Plataea due to the long-embittered envy and cruelty of Thebes and the faithlessness of Sparta, the harsh brutality of Cleon against Mytilene and the cynicism of the Athenians at Melos 12 years later, when the premises that it is in human nature for the strong to dominate the weak, and that Athens must for its safety control all islands, are used to justify any aggression and a demand for immediate submission, and slaughter if submission is not immediate. Occasionally he is forced into personal comment, as on the pathetic fate of the virtuous and much liked Nicias.

He had the strongest feelings, as a man, as a citizen of Athens whose part was the largest in the tragedy that he recorded, above all in his passion for the truth as he saw it, which not only kept him free from vulgar partiality against the enemy, whether state or party. but served him as a historian in the accurate narrative of events, accurate not only in their detail and their order, but in their relative importance — he does not for example exaggerate the importance of the campaign in which he was himself in command. That is why he offers no self-defense for his failure. (Characteristically he mentions his exile not in its order as an event of the war, but in his "second preface" — after the peace of 421 — to explain his opportunities of wider contacts.)

Subsequent Fame. — 'The story of his later fame is a curious one. It has been mentioned above that in the two generations after his death three historians began their work where he had left off; but apart from this silent tribute and late stories, credible enough, of his great influence on the orator Demosthenes (*q.v.*), Thucydides is nowhere referred to in surviving 4th-century literature! not even in Aristotle, who, in his *Constitution* of Athens, gives a narrative of the revolution in Athens in 411 that diverges in many ways from that of Thucydides. It was not till the end of the 4th century that Theophrastus coupled him with Herodotus as a founder of history properly so-called. We know little of what the scholars of Alexandria and Pergamon did for his book; but copies of it were being made in considerable numbers in Egypt, and so doubtless more elsewhere, from the 1st to the 5th centuries A.D. Suffice it to say, that by the 1st century B.C. as is clear from the writings of Cicero and Dionysius (who vainly disputed his preeminence), Thucydides was established as the great historian, and from that time onward his fame has been secure wherever he has been known.

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(A. W. GE.)

THUGS, or THAGS, a well-organized confederacy of professional assassins, who traveled in gangs through India. wormed themselves into the confidence of wayfarers and, when a favourable opportunity occurred, strangled them by throwing a handkerchief or noose round their necks and then plundered and buried them (Sanskrit *sthag,* "to conceal,'! hence sthaga, "a cheat," in modern vernaculars *thag*). A11 this was done according to certain ancient and rigidly prescribed forms and after the performance of special religious rites, in which the consecration of the pickax and the sacrifice of sugar formed a prominent part. From their using the noose they were also frequently called *phansigars,* or "noose operators." Though they themselves traced their origin to seven Mohammedan tribes, Hindus appear to have been associated with them at an early period; at any rate) their religious creed and practices as staunch worshipers of Kali (Devi, Durga), the Hindu goddess of destruction, had certainly no flavour of Islam. The fraternity possessed a jargon of their own (*Ramasi*), and signs by which its members recognized each other.

Though sporadic efforts were made toward the extinction of the gangs, it was not till Lord William Bentinck took vigorous steps (1828–35) that the system was seriously attacked. His chief agent, Captain (afterward Sir William) Sleeman, with the cooperation of a number of native states, succeeded so well in grappling with the evil that between 1831 and 1837 no fewer than 3,266 thugs had been committed, of whom 412 were hanged, 483 admitted as approvers and the remainder transported or imprisoned for life.

According to the *Thuggee* and Dacoity Report for 1879, registered Punjabi and Hindustani thugs then still numbered 344; but all of these had already been registered as such before 1852, and the whole fraternity thereafter became extinct.

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THUGUT, JOHANN AMADEUS FRANCIS DE PAULA, BARON (1736–1818), Austrian diplomatist, was born at Linz on May 24, 1736. In 1769 he was appointed charge d'affaires at Constantinople, and in that capacity secured a grant of money and a promise of the territory of Little Wallachia from the Turks during the negotiations connected with the first partition of Poland. (See POLAND: Histovy.) In 1771 he was ennobled and appointed internuncio at Constantinople and was actively engaged, under the direction of Prince Kaunitz. in all the diplomacy of Austria in Turkey and Poland until he secured the cession of the Bukovina on May 7, 1775.

After 1775 Thugut traveled in France and Italy, partly on diplomatic service. In 1778 he acted as intermediary in Maria Theresa's negotiations with Frederick the Great. In 1780 he was Austrian envoy in Warsaw. but in 1783 applied for leave and spent four years in Paris, where he invested his savings and became acquainted with many of the leaders in the Revolution. From 1787 to 1789 he was minister at Naples. In 1790 he was sent by the emperor Joseph II to Bucharest, nominally as commissioner with the hospodar of Wallachia, but in reality in order that he might open negotiations for peace with the Turks. In 1792 he was associate diplomatic agent at the headquarters of the allied army which invaded France: and was then appointed director of the foreign affairs of Austria (March 25, 1793), becoming chancellor in 1794 on the death of Kaunitz.

The selfish policy which Thugut followed (1793–1800) in Austria was bitterly resented by Austria's allies, and although Thugut probably thought that he was only doing his duty, he committed many acts which were more than dubious. After the defeats of Austria in Italy in 1796–97 and the peace of Campo Formio, it became a fixed object with the French, and with a growing party in Austria who held him responsible for the disasters of the war. to secure Thugut's removal. The battle of Hohenlinden (Dec. 3, 1800) made his position untenable. so retiring from public life he left Vienna for Pressburg. He later returned to Vienna where he died on May 28, 1818.

THULE, Greek and Roman name for the most northerly land in the world. Pytheas (c. 300 B.C.), according to Polybius' account of his voyage, reached it after six days' sail from Britain; it was inhabited, but corn grew there sparingly and ripened ill; in summer the nights were long and bright. The few surviving fragments of his works do not determine where his Thule was. Scholars at various times have believed it to be the Shetlands, Iceland, or some section of the Norwegian coastline.

Agricola's fleet in A.D. 84 sailing up the east coast of Scotland is said to have espied but not to have reached Thule (dispecta est Thule) but the phrase is merely literary. The actual point meant may be the Orkneys or the Shetlands, or even some fragment of Scotland seen across the water. In some later wrtiers (Procopius, etc.) Thule seems sometimes used to denote Scandinavia. The phrase "ultima Thule" is commonly used to describe the farthest limit possible.

THULIUM (symbol Tm, atomic number 69, atomic weight 168.94. one stable isotope. Tm^{169}), a very rare metallic element belonging to the rare earth group. It was discovered by P. T. Cleve in 1879 while examining crude erbium oxide. The name is derived from Thule. Latin for the northernmost part of the inhabitable world; whence the phrase "ultima Thule" meaning a remote goal or end. It was first obtained in a fairly pure compound by C. James in 1911 by the fractional crystallization of its impure bromate; this separation involved more than 15,000 operations. Thulium occurs in very small amounts along with its commoner associates in the minerals gadolinite, euxenite, xenotime, etc. The oxide (Tm_2O_3) has a greenish-white colour. Salts of thulium possess a pale green colour and the solutions show strong characteristic absorption spectra. In 1946 there was some doubt as to whether the salts of this element had ever been prepared in the pure iorm since the atomic neight as determined by a mass spectrograph gave a value of 168.95 nhile the best chemical value was 169.4. The chemical methods would be influenced by the presence of other rare earths and this difference seems to indicate that some of the other rare earths must have been present.

Thulium can be separated fairly rapidly from the other rare earths by ion-exchange methods. The metal is produced by reducing the anhydrous fluoride with calcium. It has a melting point between 1,550° and 1,650° C. and boils at about 1,800° C. The X-rav densitv is 9.372 grams per cubic centimetre. It crystallizes in the hexagonal close-packed system with $a = 3.533$ and $c = 5.551$. It has an appreciable vapour pressure at the melting point.

When thulium is irradiated in a nuclear reactor, Tm^{170} with a 129-day hali life is formed. This isotope strongly emits an 84 Kev X-ray, and is very useful in making small portable X-ray units for medical use. No electrical equipment is required and the units only have to be recharged with a reactivated thulium button every few months. (See RAKE EARTHS.) (F. H. SP.)

THUN, a town in the Swiss canton of Bern. on the banks of the Aare, just as it issues from the Lake of Thun. and by rail 19 mi. S.E. of Berne. Its population in 1960 was 29.034, mostly German-speaking and Protestants. From 1798 to 1502 Thun mas the capital of the canton Oberland of the Helvetic republic. It is now the capital of the Rernese Oberland.

THUN, LAKE OF, in the Swiss canton of Bern. the second lake (the first being that of Brienz) into which the river Xare (*q.v.*) expands. These two lakes occupy an ancient terminal basin of a glacier and are separated by a lacustrine delta on which Interlaken stands. Lake Thun (with the town of Thun at its north-western end) is 11½ mi. long. 2 mi. wide. its maximum depth is 712 ft., while its area is 18½ sq.mi., and its altitude 1.831 ft.

THUNDER, the noise that accompanies lightning (*q.v.*). The electrical discharge causes sudden heating and therefore expansion of the air along the lightning channel. This is followed by sudden cooling and contraction, thereby creating air vibrations similar to those caused by an explosion. Thunder is characterized by its prolonged duration and undulating intensity. Since every point along the lightning path represents an individual sound source and the various points are at different distances from the observer, the arrival time and loudness of the sounds produced vary. Intensity fluctuations are also caused by interference of the sound waves, but not by echoes from clouds, because clouds absorb, rather than reflect. sound, Most of the thunder energy lies in the subaudible frequency range; it often makes houses vibrate and windows and dishes rattle. Because of the great difference in speed between light and sound, lightning apparently precedes thunder by roughly five seconds for every mile separating the nearest lightning point from the observer. See ELECTRICITY, ATMOSPHERIC; METEOROLOGY; THUNDERSTORM. (Hs. H. S.)

THUNDERSTORM. A thunderstorm is a large cumulus cloud in which localized centres of electric charge have developed. Lightning, and the accompanying thunder from which the storm derives its name, represents a spark discharge between these centres, or between one of them and the ground. So universal is the development of charge centres in large intense cumulus clouds that the term "thunderhead" is used to describe a large cumulus even though the physical processes which lead to the development of the convective cloud may be only indirectly related to the processes which bring about the lightning and thunder.

Thunderstorms are sometimes referred to as "weather factories" because they are accompanied by a wide variety of weather elements such as hail, showery rain, strong and gusty winds and sudden temperature changes at the earth's surface. The violence of the weather accompanying thunderstorms is indicative of the strong vertical air currents and the complex physical processes operating within them.

Cumulus clouds are manifestations of convective overturning in the atmosphere; *i.e.,* a cumulus cloud represents an air parcel which is rising through its environment because it is warmer and more buoyant than other air parcels at the same levels. In principle, this overturning is similar to that in any thermally unstable fluid. When the atmosphere becomes sufficiently unstable, convective overturning is locally severe enough to cause thunderstorm development.

Thunderstorm Structure and Circulation.— The average thunderstorm consists of three to five convective cells, each of which undergoes a life cycle characterized by changes in the direction and magnitude of the strong nearly vertical air currents. Three stages in this life cycle are recognized. In the initial stage, the cell contains strong upn-3rd-moving air currents which extend from below the cloud base to the cloud top. The updrafts may reach speeds of seven to ten metres per second. If the air is sufficiently unstable, there will be a continual supply of energy for the updraft and the cell will continue to develop in size and intensity. With increase in size comes an increase in total cloud water content. About 15 to 20 minutes after the establishment of an active updraft, precipitation particles will have grown to a size where they become of importance both in the further development of the cell and in the formation of the charge centres. The precipitation usually will be in the form of snow and snow pellets in the upper parts of the cell (colder than about – j° C.) and raindrops in the lower, warmer regions of the cell. At this time the cell passes into the mature stage of development.

In the mature stage of development, both upward- and downward-moving air currents are present within the cell. The updraft of the cumulus stage gives way to downdraft as the size and number of precipitation particles increase. This reversal of the updraft is also aided by evaporational cooling which occurs as clear air from outside the cloud is mixed into the cloud by the turbulent motions. At first, the downdraft is small and located on one side of the updraft. Gradually, however, it works its way across the cell and squeezes off the updraft, at which time the cell goes into the final or dissipating stage.

It is with cells in the early mature stage that thunderstorms reach their greatest violence. Updraft speeds are usually 10 to 15 m. per second, but may occasionally reach values as high as 35 m. per second. Downdrafts may be as strong as 1j m. per second. At the ground, the onset of heavy rain marks the beginning of the mature stage. The downdraft, which coincides closely with the rain area, reaches the surface a few minutes after the first rain. Because of the continued evaporation, air in the downdraft is cold. which fact accounts for its great downward speed. As the downdraft nears the ground, it is diverted and spreads outward in all directions as a cold gusty wind blowing from the rain area. Even in arid regions where the rain may completely evaporate before reaching the ground, the cold downdraft spreading over the surface is a well-known signal of a nearby thunderstorm.

A thunderstorm cell in the dissipating stage is filled throughout by weak subsiding air and light precipitation. Rain at the earth's surface is much less intense than was the case during the mature stage. The cold outflow gradually subsides as a result of the waning downdraft.

The visual appearance of thunderstorms varies greatly from place to place and with kinds of storms. In arid regions, thunderstorms appear as giant towering cumulus clouds, standing in bold relief against the clear blue sky. Frequently in such regions one can see the uppermost parts of the cloud carried off by high winds to form what is known as an anvil top. In other more humid regions,' thunderstorms are frequently surrounded by smaller clouds which obscure the active parts of the storm to a ground observer. From an airplane, however, one can see the thunderstorm thrusting upward above the lower clouds.

The time duration of a thunderstorm is somewhat variable; however, observations show that the first two stages of development usually last about 1j to 20 minutes each. During these stages the visual cloud will frequently reach heights of 30,000 to 60,000 ft. (average about 40,000 ft.) and horizontal dimensions of several miles. The duration of a cell in the final stage varies over wide limits. Some storms end abruptly, whereas others may linger for several hours as a gentle rain from a large, formless cloud mass.

These differences result from differing conditions of the air masses in which the clouds form.

Thunderstorm Electricity.— Electrical charge centres become well established during the mature stage. In a typical thunderstorm. the charge structure will consist of an upper positive charge centre locnted in the regions where the temperature is approximately $-10°$ to $-20°$ C. and a lower negative charge centre in the vicinity of the freezing level. A second positive centre in the rain area at the base of the cloud is occasionally observed. Typical values for the charges in the upper positive and lower negative centres are 20 to 30 coulombs. The lower negative centre is thought to be fairly compact (estimates of a one kilometre radius sphere have been offered) whereas the upper positive centre may consist of a central region of compacted charge surrounded by a large region of diffuse charge.

Lightning is a crash discharge between the upper positive centre and the lower negative centre or between one of these and the ground. Occasionally one also observes a lightning flash from one of the centres into the clear air around or above the cloud. The first electrical discharges usually take place entirely within the cloud between the two main charge centres. These discharges will be rather small at first and will increase in magnitude as the storm continues to develop. Evidence indicates that the great majority and possibly all of these lightning strokes transport negative electricity from the cloud to the ground. The charge transferred by a lightning flash ranges from 5 to 200 coulombs (averaging about 25). Each lightning flash usually consists of several strokes in rapid sequence with time separations of a few hundredths of a second. Each stroke follows the ionized path of the preceding one.

The sound of thunder originates in a compression wave formed along the highly heated path of the lightning stroke. Each portion of the path of a lightning stroke sends out intense sound waves which travel different paths to the observer. Since sound travels at the rate of approximately 330 m. per second, and since the strokes may be several kilometres in length. the thunder is usually hesrd :ts a drawn-out rumbling. having character and time duration depending upon the length and shape of the flash and upon its distance from the observer. Under ordinary atmospheric conditions. thunder cannot be heard at distances greater than 1j to 20 km.. although under some conditions of temperature inversion (temperatures increasing with height as opposing the normal decrease of temperature with height) it may be heard at a distance of 40 km. Since light travels at a very great speed, and the sound of thunder travels at a speed of about 1,000 ft. per second, one can estimate the distance to a thunderstorm by timing the interval between the sighted lightning flash and the sound of the thunder. The time in seconds equals the distance in thousands of feet.

Answers to questions as to how a storm generates electrical charge and separates this charge into two major centres continued to elude scientists throughout the early 1950s. By 1957 there were two schools of thought on this problem. One group of scientists believed that electric charges are generated in some manner by the coexistence of liquid and solid phases of water (snow and rain) within the upper parts of the cloud. A second group suggested that the primary source of the charge generation is with ions which are continually being formed in the atmosphere by cosmic radiations and radioactive disintegrations from materials at the earth's surface. Both groups believed that the charges, once generated, could be separated into two centres by the falling precipitation. Experiment indicated that in the upper parts of the cloud the particles (mostly snow and ice crystalsj are predominately positively charged; near and below the freezing level the particles (mostly rain) are predominately negatively charged. In the middle regions charges of both signs are intermingled.

Thunderstorm **Formation.**—A deep layer of moist air and a vertical temperature distribution favourable for the development of intense local overturning are essential for thunderstorm development. One of the tools used by meteorologists to determine the possibilities for thunderstorms is a plot of air temperature as a function of height above the earth's surface. The rate of decrease of temperature with height is known as the lapse rate. In general, steep lapse rates (rapid decrease of temperature with height) are most favourable for thunderstorms since it is under these conditions that an air parcel made warmer than its environment is capable of rising through the atmosphere because of buoyancy forces. After any given parcel of air is lifted to the point of condensation at the cloud base, the released latent heat of condensation will be added to the parcel. This will assist further ascent. In the upper parts of the thundercloud! where snow and ice crystals are found, the latent heat of fusion will also contribute to sustaining the updraft currents.

Thunderstorms can be classified according to factors that contribute to the development of steep lapse rate with resultant convection. Five important classes are given:

1. Heating of air by contact with warm surfaces. (a) When the surface of the ground is warmed by radiation from the sun, water vapour may be carried up by convection currents to a level at which condensation occurs. With favourable lapse rates of temperature in the air above this level, thunderstorms may develop. A special case of this class is the heating of mountain slopes at high levels, which frequently contributes to the development of thunderstorms near the summits. (*b*) When air flows over warmer ground or warmer water, the air may become warmed sufficiently from below for convection and possibly thunderstorms to occur.

2. Lifting of warm air over cold currents. If a current of cold air meets a current of warm air, the warmer air, being lighter, is forced upward either by cold air underrunning warm air or by warm air overrunning cold air. Clouds form in the rising warm air; and if conditions are favourable, tower upward to form thunderstorms.

3. Converging air flow within warm air currents. A converging flow may force warm air up to its condensation level, releasing convection.

4. Interaction of cold and warm air currents at different levels. The underrunning of cold air by warm air may initiate convection. Similarly, overrunning of warm air by colder air as well as combinations of these factors may be effective in releasing convective overturning and thunderstorms.

5. Lifting of air by movement upslope from lower to higher ground. Movement of air against a mountain range or other upslope surface may lift air to its condensation level and initiate convection.

The Distribution **of** Thunderstorms.— A substantial fraction of the thunderstorms over the world form because of surface heating by sun's radiation (class 1*a*) often combined with special convergence effects (class 3). Summer thunderstorms over humid continents and over mountain regions in the temperate latitudes and the almost daily storms of large regions of the tropics are of this type. These storms show a well-marked diurnal variation; they develop generally during the afternoon. Storms of class 1*b* are characteristic of the rear of barometric depressions occurring over the sea in winter especially just off the east coasts of the large continents where cold air may pass over comparatively warm water.

The "frontal" storms of class 2 are found in middle latitudes. They are associated with line squalls (squall lines) and "warm front" precipitation in extratropical cyclones.

Storms of classes 3 and 4 frequently occur in advance of "cold fronts" or troughs of low pressure in the temperate zone and tend to occur more frequently at night than during the day.

Storms of class 5 occur especially on windward mountain slopes in middle latitudes.

Thunderstorms have been known to occur in almost every part of the world; however, they are rare in the polar regions and infrequent poleward of latitude 50° N. and 50° S. According to a study by C. E. P. Brooks, the places of maximum thunderstorm activity in the world are Java (22j days per year). central Africa (150), Panamá (135), southern Mexico (142) and central Brazil (106). In the United States the areas of maximum activity are the Florida peninsula and the coast of the Gulf of Mexico (70–80) and the mountains of New Mexico (50–60). Central Europe and Asia average less than 20 thunderstorm days per year. Brooks estimated that at any one moment there are about 1,800 thunderstorms in progress throughout the world.

Thunderstorms and Severe Weather.— Thunderstorms are associated with many kinds of severe weather phenomenon. Squall lines are lines of thunderstorms mhich sweep across the surface as a single unit. Usually associated with advancing cold fronts, squall lines are well known for their regions of high wind, heavy rain and hail. Tornadoes are another type of severe weather associated with thunderstorms although the exact details of this association are not known.

Thunderstorms also play a key role in tropical hurricanes. It is well known that hurricanes, when viewed by radar, are characterized by lines of convective storms which spiral inward toward the eye of the hurricane. It is likely that the thunderstorm plays a major role in the vertical circulation of the hurricane.

Because of the turbulence which accompanies the updrafts and downdrafts, thunderstorms are regarded as hazards to airplane flight. Pilots are unanimous in their opinion that light planes should not be flown into thunderstorms. Military and commercial planes of the types flown in the late 1950s were sufficiently sturdy and well enough instrumented to permit a flight through a thunderstorm with little more danger than passenger discomfort.

See also LIGHTNING AND LIGHTNING PROTECTION; SQUALL AND SQUALL LINE; TROPICAL STORM; TYPHOON.

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THÜNEN, JOHANN HEINRICH VON (1783–1850), German agriculturalist, best known for a pioneering work on the effect of transportation costs on the location of production, was born in Jever on July 24, 1753. Vol. 1 of his *Der isolierte Staat*, containing the important theoretical contribution, appeared in 1826, and later volumes presented Thunen's own agricultural accounts in support of his theory. Thunen imagined an isolated city, set in the middle of a level and uniformly fertile plain without navigable waterways and bounded by a wilderness. His analysis showed how agricultural products would be grown in zones forming concentric rings around the city. Heavy products. in proportion to value, and perishables would be produced close to the town; lighter and durable goods would be produced on the periphery. As transport costs to the city increased with distance, the returns to the land would diminish. At a certain distance from the city, land rent would become zero. The exact distance would be a function of price relationships. Moreover, if land rents vary, then the methods of cultivation will vary, with land being used less intensively as it becomes less valuable. Subsequent writers often built upon Thunen's model, although his simplifying assumptions eliminated many of the most critical problems. Thunen died in Tellow, Sept. 22, 1850. (J. P. CA.)

THURBER, JAMES GROVER (1894–1961). writer and artist, considered by many the best American humourist since Mark Twain, was born in Columbus. O., Dec. 8. 1594. and educated at its public schools and at Ohio State university. Columbus. He was a newspaper reporter in Columbus, in Paris. France, and in New York city before becoming associated with the *Sew Yorker* 3s 3 staff member (1927–33) and a leading contributor.

Seriously a writer and only incidentally a comic artist. Thurber produced both writings and drawings showing odd characters in astonishing situations, amusing aspects of the war between men and women, startling forays into the subconscious and fascinating dogs and other animals, real and imaginary.

His writings reveal a sensitive literary style and skill in many forms. *My Life and Hard Times* (1933) is a hilarious autobiography. "The Secret Life of Walter Mitty," his best-known short story, presents an unforgettable character in the meek, henpecked husband who in his daydreams is a fabulous hero. Thurber's fables blend delightful nonsense with much wisdom about humanity. A play, *The Male Animal* (1940), written with Elliott Nugent, is an effective plea for academic freedom as well as a gay comedy. While a keen satirical sense is shown in many essays, parodies and burlesques, a gentle humour pervades such fairy tales as *The 13 Clocks* (1950). *The Thurber Album* (1952) is an affectionate account of family and friends in the midwest. and *The Years With Ross* (1959) is a witty record of associates on the *New Yorker*. The best collection of the writings and drawings is *The Thurber Carnival* (1945). Thurber died in New York city on Nov. 2, 1961. (WM. B.)

THURET, GUSTAVE ADOLPHE (1817–1875), French botanist, noted for his work on the reproduction of algae, was born at Paris on May 23, 1517. He received a law degree in 1838 and then studied under algologist Joseph Decaisne. He traveled to Constantinople in 1840 as French attaché, and after returning to France. being a man of independent means, devoted himself entirely to science. Thuret's first paper (1840) detailed the discovery of flagella of spermatozoids in *Chma*. In 1844 Decaisne and Thuret announced the finding of spermatozoids in *Fucus*. The first accounts of fertilization and hybridization in *Fucus* mere given by Thuret (1854), and later (1867), jointly with Edouard Bornet, he determined the complicated life cycle of Florideae, a group of red algae. His *Études phycologiques*, a folio volume containing observations on and illustrations of marine algae, was published posthumously in 1878. Before 1857, Thuret spent much of his time studying algae on the Atlantic coast of France. In 1857 he moved to Antibes on the Riviera, where he established an outstanding botanic garden. Thuret died at Nice on May 20, 1875.

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THURGAU, a canton of northeast Switzerland, bordered by the Lake of Constance and, for a short distance, by the Rhine below the lake. It is in contact with Schaffhausen and Zurich to the west and St. Gall to the south. Thurgau is divided into three well-wooded hill masses running northwest to southeast by the middle course of the river Thur (rising in the Toggenburg, *q.v.*) and by its affluent, the Murg.

The canton is a highly prosperous agricultural area, and though termed the "garden and granary of Helvetia" it also possesses an important cotton spinning, dyeing and printing industry. The population in 1960 was 166.420. Its capital is Frauenfeld on the Murg, pop. 14.702. Other towns are Arbon (11,608), Kreuzlingen (12.597) and Romanshorn (7,755).

History.— The Thurgau originally took in all the country, roughly speaking, between the Reuss, the Lake of Lucerne, the Rhine and the Lake of Constance; but many smaller districts (Ziirichgau, Toggenburg, Appenzell, St. Gall) were gradually carved out of it, and the county was reduced to about the size of the present canton when in 1264 it passed by the gift of the last count of Kyburg to his nephew Rudolph of Habsburg. chosen emperor in 1273. In 1460–61 it was seized by the confederates and henceforth it was ruled as a "subject district" by seven members of the League—Bern occupied in the west, not being admitted to a share in the government until 1712, after one of the mars of religion. In 1499 the confederation obtained from the emperor the supreme jurisdiction.

In 1798 it became free, and was one of the 19 cantons of the Helvetic republic, being formally received (like the other "subject lands") as a full member of the Swiss confederation in 1803 by the Act of Mediation. The very advanced Cantonal constitution dates to 1869.

See SWITZERLAND: *Government*.

THURIBLE, the ecclesiastical term for a censer, a portable vessel in which burning incense (*q.v.*) can be carried. The censer, to use the more general term, is a vessel which contains burning charcoal on which the aromatic substances to be burned are sprinkled. The early Jewish portable censer would seem to have been a bowl with a handle, resembling a ladle. A similar form was used by the ancient Egyptians long prior to the Jewish use. The Greek and Roman censers (*thumiaterion* and *turibulum* or *thuribulum*) are of quite different shape. They are small portable braziers (*foculi*) of bronze or sometimes of silver and of highly ornate design.

The censers or thuribles in Christian usage have been specially adapted to be swung, though many early specimens of heavy weight were obviously not meant to be used in this way.

THURII or THURIUM, Italy. a city of Magna Graecia on the Gulf of Tarentum, near the site of the older Sybaris (*q.v.*). It owed its origin to an attempt made in 452 B.C. by Sybarite exiles and their descendants to repeople their old home. The new settlement was crushed by Crotona, but the Athenians lent aid to the fugitives, and in 443 Pericles sent out to Thurii a mixed body of colonists from various parts of Greece. among whom were Herodotus and the orator Lysias. In 390 it was severely defeated by the Lucanians, and at length called in the help of the Romans against the Lucanians. and then in 282 against Tarentum. Thenceforward it was dependent, and in the Second Punic War it was depopulated and plundered by Hannibal (204). In 194 a Roman colony was founded, known for a time as Copiae, but afterwards as Thurii.

THURINGIA (Land THÜRINGEN), former German Land and Free state, after 1933 a Land of the German reich; it consisted of the former Thuringian states of Saxe-Weimar-Eisenach, Saxe-Meiningen, Reuss, Saxe-Altenburg, Saxe-Gotha (Coburg having been merged with Bavaria), Schwarzburg-Rudolstadt and Schwarzburg-Sondershausen. which decided in 1919 to combine into one state.

After World War II, Thuringia became a Land of the German Democratic Republic, but it was later (1952) divided into administrative districts including those of Erfurt, Suhl and Gera.

A considerable part of the country is occupied by the Thuringian forest. Among the chief elevations are the Beerberg (3,222 ft.), the Schneekopf (3,209 ft.) and the Inselsberg (3,005 ft.). The Altenburg district in East Thuringia is traversed by the westerly offshoots of the Erzgebirge, while the Rhon mountains extend into West Thuringia. The southeastern portion of Thuringia belongs to the bleak, mountainous region of the Frankenwald and the Vogtland. The principal river is the Saale, which runs in a northwesterly direction as far as Saalfeld. and then flows northeast by Rudolstadt and Jena. Among the other rivers are the Werra, Ilm, Gera, Unstrut, Elster, Weisse, Wipper, Helbe and Pleisse. The district watered by the Pleisse contains some of the richest agricultural soil in Germany. The chief mineral resources of Thuringia are lignite (found mainly in the Altenburg district), and potash in the valley of the Werra and in the Sondershausen district. Iron ore, marble, cobalt, copper, slates, chalk and basalt are also found; and there are salt works at Salzungen and Neusalza, and brine springs at Heinrichshall and elsewhere. Among the principal industrial products of Thuringia are textiles, glass and porcelain, iron goods and machinery, paper and leather goods, musical instruments, beer, chemicals, toys and optical instruments. In 1950 Thuringia had 2.837,641 inhabitants and an area of 6,022 sq.mi.

Leading cities include Weimar, the capital of the former Land, Gera, Jena, Gotha, Eisenach, Altenburg and Greiz.

History.— In the 5th century the Thuringians lived between the Harz mountains and the Thuringian forest. They were tributary to Attila the Hun. under whom they served at the battle of Châlons in 451. In the 6th century they n-ere conquered by the Franks and remained under the direct rule of the Frankish kings until 634. when King Dagobert I appointed Radulf duke of the Thuringians. under whom they became virtually independent. They were again brought under Frankish rule by Charles Martel, who abolished the office of duke and divided the country among Frankish counts. About 804 Charlemagne. in order to defend the line of the Saale against the Slavs. founded the Thuringian mark. In 849 King Louis the German recognized Tlakulf as duke and some of his successors bore the title of margrave until the death of Burkhard in 908, when the country was seized by Otto the Illustrious. duke of Saxony. Thuringia was retained by Otto's son and successor. Henry I the Fowler.

In the 11th century a new dominion was founded by Louis the Bearded. who by purchase. gift or marriage obtained several counties in Thuringia. These passed on his death in 1056 to his son Louis the Springer (d. 1123), who took part in the Saxon risings against the emperors Henry IV and Henry V. His son Louis was appointed landgrave of Thuringia in 1130 by the emperor Lothair II; by his marriage with Hedwig of Gudensberg in 1137 he obtained a large part of Hesse. Louis was succeeded in 1140 by his son Louis II the Hard. who married Judith, a sister of the emperor Frederick I, and on his behalf took a leading part in the opposition to his powerful neighbour Henry the Lion, duke of Saxony. In 1172 he was succeeded by his son Louis III the Pious. He acquired the Saxon palatinate in 1179, on the death of Adalbert, count of Somrnerschenburg, went to Italy to assist Frederick I in 1157, joined in the war against Henry the Lion in 1180, and distinguished himself at the siege of Acre in the Third Crusade. on the return from which he died at Cyprus in 1190. He was succeeded by his brother Hermann I. during whose reign Thuringia suffered greatly from the war between Philip duke of Swabia and Otto of Brunswick. The next landgrave (1217–27) was his son Louis IV, a celebrated figure in medieval German literature, who married St. Elizabeth. daughter of Andrew II, king of Hungary, and died at Otranto while accompanying the emperor Frederick II on crusade. The next ruler was Henry Raspe, who made himself regent on behalf of his nephew Hermann II from 1227 to 1238 and in 1241 succeeded his former ward as landgrave.

After a disputed succession to the landgraviate it fell in 1263, together with the Saxon palatinate, to Henry III margrave of Meissen. Two years later Henry apportioned Thuringia to his son Albert the Degenerate, who sold it in 1293 to the German king Adolph of Xassau for 12,000 marks of silver. Albert's sons Frederick the Undaunted and Dietrich contested this transaction, and the attempts of Adolph and his successor Albert I to enforce it led to the infliction of great hardships upon the Thuringians. Frederick defeated Albert decisively and in 1314 was formally invested with Thuringia by the emperor Henry VII. His son Frederick II the Crave (1323–49) consolidated the power of his dynasty against rebellious vassals and the neighbouring counts of Weimar and Schwarzburg. His son Frederick III the Strong (1349–81) and his grandson Balthasar (1381–1406) further extended their dominion by marriage and conquest, and the latter of these founded the university at Erfurt (1392). Balthasar's son. Frederick the Peaceful, became landgrave in 1406 but left the government largely to his father-in-law Günther, count of Schwarzburg. He died childless in 1440, and Thuringia then passed to the electoral dynasty of Saxony. After a joint rule by Frederick II and his brother William, the latter in 1445 became sole landgrave as William III and died without sons in 1482. In 148j his nephews and heirs Xlbert and Ernest made a division of their lands, and Thuringia was given to the Ernestine branch of the family of Wettin, with which its history down to 1918 is identified.

THURLES, a town of County Tipperary. Ire., lies on both banks of the Suir. 92 mi. S.W. of Dublin by road. Pop. (1961) 6,421. Originally called Durlas O'Fogarty, in 1174 it was the scene of the defeat of Strongbow by Roderick O'Connor and Donal O'Brien. A preceptory was founded there by the Knights Templars, who held a 13th-century castle. The Cistercian abbey of Holy Cross, founded by Donal O'Brien (1168–94), stands $3\frac{1}{2}$ mi. S.W. of the town. Thurles is the seat of the Roman Catholic archdiocese of Cashel. In the town, which is a marketing and distributing centre for a large agricultural area, is a large beet sugar factory.

THURLOE, JOHN (1616–1668), English politician, son of Thomas Thurloe, rector of Abbot's Roding in Essex, was baptized on June 12, 1616. He studied law, entered the service of Oliver St. John. through whose interest he was appointed a secretary to the parliamentary commissioners at Uxbridge in 1645; other employments followed. On March 29. 1652, he mas appointed secretary to the council of state. His duties included the control of the intelligence department and of the posts, and his perfect system of collecting information and success in discovering the plans of the enemies of the administration astonished his contemporaries. In the parliaments of 1654 and 16j6 he represented Ely; he was appointed a member of Cromwell's second council in 1657.

After Oliver's death Thurloe supported Richard Cromwell's succession, and took part in the administration. sitting in the parliament of Jan. 1659 as member for Cambridge university. Appointed secretary of state on Feb. 27, 1660. he appears to have steadily resisted the Restoration, and his promises of support to Hyde in April inspired little confidence. On May 1j, 1660, he was arrested on the charge of high treason, but was freed on June 29, subject to the obligation of attending the secretaries of state "for the service of the state whenever they should require." He subsequently wrote several papers on the subject of foreign affairs for Clarendon's information. He died on Feh. 21, 1668.

His extensive correspondence, the originals of which are in the Bodleian Library at Oxford and the British Museum (*Add. MSS.* 4156, 4157, 4158), is one of the chief sources of information for the prriod. A portion was published with a memoir by T. Birch in 1742, and other correspondence is printed in R. Vaughan's *Protectorate of Oliver Cromwell* (1836).

THURLOW, EDWARD THURLOW, 1ST BARON (1731–1806), was twice lord chancellor of England (1778–83; 1783–92). Though his tenure was a long one, he is remembered more for his oratory, his caustic wit and his bad temper than for his legal acumen. Thurlow was born at Bracon Ash, Norfolk. on Dec. 9, 1731, the first son of an Anglican clergyman of modest economic circumstances and no connections. After going down from Cambridge without a degree because of indolence and insubordination, traits he retained throughout his life, he was admitted to the Inner Temple in 1752 and called to the bar in 1754. His signal triumph over Fletcher Norton. in a case tried before Lord Mansfield in 1758, marked the turning point of his career. He precociously took silk in 1762. An impromptu argument in Kando's coffeehouse—whose barmaid was to become mother of his three daughters though not his wife—caused him to be retained in his greatest success as counsel in the case involving the heirship to the great Douglas estates. In 1765 he entered commons as a member lor Tamworth. There, his strong opposition to Wilkes was followed by his appointment as solicitor general in 1770. His speeches against jury trial in libel cases and his prosecution of the publishers and printers of the "Junius" letters brought him the attorney general's post in 1771. His oratorical capacities, well displayed in his venomous attacks on Lord Clive and the American colonies and his defense of the slave trade, caused his party to elevate him to the peerage and the woolsack. He ruled in the house of lords with an iron hand. A 'Tory by declaration, his sole guiding principle was expediency. which generally led him to support the will of King George III. a course which permitted him to retain his high post in such disparate ministries as those of North, Rockingham. Shelburne and Pitt. He died on Sept. 12, 1806 at Brighton. Thurlow had few friends and many enemies, the latter including the greatest politicians of his time: the younger Pitt, Charles James Fox and Edmund Burke. In law, his greatest claim on posterity derives from his sponsorship of John Scott, later Lord Eldon. Perhaps equally important mere his kindnesses to the poet George Crabbe and to Samuel Johnson. His portraits, painted by Reynolds, Romney and Lawrence, among others: reveal a swarthy complexion, harsh but regular features, sparkling dark eyes and a severe demeanor. But not even these masters could portray the voice which was his outstanding feature and the cornerstone of his career.

BIBLIOGRAPHY.—There is a bibliography in the only full-length biography, Robert Gore-Brown, *Chancellor Thurlow* (1953); *see* also Campbell, *Lives of the Lord Chancellors,* vol. vii (1846); H. P. Brougham, *Statesmen in the Time of George III,* 6 vol. (1845).

(P. B. K.)

THURMAN, ALLEN GRANBERY (1813–1895), U.S. jurist and statesman, was horn at Lynchburg (Va.), on Nov. 13, 1813. In 1819 he removed with his parents to Chillicothe (O.), where he attended the local academy for two years, studied law in the office of his uncle, William Allen, and in 1835 was admitted to the bar, becoming his uncle's law partner. He began to take an active part in politics in 1844, and in 1845–47 was a Democratic representative in congress, where he advocated the Wilmot Proviso.

He was Democratic candidate for governor of Ohio in 1867, and was defeated by Rutherford B. Hayes by a majority of less than 3,000 votes; but the Democrats gained a majority in both branches of the state legislature. and Thurman was elected to the Cnited States senate. where he served from 1869 until 1881—during the 46th Congress (1879–81) as president *pro tempore.* Here he became the recognized Democratic leader and in 1879–81 was chairman of the judiciary committee. He introduced the Thurnian bill. for which he was chiefly responsible. which became law in May, 1878, and readjusted the Government's relations with the bond-aided Pacific railways.

Thurman was a member of the electoral commission of 1877, and was one of the American delegates to the international monetary conference at Paris in 1881. In 1876, 1880 and 1884 he was a candidate for the presidential nomination, and in 1888 was nominated for vice-president on the ticket with Grover Cleveland. but was defeated in the election. He died at Columbus (O.), on Dec. 12. 1895.

THURROCK, an urban district (1936) in the Thurrock parliamentary division of Essex. Eng.. lying along the north bank of the Thames. This area, mainly agricultural, was largely reclaimed from the marshes by the Dutch. who also used chalk from the Purfleet quarries in the embankment of the Thames in the 17th century. Area 63.4 sq.mi. Pop. (1061) 114,302.

Grays, 23 mi. E. of Charing Cross. London, by road, is the administrative centre. From being a fishing village it became a large river port for the hay and corn market and it mas further enlarged when the Tilbury docks ($2\frac{1}{2}$ mi. S.E.) were built. In 1906 an artificial beach of fine sand was made there.

Tilbury docks (*q.v.*) were constructed in 1884–86 on land that had been, until 1852, uninhnhited marsh. They were built by the East and \West India Dock company and are now owned by the Port of London authority. The original blockhouse at Tilbury, which was built by Henry VIII. was rebuilt in the 17th century. It was taken over by the ministry of works in 1949 and opened to the public in 1958. The fort has a gateway by Inigo Jones. It was at West Tilhury that Elizabeth I made her iamous speech to her troops in 1588 just after the defeat of the Armada. East Tilhury is built on the site of a 7th-century monastery. and the church, like many others in the district. dates from the 13th century.

At Mucking (Anglo-Saxon, "much pasture") is St. Clere's hall !formerly New Jenkins). dating from Elizabethan times: Ford place, at Stifford. rebuilt in 1655. has beautiful plaster ceilings. In 1381 Jack Straw. the revolutionary priest of Fobbing, led the peasants in revolt against the poll tax. and in the marshes nearby the last great prizefight with bare knuckles is said to have taken place. Orsett was once the seat of the bishops of London. Aveley is a residential area on rising ground and near the village is the mansion of Belhus in what is now a public park.

Thurrock's industries stretch along the 20 mi. of Thames-side. There are a paperboard mill. soap and margarine works at Purfleet; several cement works: timber yards at Grays; a shipbreaking yard: Tilbury docks with a passenger landing stage; a large shoe factory with its own technical college (1948) at East Tilbury; and, at the eastern end of the district, the Shell Haven oil refinery at Thames Haven and a refinery at Coryton for storing, blending and refining oil. The Wet Thurrock industrial estate along the river bank covers over 4 sq.mi. and special facilities and concessions are granted to occupiers.

THURSDAY ISLAND, an island belonging to Queensland, Austr.. about 22 mi. N.W. of Cape York in Torres strait. Area: $1\frac{1}{4}$ sq.mi. Pop. (1954) 2.062. The island was granted some self-government in 1939. Pearl fleets operate from Port Kennedy and pearls, mother-of-pearl and trochus shell and *bêche-de-mer* are main products.

THURSQ, a small burgh and seaport of Caithness, Scot.. at the mouth of the Thurso river. on Thurso bay, 20 mi. W.S.W. of John o'Groats by road. Pop. (1961) 8,038. It is the most northerly town on the mainland of Scotland. In Sir John square there is a statue of Sir John Sinclair (*q.v.*), who did much for the improvement of Scottish agriculture. The town hall contains a public library and museum. which possesses the geological and botanical specimens of the "Thurso baker," Robert Dick (1811–66), and a collection of northern birds. To the east is Thurso castle, and near it is Harold's tower, built over the grave of Earl Harold, once owner of half of Caithness and half of the Orkneys and Shetlands, who fell in battle with Earl Harold the Wicked at the end of the 12th century. About $\frac{3}{4}$ mi. W. stand the ruins of the bishop of Caithness' palace, destroyed by fire in 1222.

Thurso was the centre of the Norse power on the mainland when at its height under Thorfinn (1014), and afterward till the battle of Largs (1263). In 1330 the weights and measures of Thurso were adopted for all Scotland. Today its main industry is fishing, and it also has a market. At Dounreay (8 mi. W.) the second atomic power station in Great Britain was begun in 1954.

THURSTAN or TURSTIN (d. 1140), archbishop of York, was the son of a certain Anger, or Auger, prebendary of St. Paul's, London, and a brother of Audoen (d. 1139), bishop of Evreux. He himself was a prebendary of St. Paul's, and was also a clerk in the service of William II and then of Henry I, who secured his election as archbishop of York in Aug. 1114. He then entered upon the great controversy which occupied him during a large part of his subsequent life and made him for several years an exile from England. Archbishop Ralph of Canterbury refused to consecrate him unless he made a profession of obedience to the southern see; this Thurstan refused and asked the king for permission to go to Rome to consult Pope Paschal II. Henry I declined to allow him to make the journey, while Paschal declared against Archbishop Ralph. At the Council of Salisbury in 1116 the English king ordered Thurstan to submit, but instead he resigned his archbishopric. although this did not take effect. The new pope, Gelasius II, and also his successor, Calixtus II, espoused the cause of the stubborn archbishop, and in Oct. 1119, he was consecrated by Calixtus at Reims.

Enraged at this the king refused to allow Thurstan to enter England. and he remained for some time in the company of the pope. At length, however. his friends succeeded in reconciling him with Henry, and. after serving the king in Normandy, he was recalled to England. In 1138 he made a truce at Roxburgh between England and Scotland. and took active part in gathering together the army which defeated the Scots at the Battle of the Standard in Aug. 1138. Early in 1140 he entered the order of the Cluniacs at Pontefract where he died on Feb. 6. 1140. Thurstan displayed marked generosity toward the churches of his diocese during his bishopric and was also the founder of a number of religious houses.

See his life in the *Fasti eboracenses,* ed. J. Raine (1863).

THURSTONE, LOUIS LEON (1887–1955), U.S. psychologist who pioneered in the application of mathematical and statistical methods to psychological problems, was born in Chicago, Ill., May 29. 1887. After taking an engineering degree from Cornell university. Ithaca, N.Y.. he served as assistant to Thomas Edison and taught engineering at the University of Minnesota, Minneapolis. An interest in the mathematical relations between amount of practice and improvement in performance led him to The University of Chicago, where he received a Ph.D. in psychology and where he remained for most of his professional life thereafter. He died in Chapel Hill: N.C., Sept. 29, 19jj.

Most notable among Thurstone's accomplishments were improved methods of measuring intelligence and his development of multiple-factor analysis. The latter is widely used in research on the nature of human ability and for the practical purpose of constructing tests to measure different types of ability. His literary output was comparatively small. including a score or two of research papers and a few books and monographs. but these were so influential that he was one of the United States' most frequently quoted psycholopists. Thurstone's major books were *Vectors of the Mind* (193j) and *Multiple-Factor Analysis* (1947).

(DL. W.)

THYME. The genus *Thymus* (family Labiatae) comprises a number of fragrant aromatic undershrubs, with very small leaves and whorls of small purplish, nectar-bearing flowers in the axils of the leaves or at the ends of the branches. The common garden thyme, a native of the Mediterranean region, is T. *vulgaris;* the wild thyme of English banks is T. *serpyllum,* naturalized in eastern North America. Pot marjoram (*Origanum*) and sweet marjoram (*Majorana*) are also closely allied. All these plants, easily grown from seed or cuttings in ordinary garden soil, are useful culinary flavouring agents and are remarkable for their essential oil, from which thymol, a widely useful medicinal, is produced.

THYMELAEACEAE, a family of dicotyledonous plants, with about 43 genera and in excess of 700 species recognized. They are mostly shrubs or trees, rarely herbaceous, and representatives occur in most parts of the world, even in arctic regions. Large genera are *Gnidia,* with about 175 species, chiefly African, *Wikstroemia,* with 120 species, chiefly Indo-Malaysian, and *Pimelea,* chiefly Australian, with 100 species. The bast fibres of many species are very strong, and are extensively utilized in various parts of the world, and especially in Japan, for manufacturing thin tough writing paper. Some species of *Daphne* (*q.v.*) are cultivated for ornamental purposes. Eaglewood or agalloch, prized because of its pleasant odour, is the product of representatives of the genus *Aquilaria.* (E. D. ML.)

THYMUS. The thymus is a soft, flattened organ lying behind the breastbone. Its function is not well understood. It consists of two lobes of unequal size, which partly cover the trachea, the large vessels in the chest and the serous covering of the heart, the pericardium. As a food, the animal thymus is called the sweetbread or, more specifically, neck sweetbread, to differentiate it from the pancreas, the stomach sweetbread. During life, the thymus changes markedly in absolute and relative size. It is proportionately largest at birth, averaging about 12 g. or 0.42% of the total body weight. At the age of puberty the thymus reaches its absolute maximum size (about 37 g.). After puberty the organ gradually decreases in size (involutes) until, between age 60 and 70, the average weight is around six grams. Large individual deviations from these averages may occur. In addition to physiologic involution, a much more rapid so-called accidental involution may take place as a result of infection, poisoning or starvation.

Functions. — Although the thymus has the microscopic structure of a lymphatic organ and as such participates in the production of lymphocytes, many studies have seemed to show that the thymus is an endocrine organ. The fact that the thymus reaches its maximum size during puberty and then involutes has suggested to some investigators that the organ plays an active role in processes of growth and sexual maturation. Experiments with injections of thymus extracts into rats have led to similar assumptions. However, the growth of the thymus as well as its involution is essentially no different from the same process in other lymphatic organs, and the experiments with thymus extracts have not been substantiated. Injections with pituitary growth hormone result in an increase in the size of the thymus, while removal of the pituitary as well as administration of steroid hormones, including the sex hormones, tends to decrease its size. It is possible that these hormones are instrumental in the normal growth and involution of the thymus. It has been suggested that accidental involution may be caused by a high level of secretion of adrenal cortical steroid hormone.

Operative removal of the thymus is sometimes employed with variable results in the treatment of myasthenia gravis, a disease characterized by a progressive weakening of the musculature.

A condition in children known as status thymicolymphaticus was believed to be associated with sudden death occurring under circumstances that normally do not lead to death. This term indicates an overgrowth of lymphatic tissue. including the thymus, accompanied by a constitutional susceptibility to sudden death. The theory that there is such a causal relationship, however, appears to have been abandoned.

Microscopic Structure. — The thymus is encased in a thin capsule of connective tissue. This connective tissue penetrates the interior of the organ in the form of walls that branch and fuse, thus dividing the thymus into a multitude of connecting lobules having a diameter of .05 to 2 mm. The thymus tissue itself contains two types of cells. reticular cells and lymphocytes. The reticular cells. which are larger than the lymphocytes. are characterized by a large pale nucleus; they form a three-dimensional network in the meshes of which the lymphocytes are found. In the peripheral areas of the lobules, the so-called cortex, the lymphocytes are more densely packed and the reticular cells relatively more sparse. The central zone of the lobule, the medulla, contains fewer lymphocytes and more reticular cells than the cortex. The reticular cells of the thymus differ from the reticular cells of other lymphatic tissues in that they are derived embryologically from epithelial tissue and not from the mesenchyme (the embryologic connective tissue). The lymphocytes of the thymus are not only morphologically identical with the lymphocytes of other lymphatic tissues; they also exhibit the same physiologic behaviour and the same reactions to noxious stimuli. In the medulla of the thymus are the so-called Hassall's bodies. These structures are composed of concentrically arranged cells, which are degenerated at the centres of the bodies where also processes of cornification can frequently be seen. The function of Hassall's bodies, if any, is unknown.

The involution of the thymus consists microscopically of a decrease in the amount of thymus tissue, which is replaced by fat tissue originating in the interlobular connective tissue. This process affects first the cortex but gradually extends also to the medulla, which decreases in quantity. Finally the thymus becomes a mass of fatty tissue containing centrally a remnant of the medulla with varying numbers of Hassall's bodies.

Embryology. — The thymus arises from the third branchial pouch in the form of two epithelial cell masses, which at first are tubular but subsequently become solid. Lymphocytes wander in from the surrounding mesenchyme, thus separating the densely packed epithelial cells and converting the solid cell mass into a reticulum. The lymphocytes of the thymus are not derived from the epithelial cells. See also LYMPH AND LYMPHATIC SYSTEM.

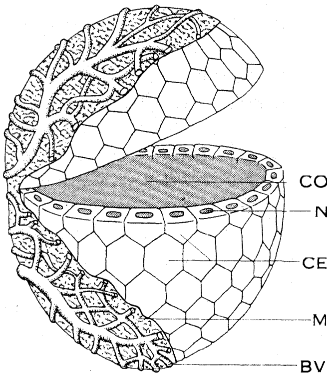
(P. P. H. DE B.)

THYMUS, DISEASES OF. Many functions have been attributed to the thymus (*q.v.*), but thus far the function of this organ and its relationship to clinical disease are not well understood. Classical extirpation experiments in animals have given no conclusive results. *Myasthenia gravis* (see PARALYSIS) is associated in many instances with a tumour of the thymus; in many cases of hyperthyroidism, a disease associated with thymic enlargement, muscular weakness is a prominent feature. In a number of cases a thymic tumour has been associated with depressed red blood cell formation and anemia which is at times relieved by surgical removal of the tumour. Certain relationships have been found between the thymus and the transmissibility of leukemia in experimental animals. A great deal has been written about the relationship of thymus enlargement to sudden death in infants, particularly during anesthesia. Evidence indicates, however, that the thymus — originally described as enlarged and as associated with the syndrome known as lymphatic constitution or status thymicolymphaticus — is normally developed in such cases. The symptoms in such patients are usually caused by infections of the respiratory tract and other local or general conditions. There is evidence to indicate a relationship between previous irradiation of the upper chest in children and the development of carcinoma of the thyroid. Prophylactic irradiation to prevent sudden death in infants is not warranted. All tumours originating in the thymic area should be regarded as potentially malignant.

(A. M. HY.)

THYROID GLAND, an endocrine gland situated below the "Adam's apple," consisting of two oblong lobes lying on either side of the windpipe and connected by a narrow band of tissue called the isthmus. The lobes of the gland as well as the isthmus consist of numerous tiny hollow sacks called follicles, more or less rounded in shape and varying from 0.05 to 0.5 mm. in diameter. The shell of each follicle is built of cells closely packed together and is wrapped in a thin membrane (see figure). The membrane is covered with a dense mesh of blood capillaries, which ensure a steady and abundant supply of fresh plasma through the membrane to the cells; in fact the thyroid gland is one of the most extensively vascularized organs. Besides blood vessels, there are also lymph vessels and nerves around the follicle. The space inside the follicle is filled with a viscous fluid called colloid.

Every follicle of the thyroid gland makes thyroid hormone, stores it and secretes it into the blood stream. This hormone consists of two chemically closely related substances, L-thyroxine (or L-tetraiodothyronine) and L-triiodothyronine. Under normal conditions, most of the hormone is made up of thyroxine. The four and three atoms of iodine present in these two molecules account, respectively, for 65% and 58% of the hormone weight. It is possible to administer radioactive iodine and trace its progress in the thyroid, to observe how the gland uses it to make up the hormone. The iodide diffusing from the blood capillaries into the cells is retained by and concentrated in the cells. Then the iodide is taken up into organic compounds to form thyroxyl and triiodothyronyl radicals, which are thyroxine and triiodothyronine attached to a large protein called thyroglobulin. This phenomenon occurs at the edge of the cells next to the colloid. The new thyroglobulin becomes mixed with the thyroglobulin present in the colloid and stays there, thus providing a hormone store. Release of the hormones occurs when an enzyme, presumably secreted by the thyroid cells into the colloid, breaks down thyroglobulin to its amino acid components. The thyroxine and triiodothyronine molecules thus freed are small enough to cross the cell wall and to enter the blood vessels around the follicle; they become distributed over the entire body.



THYROID FOLLICLE
From periphery to centre are shown blood vessels (BV), membrane (M) and cells (CE) which make up the shell of the follicle. Appearing on the section plane are the *nuclei* (N) and the colloid (CO) which fill up the space inside the hollow follicle

In blood the thyroid hormone binds loosely to plasma proteins, mainly to a-globulin. To measure the level of thyroid hormone in the blood, the hormone is separated from inorganic iodine (iodide) by isolating plasma proteins, and the iodine content of these proteins is determined. The amount of so-called protein-bound iodine indicates whether or not the thyroid hormone level is normal. Too low or too high levels cause widespread functional disturbances, since the hormone controls the oxidation rate of foodstuffs inside the cells over the entire body.

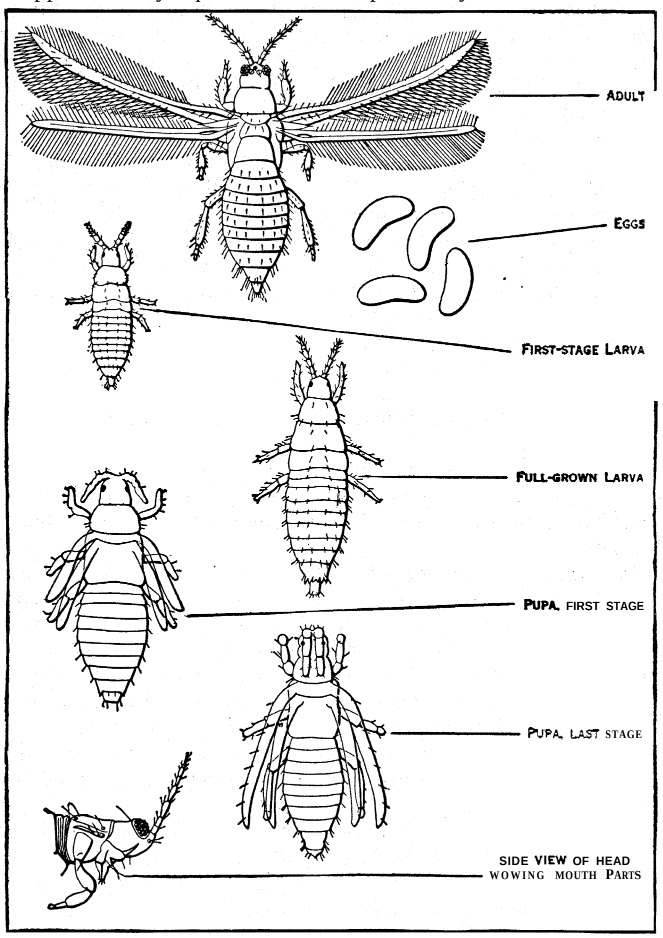
The amount of thyroid hormone secreted by the thyroid gland is controlled by another endocrine gland, the pituitary. When the level of thyroid hormone in blood diminishes, due to its utilization in the tissues, the pituitary gland releases a hormone which stimulates the thyroid. This thyroid-stimulating, or thyrotrophic, hormone first induces the release of the thyroid hormone stored in the colloid by accelerating the breakdown of thyroglobulin. The amount of colloid in the follicle diminishes and may even nearly disappear under prolonged stimulation. The thyroid cells increase in size by protruding inside the follicle, and thus increase their capacity to produce the hormone. Under normal conditions, the appropriate level of thyroid hormone in the body is readily re-established; this higher level induces the pituitary to stop releasing thyrotrophic hormone; the thyroid stimulation ceases, the stores of thyroglobulin are repleted and the cells regress to their original size. Thus the level of thyroid hormone in the body is kept within a constant range by a mechanism in which the effects of thyroid hormone and of thyrotrophic hormone work in closed cycle (feedback mechanism), each hormone controlling the secretion of the other. See also CRETINISM; ENDOCRINE GLANDS; ENDOCRINOLOGY; HORMONES: PITUITARY BODY.

(H. G. I.)

THYRSUS, a kind of staff carried by Dionysus (*q.v.*) and his votaries (Gr. thyrsos). It was a reed, sometimes having a spear point at one end, topped with a pine cone. Another form terminated in a bunch of grapes and vine leaves, or ivy berries and leaves. The pine cone or bunch of leaves was sometimes supposed to cover the head of a spear, and the thyrsus was termed *thyrsologchos*.

See F. J. M. de Waele, *The Magic Staff or Rod* (1927).

THYSANOPTERA, the name of a small order of insects commonly known as *thrips.* Most of the species are not far from $\frac{1}{25}$ in. in length, though some of the tropical and Australian giants of the order measure about $\frac{1}{2}$ inch. To the group belong such destructive species as the greenhouse thrips, pear thrips, orange thrips and onion thrips, as well as some which carry virus diseases of tomato, pineapple, bean, sugar cane, etc. Though extremely abundant as individuals, possibly outnumbering beetles or flies or ants, they are commonly overlooked, even by entomologists, because of their small size; and not more than 3.000 species have been described. Their distribution is world-wide and includes all areas that are sufficiently warm for the development of a summer vegetation. They feed upon the sap of nearly all kinds of seed plants (and also a few ferns), extracting it from the buds, flowers, leaves or stems by means of their sucking mouth-parts. Others take juices from decaying plant remains, fungi, small insects and mites. One has been reported to ingest human blood occasionally; and one large group of species takes in the minute spores of various fungi, instead of juices. Some are restricted closely to a single kind of plant, while others occur in approximately equal abundance upon many kinds of unrelated



BY COURTESY OF THE U.S. DEPARTMENT OF AGRICULTURE
LIFE HISTORY OF THE PEAR THRIPS (TAENIOTHRIPS INCONSEQUENS. MAGNIFICATION UPPER FIGS X30, LOWEST FIG. X47)

plants. Certain leaf-feeders produce a curling of the leaf, or even its folding along the mid-vein, thus creating a shelter for the insects within. Others, found only in galls in Australia, are thought to be the direct cause of these enveloping plant growths, though it is possible that the galls are induced by other insects.

They are elongate, slender-bodied insects, with antennae consisting of four to nine true joints, and with asymmetrical piercing mouth-parts. The wings are almost invariably long and strap-like, with greatly reduced venation and long fringes of marginal hairs. The tarsi are two-segmented; the apex of each tarsus contains a minute protrusible bladder nhich enables them to climb even the smoothest surface. The young closely resemble the adults in general form, though generally paler and more brilliantly coloured. Before becoming adult, they pass through a prepupal stage and one or two pupal stages. Wings, commonly present in the adults of both sexes, are invariably lacking in the males of certain species and frequently reduced in both females and males, especially under optimum environmental conditions. Parthenogenesis is frequent in the order, and males are either unknown or very rare in several species. In other species parthenogenesis occurs, although males are common. In a few highly specialized species embryonic development is largely, or even fully, completed within the body of the mother, the young being born alive in the latter event.

The Thysanoptera are divided into two suborders: (1) Terebrantia, in which the female has a saw-like ovipositor and usually a conically-pointed abdomen, the male having the abdomen bluntly rounded; and (2) Tubulifera, in which the female is without an ovipositor, both sexes having the last segment of the abdomen (except in a very few instances) tubular in form. The Terebrantia are the more primitive group, with more veins in the wings and often with the wings relatively broad. Most of the species of this group feed upon living plants. The female usually inserts the eggs under the epidermis of the plant by means of her ovipositor. A number of fossil species are known, particularly from Baltic amber. The Tubulifera, on the other hand. are more specialized: the ovipositor has been lost, the antennae have usually fewer segments, the wings are narrow and the veins have been reduced to a single median vestige. Most of the species of this group are found under and on the bark of living or dead trees, on fungi, in turf and under leaves, although a few live on foliage or in flowers, or are predacious. Lacking an ovipositor, those species which lay eggs usually hide them in protected places. This group is almost unknown as fossils.

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THYSANURA, an order of primitive wingless insects comprising the bristletails, silverfish (*q.v.*) and firebrats. They are recognizable by their elongate feelers and tail processes (cerci). Active chiefly at night, they scurry about for cover—crevices about buildings, undersides of rocks, leaf mold—when exposed to light. See also APTERYGOTA.

THYSDRUS, an ancient city of north Africa (the site is occupied by the modern village of El Djem, 43 mi. S. of Sousse by rail). It acquired importance because of the fertility of its environs, and also as the meeting place of six ancient roads. The amphitheatre, 163 by 133 yd., is the finest Roman monument in north Africa, and is second in size only to the Flavian amphitheatre (the Colosseum) in Rome.

THYSSAGETAE, an ancient tribe described by Herodotus (iv, 22, 123) as occupying a district to the northeast of Scythia separated from the Budini by a desert seven days' jouney broad.

THYSSEN, AUGUST (1842–1926), German industrialist, "steel baron of the Ruhr territory," was born at Eschweiler, May 17, 1842. Thyssen's rolling mill, founded in 1867, became Thyssen and Co. in 1871 when he originated "vertical cartelization," unifying the financial. technological and market controls of facilities for producing basic steel with operating properties in related industries, such as coal mining. Thyssen sought additional private gain by vertical cartelization and was pressed to accelerate it by Bismarck. who saw in the technical integration which accompanies cartelization. a means of speeding military production. In addition to his practical motives. Thyssen had a pronounced technological bent. being first among German steel men to introduce the blast furnace as well as the Thomas process for utilizing the rich bed of phosphoric ore in Alsace-Lorraine in conjunction with the abundant coking coal of the Ruhr valley. Thyssen's great financial power. later augmented by collaboration with his son, Fritz Thyssen (1873–1951), was used after World

War I for political manipulations detrimental to the Weimar republic and beneficial to Adolf Hitler.

Thyssen died at Landsberg castle, near Kettwig, April 4. 1926. (G . Z.)

TIARA, the papal crown, a bee-hive shaped, somewhat bulging head-covering, ornamented with three crowns (whence *triregnum* or "triple crown"). It has no sacral character, being solely the ensign of sovereign power (cf. Innocent III Serm. vii in *S. Silvest.*), and is therefore never worn at liturgical functions, when the pope always wears the mitre. The tiara is first mentioned, under the name of *camelaucum,* in the *Vita* of Pope Constantine (d. 715), and next under the name of *pileus phrygius* or *phrygium,* or the *Constitutum Constantini,* the so-called "Donation of Constantine." In the 9th century it appears in the 9th *Ordo* of Mabillon in connection with the description of the consecration of the pope. On papal coins it first appears on those of Sergius III (d. 911) and then on those of Benedict VII (d. 983). At this period it was, according to the *Ordo* above mentioned, a sort of cap of white stuff, and helmet-shaped. Before the 9th century the tiara was certainly without any crown; any such ornament mould not have been in keeping with the circumstances of the time and seems also to be excluded by the terms of the *Constitutum Constantini.*

At the beginning of the 12th century, however, the papal tiara was already decorated with a circlet, as the 12th *Ordo* and statements made by Bruno of Segni (d. 1123) and Suger, abbot of St. Denys (1121–51), prove; but it is only in representations of the tiara dating from the late 13th century that the circlet appears as a regular spiked crown. The two pendants at the back of the tiara (*caudae, infulae*) are likewise traceable only to this period. The second circlet was added by Boniface VIII, as is proved by three statues executed during his lifetime (one in the Lateran church and two in the crypt of St. Peter's).

The earliest effigy of a pope with a triple-crowned tiara is, therefore, that of Benedict XII (d. 1342), of which the head is preserved in the museum at Avignon, while an effigy of the same pope in the crypt of St. Peter's at Rome has a tiara with only two crowns.

TIARET (*Tahert*), a town of Algeria: in the Tell Atlas, *département* of Tiaret, 122 mi. S.E. of Mostaganem by rail. Pop. (1954) 22,503. It occupies an important strategic position on a mountain pass at an elevation of 3,552 ft. The Wadi Tiaret flows through the town in a series of cascades. The upper town, the residential quarter, is on the right bank of this stream. The citadel occupies a separate hill on the other side of the wadi. The chief business centre is the lower town, where are also the principal public buildings. On another hill opposite the citadel is the native town.

TIBER, a river of central Italy (anc. *Tiberis;* Ital. *Tevere*). It traverses the Tuscan Apennines—in which it rises at a point about 12 mi. N. of Pieve San Stefano, 4,160 ft. above sea level, nearly 20 mi. E. from the headwaters of the Arno—in a series of picturesque ravines, flows nearly south by Borgo S. Sepolcro and Città di Castello, then runs between Perugia and Todi to Orte, where it receives the Nera (which brings with it the waters of the Velino; see TERNI), skirts the west foot of the Sabine mountains in a broad shallow valley, then crosses the Roman Campagnn, cutting its way through Rome, and finally enters the Tyrrhenian (Mediterranean) sea by two arms at Ostia and Fiumicino, the latter artificial. Its principal tributaries are the Paglia, the Nera and the Anio or Teverone. and it is generally navigable by boats up to the confluence of the Nera, a distance of 104 mi.. though, because of the rapidity of the current, there is very little navigation above Rome. The total length of the river is 252 mi., of which 21 mi. lie between Rome and the sea. This latter portion of the river's course is tortuous, but in spite of this. and although the depth varies from only 7 to 20 ft., and in places at low water does not exceed 4 ft., it is nevertheless navigated by vessels up to 180 tons burden. The area of the Tiber basin is 6.719 sq.mi., and it is the largest in Italy except the Po. The stream is heavily charged with sediment, and from that circumstance got its ancient epithet of *flavus* (tawny). The discharge at the mouth is 230 cu.m. per second, but it can fall as low as 90, and in floods rises to 3,400. It has advanced at each mouth about 2 mi. since Roman times, while the effect of the sediment it brings down is seen on the northwest almost as far as Palo (anc. *Alsium*), and on the southeast beyond Tor Paterno (see LAVINIUM) in the gradual advance of the coast. The rate of advance at Fiumicino is estimated at 13 ft. per annum. From Rome to the sea the fall is only 6 per 1,000. The arm which reaches the sea at Fiumicino is a canal, dug by Claudius and improved by Trajan (see PORTL-s).

In the prehistoric period the mouth of the Tiber must have been situated at the point where the hills which follow it on each side cease, about 12 mi. below Rome. On the right bank they are of Pliocene gravel, on the left of tufa; and on the latter, on a cliff above the river (the ancient *Puilia saxa*) stood Ficana (marked by the farmhouse of Dragoncello), which is said to have owed its origin to Ancus Martius. Beyond these hills the low coast belt formed by the solid matter brought down by the river begins; and on each side of the mouth in the flat ground were salt marshes. (See OSTIA, PORTUS.)

TIBERIAS, a town formerly in Palestine and from 1948 in Israel, on the western shore of the Sea of Galilee, attractively situated on a narrow strip of land between the high ground and the water, 680 ft. below sea level; pop. (1956 est.) 17,400. The old city lay to the south of the modern.

History.—Tiberias was built about A.D. 21 by Herod Antipas, and was so called after the emperor Tiberius. Herod made it his capital and developed its life on Greek lines. The town was built on an ancient site, probably Rakkath (Josh. xix, 35), and in the course of construction a graveyard was disturbed. In consequence the Jews. fearful of uncleanness, refused to live there, and Herod had to resort to compulsion to people his town (Joseph, *Antiq.*, xviii, 2. 3). No mention is made of Tiberias in the Gospels. except the casual reference in John vi. 23. The city was of too recent date and too Hellenistic in outlook to invite attention, and it is unlikely that Christ ever visited it. It flung open its gates to Vespasian and his legions to earn considerations and favour. Hadrian sought to implant paganism by erecting a temple, but with no marked success. Toward the close of the 2nd century the Sanhedrin transferred itself thither from its first Galilean home at Sepphoris.

From the rabbinic school at Tiberias came Judah hak-Kadhosh, the collector and editor of the Mishnah (*c.* 220). The Talmud was edited there 200 years later. The Jewish philosopher Maimonides and Rabbi 'Xkiba were buried there.

Christianity found in Tiberias no congenial soil. and not until the 4th century could it make headway. In the 5th century there was a bishop of Tiberias, who subscribed to the acts of the council of Chalcedon. In 63; the Arabs arrived. \\!hen the crusaders established their kingdom of Jerusalem. Tancred was appointed ruler in Galilee; Tiberias became his capital and was in part rebuilt on a new site farther north. In 1187, before the battle of Hattin. it fell into the hands of Saladin. In the 18th century Dhahir el-Armi fortified the town; and in their advance on Damascus, British troops seized it in Oct. 1918.

In 1948. when the new state of Israel was proclaimed, many of the Arabs living there were evacuated. (E. Ro.; X.)

TIBERIUS (TIBERIUS CLAUDIUS NERO) (42 B.C.–A.D. 37), Roman emperor. was born on Nov. 16, 42 B.C. His father. who bore the same name. mas one of Julius Caesar's officers. He had proposed to confer honours on Caesar's assassins, then joined Mark Antony's brother in his attack on Octnvian, took refuge with Mark Anton!;. and returned to Rome when the general amnesty was proclaimed in 39 B.C.

Livia, the mother of Tiberius. was also of the Claudian family, out of which her father had passed hy adoption into that of the Livii Drusi. Her husband ceded her to Octavian (the future Augustus) in 38, and three months after her new marriage Drusus, brother to Tiherius. was born. Livia had no children by Augustus and therefore devoted all her remarkable gifts to the advancement of her sons.

Tiberius passed through the list of state offices in the usual princely fashion, beginning with the quaestorship at the age of 18 and attaining the consulate for the first time at 29. From the capacity for civil affairs which he displayed as emperor it may be inferred that he applied himself with determination to learning the business of government.

But from 22 to 6 B.C. and again from A.D. 4 to 10 by far the greater part of Tiberius' time was spent in the camp. His first service was as legionary tribune in one of the desperate wars in the Spanish peninsula. In 20 B.C. Augustus sent Tiberius with an army to seat Tigranes of Armenia on the throne as a Roman vassal. This he did without opposition. He spent the following year as governor of Transalpine Gaul. In 15 he was dispatched to aid his brother Drusus in subjugating the Raeti and Vindelici in the mountains at the source of the Rhine and Danube. Drusus attacked from the eastern side while Tiberius operated from the upper waters of the Rhine, and the mountaineers were subdued, which ensured the safety of communications between northern Italy and Gaul.

In 12 B.C. Agrippa, the great general of the emperor Augustus, died at the age of 51, leaving Julia, the emperor's only child, a widow. Vipsania, who was the daughter of Agrippa by an earlier marriage, was wife of Tiberius, and had borne him a son, Drusus. Livia, with great difficulty, prevailed upon Augustus to replace Agrippa by Tiberius, who was compelled to exchange Vipsania for Julia: with bitter grief on his part. During the year of mourning for Agrippa, which delayed his new marriage, Tiberius was occupied with a victorious campaign against the Pannonians, followed by successful expeditions in the three succeeding summers. For this he received the triumphal insignia, now first separated from the triumph itself.

On the death of Drusus in the autumn of 9 B.C., Tiberius, whose reputation had hitherto been eclipsed by that of his brother, stepped into the position of the first soldier of the empire. The army, if it did not warmly admire Tiberius, entertained a loyal confidence in a leader who, as Velleius (the historian who served under him) reports, always made the safety of his soldiers his first care.

In the campaign of the year after Drusus' death Tiberius traversed all Germany between the Rhine and the Elbe, and met with slight opposition. He was rewarded with the full triumph, the military title of "imperator" and his second consulship. In 7 B.C. there was another but insignificant campaign in Germany. Next year Augustus bestowed on his stepson the tribunician authority for five years.

Tiberius was thus in the most formal manner associated with the emperor in the conduct of the government on the civil side. Tacitus goes too far, however, when he says that this promotion marked him out as the heir to the throne.

Tiberius at this time suddenly begged permission to retire to Rhodes and devote himself to study. He seems to have declined absolutely at the time to state his reasons for this course, but he obstinately adhered to it. The departure from Italy was as secret as it could be made. Years afterward, when Tiberius broke silence about his motives, he declared that he had retired in order to allow the young princes, Gaius and Lucius, sons of Agrippa and Julia, a free course.

There was perhaps a portion of the truth wrapped up in this declaration. Like Agrippa, who retired to Mytilene to avoid the young Marcellus, Tiberius had clearly no taste to become the servant of the two children whom Augustus had adopted in their infancy and evidently destined to be joint emperors after his death. But it may well be believed that Tiberius, unlike Agrippa, had no burning ambition to see himself in the place destined for his stepsons; and it may have been in his eyes one of the attractions of exile that it released him from the obligation to aid in carrying out the far-reaching designs which Livia cherished for his sake. But the contemporaries of Tiberius were no doubt right in believing that the scandal of Julia's life did more than all else to render his position at Rome intolerable. His conduct to her from first to last gives a strong impression of his dignity and self-respect. When at length the emperor's eyes were opened, and he inflicted severe punishment upon his daughter, her husband, now divorced by the emperor's act, made earnest intercession for her and did what he could to alleviate her suffering.

At Rhodes Tiberius lived simply, passing his time mainly in the company of Greek professors, with whom he associated on fairly equal terms. After five years' absence from Rome, he begged for leave to return; but the boon was angrily refused, and Livia with difficulty got her son made nominally a legate of Augustus, so as in some degree to veil his disgrace. The next two years were spent in solitude and gloom. Then, on the intercession of Gaius, Augustus allowed Tiberius to come back to Rome, but on the express understanding that he was to hold aloof from public functions. He had scarcely returned before death removed (A.D. 2) Lucius, the younger of the two princes, and a year and a half later Gaius also died. The emperor was thus left with only one male descendant, Agrippa Postumus, youngest son of Julia, and still a boy. Four months after Gaius' death Augustus adopted Agrippa and at the same time Tiberius. The emperor now indicated clearly his expectation that Tiberius would be his principal successor. The two essential ingredients in the imperial authority—the *proconsulare imperium* and the tribunicia potestas—were conferred on Tiberius and not on Agrippa, who was too young to receive them.

Tiberius' career as a general now began anew. In two or three safe rather than brilliant campaigns he strengthened the Roman hold on Germany, and established the winter camps of the legions in the interior, away from the Rhine.

In A.D. 5 it became necessary to attack the formidable confederacy built up by Maroboduus, with its centre in Bohemia. At the most critical moment, when Pannonia and Dalmatia broke out into insurrection, Maroboduus accepted an honourable peace. The four serious campaigns which the war cost displayed Tiberius at his best as a general. When he was about to celebrate his well-won triumphs, the terrible catastrophe to Varus and his legions (A.D. 9) produced a profound change in the Roman policy toward Germany. Although Tiberius with his nephew and adopted son Germanicus made in A.D. 9 and 10 two more marches into the interior of Germany, the Rhine was permanently accepted as the frontier. Tiberius was thus robbed in great part of the fruit of his campaigns; but nothing can deprive him of the credit of being a chief founder of the imperial system in the lands of Europe. From the beginning of 11, when he celebrated a magnificent triumph, to the time of the emperor's death in 14 Tiberius remained almost entirely in Italy, and held rather the position of joint emperor than that of expectant heir.

Tiberius ascended the throne at the age of 56. What struck every one of his contemporaries most was his absolute impenetrability. All his feelings, desires, passions and ambitions were locked behind an impassable barrier, and had to be interpreted by the very uncertain light of his external acts. It is recorded of him that only once did he as commander take counsel with his officers concerning military operations, and that was when the destruction of Varus' legions had made it imperatively necessary not lightly to risk the loss of a single soldier. The penalty of his inscrutability was widespread dislike and suspicion. But behind his defenses there lay an intellect of high power, cold, clear and penetrating all disguises.

Few have ever possessed such mental vision, and he was probably never deceived either about the weakness of others or about his own. For the littleness and servility of public life below the court he entertained a strong contempt. It is a question whether he ever liked or was liked by a single being; but he did his duty by those with whom he was connected after a thorough though stern and unlovable fashion. As a general he commanded the full confidence of his soldiers, though he was a severe disciplinarian; yet the men of his own legions greeted his accession to the throne with a mutiny.

Tiberius proved himself capable in every department of the state more by virtue of industry and application than by genius. His mind moved so slowly and he was accustomed to deliberate so long that men sometimes made the mistake of deeming him a waverer. He was in reality one of the most tenacious of men.

The persuasion entertained by many at the end of his life that he had always been a monster of wickedness. but had succeeded in concealing the fact until he became emperor, has slightly discoloured the narratives of his earlier years. Tiberius was called "the gloomiest of mankind" by the elder Pliny and he came to be disposed to brood over mysteries and superstitions. As this gloom deepened his will grew neaker. and his power tended to fall into the hands of unworthy instruments.

The change of masters had been anticipated by the Roman world with apprehension, but it mas smoothly accomplished. Livia expected to share the imperial authority nith her son. At first Tiberius allowed some recognition to the claim; but he soon shook himself free of her. and later became estranged from his mother and held no communication with her for years before her death.

The history of Tiberius' relations with other members of his family is hardly less miserable. Perhaps with any other commander than Germanicus the dangerouc, mutiny of the troops on the Rhine which broke out soon after Tiberius' accession would have ended in a march of the discontented legions upon the capital. The perilous episode of Arminius caused the recall of Germanicus and his dispatch to the east on an honourable but comparatively inactive mission. Tiberius seems to have set Piso to watch and thwart him. but there is no authority for the suspicion that he had him poisoned.

The death of Germanicus was followed four years later by that of the emperor's son Drusus. When Drusus died, Tiberius nominated two of the sons of Agrippina. Germanicus' widow. as his heirs. But Sejanus, Tiberius' minister, had grown strong by nursing the emperor's suspicions and dislike for the household of Germanicus. and the mother and the princes were imprisoned on a charge of crime.

In his memoirs of his own life Tiberius declared that he killed Sejanus because he had discovered that he entertained a mad rage against the sons of Germanicus. But the destruction of Sejanus did not save Agrippina and her two children. The third son. Gaius Caesar (Caligula), lived to become emperor when Tiberius died in 37.

Throughout his reign Tiberius strove earnestly to do his duty to the empire at large: his guiding principle was to maintain with an almost superstitious reverence the constitutional forms which had been constructed by Augustus. Only two changes of moment were introduced. The imperial guard, hitherto only seen near the city in small detachments. was by the advice of Sejanus encamped permanently in full force close to the walls. By this measure the turbulence of the populace was kept in check. The officer in command of the guard became at once the most important of the emperor's lieutenants. The other change was the practically complete abolition of the old comitia. But the senate was treated with an almost hypocritical deference and a pedantically precise compliance with the old republican forms was observed toward the senatorial magistrates.

The care expended by Tiberius on the provinces was unremitting. Soldiers, governors and officials of all kinds were kept in wholesome dread of vengeance if they oppressed their inferiors or encouraged irregularity of any kind. Strict economy permitted light taxation and enabled the emperor to show generosity in periods of exceptional distress. Public security both in Italy and abroad was maintained by a strong hand. and commerce was stimulated by the improvement of communications. Jurisdiction both within and without the capital was on the whole exercised with steadiness and equity, and the laws of the empire were at many points improved.

The social and moral reforms of Augustus were upheld and carried further. Such risings against the emperor's authority as occurred within the Roman domain were put down with no great difficulty. The foreign or rather the frontier policy was a policy of peace, and it was pursued with considerable success. With few exceptions the duties of the Roman forces on the borders were confined to watching the peoples on the other side while they destroyed each other. On the Rhine. at least, masterly inactivity achieved tranquillity which lasted for a long period.

Historians of Rome in ancient times remembered Tiberius chiefly as the sovereign under whose rule prosecutions for treason on slight pretexts first became rife, and the hateful body of informers was first allowed to fatten on the gains of judicial murder. Xugustus had allowed considerable licence of speech and writing against himself. and had made no attempt to set up a doctrine of constructive treason.

But the history of the state trials of Tiherius' reign shows conclusively that the straining of the law. proceeded in the first instance from the eager flattery of the senate. was in the earlier days checked and controlled to a great extent by the emperor, and was by him acquiesced in at the end of his reign. with a sort of contemptuous indifference, until he developed, under the influence of his fears. a readiness to shed blood.

Ancient authorities are Tacitus, to some extent biased by senatorial traditions; Suetonius, a rather scandalous biographer; and Velleius Paterculus, the nesreit in point of time, an officer who had served under him. Dio is probably dependent on Tacitus. Thr chief account of Tiberius in English is that containrd in Charles Merivale's *History of the Romans Under the Empire* (1850–64). E. S. Beesly wrote an interesting defense of him in his *Catiline, Clodius and Tiberius* (1878). Another history of this period is Hermann Schiller's *Geschichte der römischen Kaiserzeit* (Gotha, 1883). Much historical information is given in the editions of the *Annals* of Tacitus. of which the best in English is that of Henry Furneaux (Oxford, 1884): Freytag, *Tiberius and Tacitus* (Berlin, 1870) (following Stahr, *Tiberius*, Rcrlin, 1863), exposes the inconsistencies of Tacitus' account. *See* also Ihne, *Zur Ehrenrettung des Kaisers Tiberius* (Strassburg, 1892); Gentile, *L'Imperatore Tiberio secondo la moderna critica storica* (1887); J. C. Tarver, *Tiberius the Tyrant* (1902); E. S. Beesly, *Cataline, Clodius and Tiberius* (1907); A. Lang, *Kaiser Tiberius* (Jena. 1911); O. Kuntz, *Tiberius Caesar and the Roman Constitution* (Seattle, 1924). For the imperial administration of the provinces by Tiberius *see* Thcodor Mommsen, *History of Rome,* vol. v. trans. by W. P. Dickson (1862–75).

TIBESTI, a mountainous region of the central Sahara. inhabited by the Tibbu people. Tibesti includes the highest summit of the Sahara, the volcanic massif of Emi Koussi, which reaches 11,204 feet. The eruptive rocks have forced their way through a substratum of crystalline rocks covered by horizontal Silurian grits. the scarp of which is quite brusque above the surrounding plains, which are hundreds of metres above sea level.

Great dry watercourses, deeply cut in all the faces of the massif, ndicate a climate formerly more humid. The daily variations of temperature reach 30° at times.

The inhabitants, at most 10,000, are chiefly nomads, although there are some sedentary elements.

Tibesti had been partly explored by Gustav Nachtigal in 1870. After that no European went there until 191j, when Col. S. Tilho wrote a very complete description of it and mapped it. The frontier was fixed by the Franco-English convention of Sept. 8, 1919.

See S. Tilho, "Exploretion en Afrique centrale," *La Géographie,* xxi (1916–I?),"Carte de Tibesti." *La Géographie,* xxxvi (1921); C. Löfler, "La pacification du Tibesti," *L'Afrique française* (1916); D. A. A. Rottier, "Etude sur le Tibesti." *Bulletin du Comité d'études historiques et scientifiques de l'Afrique occidentale française* (1922).

TIBET, a country of central Asia. annexed to the People's Republic of China in 1951 and since regarded as an autonomous region of China. Tibet is called by Tibetans Bod (Bodyul), by Indians Bhot, by Mongols Tobet and by Chinese Tufan and Hsits'ang. Xrca 469.413 sq.mi. Pop. (1953 est.) 1,273,969. The inhabitants are scattered on a mountainousplateau extending approximately irom 74° to 100° E. long. and from 2i° to 37° S. lat.

Culturally Tibet includes parts of the Chinese provinces of Szechwan, Kansu and Yünnan, and Ladakh in Kashmir (*qq.v.*). Although the people in this vast area differ ethnologically in customs, dress and dialects, they have a common written language. Tibet is known as the land of lamas. and Lhasa. the capital. is the mecca of Lamaist Buddhism. Before Outer Mongolia and China fell under Communism, pilgrims flocked to the holy city from remote Manchuria and Mongolia, some even irom the U.S.S.R.

Historically, Tibet has on occasion ruled, and long influenced the frontier states of Nepal. Sikkim and Bhutan on the southern slopes of the Himalayas. From the 13th century until 1951 it was ruled by a religious hierarchy and the pontiff of the Lamaist Church wielded temporal power. In the 17th century. the head of a reformation Lamaist sect (Ge-lug-pa, known as the Yellow Hat sect) achieved political ascendancy. He was officially acknowledged by the Chinese emperor as the dalai lama. This marked the beginning of 250 years of Chinese tutelage over the heads of Lamaism. In 1911 China became a republic. Years of civil wars and internal dissension ensued. With the encouragement of the British, Tibet openly defied Chinese overlordship. Though nominally under Chinese sovereignty or suzerainty, Tibet was, to all intents and purposes. an independent nation from 1913 to 1950. In 1950 Communist China invaded Tibet nhich capitulated and signed an agreement in Peking in 1951. However, sporadic revolt against Chinese rule immediately broke out. Even the announcement by the Communist regime in 1957 that it would not attempt to introduce any "democratic reform" in Tibet during the second five-year plan period (1958–62) did not bring about the desired pacification for the Tibetans love their own nay of life and resent any outside interference. The crisis came to a head in March 1959 with a mass revolt against the Chinese occupation forces. This was ruthlessly crushed and culminated in the flight of the dalai lama to India.

PHYSICAL GEOGRAPHY

Geology. — The Tibetan plateau was an ingression area of the Mesozoic and the Cenozoic eras and is geologically very young. Millions of years ago there were no mountains and the whole area was a huge sea. The Himalayas, the world's highest mountain mass. were uplifted in the course of ages and are still growing. The horizontal strata of conglomerate rock is composed of pebbles, pressured together through time, and limestone! containing marine fossils. The lakes in the Chang Thang area are the remnants of the ancient sea. This Cenomanian transgression did not extend to the Kunlun complex which is much older than the Himalayas. The Runlun is composed essentially of Devonian limestones and slates of the Paleozoic era while the metamorphosed limestones and quartzites of the Himalayan ranges were classified as Jurassic. It is probable that during the glacier periods the whole highland was covered with ice sheets. The Pleistocene deposits are enormously thick in many places, an estimated deposit of 3.000 ft. was formed in the upper Sutlej valley.

Physiography. — Tibet is on a high plateau surrounded by mountain masses. In Tibet proper, the mountain ranges run from northwest to southeast with deep or shallow valleys forming innumerable furrows between them. The lofty Himalayan chain sprawls along the entire southern frontier and shuts off the warm monsoon from the Indian ocean.

The great Himalayas extend over 1,500 mi.. and to their north, four other ranges stretch across Tibet: the Ladakh, the Kailas range (*q.v.*) or Trans-Himalaya (in Chinese Kang-ti-szu Shan), the Rarakorum .range (*q.v.*), and the Kunlun (*q.v.*) or Kuen-lun. The highest point of the Ladakh range is Gurla Mandhata (25,354 ft.), 12 mi. S. of Lake Manasarowar. North of Manasarowar the Kailas range contains a crowded cluster of peaks. several of mhich exceed 20.000 ft. The Kunlun range, extending from longitude 77° to 93° E.. forms the northern border of the Tibetan protuberance (see also HIMALAYA).

In eastern Tibet the mountain ranges transverse from north to south. The meridional chains for many years steadfastly resisted the penetration of Chinese culture into Tihet, but they permitted the beneficial moist air to flow northward along the river beds of the Yangtze, Mekong and Salween, into the deep ravines and broad valleys cloaked with vegetation and extensive forests.

Most of the large rivers of Asia rise in the Tibetan highlands. The Yangtze has its uppermost source south of the Wu-lan-wu-la (Ulan Ula) range. The Mekong and the Yellow river rise on the eastern fringe of the Thanglha Ri (Dangla range). The Salween rises north of Lhasa near Ngachuka. The Irrawaddy has its origin near the eastern tip of the Kailas range. The Indus. Sutlej and Brahmaputra all rise in the deep valley south of the Kailas complex near Lake Manasarowar. The Brahmaputra (Tsangpo) is the longest river inside of Tibet and flows for 800 mi. before entering India. Many tributaries swell its stream in its course: Kyi Chhu and Giamda from the north, Nyang Chhu from the south and Yigrong and Nagong from the east.

Between the Kailas and the Kunlun ranges is Chang Thang. an extensive lake basin. studded with innumerable lakes. The lake region covers two-thirds of the territory of Tibet, but three of the largest lakes of geographic Tibet, Koko Nor, Manasarowar and Yarndrog Tsho, lie outside of the lake basin. (See also articles on the individual rivers and lakes.)

Climate. — The precipitation in Tibet decreases from south to north. because of the increasing distance from the ocean. The Himalayas capture most of the rainfall of the summer monsoon and on the southern slopes it often reaches 200 in. annually. A little rain may get through the mountain passes, but is deposited on the Kailas range, beyond which is a region of extremely arid climate. The total fall of rain and snow over most of Tibet is under eight inches per year. The temperatures are low, as befitting the high altitude. Climate is generally rigorous. Its severity is much aggravated by the winds which blow with gale force during the greater part of the year. The temperature varies considerably in 24 hours, a climatic condition that differs little throughout the year. It is always bitterly cold in the morning and evening and the temperature usually drops below zero. At noon it may rise to 100° F. and the sun is scorching. Only during three to four months in the year is the Tibetan highland free from frost, and snow may fall in summer. However, in the lower land (under 12,000 ft.), in river basins and in southeastern Tibet, the climate is mild and pleasant. The air is dry, and, in the absence of dust storms, the sky is eternally blue.

Vegetation. — In the expansive wind-swept, cold, dry, northern plain which comprises two-thirds of the area of Tibet proper, there are no trees. The average elevation is over 15.000 ft. In sharp contrast. the Sutlej river valley in Ngari district and the Chumbi valley (*q.v.*) in southeastern Tibet, have vast areas of profuse virgin forests. Trees found include giant conifers, varnish trees! spruce, fir! cypress, oak, walnut, maple and poplar. Cereals, mainly barley and buckwheat are grown in the river valleys between the Himalayas and the Kailas. In the woodlands many kinds of medicinal herbs are grown which are in demand in China and India. *Peimu* (*Fritillaria roylei*), acanthus, rhubarb, saffron (*Crocus sativus*) and calamus (*Acorus* calamus) are some of the popular drugs found in Tibet.

Animal Life. — Domestic animals, raised mainly in eastern Tibet include sheep. goats. yaks, horses and donkeys. The sheep provide the nomadic people of northern Tibet with skins for garments, and meat. milk and butter for food. The yak. a long-haired domesticated ox. is the typical draft animal and the chief means of conveyance for highland travel. It carries heavy loads (160 lb.) on bad roads. through steep passes and at high altitudes, but it cannot withstand the warmer climate and dense air of lower altitudes or be used for tilling land. Its meat and milk form the stable food of all Tibetans and its tail is highly valued in India. Herds of about 1,000 sheep and 200 yak are not uncommon.

The horse of eastern Tibet once famous for its small stature and stocky nimbleness, has degenerated in the 20th century, so much so, that the riding horses in Tibet now come from the steppes of Tsinghai province, China.

Among the wild animals' found in Tibet the following are the commonest: wild yak. wild horses or ass (*kyang*), snow leopard, lynx, brown or black bear. wild sheep (*yuan*), gazelle (gon), antelope (*cho*), marmot and deer. The musk deer (*q.v.*), a hornless species, is found abundantly in eastern Tibet. The musk sac is a gland or pouch under the skin of the male deer's abdomen. Musk is dark-purplish or brown in colour. is unctuous to touch and has a remarkable permanence and stability of colour. Its scent is most penetrating and persistent, hence its importance for making perfumes. It is exported to Europe via India and China.

The common birds of Tihet are swan, stock or heron, hawk, gull, fishing eagle, bar-headed goose, raven, chough lark. sparrow, woodpecker and pigeon. The Tibetan chicken has an elongated body. and at night it perches either on treetops or on roofs. Tibetan farmers raise poultry. but they eat only the eggs and not the meat. In eastern Tibet there are several rare and handsome varieties of pheasants.

GEOGRAPHIC REGIONS

The boundaries of Tibet were never clearly defined. The country is large and difficult of access Lying on the borders are tracts of no man's land. or the habitats of roving bands of primitive natives. Tibet is generally divided into five main regions: U (pronounced Wei), Tsang, Ngari. Chang Thang and Kham. U, meaning "the centre," is both the political and cultural centre of modern Tibet. U covers the valleys of Kyi Chhu and Yarlung, tno large tributaries of the Brahmaputra river. Both Lhasa and the ancient capital Yarlung are located in the U district. West of U is the Tsang district, of which Zhikatse (Shigatse) is the capital. North of Zhikatse is the self-contained religious-political centre of Trashi Lhdmpo. After the return of the panchen lama in 1952, his entourage, with Communist Chinese support, set up a semiautonomous political organization, Panchen Kanpo Lija committee. (See History and Government sections below.) Further west is Ngari, a sparsely populated highland nith snow-clad mountains and deep river canyons, where the nomads drive their flocks and herds from one valley slope to another seeking scanty pasturage. Chang Thang, the vast windsnept northern plain, is an inhospitable waste of frozen desert with few inhabitants. Of all the Tibetan regions. Kham. comprising eastern Tibet. is the most fertile and the most populated. Lower in elevation and heavier in rainfall the river gorges are covered nith extensive forests. The lower river basins are cultivated. The eastern boundary of Kham was long disputed. The Tibetans held that Kham should embrace the whole territory extending from Taichao (Giamda) on the west to K'ang-ting (Tatsienlu) on the east; precisely the same area nas designated by the Chinese government to form the province of Sikang As a result armed conflicts occurred frequently in the first three decades of the 20th century. In 1933 a temporary settlement was reached to demark the border line along the north-south course of the Yangtze river. This line now forms the eastern boundary of the so-called Tibetan Autonomous region. East of the line was Sikang province, which in 1956 was transformed into the Kantse Tibetan Autonomous chou and became a part of the Chinese Szechwan province. Kham is under military occupation administered by the People's Liberation committee of Chamdo area.

THE PEOPLE

Racial Characteristics. — The Tibetans belong to the Mongolian race and are closely related to the aborigines inhabiting the mountains in western China. There are also numerous similarities between the Tibetan language and that spoken by the Shan and Kuki (*qq.v.*) of northern Burma. The Tibetans are a homogeneous people with black hair: brown eyes and brown skin, and are sparsely scattered over an area from Ladakh in Kashmir to the northwest provinces of China. They divide themselves into three racial groups: Bodpo in central and western Tibet, Khampa in eastern Tibet and Xmdo in northwest China. There are no appreciable racial differences in the three groups, all uphold the Lamaist religion, and use the same language. The people in eastern Tibet may be slightly taller. The chief difference is in culture. The people in central Tibet look down on the Khampa as inferior in culture, while the Amdo have closer contact with elements of Chinese civilization. (See also MONGOLS.)

Language. — The Tibetans possess a language which was reduced to writing in the 7th century, about the same time the Mahayana form of Buddhism was introduced into the country. The Tibetan alphabet is based on the Sanskrit alphabet in use in Rashmir at that time. The Tibetan language is a singularly refined language. There is a honorific and nonhonorific word for each expression. Sometimes there are three distinctions the most honorific used in addressing the high priests and the nobility, the less honorific to equals and nonhonorific to inferiors. Hence for a learned person there are three sets of vocabularies. The ability in employing the correct expression is a measure of one's standard of culture. (See also TIBETAN LANGUAGE.)

Social Organization. — There are three main classes of people in Tibet: nomads, farmers and townsfolk. The country is too high for ordinary agriculture; even pasturage is too scanty to sustain animal husbandry on a large scale. Few towns have populations exceeding 5,000 and Tibetans are designated according to the following occupations: clergy (lamas), nobility, traders, herders and peasants.

Lamas. — Prior to Communist Chinese domination it was estimated that about 20% of the population belonged to the clerical order. The priests of the Yellow Hat sect observed celibacy. Theoretically, the doors of the monasteries were open to all and no age limit and no academic qualifications were set for entrance. Sons of the rich and of the poor, sons of the nobles and of the commoners were all admitted on an equal basis. However, monks from the upper classes had better chances for advancement within the church, because their wealth allowed them to pay fees and buy exemptions.

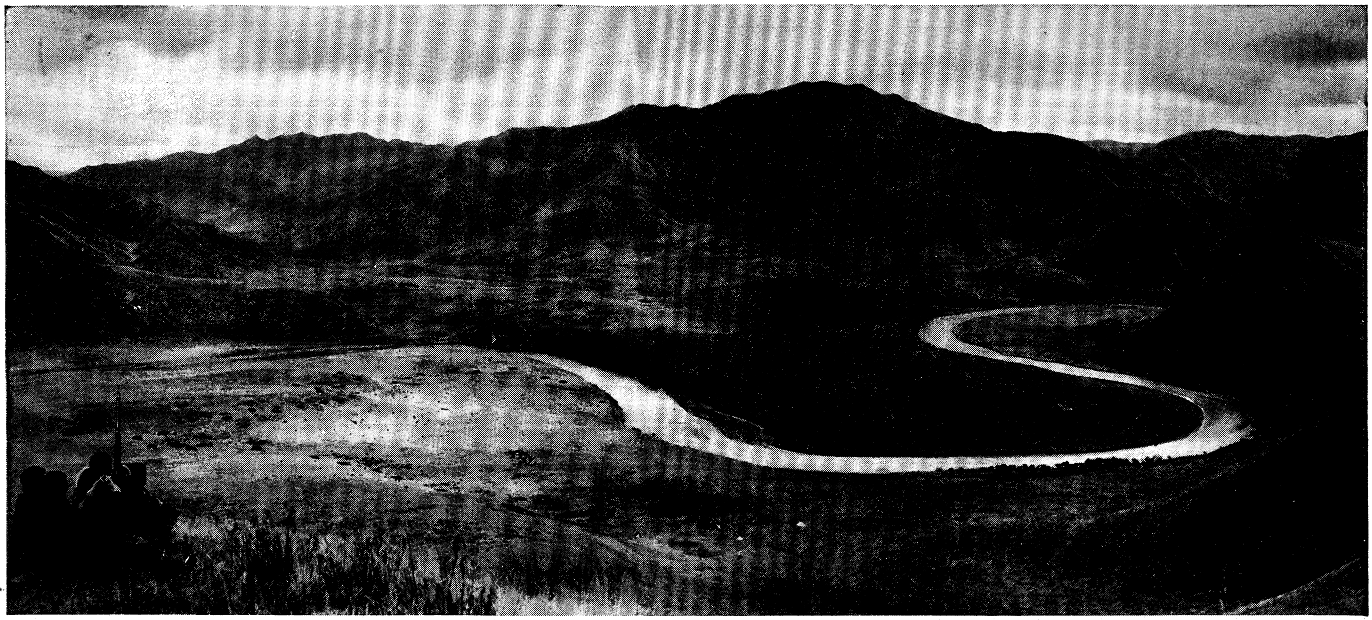
In Tibet there were no public schools; the monasteries were the only seats of learning. These were well organized and efficiently administered, and offered planned curriculums for student lamas. After completing a 16-year course a graduate was given the coveted title *geshi*. **A** geshi was respected all over the country and was qualified to serve in the government or on the administrative board of the monasteries. Not all the enrolled lamas intended to acquire a serious education and many came for vocational training as calligraphers, printers, painters and craftsmen. A large number specialized in performing rituals for the sick or engaged in farming, Groups were also trained as warrior-lamas and wore long hair, special uniforms and took vigorous physical exercises daily. They guarded the monasteries, enforced discipline, maintained public order during the new year festivals, acted as bodyguards to high lamas while traveling and at the order of the abbot, would take up arms against another monastery, against any private person, against foreign invaders or even against the government. Thus in one sense they formed a sort of national or home guard.

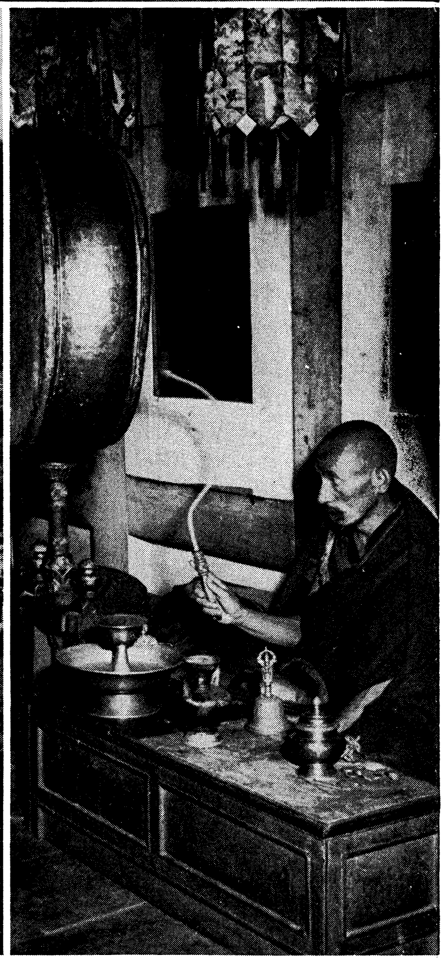
Monasteries obtained endowments from both the government and private persons. Government endowments may have included subsidies in kind, fund, real estate and even magistrate's districts. Private endowments included alms and donations in money and kind from members of the congregation or from outsiders. To this must be added interest and dividends on usury and trading, in nhich all monasteries freely engaged. The three large monasteries of Drepung. Sera and Gaden (Ganden) owned sizable real estate, and enjoyed considerable autonomy.

The highest lamas were the "incarnations," of whom there were more than 100, including the dalai lama and the panchen lama. A unique phenomenon in lamadom was the female incarnation of Pan-Dan Lha-Mo, the patron goddess of the dalai lama, at the famed Samding monastery, on a beautiful lake about two days' journey east of Gyangtse. (See LAMAISM.)

Nobility.—There were about 150 noble families. The Tibetan nobleman traced his descent to one of three sources. The first could be from an ancestor who was ennobled for service to the country. The founder of the Pa lha family, for example, was a former Bhutanese priest of the 17th century whose work in the service of the Lhasa government nas rewarded by the gift of an estate near Gyangtse containing 130 farms. The second, from the family in which a dalai lama or a panchen lama took rebirth, which however lowly was ennobled and received large estates from the government. Some of the leading Lhasa nobles were descended from brothers of the previous dalai lamas. The third class of the aristocracy was the oldest and smallest of all. Its members traced their lineage to the early monarchs who ruled Tibet before the 10th century. However. a rich commoner could apply for and be granted a nobleman's estate for which there was no issue.

Traders — Petty trading was a side occupation of many people, and professional traders were few. Commercial transactions requiring long journeys mere carried on by the men. while the women managed the shops and small retail trade. Nobles and monks alike engaged in trade. The large monasteries traded nidely and had administrative departments in charge of trade. Chinese, Indians, Nepalese and Kashmiris also played a part in the commercial ac-



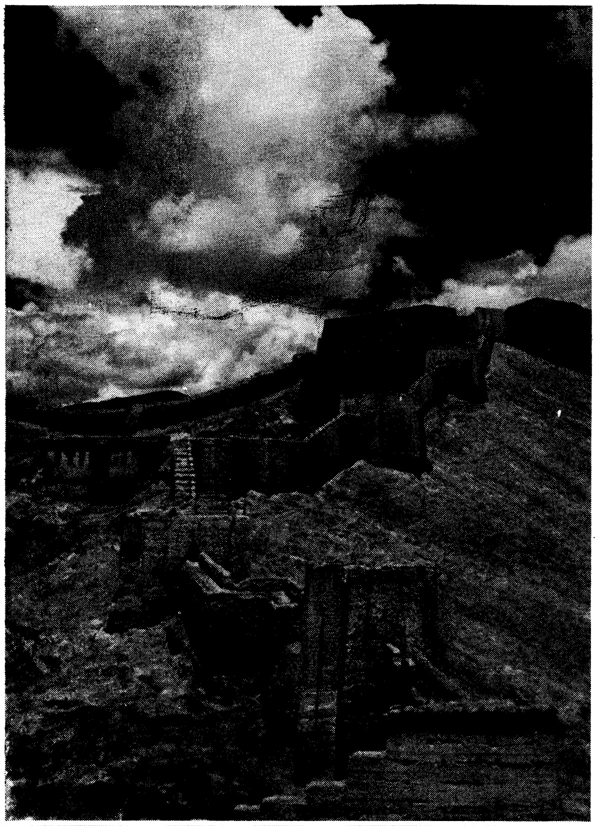


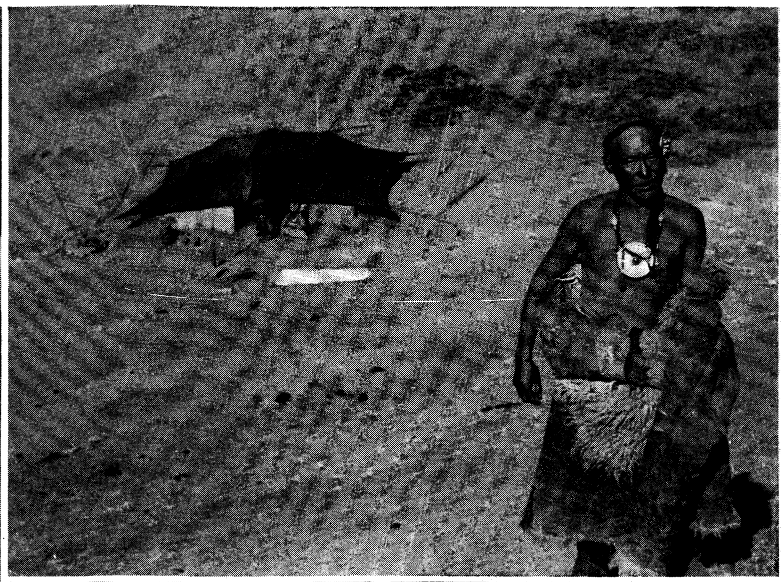
PHOTOGRAPHS, (TOP) CARTER D. HOLTON, (BOTTOM LEFT) EASTFOTO, (BOTTOM RIGHT) LOWELL THOMAS, JR.

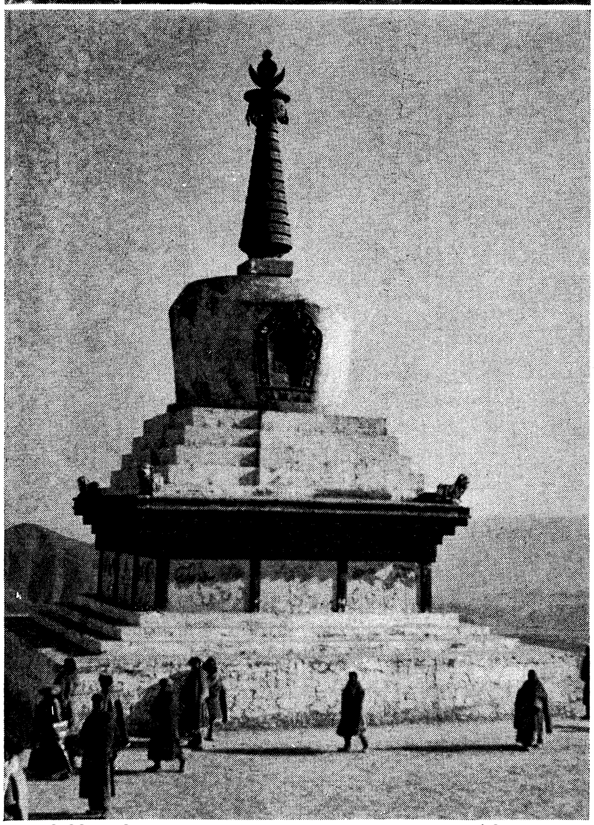
VIEWS OF TIBET

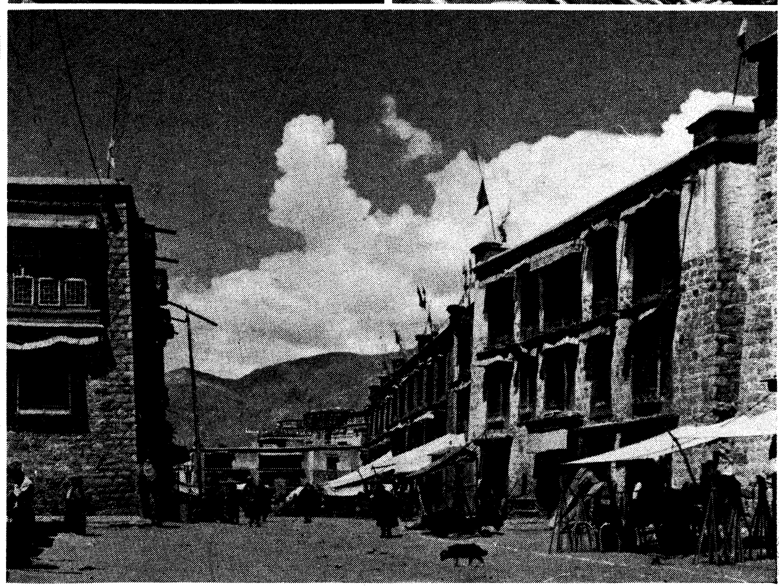
Top: Nomad country of northeastern Tibet showing shepherds and their herds encamped on both banks of the T'ao, a tributary of the Yellow river. Most grazing land in Tibet is at an altitude of more than 14,000 ft. Bottom *left:* Lhasa, the capital. The Potala, palace of the daiai lama constructed in the 17th century, is located on the hill overlooking the city *Bottom* right: Monk beating drum while praying within the Potala. He also sounds the cymbals and rings the bell

TIBET









PHOTOGRAPHS, (TOP LEFT) FOSCO MARAINI FROM MONKMEYER, (TOP RIGHT, BOTTOM LEFT) CARTER D. HOLTON, (CENTRE LEFT) HARRISON FORMAN, (CENTRE RIGHT, BOTTOM RIGHT) LOWELL THOMAS, JR

SCENES IN TIBET

Top left: Wall around Gyantse, an important trading centre about 145 mi. from Lhasa

Top right: Nomad herdsman standing near his tent. Such tents are made of woven yak hair and are from 12 to 50 ft. long. The slit-like opening in the roof is for smoke to escape

Centre left: Northern Tibetans. The woman has 108 braids in her hair, symbolic of the 108 volumes of *Kanjur,* the scriptures of Lamaism

Centre right: Artist working on a thang-Ka, or religious picture, of the Buddha

Bottom left: Chorten (shrine) at the monastery of Pientu. Believers walk around the chorten to absolve themselves or to obtain special blessings

Bottom right: View down a street in Lhasa tivities in Tibet. The most profitable items of trade, tea, wool, gold and rice, were controlled by the Tibetan government, now a monopoly of the State Trading company of Communist China.

Herdsmen.—The nomadic herdsmen and shepherds were hardy and independent, and pastured their flocks mainly in the uplands at altitudes of more than 14,000 ft.. mainly in the high wilderness of northwestern Tibet. Some pastoral groups practised seasonal migration; during the winter they stayed in the lowland and in the summer grazed their animals on mountain slopes.

Peasants. — The peasants inhabited mainly the south and southeast. Women. in addition to their domestic duties, laboured in the fields with their menfolk. Some peasants worked as tenants for the government, monasteries, high lamas or noblemen. and the land was granted to them as family allotments in return for which they paid taxes and labour service. Some worked as drafted or hired labour, and the land was directly managed by the government, the monasteries or the nobility. Only a very small number owned and worked plots of land.

Religion. — In Tibet everything began and ended with religion. It is said the Tibetans would not die for their country, but they would die for their religion. The early animistic religion of Tibet was Bon-po (Bon or Pon) a shamanism (*q.v.*) or nature worship. Buddhism was first introduced into Tibet in the 7th century, at a time when Buddhism had already degenerated. A corrupt form of Buddhism. known as tantrism, with emphasis on magic and exorcism was prevalent in India. For several centuries there mas a fierce struggle between the Bon-po religion and Buddhism and the two faiths eventually compromised. Bon-po followers accepted the principal Buddhist tenets and even claimed Buddha as one of their own divinities, while into Buddhism were incorporated many of the hideous Bon-po deities and rituals. The devil dance which was performed in every Buddhist temple during the year's end for the purpose of expelling the evil spirits. was borrowed from Bon-poism, and also the common practice of offering stones and hanging festoon flags over sacred spots. Tibetan Buddhism is commonly referred to as Lamaism by westerners, a term neither used nor resented by Tibetans who always regarded their religion as unadulterated Buddhism, and lama was their venerable appellation for a high priest.

By the mid-11th century. Buddhism gained complete ascendancy in Tibet. new monasteries sprang up everywhere. Remnants of the Bon religion still exist among the herdsmen in Chang Thang, and the aborigines of Kongpo and the eastern Himalaya regions. In the 13th century Lamaism spread to Mongolia. The high priest of Sakya Gompa monastery converted Kublai Khan to Lamaism, who, after he became the emperor of China, made the Sakya Gompa hierarch the imperial preceptor and sovereign of central Tibet. This marked the beginning of theocracy in Tibet. With power, grew the moral decadence of the priesthood. The priests indulged in mundane pleasures. Different religious sects rivaled for power and moral codes became degraded.

In the 15th century there was a successful reformation movement led by Tsong-kha-pa, who advocated celibacy and abstention from intoxicants and other worldly pursuits. To distinguish him and his followers from those of older religious sects he wore a yellow hat. Hence the reformed sect was commonly known as the Yellow Hat sect and the older sects as the Red Hat sects. Tsong-kha-pa and two of his disciples founded the three large monasteries Drepung, Sera and Ganden, in Lhasa. His youngest disciple, Gentun Drupa, founded the Trashi Lhiimpo monastery at Zhikatse. Gentun Drupa was the first of the dalai lama incarnations. (See TIBETAN BUDDHISM and also History below; for Tibetan religious art see TIBETAN ART.)

Customs. — Shut off from the rest of the world for centuries by insurmountable mountains and tremendous gorges, the Tibetans developed peculiar customs and habits. They formed a small world of their own and fairly successfully resisted the penetration of outside influence until 1950 when the Chinese People's Liberation army began its drive on Tibet.

Dwellings. — 'The finest dwellings in Tibet were the mansions of the nobility. With the exception of a few minor nobles who lived in Zhikatse and Sakya Gompa, all the noble families maintained town houses in Lhasa which were built of stone around a rectangular courtyard. On three sides of the courtyard were stables and storehouses; on the fourth side. opposite the gate was the mansion itself, generally three stories high. The family quarters and chapel were located on the third floor where the rooms, unlike those, below which were dark and ill-ventilated, may have had glass windows and doors. The walls and the ceiling were painted with pictures and auspicious designs.

The common people lived in one or two story buildings. The roof was flat and made of clay like the earthern floor, but unpolished. Windows were plentiful but glass was rare. Instead the windows were covered by wax paper or other similar material, protected by strong wooden shutters. The houses of the village peasants were, as a rule, solid and substantial. There. too. the walls were of stone or sun-dried bricks, though occasionally of clods of earth. 'Flat roofs of beaten earth were usually used throughout the Tibetan interior. but in the Chumbi valley and other rainy districts the roofs were gently sloped. Where pine trees grew, the roofs were constructed of pine shingles, kept in position by heavy stones. The herdsmen dwelled in tents of yak hair, rectangular in shape and ranging from 12 to 50 ft. in length. An aperture about 2 ft. in width along the middle of the roof let out the smoke.

Food and Drink. — The staple diet of the ordinary Tibetan is yak's meat. mutton, barley flour. cheese and tea. Tibetans eat neither chicken nor fish. Those who dwell in the lower altitudes, also eat rice. fruit and vegetables in small quantities.

The main beverage is tea. Brick tea from China is used, and is boiled in water flavoured with soda ash. When thoroughly boiled, the mixture is taken but with a ladle and poured through a strainer into a churn. Butter and salt are added and the whole churned until it is well mixed. The consumption of this beverage among Tibetans is enormous. for they drink on an average from 30 to 50 cups of tea a day. The other chief beverage is beer. It is brewed from barley and is only mildly intoxicating.

Dress. — The Tibetan dress consists of a very full gown with a high collar and long sleeves. The summer gown is usually of ordinary Tibetan cloth, but the wealthier classes may wear silk. The winter gown is sometimes of sheepskin, sometimes of cloth lined with lambskin or wadded cotton. Tied tightly around the waist with a woolen or cotton band, it is puffed out above. and in the capacious pocket thus formed are carried drinking cups and other odds and ends. For laymen the robe reaches to the knee, for priests and women to the ankle. In central Tibet and in parts of eastern Tibet the women wear aprons, woven in varied colours and often so broad that they nearly meet at the back. Shirts are of cotton or silk; trousers differ greatly in shape from the western pattern and are of silk or cloth. The boot is of cloth, felt or leather. and of various colours. It rises to the kneecap, with a slit behind the knee. and is tied with gay-coloured woolen garters three or four feet long. Men's hats are of various Binds. It is only in a few districts that men wear necklaces. Earrings are very common and, among the official classes! universal.

The women of Tibet, especially those who rank among the upper classes, display their headdress made of pearls, turquoise and coral on a wooden frame. Herdswomen plait their hair into many tiny queques which are then bundled into a big one below the nape of the neck and adorned artistically with red and yellow stones. Some women drape over their hair a large cloth sewn with silver and brass coins and shells mhich jingle at every step they take. They are physically strong and perform heavy manual tasks. When not tanned by exposure to the elements, they are often fair, and those of the upper classes take great care of their complexions. Throughout Tibet it is a general custom for women to smear caoutchouc on their faces. Rough pads of felt, soaked in a red colouring matter, are also used. In addition to the headdress, numerous ornaments are worn including rings, earrings. necklaces and girdles. The women wear charm boxes on the chest immediately below the throat. These usually contain a small image of a deity and a talisman written for the wearer by a lama.

Family Organization. — Tibetan women, after marriage, held a comparatively high family status, but in religious affairs their position was lower. For instance, of the three forms of blessing accorded by the dalai lama to different suppliants (touching the head with both his hands, with one hand or merely with a tassel) the last and lowest form was the one used for all women. Although the Tibetan woman enjoyed a great measure of independence, she usually had little or no share in the choice of her husband. A son was consulted by his father as to the bride proposed for him, but the parents rarely consulted a daughter.

Priests of the Red Hat sect were permitted to marry. Their wives were in charge of the lama's belongings, leaving their husbands free to devote themselves to religion.

Monogamy, pologamy and polyandry were all common in Tibet. Polyandry was the predominant form of marriage. The husbands were generally brothers, sometimes partners of a business. When a woman married the elder brother she married all the younger brothers as they became of age. A more unusual case was that of a widowed father and a grown-up son marrying the same woman. The preservation of the family estate seemed to underlie the marital oddities, for it was always the woman who controlled the family finance.

The aristocracy could only marry in their own class and this rule mas strictly applied. Relatives did not intermarry as inbreeding was avoided. Divorces were rare and had to be approved by the Tibetan government.

Calendar.—The Tibetan calendar is basically the lunar calendar in use in oriental countries for thousands of years. In the calendar certain days are marked as auspicious and certain others as inauspicious. The Tibetans consider the days of the full moon and the new moon and the days lying in between as particularly auspicious. To keep away from possible bad luck on ominous days they strike off these days in the calendar. And to make up the loss they duplicate the lucky days. So if Jan. 10 is a lucky day, two Jan. 10 days may be found in succession; while if Jan. 14 is an evil-portending date, that day may not be shown at all. The years are marked by matching the five elements against the 12 zodiacal signs (*e.g.*, 1953 was a Wood-Tiger year and 1958 a Fire-Dog year), making one complete cycle every 60 years.

Festivals.—The Tibetan year was marked by numerous saints' days and festivals in which both lamas and laity took part. In addition to the great national holidays, each locality had its own particular auspicious days on which the tutelary deities were worshiped and local religious ceremonies were performed. The 8th, the 10th; the 25th and 30th days of each month were considered especially auspicious, also the days of the full moon and the new moon. On these last two days the people made their way to the local monastery, clad in gala robes and carrying offerings of flowers. incense and money. Butter was also presented for the sacred lamps on the altar. The presentation of offerings to the gods is followed by prostration before the altar and the performance of devotions. Birthdays are unimportant dates in Tibet; they are generally not known and never celebrated.

The most important yearly event was the New Year or the Great Prayer festival at Lhasa. Commencing on New Tear's Eve, which usually falls sometime in February according to the Tibetan-Chinese lunar calendar the ceremony and celebrations lasted the greater part of a month. First, houses and doorways were decorated with juniper boughs; puddings were prepared and a stock of wine laid in. The people passed the time in eating, drinking, dancing, singing and all kinds of merrymaking, combined with prayer when they felt so inclined. On the morning of the third day began the Great Prayer festival (*Monlam Chempo*).

From the dawn of the new year, monks from the neighbouring monasteries began to pour into Lhasa. By noon, thousands of priests had assembled. The next ten days were occupied by religious services, held thrice daily in the Great Temple of Lhasa. The festival of lights was performed on the 15th day of this month. All the local monasteries and larger houses in the district were illuminated with thousands of small butter lamps. The 20th day marked the commencement of sports, and one of the most important events was horse racing.

During each year's prayer festival, the civil authority of Lhasa was turned over to two proctors of the Drepung monastery. After an impressive installation ceremony at the public square, the proctors appointed their o n staff and policemen whose principal duties were to maintain order, for, during the festival, thousands of lamas roamed the streets and affrays among themselves and with the civilians were common. But the lama magistrates also collected business taxes and inspected private abodes. Heavy fines were imposed for uncleanness and disorderly conduct. Invariably the proctors derived a sizable fortune from the fines during the Great Prayer festival which lasted 21 days. It provided also an opportunity for financial gain for the other lamas because three services were held daily during this period and after services alms were doled out to the congregation by rich patrons.

The daily services during the Great Prayer festival were conducted by the chief abbot of the Ganden monastery who is considered the successor of Tsong-kha-pa. On the 15th day the dalai lama conducted a sermon himself and bestowed benedictions to the multitude.

HISTORY

Prior to the 7th century A.D. Tibetan history is wrapped in myth and legend. According to the orthodox tradition. the forefathers of the Tibetan people were a monkey and an ogress. However another story relates that in the very beginning the void gave birth to a most wonderful egg. When it burst open five months later, space, heat, fire, oceans and mountains issued from it; and from its very interior came forth man.

Tibetan histories usually refer to the division of the Tibetan people into four or six tribes or clans. The most ancient accounts give Shipuye or Pugye as the first king of Tibet, but the later Buddhist chronicle of central Tibet depicts Tibetan royal genealogy as commencing with Nyakhri Tsanpo, the son of an Indian king whose name varies in the different texts. After the first king, five groups of kings are: seven heavenly **Khri** ("thrones"); two upper Teng ("high ones"); six middle Legs ("good ones"); eight earthly De ("worldly"); four lower Tsan ("mighty"). With some slight difference, this system is essentially the same in all the chronicles. During the time of Shipuye, the principal metals mere discovered, agriculture and irrigation were introduced, the great castle of Yarlung was built and the Bon-po religion arose. After the mythical series of kings, Namri Sontsan appears as the first historically identified ruler. He conducted expeditions to western China, northern India, Nepal and even faraway Persia.

Early *Kings.*— In the 7th century Tibet was not a unitary state. Independent chieftans continued to maintain a great deal of power and constituted a strong and warlike nobility that furnished many generals and ministers to the state. In their turbulence, they often revolted against the royal authority. Kivalry between individual chiefs was very common and the struggle was mainly within the state for predominance in the government. The principal offices in the court were hereditary. The nobility, who held landed property, constituted the real power outside the court. Songtsen Gampo (620–649) and Khrisong Detsen (755–797) are two famous kings. The former is credited with the invention of Tibetan writing and the introduction of Buddhism. The most important personalities under his reign were Thonmi Sambhota, his envoy to India, and Gardon Tsan (d. 667), his capable minister. Tibetans came into contact with Chinese, Nepalese, Turks and the people of Khotan and Kucha, and a little later with the Arabs. The petty kingdom of Namri Sontsan grew in less than a century to be a major central Asian power. During the reign of Khrisong Detsen. Tibetan power reached its peak and Buddhism was affirmed as the chief religion of the state. Padmasambhava, a famous tantric teacher. came to Tibet from Kashmir; the monastery of Samye was built in 762–66; and the first seven monks ordained. Under this king. Tibet gained prominence by military victories in its old struggle with the T'ang empire in China.

A third famous king, Ralpachan (815–838), was the most fervent Buddhist who ever rose to the throne in Tibet. The peaceful nature of the king manifested itself in a lull in military activity. In his zeal for Buddhism, the king gradually removed the aristocracy from positions in the court and filled their places with Buddhist monks. A real persecution of the old Bon-po religion seemed inevitable. All this contributed to a growing tension that ultimately burst into revolution. In 838 a conspiracy was formed and the king was assassinated by two noblemen of the families of Sbas and Cog ro. The conspirators placed on the throne the elder brother of the murdered king. Lang Darma, a Bon-poist. Buddhist temples were closed and destroyed, and monks were forced to break their vows or flee. In 842 Lang Darma was murdered by a monk, but his persecution had inflicted a heavy blow on Buddhism.

Religious Renaissance. — The old kingdom of Songtsen Gampo dissolved into a great number of petty local chieftaincies. The descendants of Lang Darma succeeded in founding a strong state in the west (Guge, Ladakh). but they could not exercise any effective power in central Tibet. During this period the Bon-po followers resorted to plagiarism, appropriating many Buddhist books, which they claimed to have dug out from places where their ancient masters had hidden them. This removed many fundamental differences between the two religions and compromised the position of Bon-po. This animistic religion borrowed so freely from the abundant tenets of Buddhism that it eventually lost its own characteristics and became absorbed into its rival.

At this time the kings of Guge sent groups of young students to India to rejuvenate Tibetan Buddhism and specifically to clear up certain doubts in the teachings of the occultist school. The most notable of these was Rinchen Zampo (958–1055), who with his associates and pupils translated many Buddhist texts on Vajrayana. The greatest event took place in 1032 when the great Bengali teacher Atisa (982–1054) was invited to Guge by its king. Atisa carried his evangelistic work far from the monastery Thoding, then the cultural centre of Guge, to central Tibet, including such places as Samye, Lhasa and Nye thang. During this period the Buddhists, like the Bon-po followers before them, now claimed to have rediscovered many buried texts (*terma*). This new wave of translation and reintroduction of Buddhist texts gave rise to later schools rivaling the old school (Nyingmapa). The old school recognized Padmasambhava as its earthly master. The newer school, Kadampa, returned to Atisa and Rinchen Zampo; another new school. Kagyurpa. claimed descent from Tilopa, Naropa. Marpa (1012–96) and Milaraspa (1041–1123); yet another new school. Sakyapa. claimed the Indic Siddha, Virupa, as its first master. 'Brog mi (992–?), a famous translator, belonged to this school.

Relations With the Mongols. — In the 13th century Tibet was still divided between an uncertain number of chiefs. religious leaders and laymen who ruled by right of succession or of election over different territories. In 1239, during the time of Godan, Ogadai's second son, Mongol troops were sent to attack Tibet. In this perilous moment the Tibetans turned to Sapan (1182–1251), the abbot of Sakya Gompa monastery. who seemed to possess the greatest authority and influence in the whole country, and empowered him to deal with Godan.

Sapan's nephew, Phaspa (1235–80), was not only a Buddhist saint but a remarkable genius. While still in his teens, he so much impressed Kublai Khan (1260–94). who had conquered the eastern part of Tibet and was soon to become emperor of China, that he was requested by Kublai Khan to initiate him into Lamaism and was thus acclaimed the imperial preceptor. Phaspa also won a debate before the emperor over the Nestorians, Mohammedans and the Taoist theologians of China. The emperor Kublai Khan made Lamaism the national religion of his empire. At the age of 31, Phaspa was ordered to invent a writing system for the Mongols. He accomplished this task within five years, basing it on the Tibetan alphabet. But his composition did not prove satisfactory and it disappeared in less than a century without having been very widely used.

The Mongols made the Sakya Pandit the ruler of central Tibet, and Lamaism the national religion of China. However, the Mongol rule in China was short-lived. The power of the Sakya hierarchy declined with the downfall of the Mongols and Tibet soon fell a prey to anarchy. The nobility, taking advantage of such disorder, often took arms to claim rights or avenge injuries. In these chaotic times, several rival religious sects emerged.

Toward the end of the 14th century, a great religious reformation movement was gathering momentum in Tibet. Tsong-kha-pa was born about 1357 at Tsongka near Sining and came to central Tibet in his early teens; after a mixed education in the existing monasteries, he founded the Yellow Hat sect (Ge-lug-pa), and instituted a stricter code of morals. In 1409 he built the Ganden monastery.

Two of his renowned disciples were Gyethub (1364–1432) and Khedru (1385–1438); both were prolific writers. Other outstanding members of the Yellow Hat sect were Jamyang Chorje who in 1417 founded the monastery of Drepung, and Gyamchen Chorje who in 1418 founded the monastery of Sera. In 1447, Gentun Drupa, Tsong-kha-pa's youngest disciple, founded the Trashi Lhiimpo monastery at Zhikatse. Gentun Drupa died in 1474, but his spirit was believed to have entered the body of a baby born two years later. This child became his successor; and thus began the system of priestly incarnation which was of tremendous significance in later Tibetan history.

All through this period the fortunes of the various noble families and different sects of Tibetan Buddhism were intricately related. The Phamo Drupa family allied itself with the Drikunpa sect. rose against the Sakya hierarchy, won recognition from the Chinese emperor and took control of all central Tibet. Internal dissension in the 15th century broke its position and the power of the Phamo Drupa family devolved upon one of its subordinates. The succeeding family. Rinpung. seized Zhikatse in 1436 and gradually occupied the whole of Tsang. They in turn were replaced in 1556 by one of their subordinates. who had also started his conquest of Tsang from Zhikatse and who became the ancestor of the so-called Tsangpa kings. The latter remained in power until 1642. Both Rinpungs and Tsangpa kings were patrons of the Red Hat sect. Karmapa. During this period Tibet was torn by wars. Monasteries gradually succeeded in taking the upper hand, guiding the political life of Tibet. Landed property confiscated or seized when someone died without legitimate or recognized heirs passed into the hands of the monasteries. The centre of the struggle for power involved the Red Hat sect, supported by the rulers of Tsang, and the rising Yellow Hat sect which opposed the Karmapa's corrupt formalism.

In 1566 the Ordos Mongols attacked Tibet and some captured lamas were taken to their chief, Altan Khan, who was attracted to the form of Buddhism preached by the Yellow Hat sect. and who subsequently sent a mission to Lhasa. In 1577, upon the invitation of Altan Khan, Sonam Gyatso. one of the incarnations at the Drepung monastery and third of the dalai series, visited Mongolia, converted the Mongolian chief to the Ge-lug-pa faith, and received in return the title. Vajradhara dalai lama ("holder of the thunderbolt," "ocean lama"). This marked the first time the incarnation came to bear the name dalai, a Mongolian translation of Gyatso, "the ocean." Altan Khan died in 1582 and at the earnest request of the khan's son, Sonam Gyatso, the 3rd dalai lama. visited Mongolia a second time. He died while on a journey to China.

After the death of the 3rd dalai lama in 1588 the grandson of the hlongolian Altan Khan was selected as the reincarnation. The high priest's rebirth in a princely family of Mongolia served above all to weld together still more firmly the relations between the Yellow Hat sect and its Mongolian patrons and to lead toward new developments. the alliance between the former and the power of Mongol arms. This young reincarnation traveled along the road outside of the Great Wall of China, stayed in Koko Nor for three months and then resumed his journey through the whole of Tibet. He won great popularity among Mongols and Tibetans alike.

At the beginning of the 17th century the chief of Tsang extended his power and occupied Lhasa. The 4th dalai lama, Yonten Gyatso (1588–1615), had to seek safe abode in Samye. It was through the insistence of the Yellow Hat sect that a Mongol army commanded by two of Kholoche's sons entered Tibet and induced the Tsang king to halt aggression. In 1621 the Mongol troops again descended on Tibet. The Tsang king was defeated and besieged in Lhasa. Yellow Hat sect leaders acted as peacemakers and retrieved most of the monasteries that were annexed to

Tsang's doininion as well as the monasteries that were obliged to change their sect by the domination of the Red Hat chaplains.

In 1638 Gushi Khan, the chief of the Oelet Mongols and upholder of the Yellow Hat sect: sent envoys to invite the 5th dalai lama, Kgag-Wang Lobsang Gyatso, but the invitation was not accepted. In 1641 the 5th dalai lama and his regent with Gushi Khan's help defeated the Tsangpa king. He moved from the Drepung monastery to the Potala, which he rebuilt on the ruins of a palace, formerly occupied by King Sontsan Jampo. The Yellow Hat sect then held complete spiritual sway and temporal power over the entire Tibetan nation. The 5th dalai lama died in 1682, but his regent Sanggye Gyatso, unwilling to desist from his task concealed the death and ruled in his master's name. He consolidated the Tibetan unification and finished the work of building Potala palace.

The 6th dalai lama, Tsangyang Gyatso, was a romantic young man, given to drinking, women and song. He incurred the displeasure of the commander of the Mongol forces, Latsang Khan, who. in 1705, disposed the dalai lama and replaced him with a candidate of his own choice. The deposed dalai lama died mysteriously. The interference of the khan was resented by all of the Yellow Hat sect, and representatives of the three monasteries of Lhasa went for help to the Junkars, another Mongolian tribe in Sinkiang. In 1716 the Junkars swept down through the vast northern plain. deieated the Latsang Khan, and sacked the monasteries. This caused direct intervention by the Manchu empire.

Domination by the Manchu Empire. — Tibetan relations with the Manchus were established while the Manchu kingdom was still a dependency of the Ming empire. The western Rlongols were instrumental in bringing about this relationship. In 1612 and 1644 the 5th dalai lama twice sent overtures to Mukden. In 1646 when informed of Manchu's success in China he sent a letter pledging allegiance. In 1651 the Manchu court sent an official invitation to the 5th dalai lama and to the panchen lama. Lozang Chorgyen (1569–1662). The latter, taking his advanced age as an excuse, declined, but the 5th dalai lama started for China in 1652 and won official recognition. In 1713 the emperor K'ang Hsi extended his patronage to the panchen lama, Lozang Yeshi (1663–1737), proclaiming him panchen ratna (in Tibetan, panchen erdeni, meaning "great pandit, the gem").

The Junkar's invasion caused prompt reaction on the part of the Chinese emperor. In 1717 K'ang Hsi sent a small relief army which was trapped by the Mongols near Nam Tsho and was annihilated. In 1718 the emperor, now acting against his counsellors' advice; sent a new army from Koko Nor and another from Szechwan. In 1720, having wiped out all the Junkars in Tibet. he put on the throne in the Potala, a boy incarnation from Litang as the 7th dalai lama (1708–57).

In 1726 the emperor Yung Chêng dispatched a civil officer to Tibet to arbitrate a dispute among the Mongolian generals. This marked the beginning of the appointment of the ambans (resident ministers). In 1750 the ambans killed the Tibetan regent. The people in their turn massacred the Chinese in Lhasa. The emperor Ch'ien Lung dispatched an army, restored Chinese authority and strengthened the power of the ambans.

In 1788 the Gurkhas, who had recently gained ascendancy throughout Nepal, occupied some Tibetan districts near the Nepalese frontier. Three years later they pillaged Zhikatse. The Manchu government dispatched an army, composed partly of Chinese and partly of Tibetans, under Manchu leadership. This army marched through Tibet during the bitterly cold winter, defeated the Gurkhas decisively during the spring of 1792 and dictated peace terms within a short distance of Kathmandu. the Gurkhas' capital. Suspecting also that the British, who were by then established in India. had helped the Gurkhas, the Chinese closed Tibet as far as possible to foreign influence. It was decreed that all foreign questions should be dealt with by the ambans, not by the Tibetan government.

In 1855 another Gurkha invasion occurred, and this was more successful. The resulting treaty empon-ered the Gurkhas to establish an agency in Lhasa and other centres. gave them an annual subsidy of 10,000 rupees and extraterritorial rights. In return the Gurkha government undertook to aid Tibet if the latter were attacked by another nation.

At the time of the Younghusband mission (see below). when British troops entered Tibet, the 13th dalai lama (1876–1933) fled to Urga (Ulan Bator) Mongolia, where he remained until 1907. In November of that year he arrived at Koko Kor on his way back to Tibet; he was invited to Peking by the Manchu emperor and arrived on Sept. 28, 1908; after a brief sojourn returned to Lhasa in Dec. 1909. During the period of the dalai lama's exile, China, aroused by the British action, was taking measures to strengthen its hold upon eastern Tibet. In April 1905 a revolt broke out in Bathang (Ba-an), and the disorders spread through southwestern Szechwan and northwestern Yiinnan, where several monasteries were involved. Chao Erh-feng, viceroy of Szechwan, was appointed to subdue this rebellion. His drastic methods during the following four years temporarily brought order to eastern Tibet. In Jan. 1910 Chao with 2,000 troops marched into Lhasa. For a time his vigorous administration gave China effective control of Tibet. The dalai lama fled to India upon the arrival of the Chinese force and remained there about two years. In 1911, revolution broke out in China and Manchu rule was overthrown. The Chinese garrison in Lhasa after days of riots and looting, was forced to withdraw. The dalai lama returned to Lhasa in 1912.

Relations With the British. — British official relations began in 1774, when Warren Hastings was in charge of the British East India company. The dalai lama steadfastly refused to receive any British emissary, so Hastings approached the other pillar of Lamaism. He sent George Bogle to the panchen lama at Trashi Lhiimpo, but because of some opposition from the Nepalese, trade relations were not opened up as had been hoped. In 1783 a second mission. under Samuel Turner. was sent to the panchen lama and was able to obtain trading privileges for the Indians only.

When the Manchu empire became corrupt and tottering, it failed to give effective protection against the Gurkha invasion of Tibet in 1855 and looked on helplessly while its tributary states, Burma, Sikkim, Nepal and Bhutan were made dependents of Great Britain. In the spring of 1903, Lord Curzon, the viceroy of India, sent Col. Francis Younghusband with a small escort to Kampa Dzong, 15 mi. N. of the alleged frontier, to meet Tibetan and Chinese delegates in order to discuss the problems of boundary and trade, but they were unable to persuade the Tibetan government to undertake negotiations. At last, in Nov. 1903. Younghusband advanced to Gyantse. On Jan. 8, 1904, British forces on their way to Gyantse had reached Düna without encountering any armed resistance. On March 31, when they attempted to move beyond Diina, they were obstructed by Tibetans, and a bloody battle took place. After 16 engagements in which several thousand Tibetans lost their lives, the British reached Lhasa on Aug. 3. The dalai lama fled to Ulan Bator. The regent, national council and assembly entered into negotiations with the British which resulted in a convention between Tibet and Great Britain, and in a treaty signed on Sept. 7, 1904 to which China was not a party. The main terms were: (1) the opening of two new marts to foreign trade, one at Gyantse, and one at Gartok in western Tibet; (2) the abolition of trade duties between Tibet and India; and (3) Tibetan territory not to be ceded or leased to any foreign power. On Sept. 22, 1904, T'ang Shao-yi was sent to India by the Chinese government to negotiate with the British government in regard to Tibetan affairs. The resulting Anglo-Chinese treaty was signed on April 27, 1906. A year later, on Aug. 31, 1907, an Anglo-Russian convention was concluded. Under its terms Russia recognized the special British interests; the two powers agreed that neither would enter into negotiations with Tibet except through the Chinese government and that neither would send representatives to Lhasa. In Oct. 1913, a conference was held in Simla at which the Chinese republic, Tibet and Great Britain were represented. The convention provided for a division of Tibet for administration purposes into two sections. Inner and Outer Tibet. Inner Tibet was to be administered by China, while Outer Tibet was to be autonomous. But China repudiated the action of its commissioner and never signed this agreement. It was signed, however, by British and Tibetan representatives July 3, 1914.

Rivalry Between Dalai and **Panchen.**—The dalai lama with his private church, the triumvirate of Drepung, Sera and Ganden, the two esoteric academies of Gyeme and Gyuto and the oracle of Naichung. formed the nucleus of the Yellow Hat sect organization. Tibetans refer to them as the Seven Great Symbols. The panchen lama, with his Trashi Lhumpo monastery at Zhikatse, maintained a court and a separate organization exactly like those of the dalai lama but on a smaller scale. The panchen lama is considered an incarnation of Amitabha (Tibetan Erpame, "Buddha of the boundless light"), and the dalai lama an incarnation of Avalokitesvara (Tibetan Chenrezi, "the compassionate"). Theoretically, in the ranking of the living Buddhas, the former stood higher than the latter. But in fact the first panchen lama was originally only the teacher of the 5th dalai lama. who, out of gratitude to him. had declared him to be an incarnation and had conferred on him the Trashi Lhiimpo monastery with its enormous benefices. This monastery was founded by the first in the line of the dalai lamas.

During the intricate development of world politics in the 20th century, the dalai lama and the panchen lama became deeply involved. The panchen lama had for generations been supported by the Chinese as a rival to the dalai lama.

In 1904 the 9th panchen lama took the absence of the dalai lama from the country during the Younghusband mission as an opportunity to contest the leadership of Tibet. He courted the favour of the invaders by signing a truce with them at Gyangtse and later even visited Calcutta to solicit British support. But the British, who had succeeded in imposing a convention with the representatives of the dalai lama, preferred to deal with Lhasa.

Shortly after the return of the dalai lama to Lhasa in 1909, a sharp disagreement broke out over a proposal for a political reorganization between the Chinese and the dalai lama, who was forced to leave the country and took refuge in Darjeeling, India. The panchen lama this time curried the favour of the Chinese and for several months lived in the Potala, the dalai lama's palace. Following the revolution in China in 1910, the dalai lama was restored to power and retribution was immediately taken. The landed estate of the Trashi Lhumpo monastery was forced to pay taxes directly to Lhasa, thus depriving the panchen lama of his source of income. The dalai lama in trying to be independent of China resorted to British influence and signed a bilateral treaty with them at Simla in 1913. The situation grew to be very uncomfortable for the panchen lama who in 1924, fled to China with his retinue. In 1933 the 13th dalai lama died. Escorted by a strong Chinese contingent the 9th panchen lama planned to return to Tibet. but his health failed and he died enroute in 1937.

The 14th dalai lama was born in Tsinghai in 1935 and discovered in 1939. A year later in the province a boy reincarnation of the panchen lama was found by his followers. The Lhasa government announced shortly afterward that it had discovered two claimants of their own. The dispute prevented the Tsinghai incarnation from being installed in Trashi Lhumpo which was directly controlled by Lhasa. In the last days of the Chinese Nationalist government, the Tsinghai boy was officially installed as the 10th panchen ratna at the Kumbum monastery in Tsinghai. When the Chinese Communists came into power in 1949, the entourage of the new panchen swiftly pledged their allegiance to the new masters of China.

Chinese Military Occupation. — The independence of India on Aug. 15, 1947, and the Communist revolution in China during 1948–49 marked a new era in Tibetan history. In early 1950 the Communist army reached the bank of the Yangtze river, just east of the Tibetan frontier fortress of Chamdo. Then in mid-Oct. 1950, the Chinese Communist army advanced into Chamdo, about 370 mi. E. of Lhasa, where Tibetan troops accepted defeat. In December the regent resigned to give place to the 14th dalai lama. The Tibetan government moved to the southern border of Tibet. The first official act of the 16-year-old dalai lama after coming to power was to grant a general amnesty to all political prisoners in Tibet. At the same time he appointed the minister captured at Chamdo to head a mission to Peking, to be followed by another mission under his commander in chief. On May 23, 1951, a Chinese-Tibetan treaty was signed in Peking, the essence of which may be summarized under four points: (1) Tibet was to retain its autonomy, with no change in the dalai lama's political system or in his status, function and power: Tibetan religion, monastic institutions and customs n-ould be respected; (2) the old position that the panchen lama enjoyed in the time of friendly relations between the 13th dalai lama and the 9th panchen lama was to be restored; (3) the Chinese Communist government was to set up a military and administrative committee, with regional military headquarters in Tibet: the Tibetan army was to be reorganized and systematically absorbed into the Chinese Cominunist army; (1) Tibet's external relations were to be handled by the Chinese Communist government. On hug. 17, 1951, the dalai lama returned to Lhasa. the city from which he had fled on Dec. 19. 1950. By this time, three forces of the Chinese Communist army had entered Tibet simultaneously, one from Chamdo on the east. another from Koko Nor on the north and still another from Iigari on the west. to take over strategic garrisons in Tibet; a fourth party comprising administrative and technical staffs arrived via India.

Both the dalai lama and the panchen lama were given seats on the National Committee of the Chinese People's Political Consultative conference held in Peking on Nov. 1, 1951. In the spring of 1952 under the shadow of the Chinese Communist troops. the 10th panchen lama, now 15 years old, scored a triumphant entry into the Tibetan capital. On June 23, 1952. the panchen lama was entrenched on the throne of his predecessors in the Trashi Lhumpo monastery which had been without its spiritual leader for 28 years. In Sept. 193'4, both the dalai lama and the panchen lama attended the first Chinese National People's congress in Peking, and in 1956 they toured India together as guests of the Indian government.

Britain transferred to India its relations with Tibet in 1947 and the British mission in Lhasa and two trading agencies were taken over by Indian representatives. In 1950, India. hearing of the imminent Chinese invasion. on the ground that military action might cause unrest and disturbance on the Indian-Tibetan border, sent notes of protest to Communist China. India's objections were summarily dismissed by Red China as an interference in Chinese internal affairs. On April 20. 1954 India signed an eight-year agreement with Peking to promote trade and cultural intercourse, and to facilitate pilgrimage and travel between the two countries. Under the agreement India retained the right to establish trading agencies at Tatung. Gyangtse and Gartok. and a number of other Tibetan towns were designated as markets for trade. No Tibetan representative participated in the negotiation, and the language of the agreement inferred India's complete recognition of China's sovereignty over Tibet.

For political consolidation and military build-up Communist China embarked on a program of extensive roadbuilding in Tibet, and hundreds of thousands of Tibetans were pressed into the work. The hazards involved in bridging high precipices and deep ravines apparently caused the deaths of many workers. Resentment was general. The lamas who were always exempted from government conscription, especially hated the new masters because no special consideration was accorded them. Further opposition was aroused by the attempt to impose land reform on the feudal religion-dominated society. Insurrection first broke out in Litang and Chamdo in eastern Tibet, then spread to the Golok tribe in southern Tsinghai and the local Chinese garrisons were attaclred. Red Chinese retaliated by bombing the Litang lamasery and killed most of the inmates. The wanton destruction of their seat of worship further infuriated the Khambas, natives of eastern Tibet. Unable to beat the Red Chinese on frontal attack, they resorted to guerrilla warfare and frequently intercepted communications on the newly constructed highways. An announcement from Peking in April 1957 not to carry out "democratic reform" in the next six years and a promise to withdraw most of the Chinese military personnel in Tibet did not achieve the desired pacification. By the winter of 1958 the Khambas and Goloks had joined forces and moved into the Brahmaputra valley south of Lhasa. The trading route from Gyangtse to Yatung was cut. The rebels, who were joined by many discontented Tibetans from central Tibet, moved from Gyangtse area toward Lhasa in Feb. 1959. The situation became tense. The commander of the Chinese Communist troops put pressure on the dalai lama to deploy Tibetan army in suppressing the revolt, which the god-king declined. On March 10, 1959 an invitation to the dalai lama from the Chinese commander to a theatrical performance at the latter's headquarters was looked upon with suspicion by the Tibetans who feared their god-king might be held as hostage. Led by the *Mimaung* ("people's committee"), Tibetans overtly and under cover of a gigantic parade, prevented the young ruler from attending the banquet. As the Red soldiers tried to break up the demonstration, riots broke out. Reinforced by Tibetan troops the rioters stormed the Red garrison and the arsenal. Street fighting lasted five days. The Communist soldiers bombarded the dalai lama's summer residence and the Drepung and Sera monasteries, inflicting severe damage on the two ancient religious institutions.

The dalai lama, his family, three cabinet ministers and many high government functionaries escaped and sought refuge in India. In a statement on arrival, the dalai lama denounced Communist China as having broken all its promises to respect Tibetan autonomy as provided in the 1951 agreement. The government of India granted the dalai lama and his followers political asylum. Red China accused India of inciting revolts in Tibet and relations between India and China became critical.

After the flight of the dalai lama, Communist China on March 28, 1959 decreed the dissolution of the Lhasa government. The country was henceforth to be directly administered by the Preparatory Committee for the Tibet Autonomous region, and the panchen lama was named acting chairman. The panchen lama moved from Zhikatse to Lhasa in the same manner as his predecessor in 1910. He pledged full co-operation in suppressing rebellions and bringing about socialistic transformation of Tibet. He attended the Second National People's congress at Peking on April 17 and participated in the election of Liu Shao-chi as the second president of Communist China. Both he and the dalai lama (in absentia) were elected to be the vice-chairmen of the said National People's congress.

On Oct. 21, 1959, the United Nations General Assembly, by 45 votes to 9 (with 26 abstentions) approved a resolution which deplored the events in Tibet and called ior Chinese respect for the fundamental human rights of the Tibetan people.

Reports of sporadic fighting continued to reach the outside world in 1960, indicating that the Chinese Communists were still having trouble with pockets of rebellious Tibetans. By mid-1960 more than 17,000 refugees had fled to India for sanctuary, attesting to the continuing wave of suppression in the mountain-kingdom.

POPULATION

No census has ever been taken of the population of Tibet. The Peking national bureau of statistics reporting on the result of a general census carried out in other parts of China in June, 1953. estimated the population of Tibet at 1.273.969. This figure may be assumed to be reasonably accurate since the Tibetan government had previously estimated the number of persons under Lhasa's jurisdiction as between 1,000,000 and 1,500,000. Many Tibetans live in the Chinese provinces of Szechwan, Tsinghai and some even in Kansu and Sinkiang. The principal urban centres are Lhasa, Zhikatse, Gyangtse and Gartok (*qq.v.*). The Chinese government estimates the total number of Tibetans in Tibet and in China as 2,800,000.

All indicators point to a declining population. High infantile mortality, lack of medical knowledge, prevalence of venereal diseases and the strains on the heart and lungs due to rarefied air, account for the abnormally high mortality rate. In addition, the family practice of sending one male child out of three to join the clerical order and the marital system of polyandry where several men share one wife formed a kind of arbitrary birth control and further limited the growth of population. On June 20. 1960 the International Commission of Jurists in Geneva concluded an 11-month investigation of the Tibetan affair, and thereby announced Communist China guilty of genocide in Tibet, in an attempt to destroy the Tibetan people as a religious group. The Peking government was accused of upholding a systematic policy of killing, imprisonment and deportation of anti-Communist Tibetans.

The extent of Chinese colonization is not known, but a statement issued by the exiled dalai lama in Nov. 1959 indicated a marked acceleration in Chinese colonization.

ADMINISTRATION

Dalai Lama.—Prior to the Chinese conquest, Tibet was the last theocratic country in the world. At the head of the government was the god-king dalai lama who held both spiritual and temporal power. He was, and still is, believed to be the embodiment of the compassionate Buddha Chenrezi, patron god of Tibet. When a dalai lama died, he was succeeded by a reincarnation boy who was found by following the indications provided by the preceding dalai lama on his deathbed, the guidance given by the state oracle and the revelations derived from the mirage over the sacred lake Nam Tsho. The rebirth may be discovered only after a long search. Sometimes more than one boy fulfilled all the indications. In such cases a preliminary selection narrowed down the number of candidates to three. The three candidates were summoned to Lhasa. Their names were written on scrolls of paper and deposited in a golden urn. After seven days of prayer, the lot was drawn before the Buddha image in the Central temple. The first name coming out of the gold urn was proclaimed the future ruler of the land of lamas.

During the absence of a dalai lama! such as the interval between his death and the finding of a successor incarnation or during the successor's years of minority, a regent was normally elected from among the highest incarnation lamas of Tibet, approved by a great assembly summoned by the government for that purpose. and invited to assume full responsibility for the government. The regent could also be appointed by the dalai lama before the latter's death. When the dalai lama attained his majority between the age of 16 and 18, the regent surrendered to him all governmental authority.

Under the dalai lama there were clerical officers recruited from the three monasteries, and lay officers! recruited from the nobility. Two first-class incarnation lamas were responsible for the dalai lama's education. A lord chamberlain. with three assistants, was in charge of the dalai lama's food, daily living and religious ceremonies. Under the lord chamberlain a secretariat was formed. There was a liaison office between the dalai lama's inner court and the outside world, including the Tibetan government,

Tibetan Government.—The highest office in the Tibetan government was called *shor*. This could be either a clerical or secular organization, and headed either by the dalai lama or by a regent. Skor also had a liaison office either staffed by the clergy or headed by a prime minister who was an eminent nobleman or a member of the dalai lama's family. Under the shor, was the cabinet (*kashag*), normally in the charge of four ministers (*shapes*). The leader of these ministers must be clerical: while the other three were secular. Under the cabinet was the secretariat headed by four monk officers and the finance office headed by four laymen. There was no organized law court and legislature in theocratic Tibet. The important business of government was handled by the 12 men mentioned above. A litigation case could be assigned to any government official and important cases entrusted to a committee by the cabinet. If the defendant considered he was unjustly condemned he could appeal to the dalai lama.

Special offices of industry and agriculture, and tea and salt taxation were created in the beginning of the 20th century. A bureau for external affairs was established in 1926, but abolished in 1951.

There was a national assembly (*tsongdu*) which did not meet regularly; both the agenda and the summoning were beyond the poner of the constituent members. The assembly was convoked by the order of the government to deal only nith specific issues. The four cabinet ministers fixed the number of participants on each occasion, and only those whom they invited could attend.

The assembly was composed of all state officials of. and above, the fourth rank, the abbots of important monasteries in and around Lhasa and certain members of the nobility. The cabinet ministers did not directly participate in the deliberations but sat in a secret chamber. The four grand secretaries and the four finance ministers presided over the conference. A motion was never put to vote. It was considered carried when all opposition was silenced. A resolution was submitted to the cabinet ministers and in turn transmitted to the dalai lama. When a resolution was found unacceptable, it could be referred back to the assembly for further deliberation, but such an occasion seldom arose.

The state owned most of the land which could be granted to individual lama dignitaries and incarnations, or monasteries or assigned to different offices in the government for their maintenance. Family estates fell into two groups: one group was made up of granted estates which were perhaps given to the nobility and held by the male heirs of the families concerned, on the basis of one heir for one estate, and were indivisible and inalienable; the other group included the private holdings of the nobility and the small percentage owned by commoners. Eastern Tibet was ruled by hereditary noblemen who drew their incomes from the land cultivated by their subjects. On July 3, 1959, a program of reforms involving large-scale redistribution of land to the peasants and the abolition of feudal customs was announced in Peking. The estates of the temples and monasteries would not be exempted from this land reform.

In 1951 the representatives of the Tibetan government signed an agreement with the Communist government of China in Peking. Under this agreement the Communist authorities promised not to alter the existing system in Tibet, and would respect the established status, functions and powers of the dalai lama. Tibetan officials of various ranks were allowed to hold office as usual; and the people of Tibet had the right of exercising national regional autonomy. In April 1956 a preparation committee for Tibet Autonomous region was formally inaugurated. This committee had authority over the Chamdo Military commission, the Tibetan government under the dalai lama and the panchen kanpo lija, *i.e.,* its jurisdiction extended over all the territories under Tibetan control before "liberation." The dalai lama was the chairman of the committee, and the panchen lama and Chang Kuohua, the Peking representative in Lhasa were the two vice-chairmen. After the flight of the dalai lama to India in March 1959, the committee was reorganized and the panchen lama was made acting chairman.

Local Government. — Beside Lhasa and its suburbs, which were under the charge of two local administrations, there were in Tibet eight regional governments each under a governor. The most important of these was Kham which comprised the entire eastern Tibet. The governor of this region, stationed at Chamdo on the western bank of the Yangtze river, was given the rank of a cabinet minister. In 1950 eastern Tibet was occupied by the Chinese Communist forces and administered by a military commission. Under the jurisdiction of the regional governments were more than 50 magistracies. Most of the local areas were administered by both clerical and secular officers. Some local officers lived in luxury in Lhasa, while the local governments were in the charge of their private secretaries or stewards. Villages were administered by headmen.

ECONOMY

The economy of Tibet is still in a primitive stage. The nature of the terrain, the lack of rainfall and the severity of the climate impose a serious limitation on the development of agricultural resources. Industry is practically nonexistent. Trade is negligible, and mineral resources still await exploration. There is great livestock and timber potential, the principal drawback is the lack of modern transportation. After invasion by the Communist Chinese army in 1950, a few trunk highways were constructed. Subsequent surveys appear to confirm the conjecture of western explorers in the 18th and 19th centuries, that the Tibetan plateau is rich in mineral wealth.

Agriculture. — Agriculture in Tibet is almost completely of the subsistence type. Without irrigation the country is too arid to grow crops and cultivation is limited to river basins and the lowlands in southeastern Tibet. The soil is alluvial, often composed of sand blown by the wind to form a layer over gravels and shingles. and its colour is light brown or grayish, according to humus content, which is poor. For fertilizer, human excrement, ashes of cow dung and sometimes the fine silt from flood waters are used.

Barley is the staple food of Tibet. Rape turnips and peas are grown in sufficient quantities. In lower altitudes, wheat, buckwheat and millet are raised. Rice grows only in a limited quantity in the southeast section of the land. The Brahmaputra basin is the granary of Tibet and supports about 60% of the population. Whenever hill streams are available, water mills are used for the grinding of barley into flour. In the northern plain radishes and potatoes are grown sparsely.

In the 1950s the Chinese Academy of Science set up experimental stations at Lhasa, Zhikatse and Chamdo. It was reported that barley of Shantung variety, spring wheat of northern China, cabbage. cauliflower, tobacco, hemp, tomatoes, sunflower and millet were found suitable to the local soil and climate.

Forestry. — In Tibet the most valuable woodland is in the Kham district, though extensive forest clad mountains are also found in the valley of the Sutlej river in western Ngari and in the Chumbi valley in central Tibet. The Pome area in Kham is estimated to contain 17,300 sq.mi. of virgin forests. In the late 1950s 30 kinds of trees including those of comparatively high economic value such as varnish trees, spruce and fir, were discovered. Conifers averaging 90 ft. high and some trees as high as 200 ft. with a girth of 5 ft. were reported and the estimated total forest timber resources in this part of Tibet alone was placed at more than 130,-800.000 cu.yd. Accessibility is the principal factor which controls its development. Chayre (Dzayul) is another district known for its profuse primeval forests.

Minerals. — Prior to 1950 no systematic mineral exploration was carried out or permitted by the Tibetan government, and mineral resources were the subject of wide speculation.

A modern scientific investigation was conducted by Swami Pranavananda, an Indian who made surveys in the 1930s and 1940s in the Mount Kailas and Lake Manasarowar districts in western Tibet. The specimens of minerals he collected were analyzed at Benares Hindu university. He discovered extensive gold fields in the district of Sankora; radium, iron, titanium and emery on the eastern shores of lakes Manasarowar and Rakas Tal; lead near Gemuk, arsenic and serpentine near Kungri-bingri pass; and large deposits of borax on the shore of Lake Tseti Tsho.

Following the capitulation of Tibet, the geological section of the Chinese Academy of Science dispatched investigation teams who reported the existence of many useful minerals including oil shale, asphalt, iron. magnesium, copper, lead, zinc, molybdenum, antimony, salt. soda, borax: glauber salt, sulfur, sylbite, alum, mica, barite, graphite, talc, gypsum, jade and china clay. A belt of iron deposits was located on the western bank of the Mekong river stretching for almost 25 mi. S. of Chamdo. The graphite obtained from Ningtsin was over 50% fine. Coal was also reported plentiful around Chamdo. Iron deposits mere also found in the Thanglha range on the border of Tibet and Tsinghai, containing ore in concentrated seams, of high quality and extractable depth. Three rich crystal deposits were found in the glaciers of the Sane range. In addition oil-bearing formations, large reserve of oil shales. arid coal mines were also unearthed as well as valuable lead. zinc and manganese deposits. The iron and coal mines in the Ngachuka area were reported in production in the late 1950s.

Water Power. — The swift-flowing rivers and mountain streams of Tibet have immense hydroelectric power potential, especially the Brahmaputra. However, only one small hydroelectric plant at Lhasa generating 2,000 kw. was in operation in the late 1950s. Communist China established a hydrographic station at Lhasa and ten substations in various parts of the country to measure the speed of the current and water level of the Brahmaputra, Kyi Chhu and Kyang rivers at different seasons.

Industries. — KO single modern industrial establishment existed in Tibet in the early 1960s. The largest handicraft industry is the weaving of woolen cloth. The spinning is done by hand and weaving by a wooden frame loom. All Tibetans do spinning in their spare time, and the weaving is done solely by women. The finished fabric is a kind of heavy coarse serge which, in addition to supplying the local needs, is exported to parts of China where there are Tibetan colonies. The second largest handicraft industry is carpetmaking which is centred mainly at Gyangtse.

Under the Communists the Lhasa power station was repaired and reinforced with three 360-kw. generators and in 1952 the Chinese army built an iron and woodworking factory. A new thermal electric station was installed in Zhikatse. An automobile repair works began operation in 1957 and a leather tannery was built in 1958.

Trade. — The Tibetans lead simple primitive lives; their wants are few. The main product is wool, which formed the principal item of export to northern India and Bombay. A small quantity came to the United States for carpetmaking. The famous fine "shaw wool," known as cashmere came from western Tibet. Other items of export were borax, salt, animal and animal products and medicinal herbs. Gold dust once important in the 18th century has dwindled to nothing. Some rock salt and borax was exported to Nepal. Bhutan and northern India.

Tea. the principal import was imported in the form of bricks from western China. The bulk came from Yaan. Tea bricks were packed in yak hides, which were not tanned but merely dried in the sun. Tea also served as a form of currency for a traveler in Tibet, was readily accepted everywhere, and was convertible into butter, barley flour or the local currency. Other exports from China were brocades, silks, chinaware, enamelware, canned foods, shoes and socks, shearing scissors; from India, felt hats, cotton and woolen cloth, tobacco, indigo, glass and ironware, petroleum, firearms, dried nuts; and from Nepal and Bhutan came rice and dried fruits.

Since 1953 Tibetan trade became a monopoly of the Chinese State Trading company. In India it is represented by the Hamalaya Trading company owned partially by Chinese and partially by Tibetans.

Finance. — The Tibetan government, prior to Chinese domination: derived its revenue from taxes, from landed estates owned by the government and from public funds loaned to private individuals at interest. Because of the scarcity of money most taxes including import and export duties were paid in kind. The taxes were paid to the district (dzong) offices and to special tax collectors who toured the country to assist with the collections. The district officers did not receive any salary from the central government. but subtracted a percentage of the take. The landlords paid their dues in grain which was stored in government granaries. Cash. butter. oil and meat was sent to the revenue office in Lhasa. Other articles were stored in the office of the local government to be disposed or sold as need arose. The tenants who worked on land directly controlled by the government paid poll taxes. The government also loaned its surplus to a privileged few, high government officials. priests and wealthy traders who made a profit by lending out the money at high rates of interest.

The chief expense of the government was the maintenance of the large monasteries in and near Lhasa. The government provided free breakfasts for thousands of lamas and spent large sums every year for building repairs but a far greater amount was spent on butter, used as oil for the myriads of lights which were kept burning day and night. The government paid only a nominal salary to the civil servants. The landed nobility lived on the income of their family estate and worked for the government as a duty. Those families which had no male heir or whose heir was too young to serve were obliged to pay the government an exemption fee. Those whose private incomes were too meagre to meet the demands of public officialslooked on gifts from interested parties as part of their remuneration.

The dalai lama had a private treasury and he owned some of the best landed estates in the country. He received offerings from pilgrims and from deceased persons and he shared the profit from wool and gold monopolies of the trade caravans. The accumulated treasures of his predecessors in the form of precious stones, diamonds, pearls, gold, silver and rare silks were part of his treasury. These had been hoarded for centuries and their value was incalculable. The expenses of the dalai lama consisted of the maintenance of his own household and private chapel, and gifts to his relatives and priests of the large monasteries.

Tibet had a currency system of its own, although much of its internal trade was transacted on barter basis. The monetary unit, the tanka, is a silver piece. The Tibetan government also attempted to mint gold pieces, but the mint was burned down after coining only a small number which are much sought by collectors. There was no bank in Tibet before 1950. Wealthy families left their savings with reputable traders who paid them interest or a share of their trade profit. The Chinese have established branches of the People's Bank of China in Lhasa, Zhikatse, Gyangtse, Chamdo and Gartok, have extended both commercial and agricultural credit and have introduced the Chinese currency.

Transport and Communications. — Before 1950, traveling in Tibet was done in the most primitive manner, either on foot or on the backs of animals. It was the deliberate policy of the Tibetan government to balk modern means of communications in order to keep the country difficult to access and to keep away outsiders.

For trading, the Tibetans relied on the centuries-old caravan routes, of which the most important were: Tsinghai (via Nag Chhu), Sikang (via Chamdo), India (via Kalimpong and Yatung) and Kashmir (via Gartok and Leh).

Under the Communist regime, a network of motor roads was planned. Several trunk lines were completed, notably the Tsinghai and Sikang highways, and many secondary lines are under construction.

Air Transport. — The first air communication between Tibet and outside world was inaugurated in April 1956. The airport is located near Lhasa. There is unscheduled service with Chengchow via Jyekundo (Yushu). There are military airfields at Chamdo, Zhikatse and Gartok.

Railways.—There are no railways in Tibet. Ground survey for a new railroad was underway, preceded by aerial survey. The projected railway will be 807 mi. long with Sining and Nagchhudzong as terminals. It will pass through complicated geological and topographical regions and its average altitude will be more than 12,000 ft.

Postal and Telegraph Service. — There are about 50 postal and telecommunication stations in Tibet. including mobile units that serve remote border areas and geological, hydrological and construction teams. Tibet's postal network in 1956 covered 4.500 mi. according to an official Chinese report. See also Index references under "Tibet" in the Index volume. (T.-L. S.)

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TIBETAN ART

TIBETAN ART is a religious art; it is an anonymous expression of the Tibetan religion, Lamaism (see TIBETAN BUDDHISM). It is anonymous because the artists regarded their work as an expression of religious faith and, therefore, a meritorious act. Buddhist art in Tibet was a continuation of medieval Buddhist art of the Pala kings who ruled in north India 750–1150 A.D. The art style is very conservative in that it follows definite rules which are described in the Buddhist canon (Tri-pitaka). The first paintings of this style are to be found in the cave temples of India. The

TIBETAN ART

BY COURTESY OF (1-5, 12) MRS. ALEXANDER SCOTT, (6-10, 14) THE CONSERVATOR OF THE MUSÉE GUIMET, (11, 13) SUMNER GERARD

EXAMPLES OF TIBETAN ART

1. Religious vessel of gold, silver and copper used only by holy Lamas. 2. Samantabhadra Bodhisattva, Genius of Goodness, on his vehicle, the elephant. Made of bronze and gilded. **3.** Statuette of Padma Sambhava, the Buddhist pandit who came to Tibet from India in the 8th century, and translated parts of the Buddhist scriptures into the Tibetan language. 4. Another view of Samantabhadra Bodhisattva on his elephant. 5. A religious vessel of gold, silver and copper inlaid with turquoise and showing Chinese influence. 6. Figure of the Lama Jigs-med-rgya-mcho. 7. Figure of Bodhisattva wearing a diadem of five Dhyani-Buddhas. 8. The Bodhisattva Siddhārtha (Gotama Buddha), founder of Buddhism, in characteristic teaching attitude. 9. Figure of Lha-mo. **10.** Delicately carved reliquary gateway. Tibetan design. **11.** The Bronhyd Lotus, the perfect eight-leaved lotus flower with silver urn in centre. The lotus represents the heart of beings and ihe urn holds the source of organic life. 12. Bronze statuette of Nepalese lion (inscribed under neck). 13. The lotus shown Fig. **11.**, with all petals closed. 14. A Buddhist incense burner with pierced cover

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TIBETAN PAINTINGS

1. Painting of the learned Atisa. Figure of naked heretic near the halo, together with the figures of a sorcerer and his disciples, is reminiscent of Indian art. Numerous visits of this saint are represented by miniature scenes. At the top of picture (to the right of the aureole) he is seen acting as mediator between two armies about to fight

2. Representation of Lchang-skya Rol-pa' i rdo-je. Chinese influence shown by architecture of the monasteries in painting. The saint carries a book and sword, attributes of his patron, the celebrated reformer, Tsong Ka-Pa

3. Painting of the fifth Dalai Lama Ngagdbang Blo-bzang-rgya-mcho. He carries the thunderbolt and bell of the Buddha Vajradhara. Disciples and seven jewels are picturesquely grouped at bottom of picture

earliest images came to Tibet in the 8th century A.D. Before this time there was no literature, and except for prehistoric images, no art in Tibet. Buddhism introduced into Tibet not only religion, but culture, writing, art and other humanizing influences. Tibetan art should be discussed in order of precedence. Though there are innumerable images of the Tibetan pantheon, the painted scrolls or thang-kas are richer in iconographical material and yield more information on religious ideas and symbology.

Banners **(Thang-kas)**.—These paintings, or embroidered or appliqued pictures, are usually hung in temples or at family altars, carried by itinerant lamas in religious processions or used to illustrate sermons. A sized canvas is stretched on a frame and then rubbed down and prepared for the paint. An outline or transfer is usually used. The colours are made of vegetables, flowers and minerals boiled or ground and held together by glue or a binder. The important details of the work, such as the faces of the deities and the religious inscriptions are put in by the lamas. These paintings are mounted on a brocaded silk border; a flat stick is put at the top and a roller at the bottom. Sometimes, a thin silk dust curtain is put over the canvas to protect it from the smoke of the butter lamps used in the temples or on the altars. The materials used are fine Chinese or Japanese brocades. The paintings are used essentially for meditation. There are several general types.

Buddha. — Surrounded by deities or lamas, Buddha is depicted in episodes from his life and teachings. The saints are also shown in this way, preaching or teaching with their disciples around them.

Assemblage of Divinities. — This type is called Tshog Shing, "assembly tree," and shows a cosmic tree arising from the waters, through the earth and up into the heavens. On its branches are shown the various deities of the pantheon. It varies according to the four principal sects (Red Cap, Yellow Cap, Sa-kya-pa and Kargyupa).

The *Wheel* of Life. — Bhavacakramudra is the "Wheel of Transmigration." Buddha explained this to his disciples as the conception of the idea of birth and death, judgment according to karma, and rebirth. This is, perhaps, the most important tenet of Buddhism.

The *Intermediate* State. — This is a special type of banner. depicting the symbolic visions that occur to the deceased between the moment of death and rebirth in accordance with his karma, in one of the six regions depicted in the Wheel of Life.

Mandala.—Sometimes called the magic circle. This is usually geometric in design (an inner circle enclosed in a square nith four entrances). These mandalas have always exerted a particular fascination because in them art, magic and psychology combine. C. G. Jung, Richard Wilhelm and Heinrich Zimmer have made interesting attempts at psychological interpretations of the mandala. There are two kinds: painted mandalas, and sand or butter mandalas. The symbology of these mandalas probably comes from the yoga doctrine which teaches that by meditation and concentration the soul can obtain complete union with the divine. It is one of the means used by Tantric sects to achieve supernatural powers. The mandala is believed to be the "dwelling of the god." The deity resides in the innermost circle and by various incantations, offerings and disciplines, the devotee (sadhaka) invokes and finally identifies himself with him. The mandala is also a symbol of spiritual power because the devotee achieves the power of the deity. Coloured sand mandalas are usually used for ceremonies of initiation. They are technically of the same type as the painted mandalas, but are impermanent, being made on the ground and destroyed when the rite is over. The coloured butter mandalas are made for certain festivals and are used only for 24 hours and then destroyed.

Horoscopes. — These are banners with mystic symbols and diagrams, Chinese trigrams, signs of the zodiac, etc. They are used by the astrologer-lamas to prophesy the future according to the birth date of the person for whom the horoscope is cast. These are also painted on silk or paper, according to the wealth of the applicant.

Great Teachers. — Dalai and Tashi lamas and their antecedents are usually depicted in historical or geneological paintings and some of these are attempts at portraiture. Related to these are the "Eighty-four Great Sorcerers" (Musée Guimet, Paris).

Images. — The earliest images seem to have been imported from China and Nepal. Images cast in the northern monasteries, even in comparatively modern times, show Chinese influences, while those cast in southern Tibet show Nepalese influences. They are of enormous variety; there are from 300 to 500 deities in the pantheon, depending on the sect and the number of local deities. The materials used are gold, silver, copper, bronze, stone, wood, clay, butter and agglomerated materials. These images are of all sizes; huge ones are used in the temples, smaller ones are used on family altars, and others are carried about in little pocket shrines. The images are usually sculptured or cast in molds, or made by the cire perdue (lost wax) method and finished by hand. (See SCULPTURE TECHNIQUE.) A cavity is always left at the base of the image or at the back and this is filled with rolls of prayers or sacred relics. The image is then closed and consecrated by the lama. The contents are sometimes referred to as "sacred intestines."

Images are divided into two main types: the pacific and the angry. The pacific deities have mild, compassionate expressions and wear either simple monastic robes or elaborate princely robes with jeweled ornaments and crowns. These are the Buddhas and Bodhisattvas (potential Buddhas). Those of the angry group wear ornaments of skulls and carved human bones; they are called Dharmapala. Other images include fairies, heavenly musicians, astrologers, great magicians, the Great Teachers, Dalai and Tashi lamas and historical persons. Among the most interesting is a type called Yab-Yum ("father-mother"), which shows Buddhas in the embrace of their Shaktis or female energies. These symbolize the merging of Compassion (the male) and Knowledge (the female) and indicate the method and the way of attaining nirvana.

There are also a goodly number of images of a grotesque nature, such as winged or horned figures on mythical animals. Their origin, significance and dating are not known. They most likely relate to the earlier Pon religion.

Ritual Objects. — Lamaism, a religion with an abundance of rites, developed a wealth of ritual objects. Among these are thunderbolts and bells, prayer wheels. magic daggers, rosaries, clay tablets, wood blocks and too many others to mention. There are also butter lamps and bowls on the altars to hold incense, flowers and water. The eight auspicious Buddhist symbols, as well as musical instruments, are always in evidence. The thunderbolt (vajra) and bell (ghanta) are held in the hands of some of the Buddhas. The thunderbolt is the symbol of power, and the bell a symbol of the void or emptiness of existence. The prayer wheel is a round metal case or cylinder which revolves on a stick and is filled with a roll of prayers. Each revolution of this wheel is a repetition of the most popular Tibetan prayer, *Om.mani.pad.me.* hum ("Hail to the Jewel in the Lotus"). Magic daggers (phurbus) are used to exorcise evil. Ghost traps made of a frame ork of wood and surrounded in intricate fashion by multicoloured threads are used to entangle evil spirits or demons, and prevent them from entering the home and injuring the inhabitants. Prayer flags and prayer stones (mani) serve the same purpose.

Chronology. — There exists, as yet, no infallible means of identifying any Tibetan art work on stylistic criteria alone. Works have not been grouped chronologically in dynasties or periods as in China.

Dating is extremely difficult and, except when images are inscribed, unreliable. Since each type. gesture and symbol is prescribed in the canonical rules, it is practically impossible to differentiate an old from a more recent image. Images of historical teachers or Dalai or Tashi lamas, of course, cannot antedate the individual portrayed.

The dating of banners is controversial; rolled paintings or thang-kas did not appear until about the 10th century AD. Unless they are among the very few dated banners. such as the Lha-mo banners (illustrated in A. K. Gordon's Tzbetan Religious Art, pp. 36–39), it is difficult to assign them to a specific period The banner of Lha-mo has an inscription in four languages — Chinese, Mongol, Manchu and Tibetan — "Made by command of the Emperor Ch'ien Lung in the 42nd year of his reign" (A.D. 1777).

Collections. — At the Musée Guimet in Paris, there are several paintings showing Gsen rabs Mibo, the prophet of Pön, and some of the Pon deities. In the American Museum of Natural History, New York city, there is also a large group of unidentified images. The most comprehensive collections of Tibetan art in the United States are to be found at the American Museum of Natural History, New York; the Newark Museum of Arts and Sciences, Newark, N.J.; and the Cniversity of Pennsylvania museum, Philadelphia.

See also CHINESE PAINTING; CHINESE SCULPTURE; JAPANESE PAINTING AND PRINTS; JAPANESE SCULPTURE; INDIAN ART.

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TIBETAN BUDDHISM. This article deals with the special form of Buddhism (*q.v.*) which has gradually evolved in Tibet since the 7th century A.D., when Tibetan rulers first began to take an active interest in this religion. It is also convenient to include the pre-Buddhist cults (known as Eon), for very little is known of them in their primitive form, whereas subsequently they have been so affected by Buddhist beliefs and practices as to have become just a rather incongruous sect of Tibetan Buddhism.

Lamas and Monasticism. — Tibetan religion attracts interest in the west mainly on account of its special system of reincarnating lamas. There are several hundreds of them, of whom the dalai lama and the panchen lama are incomparably the most important. Lama (*bla-ma*) means simply "superior," and is the normal polite title for senior monks and for those in the villages who act as the "priests" of their small communities as well as for the heads of teaching faculties in the larger monasteries and the principals of religious institutions, both small and large. In the case of such senior lamas suitably respectful epithets are added, but the term itself is of as wide application as the title "father" for a Christian priest. The reincarnating lamas (*sprul-sku*) are normally principals of monasteries and they have steadily increased in number since the 15th century (when the idea of identifying successors in this way gained general acceptance), for it greatly adds to the prestige of an institution to have an "incarnation" as its head. Nevertheless there still remain many institutions where other methods of succession are in vogue: by inheritance from father to son (in the case of married religious practisers), from uncle to nephew or by selection according to merit and learning. Of these last the abbot of dGa'-ldan (Ganden), one of the three enormous dGe-lugs-pa (Ge lug pa) monasteries on the outskirts of Lhasa, is the most important.

The widespread monastic system itself is but an elaborate development of the type of monastic life which is fundamental to Buddhism in all its forms. What is remarkable is the zeal with which the Tibetans have taken to religious life; no census has ever been made in the country, but a quarter of the population are probably members of religious institutions. Their religion serves as the basis of their whole culture.

Early History. — The first temples were built in the reign of Sron-btsan-sgam-po (or Songtsen Gampo; d. A.D. 649), who was also responsible for founding Lhasa as well as for establishing an official Tibetan alphabet based on the studies of one of his ministers, Thon-mi Sambhota. in Kashmir, which was then still a Buddhist country. Two of Sron-btsan-sgam-po's queens, one Chinese and one Nepalese, are popularly regarded as the earliest patrons of Tibetan Buddhism and thus identified as "incarnations" of the Buddhist saviouress (Tara). No spectacular progress was made with the new religion during the next hundred years, for the Tibetan leaders were engaged in conquering and controlling a huge central Asian empire, recognized under duress by the Chinese, from whom they wrested the important city-states of Kashgar, Kucha, Karashahr and Khotan on the ancient silk route, which skirts the Takla Makan desert. This brought them into contact not only with Buddhist communities but also with Manichaeans, Nestorian Christians, Arabs and Persians, followers of Islam. Central Asian Buddhism evoked active interest among the Tibetans: monks fleeing from Khotan were hospitably received by the Chinese wife (d. A.D. 739) of the Tibetan king Mes-'ag-ts'oms. monasteries being built for them presumably near Lhasa; moreover large collections of Tibetan Buddhist manuscripts preserved at Tun-huang attest the existence of Tibetan religious communities in the area. It seems that the royal family was eager to foster Buddhism, while ponerful ministerial chiefs were opposed to it. Royal authority was established during the long reign (755–797) of K'ri-sroṅ-lde-btsan (Khrisong Detsen), notable for three major events: the building of the first proper Tibetan monastery at bSam-yas (Samye) between Lhasa and Yarlung; the ordaining of the first seven Tibetan monks; and the holding of a council to decide the relative merits of Chinese and Indian forms of Buddhism. The Indian masters Sāntarakshita, representing orthodox Mahayana teachings, and Padmasambhava, manifesting the magic powers of a *mahasiddha* ("master yogin," of whom there are 84 in Sivaist and Buddhist Tantric tradition), nere responsible for the founding of bSam-yas; the views of Śāntarakshita's disciple Kamalaśīla prevailed at the council. Buddhist monks appear as ministers of state as early as the beginning of the 9th century. The third "religious" king of Tibet, Ral-pa-can (Ralpachan), who is credited with systematizing the methods of translating texts and establishing the Vinaya (monastic discipline) of the Mūlasarvāstivādin order or of Indian Buddhism as the sole orthodox Tibetan one, was murdered (838) by his brother, who thereupon set about destroying the new religion, at least in the region of Lhasa.

Ban.-Explicit references to Bon occur in the cycles of quasi-historical texts concerning Padmasambhava, who is honoured as the chief queller and converter of all forces hostile to Buddhism. The character of original Bon beliefs can be surmised from such textual references, but, since literature began in Tibet as a deliberate Buddhist concern, with the whole wealth of Indian literary traditions behind it, the Bon-pos were bound to use Buddhist terminology, often without realizing perhaps that it implied ideas that might be specifically Buddhist. That they later tried to have recourse to Hindu mythology indicates the fundamental weakness of their position. The original features of Bon seem to have been a cult of divine kingship whereby the kings were regarded as manifestations of the sky-divinity; an order of oracular priests; a cult of the gods of the atmosphere, the earth and subterranean regions; and the practice of blood sacrifices. All these features in a transmuted form have been absorbed into Tibetan Buddhism. While Bon-pos and Buddhists must both have had their interested supporters in 8th- and 9th-century Tibet, the chiefs of the country seem often to have used them as factions in political intrigues.

Tibetan Translations of Buddhist Texts. — Royal sponsors appeared again in the 10th–11th centuries, this time in western Tibet (mNa'-ris), namely Ye-Ses-'od and his brother Lha-lde, then the latter's sons, 'Od-lde, Byaṅ-c'ub-'od and Śiba-'od. They fostered learning and sent young Tibetans to India to study, of whom the most famous is probably the great translator Rin-c'en-bzaṅ-po (Rinchen Zampo; 958–1055). Large sums were expended buying the services and knowledge of Indian masters. One of the most renowned of these was Atīśa (or Atisha; 982–1054), who spent the last 12 years of his life in Tibet, surrounded by Tibetan disciples. From now on Buddhism seems to have had no determined opponents; the Bon-pos had already begun to produce their own literature on Buddhist models and were presumably often as interested in the latest Tibetan translations from Sanskrit as mere the Buddhists proper. When one remembers that much of this work was done by individual practisers of 'the doctrine, all folloning their own bent in translating philosophical or doctrinal texts, tantric cycles and their manifold commentaries, works on medicine, astrology, etc., it is remarkable what uniformity was eventually achieved.

By the 14th century the Tibetans had succeeded in translating all available Buddhist literature in India and Nepal. After the destruction wrought in the name of Islam, Buddhism had practically disappeared from India by A.D. 1200, and Nepal (primarily the Kathmandu valley) remained the sole representative of Sanskrit Buddhist culture. Practice of the doctrine rapidly began to deteriorate there, now that Indian inspiration was gone; meanwhile Tibet began to manifest itself as the chief inheritor of the whole Indian Buddhist tradition. No complete Indian canon of Mahayana Buddhism seems ever to have existed. But having collected and translated over the course of some six centuries all canonical and quasi-canonical texts, as well as the works of all Indian Buddhist writers, the Tibetans gradually produced their own canon, which had assumed by the 13th century more or less its present form. Consisting originally of a massive collection of manuscripts, this great work has appeared in several editions (printed page by page from incised wooden blocks) since the 16th century. It is arranged as 100 or 108 (depending on the edition) massive volumes of supposedly canonical texts (Kanjur, or Kagyur, "translated word") and 225 volumes of commentaries, scholarly treatises and miscellaneous writing by Indian masters (*Tenjur*, or Tangyur, "translated treatises").

Later Developments. — It has often been said that the Tibetans adopted only the more debased forms of Indian Buddhism, and the use of the term "Lamaism" has been used (like papism) to suggest a curious and falsified form of original teachings. In fact they adopted the whole of Indian Buddhism with its monastic life, its scholarly disposition, its ideal of the beneficent sage and its more popular conception of the wonder-working tantric yogin. Thus there are religious men of all kinds in Tibet: the wealthy benefactor sponsoring a new community, the independent seeker after knowledge (and sometimes the wealth that such knowledge brings), the pious monk spending his whole life translating texts, or the converted Bon-po striving to gain those special powers associated with proficiency in tantric practice.

Thus the earlier orders of Tibetan Buddhism began to develop quite spontaneously around the traditions associated with certain revered masters, but with no deliberate doctrinal or practical differences to distinguish them. The rÑiṅ-ma-pa (or Nying mapa; "old order") claimed to transmit the original teachings of Padmasambhava, the great tantric master of the 8th century, who was now identified as a Buddha. In support of their doctrines they began to "discover" texts, which had been "hidden" during the persecution following the murder of Ral-pa-can. Many of these texts, which were put together in the 12th and 13th centuries, do in fact contain very ancient traditions. The Bon-pos likewise began to discover their "hidden" literature, and the texts they produced were, needless to say, permeated by the same type of teachings. The founder of Sa-skya (Sakya) monastery (founded 1073), after which the Sa-skya-pa (Sakyapa) order is named, was simply a rÑiṅ-ma-pa who wished to establish sound doctrine. During the historical vicissitudes of the next two centuries. his successors, who were certainly learned, became the religious masters of the great Mongol Khans, from whom they received in return the mandate of political power throughout the whole of Tibet. (This political power was not held unchallenged; it endured about a century and even then the country remained more or less divided in allegiance to powerful monasteries and rival clans.)

Another important order, the bKa'-rgyud-pa (Kagyurpa; "order of the transmitted word"). was founded by the translator Mar-pa, aho had acquired his initiations and doctrines from the Indian tantric yogin Nāropa. Mar-pa was a householder; his chief disciple Mi-la ras-pa, the most renowned of Tibetan sages, was a solitary hermit. This line developed into a large number of subsects, all monastic in type.

Another order, generally reforming in intention, was associated with Atīśa or rather with his disciple 'Brom-ston, who founded Rva-sgreng monastery to the northeast of Lhasa. His order, known as the bKa'-gdams-pa (Kadampa; "precept giving") was absorbed in the 15th century by the last and now the most powerful of Tibetan religious orders, the dGe-lugs-pa (Ge lug pa; "the virtuous"), the order of the dalai lama and the panchen lama.

This last order was founded by an east Tibetan, Tson-k'a-pa (Tsong kha pa; 1358–1419), a scholarly writer and skilful preacher. who was intent on establishing monastic celibacy as the only legitimate form of religious life. He established a following in Lhasa, where he founded dGa'-ldan (Ganden) monastery. His immediate disciples founded two other monasteries, 'Bras-spuṅs (Drepung) and Se-ra, also on the outskirts of Lhasa. These subsequently became the main dGe-lugs-pa strongholds, dominating the capital with a joint total of about 20,000 monks. (The nickname "Yellow Hats" for the dGe-lugs-pa, commonly used by westerners. is possibly of Chinese origin. The corresponding nickname "Red Hats," as applied to all the other older orders, is a mistaken usage of foreigners, for it applies properly to only one subsect.) One of the most energetic organizers of the new order mas dGe-'dun-grub-pa (Gentun Drupa; 1391–1474), abbot of 'Bras-spuṅs, who was retrospectively recognized as the first rGyal-ba Rin-po-c'e ("precious conqueror"), the title by which Tibetans refer to the dalai lama.

The two foremost disciples of Tson-k'a-pa, namely rGyal-ts'ab-rje and mK'as-grub-rje (Khedru), acted as abbots of Tsoṅ-k'a-pa's own monastery, dGa'-ldan, and when mK'as-grub-rje died in 1438 dGe-'dun-grub-pa seems already to have resolved to find as his successor a boy born in the same year. Precedents for this practice can be traced back to the 13th century at least. The idea of a divine being manifest as a human teacher was already established in Indian Buddhism, and the theory of rebirth is of course fundamental to Buddhism in all its forms. It was by combining these ideas and claiming the ability to recognize one after another the representatives of such a series that the Tibetans devised a unique system of heredity. dGe-'dun-grub-pa died at the monastery of bKra-śis-lhun-po (Tashihlunpo or Trashi Lhümpo), which he had built (1447–52) in honour of his departed master, and a worthy successor was found as abbot. It was only later that his "reincarnation" was discovered. Thereafter however the system of reincarnations was accepted as the general rule. 'Bras-spuns became the seat of the "precious conquerors," and bKra-śis-lhun-po that of the "precious sages" (*Paṇ-c'en Rin-po-c'e*, the panchen lama). Political power over the whole of Tibet came to the fifth "precious conqueror" by the arms of the Mongols, who had been reconverted to Buddhism by his great predecessor, the third.

All the different orders have developed their own literary traditions, biographical, historical, doctrinal and liturgical, and thus the scope of Tibetan literature is now enormous.

Religious Theory and Practice. — In general, Tibetan religion represents the developed Mahayana Buddhism of India, which includes tantric theory and practice, known either as Vajrayāna ("vehicle of mystic power"; literally "thunderbolt") or Mantrayāna ("vehicle of mystic spells"), together with indigenous Bon notions which were easily adaptable. Thus the Bon idea of divine kingship finds a new Buddhist form in the theory of reincarnating lamas; the old priests of Bon now have Buddhist oracular soothsayers as their counterparts; the old local gods are now conceived of as serving the new religion and receive sacrificial offerings as a kind of fee for their continuing good will; the offerings consist of conventional sacrificial cakes, and the "flesh-offerings" prepared for bloodthirsty divinities are simply specially prepared cakes made to look sufficiently gruesome. Religious practice proper (study of religious texts. meditation, self-discipline and the practice of morality) is entirely Buddhist in character, and its efficacy as a way of perfection (in terms of the Buddhist ideal of blissful equanimity pervaded by loving kindness', is proved by the undoubted existence of a minority of very deeply religious men. as well as by the far greater number whose well-balanced personalities manifest the results of such a training. This is not to claim that Tibetans are always more virtuous than other peoples, though they are probably more morally conscious. Their religious susceptibilities are certainly highly developed, ranging from fervent and well-directed faith to vague superstition. Since 1950, however. when the Chinese communists invaded the country, Tibetan religion and culture have been put to a severe test; thus their future is dark and uncertain.

See also TIBET.

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Scrolls (1949), which is of prime importance; L. A. Waddell, *The Buddhism of Tibet,* 2nd ed. (1958) (D. L SN)

TIBETAN LANGUAGE, spoken in Tibet and in surrounding areas by about 5,000,000 persons, constitutes the aesternmost branch of the Tibeto-Burman languages (*q.v.*) and comprises a large number of dialects which fall into three main groups, the western, the central and the eastern. The literary form of Tibetan has been known since the 7th century. At that time Thonmi Sambhota. minister to King Songtsen Gampo, a devout Buddhist, nent to India. learned Sanskrit and invented the alphabet in which the Buddhist scriptures survive and which became the alphabet commonly used in modern times. The earliest stages of the language that have been reconstructed show a morphology consisting of prefixes and suffixes. By the time the written form became fixed the prefixes and suffixes were tending to disappear and to be replaced by features of tone accompanied by simpler forms with complex consonant clusters. This development was uneven in the various dialects. in some the clusters tended to remain; in others the tonal system developed. In general the colloquial language of modern times depends on word order and the use of particles to indicate syntactic relationships.

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TIBETO-BURMAN LANGUAGES. The Tibeto-Burman group comprises languages spoken from Tibet in the north to Burma in the south, and from the Ladakh *wazárat* of Kashmir in the west to the Chinese provinces of Szechwan and Yiinnan in the east. Various Tibetan dialects are spoken all over Tibet and in the neighbouring districts of India and China. The Himalayan dialects are spoken in the southern Himalayas, from Lahul in the west to Bhutan in the east. East of Bhutan, to the north of the Assam valley, a third small group, the north Assam group, consists of three dialects. A fourth group, the Bodpo group, comprises a series of dialects from Bhutan in the north to the Tippera state in the south, which at one time extended over most of Assam west of Manipur and the Naga hills, and even far into Bengal proper. To the west of the Bodpos, and in the neighbourhood of the Naga hills is a fifth group, the so-called Naga group. It comprises dialects of very different kinds. Some of them approach Tibetan and the dialect of the north Assam group. Others lead over to the Bodpo languages, and others again connect the Naga dialects with their Tibeto-Burman neighbours to the south and east. To the south of the Naga hills, in the long chain of hills extending southnard, is a sixth group, the Kuki-Chin dialects. The old Meithei language of Manipur lies midway between this group and the easternmost branch of the Tibeto-Burman family, the Kachin group, in the tract of country to the east of Assam and to the north of upper Burma. including the headwaters of the Chindwin and the Irraa-addy. Finally there is Burmese, the language of the ancient kingdom of Burma.

Burmese Alphabet

က	ka	ဗ	ba
	hka	ဘ	ba
	ga	မ	ma
ဃ	(gha)	ယ	ya
	nga	ရ	ya / ra
	sa	လ	la
ဆ	hsa	ဝ	wa
ဇ	za	သ	tha
	za	ဟ	ha
ည	nya	ဠ	(ḷa)
	(ṭa)	အ	qa
ဌ	(hṭa)	အာ	qa-
ဍ	(ḍa)	အိ or ဣ	qi
ဎ	(ḍa)	အီ or ဤ	qi-
ဏ	na	အု or ဥ	qu
တ	ta	အူ or ဦ	qu-
ထ	hta	အေ or ဧ	qei-
ဒ	da	အဲ	qe:
ဓ	da	အော or ဩ	qo
န	na	အော် or ဪ	qo-
ပ	pa		
ဖ	hpa	အံ	qan-

The dialects spoken in the Himalayas and in Assam can be viewed as a double chain connecting Tibetan with Burmese, the two principal languages of the group. In the first place the Kachin languages run from the easternmost Tibetan dialects in Szechwan down to the Burmese of upper Burma. The second chain has a double beginning in the north, one line through the north Assam group, the Naga, Bodpo and Kuki-Chin groups, another line proceeding from Tibetan through the Himalayan and Bodpo groups into Kuki-Chin. and finally into Burmese.

The Tibeto-Burman languages are closely related to Chinese and perhaps distantly to Tai. The agreement is apparent in the phonetic system, in vocabulary and in grammar. Together all these languages are said to form one great family, called Sino-Tibetan or Indo-Chinese.

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TIBULLUS, ALBIUS (d. c. 19 B.C.), Roman poet, the second in the classical sequence of Latin writers of elegiacs that begins with Cornelius Gallus and continues through Tibullus and Propertius to Ovid. Apart from his own poems, the only sources for the biography of Tibullus are a few references in ancient writers and an extremely short ***Life*** of doubtful authority. He was of equestrian rank (according to the ***Life)*** and inherited an estate, but seems to have lost most of it in 41 B.C. when Mark Xntony and Octavian confiscated land for their soldiers (Virgil, Propertius and Horace suffered in the same way). As a young man. however, Tibullus won the friendship and patronage of M. Valerius Messalla Corvinus, the statesman, soldier and man of letters. Despite personal reasons for staying at home, he mould even have accompanied Messalla on a mission to the east if sickness had not obliged him to remain behind when the party left Corcyra. and it is sometimes alleged that he accompanied Messalla's expedition against the Aquitanians. In any case, Tibullus was a prominent member of Messalla's literary circle. This circle, unlike that of Maecenas, kept itself aloof from the court of Augustus. whom Tibullus does not even mention in his poems. Tibullus seems to have divided his time between Rome and his country estate, strongly preferring the latter. The Albius addressed by Horace in Odes, i, 33, and *Epistles,* i, 4, is generally identified with Tibullus.

Tibullus' first important love affair, the main subject of book i of his poems, was with the woman whom he calls Delia but whose real name, according to Apuleius, was Plania. It is impossible to give an exact account of their intimacy, as the poems about her are not arranged in chronological order: sometimes he presents her as unmarried, sometimes as having a husband (unless the term *conjunx* is to be interpreted as meaning merely "protector"). It is clear, however, that Tibullus took advantage of the "husband's" absence on military service in Cilicia to establish his relationship with Delia and that this relationship was carried on clandestinely after the soldier's return until Tibullus discovered that Delia was receiving other lovers as well as himself; then, after fruitless protests, he ceased to address himself to her. In book ii of his poems Delia's place is taken by Nemesis (also a fictitious name). This Nemesis was a courtesan of the higher class, with several lovers. Though he complains bitterly of her rapacity and hardheartedness, Tibullus seems to have remained subjugated to her for the rest of his life. He died young, very shortly after Virgil (19 B.C.), as is proved by an epigram of his contemporary, Domitius Marsus. Ovid commemorated his death in his *Amores* (iii, 9).

Character and Style.—The character of Tibullus, as reflected in his poems, is an amiable one. He was a man of generous impulses and a gentle unselfish disposition. His loyalty to his friends is shown by his leaving Delia to accompany Messalla to Asia, and he was constant to his mistresses with a constancy that they scarcely deserved. His tenderness toward women is enhanced by a refinement and delicacy which are rare among the ancients.

Horace and the rest taunt those who reject their claims with the damage that the years will do to their beauty, but if Tibullus refers to old age, he does it by way of warning, not in a spirit of triumph or revenge. Cruelly though he may have been treated by his love, he does not invoke curses upon her. Instead he goes to her little sister's grave, hung so often with his garlands and met with his tears, and bemoans his fate there. Tibullus has no leanings to an active life: his ideal is a quiet retirement in the country with the loved one at his side. He has no ambition and no yearning for immortality. As he loved country life, so he clung to its faiths, and in an age of crude materialism and strange new cults he was religious in the old Roman way.

The poetry of Tibullus is distinguished by an idyllic simplicity, hut this is the simplicity of high art, not of unadorned nature. For grace and tenderness, for exquisiteness of feeling and expression, he stands alone among the Roman elegists: Quintilian, indeed, puts him at their head. In many of his poems, moreover, a symmetry of composition can be discerned, though they are never forced into any fixed or inelastic scheme. His clear and unaffected style, which made him a great favourite with Roman readers, is far more polished than that of his rival Propertius and far less loaded with Alexandrian learning; but in range of imagination, in power and originality of conception, in richness and variety of poetical treatment Propertius is much superior to him. In his handling of metre, likewise, Tibullus is smooth and musical, whereas Propertius, with occasional harshness, is vigorous and varied.

"Corpus **Tibullianum.**"—The works of Tibullus, as they have survived, form part of what is generally known as the *Corpus Tibullianum*, a collection of poetry which seems most probably to have been deliberately put together to represent the work of Messalla's circle; when and by whom this was done must in the present state of the evidence remain obscure.

The first two books of the collection are the undoubted property of Tibullus. Book i contains the poems inspired by Delia and also three elegies (4, 8 and 9) addressed to Marathus, a beautiful boy. These three elegies may reflect a literary convention, not the poet's actual feelings, as many of the sentiments throughout the book are those expected of the professed elegist: for instance, Tibullus' alleged poverty (i, 1) is at variance with the facts if he is the Albius addressed by Horace. The most interesting of the Marathus poems is that (4) in which the god Priapus is made to deliver a brief sketch of the art of love, the prototype of Ovid's fuller treatment of the same theme in the *Ars amatoria*.

Book ii is by no means entirely devoted to the liaison with Nemesis: it contains one of Tibullus's most characteristic and delightful poems, the description of a country festival (1).

The rest of the *Corpus Tibullianum* forms one book in the manuscripts; the division into two books, iii and iv, in modern editions is due to Italian scholars of the 15th century. Book iii contains six poems, the work of a poet who styles himself Lygdamus, an obvious pseudonym. They celebrate a lady named Neaera and are cultivated but on the whole undistinguished compositions. The writer's identity has been much debated, but remains unknown. If the *Corpus* does indeed represent the poets associated with Messalla, this Lygdamus should have been a contemporary of Tibullus and Ovid; and one couplet (5, 17–18) seems to indicate that his birthday was the same as Ovid's. This, together with the striking verbal resemblances which are found in his poems, has led some to identify him with Ovid; but neither this nor any other of the proposed identifications (with Ovid's brother, with Propertius, with Tibullus himself) mill stand scrutiny. (It seems certain, however, that the resemblances between the two poets are due to Lygdamus' having copied Ovid, not vice versa.)

The first poem of book iv, a panegyric on Messalla, is a turgid and worthless composition. The next 11 poems were occasioned by the love of Sulpicia (*q.v.*) for a young man called Cerinthus: poems 7–12 are Sulpicia's; 2–6 are usually thought to be by Tibullus. The whole cycle forms a unique and charming document for the literary life of Augustan Rome. The last poems (13 and 14), addressing an unnamed love, are likewise generally attributed to Tibullus.

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(J. P. P.; E. J. KY.)

TIC, a word derived from the French, means "a twitching"; a habitual, unpleasing gesture. A tiqueur is one who is afflicted with tic. "Tic" has largely replaced the obsolete term "habit spasm." It may be defined as a sudden, rapid, recurring contraction in a muscle or group of muscles; the movement is always brief, irresistible and limited to one part of the body. It does not interfere with the use of the part involved, and may be halted voluntarily but only for a time. As the tic movement becomes ingrained it is looked upon as a habit; the possessor becomes relatively unaware of its occurrence. Then a tic may be considered as involuntary. These characteristics of tic help to differentiate it from other involuntary movements, such as spasm, or the capricious, uninhibitable movements that may occur in chorea (St. Vitus' dance; *q.v.*) or in epilepsy (*q.v.*). Tics are not mannerisms.

While very nearly all tics are of psychological origin, similar repetitive movements have been observed in the late stages of encephalitis (*q.v.*). These movements that accompany brain disease may persist for years, but they tend to cease eventually.

Nervous children between 5 and 12 years of age are those most likely to have tics. but no age is immune. The movement appears when the subject is tense, and distraction will reduce it. The sufferer knows that he has a certain control of the movement but feels impelled to go through with it in order to feel better. Sometimes a group of tics occur in rapid succession, and the condition is then termed convulsive tic, a more severe form of the disease.

Tics frequently involve the face and air passages. The commonest tics are a repetitive grimace, blink, sniff, snort or click in the nose or throat, a twitch or a shrug. Tics occur in decreasing frequency from head to foot. The involuntary play of the facial muscles can be particularly looked upon as a model for tics.

Tics are the involuntary motor expression of emotional activity, a mimetic expression of the emotions, and they depend primarily upon the manner in which the *tiqueur* has experienced his early psychological and sexual development. Compulsion neurosis is common among *tiqueurs* (see NEUROSES). Compulsive neurotics are in conflict about certain of their feelings; they suffer from the irresistible impulse to perform some act contrary to the conscious will. In other words, the energy derives from the unconscious. The need to "get rid of" something is implicit in tic activity.

The use of the muscles for immediate discharge indicates intolerance of tension and inability to wait; the tiqueur feels impelled to make the movement in order to feel better. The tension is thereby discharged; in other words the person temporarily relieves himself—of what, he does not know. Such inability to wait is characteristic of the activity of children who have to learn how to accept delay of their gratifications and to channel their energies into socially acceptable activity. Should they continue this kind of intolerance into adulthood, the nervous patterns may gradually narrow their target to become a tic as the movement becomes more automatic than willed.

In persons with tic it can be determined that the usual outlets for expression of the emotions were denied in childhood: restriction of motility has resulted in an increased motor urge; overprotection, usually based on the mother's fear: has made the child emotionally dependent and lacking in self-control. Tics thus may be accompanied by other indications of maladjustment, such as bedwetting, feeding and digestive disorders and exaggerated fears.

The muscles are among the main avenues used by infants in the expression of the emotions, such expression appearing before that of speech in the developing child. It follows that primitive emotion relatively untempered by learning, or vulnerable because of bodily disease, may show itself by may of the muscular system. Somewhat later in development the musculature may be used to repress or restrain certain emotional expression. Confusion of muscular usage during formative years may result in awkwardness and other muscular problems such as "growing pains," and later, writer's cramp or certain arthritic conditions.

The treatment of the child with tic consists in paying little or no attention to it except as a warning that something in the family situation requires looking into. This most often turns out to be parental instability or disturbed family relationships. The older tic personality may respond to psychotherapy devised to mature the subject (learning why he behaves the way he does), who has usually retreated—in a defensive maneuver—to an earlier stage of psychological development where he feels more secure.

Usually there are features of both the compulsion neurosis and hysteria in tiqueurs. In hysteria (*q.v.*) repressed sexual energy is converted into symptoms. Where there is the capacity for relationship, prolonged uncovering psychotherapy may be helpful. (C. D. AR.)

TICHBORNE CLAIMANT, THE. Roger Charles Tichborne (1829–1854), whose family name became a household word because an impostor in 1868 attempted to impersonate him and obtain his heritage, was born at Paris on Jan. 5, 1829.

He sailed in March 1853 from Le Havre for Valparaiso, whence he crossed the Andes, reaching Rio de Janeiro in 1854. In April of that year he sailed from Rio and was lost at sea. His insurance was paid and his will proved in July 185j. The baronetcy and estates passed in 1862 to Roger's younger brother, Sir Alfred Joseph Doughty-Tichborne. who died in 1866. The only person unconvinced of Roger's death was his mother. She advertised for the wanderer, and in Nov. 1865 she learned, through an agency in Sydney, that a man "answering to the description of her son" had been found in the guise of a small butcher at Wagga Wagga, in Queensland. Lady Tichborne "acknowledged" him as her son when he reached Paris in 1867.

Other members of the family, however, obtained evidence that the claimant was identical with Arthur Orton (1834–1898), the son of a Wapping butcher, who had deserted a sailing vessel at Valparaiso in 1850, and had received much kindness at Melipilla in Chile from a family named Castro, whose name he had subsequently elected to bear during his sojourn in Australia. An ejectment action against the trustees of the Tichborne estates (to which the heir was the 12th baronet, Sir Henry Alfred Joseph Doughty-Tichborne, then two years old) finally came before the court of common pleas on May 11, 1871.

During a trial that lasted over 100 days over 100 persons swore to the claimant's identity, the majority of them—and they were drawn from every class—being evidently sincere in their belief in his cause. But the evidence of the Tichbornes finally convinced the jury, who declared that they wanted no further evidence. Orton was arrested on a charge of perjury and was brought to trial at bar before Chief Justice Cockburn in 1873.

The indiscretion of his counsel, Edward Kenealy, the testimony of his former sweetheart, and Kenealy's refusal to put the Orton sisters in the box, proved conclusive to the jury, who, on the 188th day of the trial, found that the claimant was Arthur Orton. Found guilty of perjury on two counts, he was sentenced on Feb. 28, 1874 to 14 years' penal servitude.

Orton died in obscure lodgings in Marylebone on April 2, 1898 (T. S.)

See J. Brown, *The Tichborne Case compared with previous impostures* (1874).

TICINO, a wedge-shaped Swiss canton, driven into Italy. Its northern boundary runs along the Lepontine-Adula alps, and its southern tip reaches beyond Lago di Lugano almost to Como. Historically, it represents early Swiss conquests from the duchy of Milan (see SWITZERLAND: *Hzstory*) loosely amalgamated to form one of the six cantons admitted to the Confederation in 1803. It is inhabited by Italian-speaking Catholics (see below). Its dominant physical features are the three river systems occupying steep-sided valleys which extend from a mountain frontier and drain southwards to Lago Maggiore. The most important system is the river Ticino, which rises in the canton southwest of St Gotthard, flows tomards that mass through the Val Bedretto, and then swings round at Airolo to a southeast course through Valle Leventina; near Biasca it receives the left-bank Brenno from the Val Blenio; the combined stream flows through the wide, low valley—the Riviera—until slightly above Bellinzona. where it receives another large left-bank affluent which has draihed the southeast slopes of the Adula group and reaches the Ticino via the Valle Mesolcina; the main stream curves again below the junction and enters the lake from the east. The Ticino receives no important right-bank tributaries. and the western part of the canton is drained largely by the Maggia and by its numerous right-bank tributaries, which receive torrent water from the western frontier. Between the Ticino and the Maggia is the Valle Verzasca.

The remainder of the canton lies south-southeast of this and consists of a triangular fragment of broken hill country, with a complicated drainage reaching the irregularly shaped Lago di Lugano.

Its total area is 1,085 sq.mi., of which approximately three-quarters are reckoned as "productive" (forests covering about 275 sq mi.). while of the remainder 28 6 sq.mi. consists of lakes. chiefly parts of Maggiore and Lugano; 13 sq.mi are occupied by glaciers. The canton is fifth in point of size, but only the much larger Valais and Vaud exceed its vine-growing area. The highest points are the Basódino (10,738 ft.), near the western border, southeast of the source of the Ticino, and the Rheinwaldhorn (11.161 ft.) in the Adula alps.

The amount of lowland is small, and occurs only in the lower river valleys and near the lakes. The lowest commune (669 ft.) is Vira (Locarno) on Lago Maggiore.

The main St Gotthard railway traverses the canton for about 75 mi. from Airolo, at the southern mouth of the tunnel, via Valle Leventina. Bellinzona, Lugano to beyond Mendrisio. Locarno is connected with this line; another follows the eastern shore of Lago Maggiore, and light railways ascend Valle Maggia to Bignasco, Valle Blenio to Acquarossa, and Valle Mesolcina to Mesocco; the latter two are electric railways. Mountain railways for the ascent of Monte S Salvatore (2.992 ft) from Lugano, and of Monte Generoso (5,584 ft.) from Capolago, have also been constructed in the extreme south of the canton.

In 1950 the population was 175,055 and in 1930 it was 159,223, of whom 145.347 were Italian-speaking, 11,662 German-speaking, and 1.278 French-speaking. The highest commune, Bosco-Vallem, near the western border and reached by the V. di Campo, had many German-speaking inhabitants, the result of an early movement eastward from Valais. There were in all 145,859 Catholics, 8,178 Protestants and 239 Jews.

In 1888 the diocese of Lugano (since joined to Basle) was created to replace the former purely Italian control over the canton by the dioceses of Milan and Como. Bellinzona (pop., [1950] 12.062) was the permanent political capital after 1881; formerly Lugano (pop., [1950] 18.122) and Lccarno (pop., [1950] 7,767) alternated with it at six-year intervals. Mendrisio (pop., [1950] 4.602) is the only other large settlement.

The canton has 261 communes and eight administrative districts; its constitution dates back to 1830, but the later political disturbances which characterize the canton have caused, and still cause, considerable modifications. The legislature (Gran *consiglio*) is composed of 65 members elected (since 1892) in the proportion of one to every 1,500 of the Swiss inhabitants. The executive (*Consiglio* di stato) of five members, is elected directly by the people. Both bodies hold office for four years. Any 5,000 electors have the right (facultative referendum) of claiming a popular vote as to bills passed by the legislature, while the same number of electors have the right of "initiative" in legislative matters, though 7,000 signatures are required in case of a proposal to revise the cantonal constitution.

History. — The canton is made up of all the permanent conquests (with one or two trifling exceptions) made by different members of the Swiss confederation south of the main chain of the Alps.

From an historical point of view Italian Switzerland falls into three groups: (1) the Val Leventina conquered by Uri in 1440 (previously held from 1403 to 1422); (2) Bellinzona (previously held from 1419 to 1422); the Riviera and the Val Blenio, all won in 1500 from the duke of Milan by men from Uri, Schwyz and Nidwalden, and confirmed by Louis XII of France in 1503; (3) Locarno, Val Maggia, Lugano and Mendrisio, seized in 1512 by the Confederates when fighting for the Holy League against France, ruled by the 12 members then in the league, and confirmed by Francis I in the treaty of 1516. These districts were governed by bailiffs holding office two years and purchasing it from the members of the league; each member of group 3 sent annually an envoy, who conjointly constituted the supreme appeal in all matters.

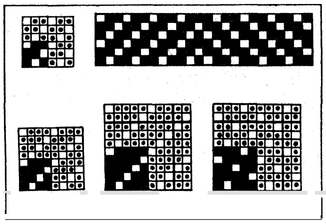
This government was very harsh and is one of the darkest pages in Swiss history. Vet only one open revolt is recorded—that of the Val Leventina against Uri in 1755. In 1803 all these districts were formed into one canton — Ticino — which became a full member of the Swiss confederation. After 1830 the local history of the canton was disturbed by friction between the Radical and Ultramontane parties.

TICINO RIVER (Ger. TESSIN, anc. TICINUS), of Switzerland and north Italy, which gives its name to the Swiss canton of Ticino (*q.v.*), and gave it in classical times to the town of Ticinum (Pavia). It rises at the foot of the Gries pass to the west of Airolo; from Airolo to the Lago Maggiore its valley bears the name of Val Leventina, and is followed as far as Bellinzona by the St. Gotthard road and railway. It flows through Lago Maggiore, leaving it at its south end at Sesto Calende, and thence flows south-southeast into the Po, which it joins a little way south of Pavia.

TICKELL, THOMAS (1686–1740), English poet and man of letters, the son of a clergyman, was born at Bridekirk near Carlisle in 1686. In 1715 Tickell brought out a translation of the first book of the Iliad contemporaneously with Pope's version. Addison's reported description of Tickell's version as the "best that ever was in any language" roused the anger of Pope, who assumed that Addison himself was the author, or had at any rate the principal share in the work. Addison gave Tickell instructions to collect his works, which were printed in 1721 under Tickell's editorship.

In 1724 Tickell was appointed secretary to the lords justices of Ireland — a post which he retained until his death, which took place at Bath on April 23, 1740.

TICKING. A strong linen, cotton or union fabric usually woven in stripes of colour; blue and red with white being the most common. The name is derived from a word "tick," common in various forms to many languages, signifying a case or sheath. Its original use was to enclose feathers, flocks or the like for beddings, but its use has been extended to include the covering for mattresses, and for awnings and tents. In some qualities it is also used as a foundation for embroidery.



VARIOUS TYPES OF TICKING

Top left, ordinary three-leaf twill; top right, "Arrow head" twill; left bottom and centre, four- and five-thread straight twills; right bottom, five-thread steen twill

White, gray or brownish warp threads are usually flax. while the coloured threads are often cotton. The weft is flax or tow. The warps of many of the cheaper kinds are made entirely of cotton, and jute is used for weft in the cheapest grades.

A feather tick should be made of fine flax yarns set closely! and there should also be a large number of weft threads per inch.

TICKLE GRASS (*Agrostis hiemalis*), a North American grass, called also hair grass and rough bent, found widely throughout the continent and in various districts occurring in weedlike abundance. The name is applied also to the somewhat similar witch grass (*Panicum capillare*), a common North American weed with hairlike flowering branches, and to some other grasses. At maturity the fruiting panicle breaks away and is blown about as a tumbleweed (*q.v.*).

TICKNOR, GEORGE (1791–1871), U.S. author and educator, was born in Boston, Mass., Aug. 1, 1791. He was educated at home by his father until at the age of 14 he entered Dartmouth college, Hanover. N.H.. as a junior, graduating two years later. In 1813 he was admitted to the bar, but soon decided against the legal profession as a life work. From 1815 to 1819 he studied in Europe, returning to the U.S. in the latter year to become Smith professor of French and Spanish languages and literatures. and professor of belles-lettres at Harvard. During his 16 years at Harvard, Ticknor was responsible for notable improvements in the university curriculum. In his own department. he introduced the study of contemporary writers, particularly in the romance languages, the language and literature curriculum having previously been confined almost exclusively to the classics. He was the first to suggest that Harvard be organized on departmental lines, a suggestion that was adopted a few years later during Charles William Eliot's presidency. From 1835 to 1838 Ticknor traveled in Europe, returning to work on his monumental History of *Spanish* Literature, which was published in three volumes in 1849, the first comprehensive study of Spanish literature. Ticknor was a founder of the Boston Public library and on his death left to it his large and valuable collection of books on Spanish literature. He was the author of a number of other works, of which the chief was a biography (1864) of William H. Prescott, the historian. Ticknor died in Boston, Jan. 26, 1871.

TICKNOR, WILLIAM DAVIS (1810–1864), U.S. publisher, head of one of the leading publishing houses of his time, was born in Lebanon, N.H., Aug. 6, 1810. Educated in the village school, at the age of 17 he went to Boston, where he spent several years as a clerk in the brokerage office of his uncle. and as a bank teller. In 1832 he entered the publishing business as a partner of John Allen, who retired the next year, leaving the business to Ticknor.

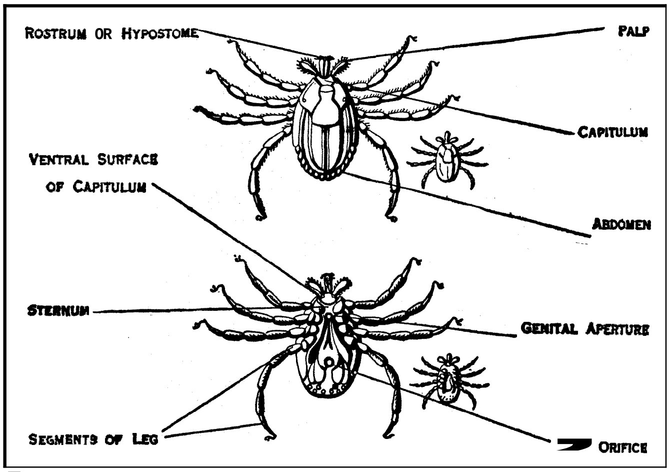
The company operated under various names during Ticknor's lifetime, eventually becoming Ticknor and Fields, when James T. Fields (*q.v.*) became his partner. The firm published the Atlantic

Monthly and the *North American Review* in addition to the works of such writers as Hawthorne, Emerson. Thoreau, Whittier. Longfellow, Holmes, Lowell. Browning. Tennyson and De Quincey.

Ticknor was a public-spirited man and a publisher of high integrity. In a day when piracy was rampant throughout the publishing business he consistently paid foreign authors for the American rights to their writings, and his example was instrumental in persuading other publishers in both England and the United States to do the same. He had a wide acquaintance among New England literary men and was a habitué of Boston's Old Corner bookstore, a rendezvous for writers. His most celebrated friend-was that with Nathaniel Hawthorne, which began in 1850. He often accompanied Hawthorne on travels and managed his business affairs. Ticknor died in Boston on April 10, 1864.

See Caroline Ticknor, *Hawthorne and His Publisher* (1913).

TICKS, the name for Acari of the order Arachnida (*q.v.*), of the families Ixodidae and Argasidae. They have on the head a median probe, armed with recurved teeth, which projects forwards. Ticks are of relatively large size, female specimens of some species measuring half an inch or more in length when distended after being gorged with blood. The mouth parts consist of two small retractile mandibles, a pair of short palpi and the toothed probe or hypostome. By means of the hypostome ticks pierce the skin and adhere to the host whose blood they



THE TICK (HYALOMMA AEGYPTUM), SEEN FROM THE DORSAL (ABOVE) AND VENTRAL (BELOW) SIDES. SHOWING THE PIERCING MOUTH PARTS (ROSTRUM) AND HOOKED LIMBS BY WHICH IT GRASPS ITS HOST

suck. In the Argasidae the palpi are simple; there is no sucker beneath the claws and there is only a slight difference between the sexes. In the Ixodidae the second and third segments of the palpi form a sheath for the hypostome; there is a sucker beneath the claws and the males have the dorsal integument continuously chitinized, whereas in the females only its anterior portion bears a chitinous plate. Both families contain pathogenic species. *Ornithodoros moubata,* belonging to the Argasidae, is widely distributed in tropical Africa from Uganda in the north to the Transvaal in the south. It is the carrier of the spirochaete of relapsing fever in man. An allied species, *O. turicata,* occurs in Mexico and Texas, where it is a pest to mankind and to poultry. *Argas miniatus* is the carrier of the spirochaete causing spirillosis in fowls in Rio de Janeiro and New South Wales. Among the Ixodidae several forms are injurious to man and domestic animals. *Dermacentor venustus* is the carrier of the human disease known as Rocky Mountain spotted fever. *Dermacentor reticulatus,* widely distributed in Europe, Asia and America, infects dogs with the hematozoon causing biliary fever. The same disease results in South Africa from the bite of *Haemaphysalis leachi. Amblyomma hebraeum,* the bont tick of the Cape Colonists, infects sheep with the sporozoon causing heartwater sickness, and in Europe sheep are inoculated with the same disease by *Rhipicephalus bursa.* The coast fever in cattle in South Africa is conveyed by *Rhipicephalus appendiculatus* and *R. simus. Margaropus annulatus* is the carrier of the germ causing the cattle disease known as Texas or xed water fever in America, South Africa and Australia. With one or two exceptions, no species of tick is confined to a particular host, and reptiles are infested as well as mammals. The bite of some ticks may produce a peculiar tick paralysis which disappears with the removal of the tick.

TICONDEROGA, a village in the township of Ticonderoga, Essex county, N.Y., U.S., on the outlet of Lake George, 100 mi. N.E. by rail of Albany. The settlement of the region was begun soon after the close of the French and Indian War and the township of Ticonderoga was set apart from the township of Crown Point in 1804. The village of Ticonderoga was incorporated in 1889. The name is a corruption of an Indian word said to mean "place between two lakes." The water from Lake George falls there about 222 ft., providing water power, and among the manufactures are paper pulp, fine grade paper and graphite. The population in the early 1960s was about 3.600.

Commanding a portage on the line of water communication between Canada and the English colonies, Ticonderoga was a place of considerable strategic importance during the French and Indian War. On an eminence overlooking the present village and Lake Champlain the French began building a fort of earth and timber in 1755 and called it Ft. Carillon. In 1758, uhen the marquis de Montcalm had gone to Quebec to oppose James Wolfe and a force of only 400 men was left at Ticonderoga, Lord Amherst with 11,000 men invested it, and on July 26 the garrison blew up and abandoned the fortifications. The fort was renamed Ticonderoga.

During the American Revolution, on May 10, 1775, a small expedition under Ethan Allen captured the fort by ruse instead of costly assault, securing large military stores. When the American expedition against Canada was driven back from Quebec they garrisoned Ticonderoga so strongly that the British commander, Carleton, shrank from attacking it. In 1777, however, Burgoyne's counter invasion from Canada arrived before the fort and occupied the precipitous Sugar Loaf hill which commanded the fort. The garrison, already reduced in numbers and supplies, felt compelled to evacuate it and on July 6 the British occupied it. Burgoyne, pressing onward to the Hudson, was driven to surrender at Saratoga in October; Ticonderoga was abandoned by the British immediately after this disaster, but was reoccupied by them in 1780. After the war it was allowed to fall into ruins but has been restored.

TICUNAN, a small group of tribes of South American Indians, constituting an independent linguistic stock. The Ticunas and their related tribes lived in western Brazil, on the lower Yavary river and on the main Amazon for some distance below the junction of the two streams.

TIDAL POWER. The idea of utilizing the rise and fall of the tides for power purposes has long attracted the attention of inventors, and many ingenious schemes have been suggested. So far, however, the only practicable method is based on the use of one or more tidal basins, separated from the sea by dams or barrages, and of hydraulic turbines through which the water is passed on its way between basin and sea or between one basin and another.

Types **of** Schemes.—Briefly outlined the more promising of the schemes of tidal power development are as follows:—

(a) A single tidal basin is used, divided from the sea by a dam in which are placed the turbines. The basin is filled through sluices during the rising tide. At high tide these are closed. When the tide has fallen through about one-half its range, the turbine gates are opened and the turbines operate on a more or less constant head until low tide or slightly after. If A be the surface area of the basin in square feet; if H ft. be the tidal range; if a constant working head of h ft. be adopted; and if the turbines operate until low tide; the volume of water used during the falling tide will be $A\ (H-h)$ cu.ft., and the energy available in the water will be

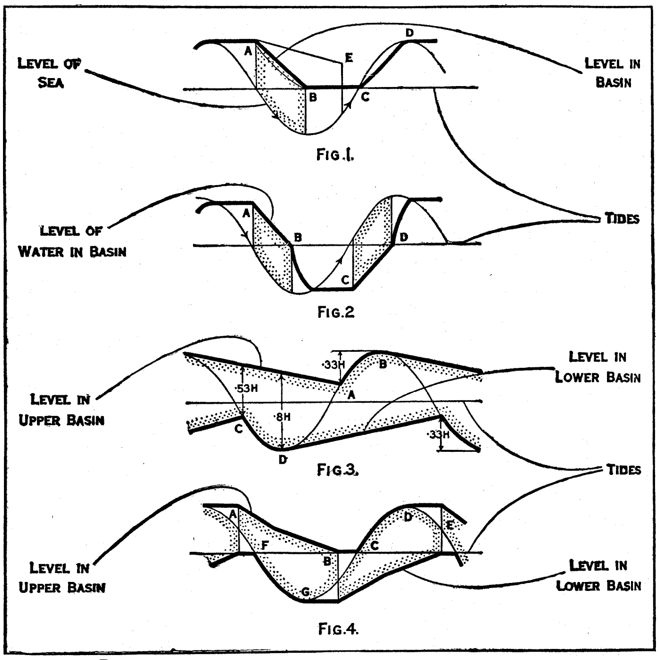
$$64A\ (H-h)\times h,\ \text{ft.lb. per tide.}$$

This expression is a maximum when $h=H\div 2$, that is, when the working head is one-half the tidal range, and then equals 16 AH^2 foot-pounds.

If A is in square miles, and if the efficiency of the turbines is 75%, the output in h.-p.-hours per tide is given by

$$\frac{0\cdot75\times64(5280)^2AH^2}{4\times33000\times60}=169AH^2.$$

The cycle of operations is shown in fig. 1 where AB denotes the working period and CD the period of replenishment of the basin. The sine curve represents the level of the sea outside the basin. Owing to the great variation in the rate of efflux of the water, in this constant-head method of operation, the power out-



PLAN OF SCHEMES FOR TIDAL POWER DEVELOPMENT

Fig. 1.—Single tidal basin, divided from sea by a dam containing turbines operating only during ebb tide. Fig. 2.—Single tidal basin, with turbines operating on rising and falling tides. Fig. 3.—Two tidal basins with turbines in dividing walls. Fig. 4.—Two tidal basins with turbines installed in walls dividing sea from each basin. The heavy lines show the water level in the basin at any instant, and the light lines show the sea level at the same instant. The shaded areas represent the working heads when the turbines operate

put varies very largely during the falling tide. This variation may be reduced considerably by allowing the turbines to operate on a more or less constant fall of level in the basin as shown by the straight full line AB. By this method of operation the necessary turbine capacity for a given output may be greatly reduced. By extending the working period beyond low tide, as indicated by the light line AE, a greater amount of energy may be developed per tide and the idle period is diminished, but at the expense of an appreciably greater variatior in head. The most efficient combination of working period and of working heads can only be determined by detailed examination of the particular site, and with a knowledge of the exact form of the tidal curve.

(*b*) A single tidal basin is used, with the turbines operating on both rising and falling tides. The cycle of operations is indicated in fig. 2. The working period per complete tide now extends from A to B and from C to D. Slightly before low water, at B, the basin is emptied through sluice gates, and at D, a little before high water, the basin is filled through the sluice gates. With a working head equal to one-half the tidal range, the period of operation is approximately 60% greater than in system *(a)* with operation down to low tide, and the work done is some 60% greater.

(c) Two basins of approximately equal areas are used, with turbines in the dividing wall. Each basin communicates with the sea through suitable sluice gates. In one of'these basins called the upper, the water level is never allowed to fall below one-third of the tidal range, while in the lower basin the level is not allowed to rise above one-third of the tidal range. The working head then varies from 0·53 H to 0.80 H, with a mean of approximately 0·66 H, and operation is continuous as indicated in fig. 3 which shows the cycle of operations. Between A and B, the upper basin is filled from the sea through appropriate sluice gates, and the lower basin discharges into the sea from C to D. For a given total basin area and a given tidal range the output is only about one-half that obtained in system *(a)* and one-third that obtained in system (b), so that except where the physical configuration of the site is particularly favourable the cost per h.p. is likely to prove very high.

(d) Two tidal basins of approximately equal areas are used. Turbines are installed in the walls dividing the sea from each basin. Fig. 4 shows the cycle of operations. From A to B the upper basin discharges through its turbines into the sea. From B to E the sea enters the lower basin through its turbines. The upper basin is filled from the sea through its sluice gates between C and D, and the lower basin is emptied through its sluice gates from F to G. The head varies from 0·25 H to 0·62 H, and the output is some 25% greater than in system *(c)* but the number of turbines required is much greater.

It is possible to arrange in each of these systems that the head shall be maintained constant during any one working period, but since this means that the working head is then limited to the minimum obtaining during that period, a loss of energy is involved, with a great additional cost of construction and complication in manipulation and with little compensating advantage. For any scheme of development involving the use of a tidal estuary of such types as are found in the Severn or Dee, the cost of any of the multiple basin systems would appear to put them definitely out of court. A scheme involving operation only on a falling tide has the disadvantage that the output is only about 60% of the output theoretically possible with double-way operation. On the other hand the output per unit of turbine capacity is sensibly the same, while it enables a much more efficient type of turbine setting to be used, and halves the number of sluice gates.

The Severn Scheme.—Up to 1928 no tidal scheme of any magnitude had been constructed. The possibilities of such an installation on the estuary of the Severn are, however, now under consideration by a committee appointed by the British Government. This would consist of a single tidal basin of about 25sq.m. in area formed by a barrage probably in the neighbourhood of Sudbury, along with a storage reservoir some 500ft. above sea-level and about 5m. away above the Wye valley. It is estimated that the scheme would be capable of developing some 500,000h.p. over a 10-hour working day throughout the year.

Fundy Bay Scheme.—Two schemes, each of the two-basin type, have been suggested for utilizing the tides in the Bay of Fundy (*q.v.*). From one of these, at Passamaquoddy Bay, where the average spring tidal range is 23·2 ft., it is estimated that from 500,000 to 700,000 h.p. can be generated. The other, which is a smaller but relatively less costly scheme, is at Hopewell at the head of Shepody Bay, and utilizes the estuaries of the Petitcodiac and Memramcook rivers as the two tidal basins. Here the spring tidal range is 45.5 ft. and the available power about 200,000 h.p. Both schemes have been before the New Brunswick Government.

Aber-Vrach Scheme.—A combined tidal and river-power scheme to which the French Government is giving financial assistance is projected at Aber-Vrach on the coast of Brittany. For the tidal station a barrage 490ft. long is to be constructed in the estuary. Four turbines connected to synchronous generators are to be installed, each capable of developing 1,200h.p., under the maximum head available at spring tides. The turbines are to operate both on the ebb and flow tides. This station will work in conjunction with an auxiliary water-power station some 4m. away on the river Diouris. The river is to be dammed at this point, forming a fresh water reservoir from which turbines having a maximum capacity of 2,700h.p. are to be supplied. Electrically driven centrifugal pumps of a capacity of 3,200h.p. will also be installed.

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(A. H. G.)

TIDES. The word tide refers to those alternating relative motions of the matter of a planet, satellite or star, which are attributed to the gravitational actions of external bodies. Such motions are known to occur in all three principal divisions of the earth. The alternating slight changes of shape of the solid body or lithosphere of the earth attributed to the gravitational action of the moon and sun are known as bodily tides. Similarly, there are the atmospheric tides in the atmosphere. and the familiar ordinary ocean tides in the hydrosphere. A still wider use of the word is based on descriptive instead of on causal and astronomical ideas, and takes for its criterion that the motions in question have certain features in common with ocean tides. This extension includes those long waves of the sea, or tsunamis, which are sometimes caused by earthquakes, as well as effects on the sea of variable atmospheric pressure and wind, known as meteorological tides. In this article tides will be considered under these sections:

I. Ordinary Tides
II. History of the Study of Tides
III. Tide-Generating Forces
IV. Dynamics of Ocean Tides
V. Actual Tides in the Ocean
VI. Tidal Analysis and Prediction
VII. Xonastronomical Variations of Sea Level
VIII. Miscellaneous Tidal Problems
IX. Atmospheric Tides
X. Bodily Tides

I. ORDINARY TIDES

General Description of Phenomena.— At most seaside places the water reaches its highest level approximately twice a day, the average interval between two successive high waters being 12 hr. 25 min., though this interval varies considerably during the course of a week. At certain places in the East Indian seas two successive high waters are separated by an interval of 12 hr., while at certain places in the China sea the interval is often more than 24 hr. At places on the shores of the oceans the time taken by the tide in rising is about equal to the time taken in falling on the same day, but in estuaries the tide usually rises more quickly than it falls. At certain places, such as Southampton, Eng., the high waters are often doubled; *i.e.*, the water reaches a maximum height, falls a little and then rises to a maximum again. At other places the low waters are often doubled. As one goes along any stretch of coast the time of high water generally becomes progressively earlier or later, while as one goes up an estuary from the sea the time of high water always becomes progressively later.

At most places, on the average, a high water is about as much above the mean level of the sea as the succeeding low water is below it. The difference in level between successive high and low waters is called the range of tide. The range of tide at any place may vary much from day to day. At most places it reaches a maximum once a fortnight, and a minimum at times midway between two successive maxima. At London bridge the greatest range of the fortnight has an average value of 21 ft. while the least range of the fortnight has an average value of 15 ft. At the head of the Bay of Fundy the range of tide reaches 50 ft. while at certain islands of the Pacific and over most of the Mediterranean the range never exceeds 2 ft. At many places outside the Atlantic the heights of two successive high or low waters are markedly different, a phenomenon known as the diurnal inequality.

At a place in a strait or narrow sea the tidal current usually flows for about 6 hr. 12 min. in one direction, and then for about the same time in the opposite direction. At the reversal of such a current there is the state of rest usually called slack water. In estuaries the current generally flows downstream for a greater length of time than it flows upstream. At a place in the open sea the direction of the current often takes all points of the compass, making the complete revolution in the tidal period. During this period there are usually two times of maximum current and two intermediate times of minimum current. The times of maximum current are separated by about half the tidal period and the directions of maximum current are nearly directly opposite; similarly for the two minimum currents. There is no fixed general relation between the time of high water and the time of maximum current. If the current flows directly in and out of a bay it will reach its inward maximum nearly a quarter period before high water at the head of the bay, so that slack water is simultaneous with high water. On the other hand, in an estuary the current continues to flow upstream for some considerable time after high water and to run downstream similarly after low water. When the current is directed toward land or up an estuary it is called the flood current; when it runs away from land or down an estuary it is called the ebb current. The speeds of tidal currents vary greatly from place to place; *e.g.*, in the Seymour Narrows, British Columbia, the maximum current reaches ten knots; in the North sea it rarely exceeds one. At some distance up certain rivers—as, for example, where the Colorado river meets the tide—a wave ten or more feet high travels up the river almost like a wall of water. This phenomenon is called a bore. Near a headland separating two bays there is sometimes a swift current termed a race.

Relation to Motions of Moon and Sun.—The times of high water bear an intimate relation to the positions of the moon and sun. The period of 12 hr. 25 min. is half that of the moon's apparent revolution around the earth. The length of time between the moon's crossing of the meridian of a place and the next high water at that place is known as the lunitidal interval, or the high-water interval, for the place. Similarly, the length of time between the moon's crossing of the meridian and the next low water is called the low-water interval. For Philadelphia, the lunitidal average is 1 hr. 30 min. In many cases, including those of British waters, the chief variation in the lunitidal interval is associated with the phase of the moon. The average value of the lunitidal interval on the days of new and full moon is known as the establishment of the port. For London bridge the establishment of the port is 1 hr. 58 min.

The range of tide may be similarly correlated. In British waters it reaches its maximum a day or so after new and full moon and its minimum a day or so after the quarters. In these circumstances the maximum tides are known as spring tides and the minimum tides as neap tides. About the time of the equinoxes spring tides are generally larger and about the time of the solstices they are generally smaller than usual. The average interval between new or full moon and the next following spring tide is known as the age of the tide at the place in question. At certain places in Canadian waters the chief variation in the range of tide is associated with the varying distance of the moon from the earth, while at others it is associated with the varying declination of the moon. The diurnal inequality is always associated with the declination of the moon or sun. But the most complete correlation between the tides and astronomical variables is provided by the harmonic methods.

II. HISTORY OF THE STUDY OF TIDES

The writings of various Chinese, Arabic and Icelandic authors show that they paid some attention to the tides, but the theories advanced are fantastic. The writings of the classical authors of antiquity contain but a few references to the tides, for the Greeks and Romans lived on the shores of an almost tideless sea.

Johann Kepler in the early 17th century recognized the tendency of the water of the ocean to move toward the sun and moon, but Galileo's explanation referred the phenomenon to the rotation and orbitalmotions of the earth. It was Isaac Newton who, in his *Principia* of 1687, laid the foundation of the modern theory of the tides when he brought his generalization of universal gravitation to bear on the subject. He gave a geometrical construction for the tide-generating force, and calculated the magnitude of the solar equilibrium tide. He considered a canal encircling the earth and applied to each particle of water the laws which he had deduced for a satellite. He accounted for many of the general properties of the tides, such as the phenomenon of springs and neaps, priming and lagging, diurnal and elliptic inequalities. The only important factor which he did not mention is the dynamical effect of the earth's rotation. Newton's work was continued by D. Bernoulli, L. Euler and C. Maclaurin who adopted not only the theory of gravitation but also Newton's method of the superposition of two ellipsoids. In 1746 Jean le Rond d'Alembert wrote a paper on atmospheric tides, but this work, like Maclaurin's, is chiefly remarkable for the importance of collateral points.

The theory of the tidal movements of an ocean was almost untouched when in 1773 Pierre Laplace first undertook the subject. In his *Mécanique célèste* he formulated the equation of continuity and the dynamical equations, and applied them to the case of an ocean covering the whole earth. He also established the principle of forced oscillations, which forms the foundation of the harmonic methods.

The connection between the tides and the movements of the moon and sun is so obvious that tidal predictions founded on empirical methods were regularly made and published long before mathematicians had devoted their attention to them. The best example of this kind of tide table was afforded by Moses Holden's tables for Liverpool, based on 20 years of personal observation by a harbour master named William Hutchinson. The use of automatic tide gauges appears to have begun about 1830.

The work of J. Lubbock, Sr. and W. Whewell is chiefly remarkable for the co-ordination and analysis of data at various ports, and for the construction of tide tables. Sir George Airy in his *Tides and Waves* of 1842 studied profoundly the theory of tidal motions in canals, while in 1847 and 1857 F. W. Beechy published the results of a survey of tidal currents over the Irish sea, the English channel and the North sea.

About 1863 W. Thomson (afterward Lord Kelvin) became interested in the problems presented by earth tides. In 1866 he took up the analysis of ordinary tidal observations and established the harmonic methods, which quickly developed. He introduced the rotation of the earth into the tidal dynamics of small seas, and in 1872 he designed a tide-predicting machine.

In 1874 W. Ferrel, of the U.S. coast and geodetic survey, published his *Tidal Researches* which included a harmonic development of the generating potential, and from the same year A. W. Baird, of the survey of India, organized a service of observation and harmonic analysis for Indian tides. In 1882 G. H. Darwin took up harmonic analysis and produced memoirs which for a long time formed the standard manual on the subject, and about this time J. E. Pillsbury. of the U.S. coast survey, began the observations of currents by means of current meters. In 1885 C. Borgen introduced new ideas into the methods of harmonic analysis. Between 1870 and 1890 F. A. Forel made illuminating studies of the seiches of Lake Geneva. Switz., and about 1890 M. Margules investigated the dynamics of atmospheric tides.

From 1894 to 1907 R. A. Harris, of the U.S. coast survey, published his *Manual* of *Tides*. This work contained charts showing cotidal lines for the whole world, based on theories and hypotheses the leading feature of which was the principle of resonance. It was assumed that in each ocean there exists regions capable of free oscillation with a period near one of the principal tidal periods, and that the nature of these free oscillations may be calculated approximately, without allowing for the earth's rotation or the interaction with neighbouring regions.

After 1900 a number of Scandinavian oceanographers, notably V. W. Ekman, O. Pettersson and J. P. Jacobsen, invented current meters and L. Favé observed tidal elevations in the open sea by means of his self-registering instrument.

In 1912 A. Blondel applied the narrow sea theory. through the principle of least action, to the tides of the Red sea. From 1913 to 1920 R. Sterneck and A. Defant developed the narrow sea theory with special reference to the Adriatic sea. Defant applied this theory to the Red sea, the Persian gulf, the English channel and the Irish sea.

After about 1895 the dynamical theory of tides and seiches was much advanced by the mathematicians: H. Lamb, H. H Hough, J. H. Poincaré. Lord Rayleigh. G. Chrystal. E. Fichot. G. R. Goldsbrough. G. I. Taylor, Harold Jeffreys, G. Bertrand, S. Goldstein and J. Proudman; while between 1920 and the latter 1950s much was done on the analysis of observations by A. T. Doodson, K. Hessen and H. Rauschelbach.

III. TIDEGENERATING FORCES

Dynamics of Earth-Moon System.—The moon attracts every particle of the earth and ocean. By the law of gravitation the force acting on any particle is directed toward the moon's centre, and is jointly proportional to the masses of the particle and of the moon, and inversely proportional to the square of the distance between the particle and the moon's centre. If one can imagine the earth and ocean subdivided into a number of small particles of equal mass, then the average, both as to direction and intensity, of the forces acting on these particles, is equal to the force acting on that particle which is at the earth's centre. If every particle of the earth and ocean were being urged by equal and parallel forces there would be no cause for relative motion between the ocean and the earth. Hence it is the departure of the force acting on any particle from the average which constitutes the tide-generating force. Now it is obvious that on the side of the earth toward the moon the departure from the average is a small force directed toward the moon; and on the side of the earth away from the moon the departure is a small force directed away from the moon. All around the sides of the earth along a great circle perpendicular to the line joining the moon and earth the departure is a force directed inward toward the earth's centre. Thus it can be seen that the tidal forces tend to pull the water toward and away from the moon, and to depress the water at right angles to that direction. In fig. 1 this distribution of forces is illustrated graphically. The relative magnitudes of the forces are given by the numbers on the figure, M being in the direction of the moon. The

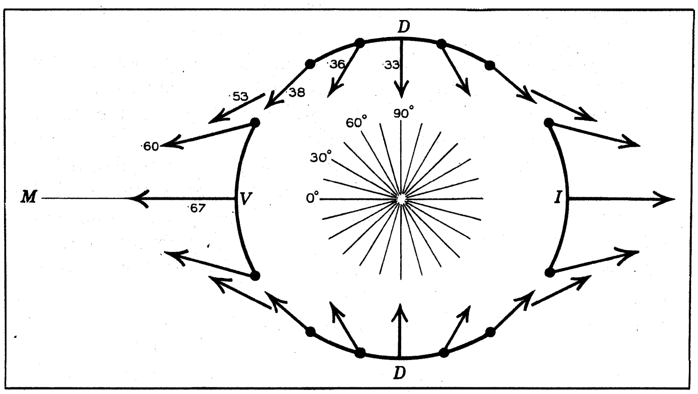


FIG. 1.— TIDE-GENERATING FORCE

separate attractions of the moon at the earth's centre and at a point on the earth's surface are each inversely proportional to the square of the moon's distance, so that the difference between the two, which gives the tide-generating force, is approximately inversely proportional to the cube of the moon's distance.

The vertical component of the tide-generating force coincides in direction with the gravitational force of the earth itself, and thus acts as a slight modification of weight. This component does not tend to alter the position of equilibrium which the water would take up in the absence of any disturbance from an extraterrestrial body. The effective tide-generating forces, therefore, are the horizontal components of those indicated in fig. 1.

Equilibrium Form of the Tide.—For many purposes it is convenient to specify the distribution of the tide-generating forces at any instant by reference to a fictitious tide. If a completely rigid earth were completely covered by a layer of ocean, and if the tide-generating forces were to remain constant, there would be an invariable elevation of water at each point of the ocean surface and no tidal currents. If the distribution of forces were the same as that of the actual tide-generating forces at any instant, then the consequential elevation of water might be used as a specification of these forces. This distribution of fictitious tidal elevation is known as the equilibrium form of the tide. It is a real and accurate specification of the actual tide-generating forces throughout the earth's body as well as on its surface. When the equilibrium form is stated for every instant there is a complete specification of these forces, and henceforth the terms equilibrium tide and tide-generating force will be used interchangeably.

In this equilibrium form the inclination, to the horizontal, of the surface of the water would be always such that the consequential pressure gradient would everywhere balance the tide-generating force. It is therefore clear that the surface of the water would slope upward from DD toward the points V and I, the water being raised by a maximum amount at V and I and depressed by a maximum amount along the great circle through DD. The surface of the water would be nearly that of an ellipsoid of revolution. The volume of this ellipsoid would be the same as that enclosed by the surface of the undisturbed ocean. Owing to the motion of the moon relative to the earth, the tidal ellipsoid moves over the earth so that V is always directly under the moon and I always directly opposite, while owing to the varying distance of the moon the equilibrium ellipsoid changes slightly in shape.

The tide-generating forces attributable to the sun's gravitation may be similarly specified. The sun's mass is nearly 27,000,000 times the moon's mass and the sun's distance is about 390 times the moon's distance from the earth. Consequently the sun's tide-generating forces are to those of the moon in the ratio of 27,000,000 to 390^3; *i.e.,* .460 or $\frac{1}{2.17}$. This means that at corresponding points of the two ellipsoids representing the lunar and solar equilibrium forms the tidal elevations on the average will be in the ratio of 2.17 to 1.

Harmonic Constituents.— The study of tides on the earth has been greatly facilitated by the fact that the tidal motions, whether in the atmosphere, hydrosphere or lithosphere, are to a high degree of precision linear with respect to the tide-generating forces which cause them. This will be demonstrated later in the case of the dynamics of the ocean tide.

The significance of this linearity is that the tide-generating force can be considered as the sum of a number of constituents, the actual tide being the sum of the individual effects that each constituent would produce separately in the absence of all the others. As an example, the lunar and solar tides can be considered separately. The tide which would be produced under the combined action of moon and sun would be almost exactly what one would obtain by adding the separate contributions of moon and sun. In other words, there is little interaction between the lunar and solar tides.

The tide-generating forces can be expressed quite precisely by a finite series of harmonic terms, and in practice it has been found. that about 30 terms generally give an adequate approximation. Furthermore, linear systems have the important property that their response is harmonic when they are acted upon by a force varying harmonically with time, the response having the same frequency as the force. The above two facts form the basis of the harmonic development of the tide, which has been in use since the time of Pierre S. Laplace.

Each term of the series representing the elevation of the equilibrium tide at some particular point on the earth's surface will be of the form H $\cos(nt-\epsilon)$, where t is time, H is the amplitude. n is the frequency or speed (commonly expressed in units of degrees per hour), and ϵ is the epoch. For any given constituent the speed is constant, while the amplitude and epoch are constant in time but may depend on geographical location. The harmonic terms representing actual tides will be of the same form. In the case of the ocean tides H may represent the amplitude of the elevation of the water surface relative to the ground, for bodily tides H may represent the amplitude of a component of particle displacement, and for atmospheric tides H may represent the amplitude of a pressure fluctuation.

Let us now consider the effect of only one tide-generating body, such as the moon. As demonstrated in the previous section, the tide-generating forces of the moon can be specified completely by the shape and geographic orientation of the tidal ellipsoid, whose major axis is oriented along the line joining the centres of earth and moon. Now for the moment, let us consider what would happen if the moon remained at a constant distance from the earth and revolved about the earth in the equatorial plane with constant speed. An observer located at any given geographical position would experience two maxima and two minima of the equilibrium tide each lunar day. The amplitude would be a maximum at the equator and would decrease with increasing northern or southern latitude to a value of zero at the poles. The rise and fall of the equilibrium tide would be approximately harmonic with speed $n = 2(\gamma-\sigma)$ where γ denotes the angular speed of the earth's rotation relative to the stars and σ the mean speed of revolution of the moon about the earth; and the equilibrium tide would be represented very closely by a single harmonic constituent. Since the moon's speed of revolution is small compared to the earth's speed of rotation. the period of this constituent is approximately semidiurnal. The moon's varying declination (angular distance from equatorial plane), varying apparent angular speed of revolution about the earth and varying distance from the earth cause many modifications in this simplified example.

If the moon revolved about the earth with constant angular speed at some constant declination not equal to zero, one of the two poles of the equilibrium tidal ellipsoid would be always in the northern hemisphere, and the other in the southern hemisphere. The two equilibrium high waters that a point on earth not on the equator would experience as the earth rotates would therefore not be equal, and the introduction of a new constituent of speed $n = \gamma-\sigma$, approximately diurnal, would be required. This effect is known as the diurnal inequality. The variable declination of the moon results from the moon's motion in an orbit whose plane intersects the earth's equatorial plane at an angle I. The lunar declination thus passes through a monthly cycle but since both north and south declinations have essentially the same effect; *i.e.,* that of decreasing the semidiurnal and increasing the diurnal contribution, the two constituents suffer a fortnightly modulation. Strictly speaking, such constituents cannot be considered harmonic, as there is implied in this term the invariability of amplitude. speed and epoch. These constituents can, however, be expressed precisely as the sum of a number of strictly harmonic terms, and more will be said about this point later.

The distance from earth to moon varies throughout a monthly cycle giving rise to a monthly modulation in the amplitude of the equilibrium tide. The maxima occur when the moon is at perigee, the point on the moon's orbit which is closest to the earth; the minima occur at apogee, when the moon is farthest from the earth. The time between successive lunar passages through perigee or apogee is the so-called anomalistic month, whose average length is 27.jj (mean solar) days. The speed of revolution of the moon about the earth varies inversely with the moon's distance according to Kepler's laws (see ORBIT). This causes the epoch of the equilibrium tide to vary according to the moon's position in its orbit, resulting in an apparent increase of period at apogee as compared to perigee. This monthly modulation of both amplitude and epoch of the equilibrium tide can again be expressed by a sum of purely harmonic constituents.

There are many other irregularities in the moon's motion, all of which can be expressed by the addition of more harmonic terms insofar as their effect on the equilibrium tide is concerned. The plane of the lunar orbit does not remain with constant orientation in space. Its movement is best described by the motion of the moon's nodes, which are the two points on the lunar orbit which lie on the plane of the ecliptic. Relative to the stars these nodes describe a westward motion known as the regression of the nodes, completing a cycle in about 19 years. Also, the major axis of the lunar orbit revolves eastward relative to the stars, completing a cycle in about nine years.

The solar effects are in every way analogous to the corresponding lunar effects.

Species.—In the above section it was seen that many cases arise where a constituent having a slow periodic variation of amplitude or epoch can be represented by the sum of two or more purely harmonic constituents. The speeds of these purely harmonic constituents will belong to the series, $n \pm \omega$, $n \pm 2\omega$, $n \pm 3\omega$, . . . , where n is the speed of the original constituent and ω is the speed corresponding to the fundamental period of variation of its amplitude or epoch. If ω is small as compared to n, the speeds of the purely harmonic constituents will cluster closely about the speed of the original constituent. In the case of the actual tide, most of the constituents are approximately semidiurnal, diurnal, or of a longer (fortnightly or longer) period of variation, and their amplitudes and epochs pass through a much longer period of variation than that of the actual constituent. As a result, the periods of purely harmonic constituents representing the equilibrium tide are clustered about 12 hr., 24 hr. and much longer periods, offering a logical basis for classification of the tidal constituents.

The scheme of .classification shown in Table I was developed by

George Darwin in 1882 and has been adopted by most of the world's tidal authorities. Within any given species the coefficient is proportional to the equilibrium amplitude, and this proportionality holds roughly between constituents belonging to different species. The subscript on the symbol designating the constituent refers to the species to which it belongs. The long-period constituents have no subscript, the diurnal species have the subscript "one," the semidiurnal species the subscript "two." In addition to the constituents tabulated in Table I, there are terdiurnal, 4-diurnal, etc., constituents in the equilibrium tide, but these are of much lower amplitude and are not of much importance on earth.

TABLE I.—Tidal Constituents

Symbol	Name	Speed	Speed in °/hr.	Coefficient
Long-period species				
Mf	Lunar fortnightly	2σ	1.098	.078
Ssa	Solar semiannual	2η	.082	.036
—	Nineteen yearly	N	.002	.033
Diurnal species				
K_1	Lunisolar	γ	15.041	.265
O_1	Larger lunar	$\gamma-2\sigma$	13.943	
P_1	Larger solar	$\gamma-2\eta$	14.959	
Semidiurnal species				
M_2	Principal lunar	$2(\gamma-\sigma)$	28.984	.454
S_2	Principal solar	$2(\gamma-\eta)$	30.000	.211
N_2	Larger lunar elliptic	$2\gamma-3\sigma+w$	28.440	.088
Kz	Lunisolar	2γ	30.082	.058

The earth's speed of rotation γ is the largest of all the parameters contributing to the speeds of the tidal constituents, and its numerical multiplier in the expression for the speed determines to which species a given constituent belongs. The other quantities in Table I which determine the speeds of the constituents are the mean motion of the moon σ, the mean motion of the sun η, the speed of revolution of the moon's nodes N, and the mean motion of the lunar perigee w. These quantities have a smaller effect and merely determine the period of the constituent within its species. It can therefore be said that the fundamental reason that the tidal constituents clump conveniently into species is that the day is much shorter than either the month or the year.

The equilibrium constituents of any given species all have the same geographical form. The long-period constituents are characterized by a standing wave symmetrical about the earth's axis. The polar regions oscillate in phase with each other and are 180° out of phase with the equilibrium tide in low latitudes. The two nodal lines lie along latitudes 35.26° north and south. The diurnal constituents have the form of a progressive wave rotating relative to the earth about its axis from east to west. At any given instant there are two maxima at opposite extremes of the earth and two minima similarly situated, all lying at latitudes 45° north and south on a great circle passing through the earth's poles. The amplitude of the diurnal equilibrium tide vanishes at equator and poles. The semidiurnal constituents also have the form of a progressive wave rotating about the earth from east to west. There are two maxima on the equator at opposite extremes of the earth and two minima also on the equator 90° from the maxima. The amplitude of the semidiurnal equilibrium tide is maximum at the equator and dies off with increasing latitude, vanishing at the poles.

Description of the Constituents.— Let us consider first the semidiurnal constituents. As can be seen from the value of their coefficients tabulated in Table I, the principal lunar constituent M_2 is the most important. The other semidiurnal constituents "beat" against M_2 giving rise to a modulation, the speed of which is equal to the difference of speeds of the two constituents. That is, the period of the modulation is the synodic period of the two constituents. The next strongest semidiurnal constituent is the principal solar constituent S_2, which beats against M_2 causing the fortnightly spring-neap modulation. Next comes the larger lunar elliptic constituent N_2 which beats with M_2 causing a monthly modulation of the latter associated with the variable distance between earth and moon resulting from the ellipticity of the moon's orbit. The lunisolar constituent K_2 actually represents the sum of two constituents, one of lunar the other of solar origin, which cannot be separated from each other by analysis because their periods are equal. The lunar part of this constituent beats with M_2 giving rise to a fortnightly modulation associated with the variable declination of the moon. It will be recalled that the amplitude of the semidiurnal part of the tide is at a maximum when the tide-generating body has zero declination. In similar fashion the solar part of the K_2 constituent beats with S_2 causing a semiannual modulation of this principal solar constituent which is associated with the variable declination of the sun.

The lunisolar diurnal constituent K_1 is similarly composed of a lunar and a solar contribution. The lunar part of this constituent beats with the larger lunar constituent O_1 causing a fortnightly modulation associated with the variable declination of the moon. It will be recalled that the amplitude of the diurnal part of the equilibrium tide vanishes when the tide-generating body has zero declination. Similarly, the solar part of the constituent K_1 beats with the larger solar constituent P_1 causing a semiannual modulation associated with the variable declination of the sun.

The constituents Mf and Ssa result from the variable declination of the tide-generating body and are at a maximum when this body is at zero declination. The lunar fortnightly constituent Mf thus reflects the variable declination of the moon, and the solar semiannual constituent Ssa similarly reflects the variable declination of the sun. In addition there is a small 19-year constituent which arises from the 19-year cycle in the regression of the moon's nodes, as well as many other minor long-period constituents.

In Darwin's harmonic development the tide-generating forces (the equilibrium tide) are not analyzed into strictly harmonic constituents; that is, the amplitudes and epochs of Darwin's constituents are not truly constant. They exhibit the 19-year cycle of the regression of the moon's nodes. However, during any one year the amplitudes and epochs vary so slightly that the constituents can be considered as true harmonic terms without incurring appreciable error. The nodal variation in amplitude is accounted for by taking the constituent coefficients c (those values tabulated in Table I) to be constant in time while denoting the true amplitude of the equilibrium constituents by the quantity fc where f is called the node factor and is the quantity which varies. The mean value of f is taken to be unity, and its values have been tabulated for each year for all important constituents. The value of f changes so slowly that it is adequate to take its mean value during any given year in place of its true value at any instant during that year.

In 1921 Doodson developed the equilibrium tide into a series of harmonic constituents whose amplitudes and epochs do not exhibit this 19-year cycle, and therefore do not need the artifice of node factors. For this reason it may be said that Doodson's development is more nearly perfectly harmonic than is Darwin's. Even though Doodson's development does not attempt to take into account such long-term variations as secular changes in the distance between earth, moon and sun, and geologic changes in sea level, it is doubtful that a more elaborate development will ever be needed for tidal work.

IV. DYNAMICS OF OCEAN TIDES

Equations of Motion.— The dynamical theory of tides introduced by Laplace in the 18th century has given much insight into the problem of tides in the ocean. The following assumptions and approximations are commonly introduced:

(1) The water is assumed to be homogeneous; (2) vertical displacements and velocities of the water particles are assumed small in comparison to the horizontal displacements and velocities; (3) the water pressure at any point in the water is given adequately by the hydrostatic law; *i.e.,* it is equal to the head of water above the given point; (4) all dissipative forces are neglected; and (5) the ocean basins are assumed rigid (as if there were no bodily tide), and the gravitational potential of the tidally displaced masses is neglected.

If assumptions (1) and (3) are valid it can readily be shown that the tidal currents at any locality are uniform with depth.

Take a to denote the radius of the earth and g the acceleration of gravity at its surface. Position on the earth's surface will be designated by the longitude ϕ and the co-latitude (angular distance from the north pole to the point under consideration) θ. Let h denote the depth of the ocean at any point, so that h is a function of θ and ϕ. Also, let ζ denote the elevation of the free surface at any point of the ocean above its mean level, and u and v the southward and eastward components of the tidal current, so that these three quantities are functions of θ, ϕ as well as of the time t. Then the equation of continuity, which expresses the condition that the volume of any mass of water must remain constant, may be written in the form

$$\frac{1}{5\sin\theta}\left\{\frac{\partial}{\partial\theta}(hu\sin\theta)+\frac{a}{\partial\phi}(hv)\right\}+\frac{\partial\zeta}{\partial t}=0 \qquad (1)$$

provided that the elevation of the sea surface is everywhere small compared to the depth of water. If this is not the case then h must be replaced by h $+\zeta$ in equation (1). This equation may be derived by expressing the condition that the net rate at which volume of water enters the sides of a vertical column is equal to the rate of increase of the volume at the top of this column by virtue of the time rate of increase of the elevation of the sea surface ζ. Along a coast line the condition that the tidal current have no component perpendicular to the coast must be satisfied.

The equations of motion are formed by equating the southward and eastward components of acceleration of the water particles to the sum of all the forces per unit mass acting on the water in the southward and eastward directions, respectively. The acceleration consists of three parts: the local acceleration; the field acceleration; and the Coriolis acceleration resulting from the earth's rotation. As an example, the southward component of acceleration is equal to

$$\frac{\partial u}{\partial t}+\frac{u}{a}\,\frac{\partial u}{\partial\theta}+\frac{v}{a\sin\theta}\,\frac{\partial u}{\partial\phi}-\frac{v^2}{a}\cot\theta-2\omega v\cos\theta$$

where the first term represents the local, the second, third and fourth terms combined represent the field, and the last term the Coriolis accelerations, respectively. Here ω represents the angular speed of the earth's rotation. At this point an additional assumption shown to be valid for tidal motion in true oceanic regions is introduced: that the field acceleration is negligible as compared to the local acceleration. In accordance with the foregoing approximations, the only forces acting on the water are the tide-generating forces and those attributable to the pressure gradient resulting from the slope of the sea surface. The southward and eastward components of the pressure gradient are given by

$$\frac{g\rho}{a}\,\frac{\partial\zeta}{\partial\theta},\quad \frac{g\rho}{a\sin\theta}\,\frac{\partial\zeta}{\partial\phi},$$

p being the water density, and the southward and eastward components of the tide-generating force are given by

$$\frac{g\rho}{a}\,\frac{\partial\bar{\zeta}}{dB'}\quad \frac{g\rho}{o\sin\theta}\,\frac{\partial\bar{\zeta}}{a+'}$$

where $\bar{\zeta}$ represents the elevation of the equilibrium tide. This quantity is a function of θ, ϕ and t and is assumed known as it can be deduced from knowledge of the relative movements of the earth, moon and sun. The equations of motion can then be written in the form

$$\begin{aligned}\frac{\partial u}{\partial t}-2\omega v\cos\theta&=-\frac{g}{a}\,\frac{\partial}{\partial\theta}(\zeta-\bar{\zeta})\\ \frac{\partial v}{\partial t}+2\omega u\cos\theta&=-\frac{g}{a\sin\theta}\,\frac{\partial}{\partial\phi}(\zeta-\bar{\zeta}).\end{aligned}\qquad (2)$$

The equations (1) and (2) serve to determine completely, at least in theory, the tidal currents and elevation over the entire oceans and for all times, given a complete description of the tide-generating forces and the boundaries of the ocean basins. In practice, however, such a general solution has never been obtained owing to the complicated nature of the distribution of sea and land masses and the varying depth of water. For this reason tidal research has been based primarily on observations and general principles (such as linearity, etc.) derived from theory.

It may be noted that these equations are linear in u, v, ζ and $\bar{\zeta}$ with the result that the tide-generating forces may be separated into several constituents, the sum of whose effects are exactly equivalent to the effect produced by the sum total of all the tide-generating constituents. Indeed, as has already been pointed out, this is the basis of the harmonic development of the tide. Let us review under what conditions the ocean tide is truly linear and under what conditions this linearity breaks down. Unless the elevation of the sea surface above its mean position is always small as compared to the mean depth h, equation (1) becomes nonlinear. Similarly, if the field acceleration becomes so large it is no longer negligible as compared to the local acceleration equations (2) become nonlinear. This is most likely to occur in regions of large tidal currents with a large spatial rate of change (current shear). Nonlinear dissipative forces may be another source of nonlinearity. All these effects are quite small in the vast oceanic regions but tend to become larger in regions of shallow water and in the vicinity of the coast line, and consequently are referred to as shallow-water tides.

As to the other approximations, that of neglecting all dissipative mechanisms (4) is not a very good one, but more will be said about this point in the section on Tidal *Friction.* The bodily tides of the earth invalidate to a certain extent assumption (5) by virtue of a small variable movement of the sea floor and of the earth's own gravitational field. If ζ_e designates the variable elevation of the sea floor above its mean position, equation (1) will stand unaltered if we take ζ to denote the elevation of the sea surface relative to the sea floor. but in the formulas for pressure gradients ζ must be replaced by $\zeta+\zeta_e$. The disturbance in the gravitational forces brought about by the displacements of water and solid earth must be accounted for by adding a term $\bar{\zeta}_e$ to $\bar{\zeta}$. Inhomogeneities in the sea water have been neglected according to assumption (1), but may have a more important effect in tidal motions than has been anticipated. At any given time of the year a large part of the ocean is covered by a nearly homogeneous layer of light, warm water 50 to zoo m. thick. Such stratification of the sea water may influence the vertical structure of the tidal current with resulting deviations from their generally assumed uniformity with depth. Bottom friction will also introduce vertical shear in the tidal current.

Suppose now that we consider the ocean's response to one harmonic constituent of the equilibrium tide. If we take a long-period constituent, $\bar{\zeta}$ will have the form of a standing wave over the entire earth. A constituent of any other species will have the form of a progressive wave rotating relative to the earth about its axis in the westward direction. Such progressive waves can, however, be expressed as the sum of two standing waves separated in longitude by go°, and separated in time also by go°. In any case, therefore, it will suffice to express $\bar{\zeta}$ in the form

$$\bar{\zeta}=H_0\cos n(t-\tau_0)$$

where n and τ_0 are absolute constants and H is a function of geographic position but independent of time. The actual response of the ocean will then be the sum of a number of solutions to such inputs. The solutions for the tidal elevation ζ and current u, v from equations (1) and (2) will have the form

$$\zeta=H\cos n(t-\tau)$$
$$u=U\cos n(t-\tau_1),\qquad v=V\cos n(t-\tau_2),$$

where H, U, V, τ, τ_1, and τ_2 are all functions of geographical position only. While it is not feasible to actually determine these functions analytically, if their values are determined for a certain location on the earth by appropriate analysis of tidal observations. the response to the constituent under consideration could be predicted for all time. In the case of the tidal elevation, wherever Hand τ have been determined for all important constituents, the tidal elevations there can be predicted for any time. It may be remarked that at a given place H_0 and H are generally quite different; *i.e.*, the true tide bears little resemblance to the equilibrium tide.

Nonlinear Distortion (Shallow-Water Tides).—At places where the tidal elevation becomes appreciable as compared to the water depth, or other nonlinear effects occur, the principle of superposition breaks down. One might think that under these circumstances the concept of harmonic constituents would be completely useless, but it has been found possible to retain this concept provided that additional constituents, the so-called shallow-water tides, be included. The regions where this phenomenon occurs are generally confined to rivers, estuaries and shallow gulfs. The shallow-water constituents are not produced by the direct action of the tide-generating forces, but by the distortion attributable to shoal water of already existing tidal constituents which have been formed in the ocean. In fact, if the region of distortion is small enough (as it usually is), the tide-generating forces have little or no direct effect on the shallow-water tide.

It is no longer correct to consider separately the reactions to individual equilibrium constituents, but let us take the simple example of only one equilibrium constituent in order to gain insight into the problem. The response of a nonlinear system to the harmonic forcing constituent will not be harmonic, but at least it will be periodic having the same period as the forcing or primary constituent. If $2\pi/\sigma$ is the period of the primary constituent, it is well known from the theory of Fourier series that a periodic function of this period can be expressed as the sum of purely harmonic terms having speeds a, za, 3a, etc. Extending this idea to the actual situation one should expect to find shallow-water constituents having periods of one-half, one-third, etc., of those of the major tidal constituents. The shallow-water constituents obtained in this way are called overtides because of their analogy to overtones in acoustics. The same symbol is used to designate these overtides as is used to designate the equilibrium constituent which gives rise to them, and again the subscript designates the species (approximate number of periods in a day) to which the overtide belongs. For example the constituent M_2 gives rise to the series of overtides M_4, M_6, etc., and K_1 gives rise to the overtides K_2, K_3, etc. In some cases an overtide will have exactly the same period as another equilibrium constituent and it will be impossible to separate the two by harmonic analysis. For example, K_2 represents the lunisolar semidiurnal constituent, but an overtide of exactly the same period as K_2 is produced by nonlinear distortion of the lunisolar diurnal constituent K_1. In this and in similar cases the symbol K_2 (referring to the actual tide) represents the combined effect of both the linear reaction to the equilibrium constituent K_2 and the overtide.

The theory of progressive shallow-water waves of finite height has been used to estimate the relationship between the amplitudes of the overtides and primary tide. The amplitude of the nth overtide is found to be proportional to the nth power of the amplitude of its primary at any given place, as the amplitude of the primary varies in time. For example, if the range of the semidiurnal tide is twice as great during the spring tides as during the neap tides, the range of the quarter-diurnal overtide resulting from distortion of the semidiurnal tide will be approximately four times as great during the spring tides as during the neaps. The range of the 6-diurnal overtides will be eight times as great during the spring tides, etc. As to the 19-year nodal variation in amplitude, the node factors f of the overtides bear a relation to those of the primary as illustrated in the following example in the case of the overtides of the constituent M_2:

$$f(M_4) = [f(M_2)]^2, \quad f(M_6) = [f(M_2)]^3, \text{ etc.}$$

The above relations seem to be confirmed fairly well in most cases by tidal observations in spite of the fact that assumptions in the theory from which they have been derived are far from fulfilled. For example, in many regions where overtides are important, such as some rivers and estuaries, the tidal wave has more nearly the form of a standing wave than that of a progressive wave, but the theory for standing shallow-water waves of finite height has not been adequately developed. Also, the nonlinear effects caused by one constituent cannot, strictly speaking, be superimposed on those caused by another.

The nonlinear interaction between two or more primary constituents can be accounted for by the inclusion of compound constituents. In the case of two interacting primary constituents having speeds σ_1, and σ_2, a series of compound constituents will result, having speeds $\sigma_1 \pm \sigma_2$, $\sigma_1 \pm 2\sigma_2$, $2\sigma_1 \pm \sigma_2$, etc., including all possible combinations of the form $a\sigma_1 \pm b\sigma_2$, a and b being integers. The relationship of the amplitudes of the compound constituents to those of their primaries has been approximated by assuming that the system responds like a power-law filter; *i.e.*, like a system whose output is equal to a polynomial function of the input. In this way the relative importance of the compound constituents of any given species as well as the dependence of their node factors on those of the primary constituents can be evaluated. No general conclusions can be drawn concerning the relative importance of two compound constituents belonging to different species.

TABLE 11.—Shallow-Water Constituents

Symbol	Speed	Speed in °/hr.	Node factor
$2SM_2$	$2\gamma+2\sigma-4\eta$	31.016	$[f(M_2)]^2$
MNS_2	$2\gamma-5\sigma+2\eta+\varpi$	27.424	$f(M_2)$
MK_3	$3\gamma-2\sigma$	44.025	$f(M_2)f(K_1)$
MK_3	$3\gamma-4\sigma$	42.927	$[f(M_2)]^2f(K_1)$
M_4	$4\gamma-4\sigma$	57.968	$[f(M_2)]^2$
MS_4	$4\gamma-2\sigma-2\eta$	58.984	$f(M_2)$

Table II includes the more important shallow-water constituents, both overtides and compound constituents. In the table, only two of each of the semidiurnal, terdiurnal and 4-diurnal shallow-water constituents are given for illustration, but there are ports for which many others would be needed to give an accurate representation of the tide. In fact for some ports the number of these constituents that would be needed is so high that the harmonic method becomes impractical. It may be noted that the two terdiurnal constituents listed in Table II are given the same symbol. Actually there is some confusion as to the designation of the compound constituents. The designations given in Table II are based on the nomenclature used by the United States coast and geodetic survey.

V. ACTUAL TIDES IN THE OCEAN

Progressive Tides in Canals.—Let us consider a long narrow canal, open at both ends, along which a tidal wave is progressing. In accordance with the uell-known properties of progressive waves, the water particle velocity at the crests of the wave will be in the same direction as that of the propagation of the wave form, while the water particle velocity at the troughs will be in the opposite direction.

Now, the rotation of the earth tends to deflect any particle in motion to the right (in a horizontal plane in the northern hemisphere) relative to the earth with an acceleration proportional to the speed of the particle. This is the so-called Coriolis acceleration that was discussed above. In order to balance this Coriolis acceleration the water surface at the crest must slope upward to the right (in the northern hemisphere), if one is facing in the direction of propagation of the wave. Similarly, the water surface at the trough must slope upward toward the left. Therefore, the crests are higher and the troughs lower along the right coast of the canal, and at any point on the right coast of the canal there will be a higher range of the tide than for a point situated on the left coast.

The above considerations are substantiated by tidal observations in the English channel and Irish sea. The tidal wave progresses eastward through the English channel passing out through the Straits of Dover into the North sea. The tidal range is greater on the French coast (the right side) than on the English coast. In the Irish sea, the tidal wave progresses northward, and the tidal range is greater on the English and Welsh coasts (again the right side) than on the Irish coast.

Tides in Adjacent Seas.—If the region under consideration is small enough the tide within it is influenced predominately by the tide immediately outside the region and not appreciably by the direct action of the tide-generating forces. It is on the water of the great oceans that the gravitational forces of the moon and sun generate the greater part of the tide, while the tides in the small seas bordering the oceans can be considered as free waves.

A great deal of theoretical work has been done on the tides of adjacent seas, but invariably it is necessary to approximate the sea by some simple geometric shape. Nevertheless, many satisfactory explanations of the actual tide in small bodies of water have been obtained.

The theory of free long waves states that a tidal wave in a narrow canal of constant depth is propagated with a velocity of $\sqrt{gh}$, the wave length being given by the expression $T\sqrt{gh}$, where g is the acceleration of gravity, h is the water depth and T is the period of the wave (time interval between successive high waters). In the case of the tide, T will have approximately the value of 12 hr. for the semidiurnal tide, or 24 hr. for the diurnal tide.

Let us neglect, for the time being, the effect of the earth's rotation and consider a tidal basin of constant depth having rectangular shape with one end closed and the other end in communication with the ocean. Only motions parallel to the length of the basin will be considered. The tides within the basin are influenced by the boundary conditions (1) that the elevation at the mouth of the basin is at any instant the same as that in the ocean immediately exterior to the basin; and (2) that the horizontal orbital motion at the closed end vanishes. The situation is analogous to the acoustical problem of stationary oscillations within an organ pipe open at one end. The spatial distribution of amplitude of the oscillation is characterized by the positions of nodes, or places where there is no tidal oscillation of the water surface, or no pressure oscillation in the case of the organ pipe, and of antinodes or places where the oscillations attain their maximum amplitude. A standing wave in the pipe has an antinode at the closed end, while one quarter of a wave length away there is a node, and so forth, with nodes and antinodes alternating along the length of the pipe with a quarter of a wave length between them. If the open end is at or near a node the oscillation within the pipe attains a magnitude much greater than that outside the mouth of the pipe, and resonance is said to occur. Thus, in the case of the rectangular tidal basin, resonance would occur if the length L of the basin had any of the values

$$\tfrac{1}{4}T\sqrt{gh},\ \tfrac{3}{4}T\sqrt{gh},\ \tfrac{5}{4}T\sqrt{gh},\ \text{etc.}$$

Or, for a given length, resonance would occur if the period of oscillation had any of the values

$$\frac{4L}{\sqrt{gh}},\ \frac{4L}{3\sqrt{gh}},\ \frac{4L}{5\sqrt{gh}},\ \text{etc.}$$

but in actual practice the successive values have diminishing importance and usually only the first one, corresponding to a quarter wave-length basin, is considered. This is called the gravest free mode.

If the basin is less than a quarter of a wave length long, the entire basin oscillates with the same phase. If the length of the basin is between a quarter wave length and a half wave length, there is one nodal line and the oscillation at the head of the basin is 180° out of phase with that at the mouth. Every node line represents a phase change of 180°.

The Bay of Fundy on the east coast of North America has the greatest tidal range of any place on earth. and this fact is attributed to a resonance phenomenon based on the foregoing considerations. The shape of the Bay of Fundy is reasonably well approximated by a rectangular basin having a length of 170 mi. and a depth of 240 ft. The above relationships indicate that such a basin would have a resonance period of approximately $11\frac{1}{2}$ hr., which is very close to that of the semidiurnal tide. It should therefore be expected that the semidiurnal tide would be greatly magnified relative to the diurnal, and this is found to be the case. At certain places at the head of the bay the spring tide attains a range of 50 ft.

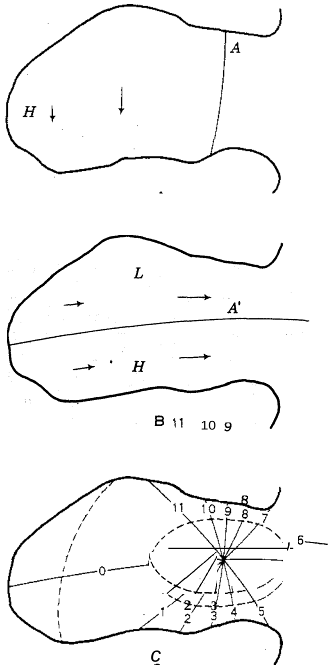


FIG. 2.— MOVEMENT OF THE TIDES IN A GULF. H INDICATES HIGH-WATER LEVEL, L LOW-WATER LEVEL. (SEE FURTHER TEXT FOR EXPLANATION.)

Elongated seas of variable depth and cross-sectional area also can be studied mathematically provided these quantities vary slowly enough along the length of the sea. Good agreement between theory and observation has been obtained for tides in the Gulf of California, the Red sea and other adjacent seas. The Gulf of California is computed to have a resonance period of approximately 25 hr., roughly that of the diurnal tide. The tide at the head of the gulf near the mouth of the Colorado river has been observed to be predominantly diurnal in character with a maximum range of approximately 20 ft. The computed variation of amplitude and phase of the M_2 constituent in the Red sea is in good agreement with the observed variation, and both theory and observations indicate the presence of a nodal line close to Port Sudan, near the mid-point of the sea's length.

To consider geostrophic effects (i.e., those resulting from the earth's rotation) it is necessary to take into account the Coriolis acceleration. Consider a standing oscillation in a gulf as shown in fig. 2A at the instant of high water at the head of the gulf. The curve A has been drawn through all points where the deviation of the water level from its mean is zero at this instant. One quarter period later the water is flowing out of the gulf. At this instant, in the absence of the Coriolis force, the elevation everywhere within the gulf would have its mean value (except for a small frictional effect), and the curve A would represent a nodal line. Actually, the elevation will be higher to the right of the outward flowing current, as is shown in fig. 2B, with the curve A' lying along points whose elevation is at the mean level. Continuity considerations show that there must have been currents flowing at the instant of high water within the gulf in order to produce the distribution of water level shown in fig, 2B. Possible directions for these currents are shown in fig. 2A.

At the intersection of the curves A and A' there will be no rise and fall of sea level, and such a point is known as an amphidromic point. Let it be assumed that the constituent under consideration

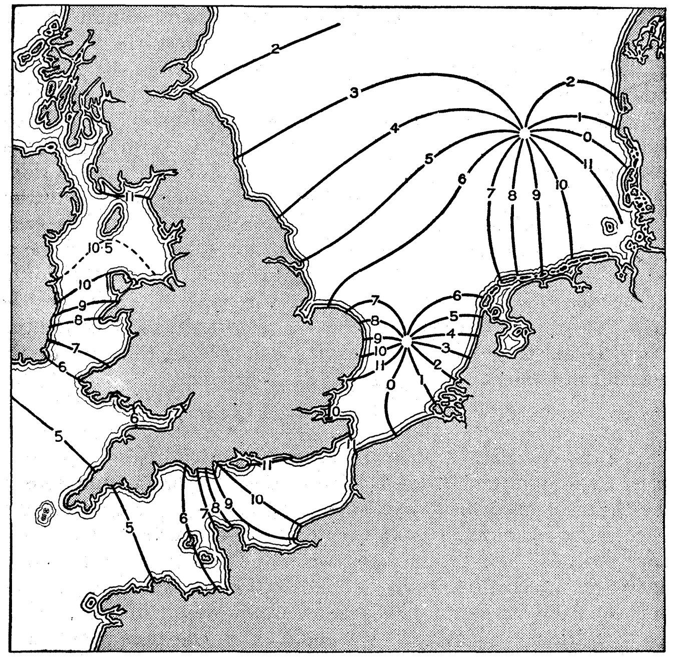
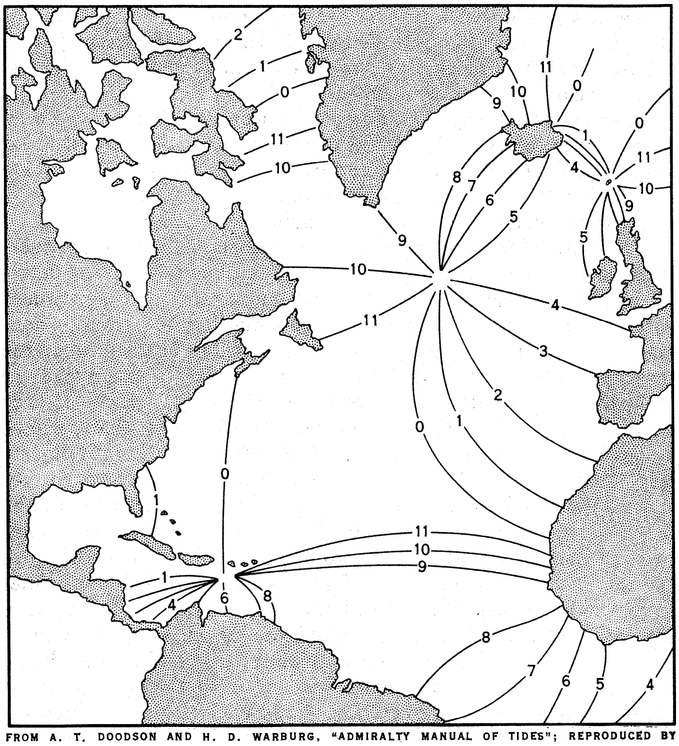


FIG. 3.— COTIDAL LINES FOR M_2 CONSTITUENT IN BRITISH SEAS. NUMBERS GIVE GREENWICH MEAN LUNAR TIME OF HIGH WATER

is a semidiurnal one, and divide its period into 12 equal time intervals called constituent hours, and let the zero constituent hour



FROM A. T. DOODSON AND H. D. WARBURG, "ADMIRALTY MANUAL OF TIDES"; REPRODUCED BY PERMISSION OF THE CONTROLLER, HER BRITANNIC MAJESTY'S STATIONERY OFFICE

FIG. 4.—COTIDAL CHART OF THE ATLANTIC OCEAN

correspond to the instant of high water within the gulf as depicted by fig. 2A. Fig. 2C then gives the curves along which high water occurs for each of the 12 constituent hours. Such curves are called cotidal lines. The hypothetical distribution of range of tide is indicated by the dashed curves, called corange lines, each of which connects points having equal range of tide. The amphidromic point, at which the tidal range is zero, lies in the centre of the concentric family of corange lines. The cotidal lines indicate the position of the crest of the tidal wave at any instant, and it is seen that this crest rotates in counterclockwise fashion (in the northern hemisphere) about the amphidromic point. Such amphidromic systems with counterclockwise movement of the tidal crest are characteristic also of the oceans and adjacent (large) bodies of water.

Geographical Distribution of the Ocean **Tide.**—Cotidal maps, such as the one described above, are useful in illustrating the distribution of tidal elevation in a body of water, but it should be kept in mind that such charts are, strictly speaking, useful only in describing a single harmonic constituent. In theory it would be necessary to have one complete cotidal map of the world's oceans for each and every tidal constituent in order to characterize completely the form of the tidal wave, or the rise and fall of water at every point in the ocean. The only constituent for which such charts have been prepared, to any extent, has been the M_2 constituent, which is somewhat representative of the other semidiurnal constituents.

Except along the boundaries of the oceans the tidal elevations are extremely difficult to measure, and what meagre knowledge we have of the geographic distribution of the tide in the whole ocean has been deduced principally by extrapolating from coastal tide stations and, where possible, making use of tidal current measurements. The equations of motion connect the tidal currents with the elevation gradients and external forces, including those of friction, and so from a knowledge of the currents and a law for the frictional forces the elevation gradients can be calculated. When the elevation is also known at a particular point, the directions of the cotidal and corange lines and also the distance apart of neighbouring members of these families of lines can be calculated. Such conditions are fulfilled for many coasts. If the elevation gradients can be calculated along a line which passes through one or more points at which the elevation is known, it is clear that the elevation can be calcuiated all along the line. In this way the semidiurnal (M_2) tide over the North and Irish seas was determined by Proudman and Doodson in 1923 (see fig. 3).

Cotidal charts for the M_2 constituent have been prepared for the oceans but they are uncertain, however, especially at large distances from the coasts and islands where tide gauge observations have been made. Tidal current determinations are rarely made in the open ocean. Another difficulty is that tide gauges are frequently located in sheltered bays or atoll lagoons where the time of high water may be delayed by as much as several hours. The cotidal chart of the Atlantic ocean shown in fig. 4 was prepared by Sterneck in 1920.

Mathematical solutions for the tide in ocean basins of simplified shapes have been obtained. Laplace in 1776 studied the dynamical problem of the semidiurnal tide in an ocean covering the entire earth and having constant depth. His solution takes into account the inertia of the water and the rotation of the earth. Some interesting aspects of this solution are summarized in Table III.

TABLE III.—*Laplace's Solution of the Dynamical Problem of the Semidiurnal Tide*

Depth (fathoms)	Ratio of elevation to equilibrium elevation at equator	Depth (fathoms)	Ratio of elevation to equilibrium elevation at equator
1,210	−7.4	4,840	11.3
2,420	−1.8	9,680	1.9

Positive values in the second column indicate that the tide at the equator is direct—that is, that high water occurs simultaneously with high water of the equilibrium tide. Negative values indicate that the tide is inverted, or 180° out of phase with the equilibrium tide. For the diurnal tide Laplace obtained the curious result that there is no tidal oscillation of elevation on this worldwide ocean of constant depth, although there are tidal currents.

Several solutions have been obtained for the special case of an ocean of constant depth bounded by two meridians. The result of one of the solutions obtained by Proudman and Doodson is shown in fig. 5, which represents a cotidal chart of the K_2 tide in an ocean of depth 14,520 ft. bounded by meridians 70° apart. The K_2 tide was selected because of mathematical simplifications, but the M_2 tide should be quite similar. Comparison of fig. 5 representing a mathematical solution with fig. 4 derived from observations discloses no striking similarities except for the general occurrence of amphidromic systems.

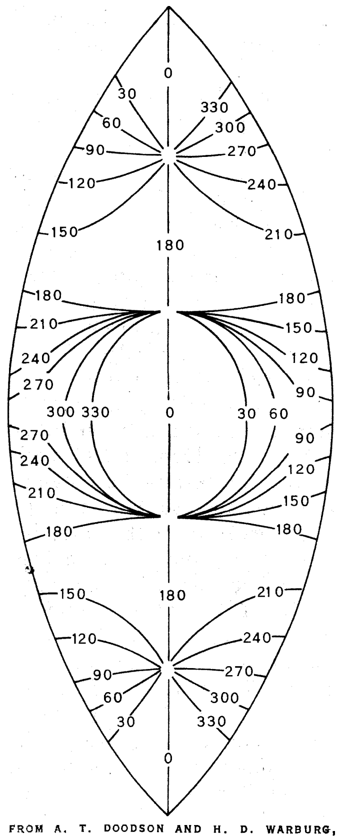


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FIG. 5.—COTIDAL CHART OF A HYPOTHETICAL OCEAN OF CONSTANT DEPTH BOUNDED BY MERIDIANS SEPARATED BY 70°

Tides in Lakes.—If all natural periods of oscillation of a completely enclosed basin are short as compared to those of the tidal constituents, the tide should be approximately at equilibrium with the tide-generating forces at all times. According to the theory of long-standing waves in a rectangular basin of constant depth, the length of the basin is equal to one-half wave length of its gravest free mode. The period of the gravest mode is given by the expression $2L/\sqrt{gh}$ where L is the length of the basin. For example, the gravest mode of a lake 20 km. long having constant depth of 40 m. will have a period of approximately $\frac{1}{2}$ hr. according to the above formula, and the tide in such a lake would therefore be determined with quite sufficient accuracy by static principles.

If the above condition is fulfilled the slope of the lake's surface is equal, at any instant, to the slope of the equilibrium tide at that location, and the actual tidal elevation at any point within the lake is determined by the condition that the total volume of water remain constant. The tide will usually differ considerably from the equilibrium tide according to these conditions, generally being considerably smaller in amplitude. For example, the maximum slope of the equilibrium tide is of the order of a metre in one-fourth the earth's circumference, 10,000 km., giving a value of 10^{-7}. For a lake whose length is 10 km. the maximum difference of elevation between its extremes will be of the order of 10×10^{-7} km. or 1 mm. The tide in small lakes is thus seen to be extremely small, and is usually overshadowed by other effects such as a variable amount of water volume related to variable runoff and evaporation, wind effects, seiches, etc.

There is no variation of tidal elevation at the centroid of the lake's surface area. If the gravest free oscillation of the lake approaches that of the semidiurnal tide, then of course the above concepts no longer are true, and a dynamical treatment of the problem is necessary. This elementary discussion has also omitted two other important effects: the yielding of the lake's bottom with the tidal deformation of the earth's body, and the potential of the tidally displaced matter of the earth (*see* section X).

VI. TIDAL ANALYSIS AND PREDICTION

Tidal Observations. — Probably the greatest achievement of tidal study is that it has been made possible to predict to a fair degree of accuracy what the sea level would be at any desired time for a great number of ports. The method used is essentially the following: The constants in the harmonic development of the tide at any place are determined by analysis of a long series of observations at that place. Knowing the values of these constants, it is possible to reconstruct or synthesize the tide for any past, present or future time. This is the harmonic method, and it can be applied to any observable tidal quantity which depends linearly on the tide-generating forces, such as the north or east components of the tidal current (not the speed or the direction of the current), the tidal variations of gravity or atmospheric pressure, etc.

The theoretical problem of the tide in the oceans has not been solved, and knowledge of the tide at any place depends on some observations having been made at the place. The prediction process may be loosely considered as one of extrapolation of the observations. It is possible that at some future time tidal theory will have been advanced sufficiently that full knowledge of the tide at a given place may be obtained theoretically without the need of previous observations at the place.

Observation of the variable elevation of the sea surface is carried out by means of an instrument called a tide gauge, which usually consists of a float and pulley system so arranged that the height of the float determines the position of a recording pen on a moving chart. The chart is made to move at constant speed by means of a clock mechanism, so that in the result one obtains a graph of the height of sea level as a function of time. Such a graph is called a marigram.

The float is usually suspended within a vertical pipe or well having a small orifice at the bottom in order that the float not be subjected to rapid erratic motions by the ocean waves. A pier piling is an ideal structure on which to fasten the tide well. The diameter of the orifice and the inner cross-sectional area of the tide well determine the frequency response of the gauge. The orifice must be small enough to insure that the ordinary high-frequency ocean waves have greatly reduced amplitude within the well, but large enough so that no appreciable lag be introduced in case of the tide. The frequency response of the tide gauge is usually arranged so that fluctuations of water level taking place over five minutes or longer are quite faithfully reproduced on the marigram, so that the gauge may be useful in recording tsunamis (seismic sea waves) and other such phenomena. The gauge is periodically levelled in with a series of bench marks located nearby on the land in order to compensate for any long-period changes in the height of the gauge as a whole that might be brought about by slow sinking of the pier on which it is fastened, etc. In this way the gauge is useful for studying extremely long-period phenomena such as the year to year variation of mean sea level.

After the marigram is obtained, the usual procedure is to read off at hourly intervals the height of sea level, and to correct these hourly tidal heights for any variation of datum that may have occurred. Vast quantities of these hourly tidal heights for many seaports are on file at the world's principal tidal agencies.

Analysis of Observations. — If a long enough series of observations has been obtained from a locality, it is possible to determine the harmonic constants for each important tidal constituent with good accuracy. The procedure for finding the harmonic constants for any one constituent will be illustrated in the case of the principal solar series, S_1, S_2, S_4, whose periods are exactly 24, 12 and 6 hr. At instants of time separated by 24 hr. each constituent of this series will have the same value. Let us assume that we have a whole year of data. If we take the average of the 365 hourly tidal heights corresponding to the zero hour of each day, the resulting value will be practically free from the effects of all the other constituents whose periods are not submultiples of 24 hr., because their phases will differ from the zero hour of one day to the zero hour of the next day. Such a constituent will sometimes have positive values on the zero hour, and another day it will have a negative value, and on the average its value will be close to zero. The constituents of the principal solar series, on the other hand, will have the same value, on the average of all the zero hours, as for the zero hour of any given day. This averaging is repeated for each of the 24 hr. of the day and in the result one obtains a complete daily cycle of the combined effect of the constituents S_1, S_2, S_4 practically free of the effects of the other constituents. The amplitudes and epochs of each of the constituents of this series can now be found by the well-known methods of harmonic analysis.

For constituents other than those of the principal solar series the averaging must be carried out in similar fashion but based on the fundamental period of the constituent under consideration instead of 24 hr. Here there is a slight complication if the data are tabulated in the form of hourly tidal heights, as the times for which the tidal values are needed do not coincide exactly with the times at which the values are tabulated. In this case it is customary to use the tabulated value in closest proximity to the time for which the value is actually needed, and it is seen that the error in time will never exceed 30 min. The small error incurred in this process can be corrected by applying an augmenting factor.

If the series of observations is short it is not possible to separate completely any given constituent from the disturbing effects of the others. However, the harmonic constants of all the constituents can be determined approximately, using the above technique, and a first order correction can then be applied. This process is called elimination.

Inference of Harmonic Constants. — It is impractical to use the method discussed above for a constituent whose amplitude is small as compared to possible errors arising from various sources. The harmonic constants of such a constituent are usually inferred from those of one of the major constituents having approximately the same period. Such inference is based on the supposition that the ocean's response to a periodic tide-generating force varies continuously and relatively slowly with the period of the force. Hence it is assumed that two equilibrium constituents whose periods are nearly equal will cause tidal constituents in the ocean at any given locality, whose amplitudes are proportional to those of the equilibrium constituents causing them.

It is best to infer harmonic constants of a given constituent X from those of one of the most important constituents whose period is as close as possible to that of X. Suppose that the constituent M_2 meets these requirements. If H represents the actual amplitude of the constituents and c their constituent coefficients (which are proportional to the amplitudes of the equilibrium constituents), the relationship

$$\frac{H\ (X)}{c\ (X)} = \frac{H\ (M_2)}{c\ (M_2)}$$

is used to relate the amplitudes of X and M_2. The epochs (intervals by which the oceanic constituents lag behind their equilibrium counterparts) can be set equal, to a first approximation, while a more refined method of estimating the epoch of constituent X is given in *Special Publication* 98, *U.S.* coast and geodetic survey. The constituent coefficients have been precisely determined from astronomic observations, and if the amplitude and epoch of M_2 have been determined from tidal observations, the amplitude and epoch of X can be calculated from the above relationships. The validity of the above relations can be checked by also evaluating the constants of X by conventional means, and it is usually found that the inference method gives fair results if the periods of the two constituents are nearly enough to being equal. It should be emphasized that the inference method can never be used to relate the constants of constituents belonging to different species.

Prediction: Tide Tables.—For many purposes it is of great importance to know in advance the times and heights of high water at a particular place on a particular day. Consequently governments and harbour authorities publish, a year or so in advance, tables giving such information for all the principal ports of the world. In a few cases tables are similarly published giving the height of water above some datum at every hour of the year, while for a certain number of navigable channels tables of the times of slack water are also issued.

The standard method of tidal prediction is the harmonic method based on the idea of harmonic constituents, and the necessary information for any particular place is provided by the process of analysis discussed above. The only theoretical results which are utilized in tidal prediction are (1) the decomposition of the entire tide-generating force as the sum of a number of harmonic equilibrium constituents; and (2) the linearity of the ocean tide. Thus, the periods of the constituents are obtained from the observed motions of earth, moon and sun, while their amplitudes and epochs are obtained from tidal observation: tidal prediction is largely an empirical science.

The process of harmonic prediction consists of the calculation of the value of each harmonic constituent for a given time, and then the addition of the values obtained for all the constituents. When this is done for every hour of a year, the computational task becomes enormous. and to obviate this special computing machines, called tide-predicting machines, have been constructed. Those in use at mid-20th century were of the analogue type and usually consisted of a series of gears or pulleys by which means the analogue addition of the constituents could be carried out. The amplitude and epoch of each constituent could be adjusted into the machine so that it could be used for any location and for any tidal quantity.

Of course. only that part of the rise and fall of the sea surface related to astronomical quantities can be predicted, and hence any individual prediction is liable to differ considerably from the actual occurrence, as will be seen below.

VII. NONASTRONOMICAL VARIATIONS OF SEA LEVEL

"Geologic" Tides.—Any change in shape of the ocean basins or in the total quantity of water in them can bring about changes of level at a given locality. Another effect, however, is to change the dynamical response of the oceans to the tide-generating forces, and we should consequently expect the tidal harmonic "constants" to change.

The geological change in sea level is quite slow as compared to that effected by the moon and sun, and is manifested by a small year to year variation in mean annual sea level. There is evidence that the average sea level over the entire earth rose by the order of 10 cm. from 1850 to 1950. This has been related to a shrinking of the ice caps of the world, particularly those over Antarctica and Greenland. About 1000 B.C., during the postglacial temperature maximum, sea level probably stood about 5 m. above its present level. At the present time there are localities where the average annual sea level is rising and others where it is falling, and this is attributed to a relative downward or upward motion of the land area in the vicinity. The horizontal extent over which these year to year sea level records appear similar gives a good indication as to the size of the portions of the earth's crust that are sinking and rising. Actually, the similarity extends over many hundreds of kilometres, indicating that masses somewhat smaller than continents are moving as a whole.

Variation of the tidal harmonic "constants" by the processes just described is probably a slow process, and it may be doubted that a detectable change would occur within tens of thousands of years. At locations where the tidal constants depend critically on the local, small-scale topography, however, this is not the case. For example, the tide up a river may depend critically on the conditions of the channel at the river's mouth. At many ports the tide has changed noticeably after the construction of port facilities, such as breakwaters, etc. In such cases the altered regime of sedimentation and erosion of sand usually plays an important part. Also, sand bars can form and disappear quite rapidly, and a semienclosed lagoon behind such a condition would experience variable tidal "constants."

Meteorologic Tides.—The principal meteorologic effects can be ascribed directly or indirectly to variations in atmospheric pressure on the sea surface, tangential stress on the sea surface exerted by the wind. heating and cooling of the sea water.

A varying atmospheric pressure acting on the oceans has the characteristic of a body force, as the pressure gradients are transmitted through the water practically simultaneously from the sea surface to the bottom. For this reason. the dynamical problem is formally equivalent to that concerned with the effect of the tide-generating forces on the oceans, and equations (1) and (2) are still valid provided that ζ is replaced by $-p_a/\rho g$, p_a being the atmospheric pressure and ρ the water density.

Under certain circumstances the dynamical response of the ocean to the atmospheric pressure disturbance can become large. If a tidal basin is subjected to a variable atmospheric pressure disturbance acting periodically with a frequency near that of one of the free modes of oscillation of the basin. the amplitude of its response will tend to increase until it is ultimately limited by frictional dissipation. The same is true in the case of a pressure disturbance travelling across the sea surface with the same velocity as that of a long free wave, or $\sqrt{gh}$. It may be noted that the depth of the open ocean is so great that storms seldom attain this critical velocity. and so suck magnifying effects are more often encountered in shallow seas.

For a longer-period fluctuation the dynamical effects are less important, and under these conditions the ocean's response is similar to that of an inverted liarometer. The sea surface is depressed approximately a centimetre for each millibar of pressure increase, and vice versa. according to the hydrostatic law

$$\zeta = -\frac{p_a}{\rho g}$$

Pressure changes of 20 millibars occurring in a few days are common at many ports. and so it may be seen that this efiect could be one of the principal sources of error in tidal predictions.

Wind blowing across the water surface exerts a horizontal stress on the water directed downwind, largely by virtue of the difference in air pressure on the lee and windward sides of the water waves generated by the same wind. An exact law for this stress as a function of wind speed has not yet been discovered, but the semi-empirical relationship

$$\tau = \gamma \rho_a v^2$$

gives a good approximation. Here τ is the wind stress, ρ_a the density of air, v the wind speed at an elevation of 15 m. above the water surface and γ is a numerical constant for which the value ,0026 gives the best fit to the empirical data.

Wind stress on the sea surface directed toward the coast has the effect of piling up water against the coast, raising the sea level. Longshore winds blowing so that the land lies to the right relative to the wind direction also tend to raise the sea level against the shore (in the northern hemisphere). owing to the effect of the earth's rotation. There are dynamic effects to be considered in both these cases as the wind is seldom so steady that static equilibrium is reached, except in small basins whose period of free oscillation is quite short.

The effect of the wind stress is enhanced by shoal water for the following reason, based on static considerations. Let us consider the balance of forces in one dimension only, say, the east-west direction The stress caused by a nest wind (blowing eastward) must be balanced by a slope of the sea surface in which its elevation increases eastnard. The horizontal pressure gradient associated with this surface slope is essentially constant with depth, so that the greater the water depth the greater is the total force exerted on a vertical water column. Therefore a given surface slope will require greater wind stress to balance it in deeper water than in the shallower water.

Meteorologic disturbances over shallow seas have given rise to disastrous storm surges, such as those that frequently inundate the coasts of the North sea and the Gulf of Mexico. These surges frequently have a roughly periodic character with periods of the order of hours, and under severe conditions their amplitude can attain several metres. The horizontal stress on the water surface due to the wind is usually more important in these surges than the normal force due to the atmospheric pressure disturbance. Such variations of sea level cannot be predicted by the same procedures used to predict the astronomic tide, but considerable success has been obtained in understanding the dynamics of these phenomena, and in a few cases fairly accurate predictions have been made, particularly in the North sea area by a method developed by R. H. Corkan and Proudman. In order to make such a prediction the wind and pressure fields must be knonn (or estimated with sufficient accuracy) over the water surface of the region and for all necessary instants of time preceding the hour to be predicted.

Variations of water density. caused either by local heating and cooling or by advection of water of different properties, give rise to variations in elevation of the sea surface. If the change in surface level is calculated on the basis that the total water mass in a vertical column remains constant, the hydrostatic law shows that the relative height of the surface is

$$\zeta_s = -\frac{1}{g}\int_{p_a}^{p_b} \alpha\, dp$$

where a is the specific volume of the water, and p_b is the bottom pressure. The quantity ζ_s has been called the steric height. and is quite closely related to the dynamic height used in dynamical oceanography. Changes of the order of 10 cm. taking place from one month to the next are common in the ocean. In the seasonal variation of sea level the changes of density of the water are much more important than the long-period tidal constituents.

VIII. MISCELLANEOUS TIDAL PROBLEMS

Tidal Friction. — The effect of dissipation of the ocean tide by friction has so far been left out of the discussion. but it is known to be an important factor. Harold Jeffreys has calculated that if the tide-generating forces of the moon and sun could be suddenly turned off, half the tidal energy in the earth's oceans would be dissipated in approximately a day. This dissipation is known to occur practically entirely by the friction of tidal currents against the bottom of a few shallow seas of the earth, and against the long shorelines of the continents and islands. It is a curious fact that probably half of the entire tidal dissipation of energy in the ocean takes place in the shallow Bering sea. This rapid rate of energy dissipation should have a considerable effect on the tides of the world.

The matter of tidal friction is of considerable importance in the motions of the planets and their satellites because it provides a mechanism whereby angular momentum is transferred from one type of motion to another. The tidal protuberance created on the primary by the tide-generating force of one of its satellites is not symmetrical with respect to the line joining their centres, and the satellite's own gravitational attraction on this protuberance exerts a torque on the primary. It can be shown in general that if there were no tidal dissipation, there would be no such torque, and that if the angular speed of the planet's rotation is faster than that of the revolution of its satellite about it, then this torque always tends to decelerate the planet's rotation. In such a case, the, gravitational force of the primary on its satellite deviates slightly from the direction toward the primary's centre of gravity. and tends to accelerate the revolution of the satellite about its primary, provided this revolution has the same sense as the rotation of the primary about its axis. Then, the distance between the primary and its satellite will increase as the satellite's speed of revolution is increased, according to Kepler's laws. The above-stated conditions apply. of course, in the case of the earth-moon system.

The same deductions can be arrived at by an alternative point of view: the frictional force of the tidal currents on the sea bottom and coasts must itself exert a decelerating torque on the earth. If the tidal currents were known accurately enough over all critical regions where the bulk of the tidal dissipation takes place, the decelerating torque could be calculated, since it is known that by far the greater part of the tidal dissipation occurs in the oceans and only a negligible amount in the lithosphere. Actually. the form of the tide over the vast regions of the oceans is so poorly known that neither the gravitational torque method nor the frictional torque method can be applied quantitatively, and it is through records of ancient eclipses and modern observations on the moon's position that the average rate of lengthening of the day and lunar period of revolution has been estimated. It should be remarked that the lunar effect on the earth's rotation should be about three to five times as large as the solar effect.

There are four principal effects: (1) tides raised in the satellites by their primaries will tend to make each keep the same face toward its primary (as the moon presently faces the earth); (2) tides raised in the primaries by the satellites will alter the rates of rotation of the primaries; (3) tides raised in the primaries by the satellites will alter the distances between them; and (4) solar tides will affect all the rotations.

On the basis of the above considerations it has been deduced that during previous ages the earth had a much shorter day and much shorter month (period of lunar revolution), and that the moon was much closer to earth. The day has probably lengthened by a second in the last 120.000 years.

Internal Tides in the Ocean. — It has been shown that the tidal current would be uniform from top to bottom at any given locality and instant provided that the sea water had uniform density throughout the oceans. In the actual case, however, variations in the salinity and temperature lead to both time and space variations in the density, and it is possible that this condition would lead to a vertical shear in the tidal current. In any case, there is no reason to believe that there should not exist tidal variations in the water density at any given point in the ocean, and there is evidence on several occasions that such tidal variations may have been actually observed.

The outstanding feature of the density structure of the ocean is that the lighter water is found in the upper layers of the ocean, and in a large number of dynamical problems the ocean can be treated successfully as though the water were stratified; *i.e.,* as though the water in any horizontal plane were homogenous. In such a situation there can exist an important class of wave motions in which the maximum amplitude of the vertical displacement of the water particles occurs at some depth beneath the surface. These are called internal waves to contrast them with the more familiar surface waves, for which the vertical displacements of the water particles have their maximum amplitude at the surface. Internal waves are similar in many respects to surface waves, but have some important differences: their speed of propagation is much less than that of a surface wave having the same wave length; and the vertical movement of the water particles (at the level of maximum movement) is a great deal larger than in the case of a surface wave having the same energy. Such waves have been observed by making periodical determinations of the vertical density profile from an anchored ship, and the results of such observations indicate that such internal wave motion is common, and that amplitudes of the order of tens of metres are to be expected. The oscillations are irregular, but frequently there appear to be dominant waves of diurnal or semidiurnal period having all the characteristics of a tidal variation. In order to prove conclusively the tidal origin of such waves. a considerable series of observations would be necessary, and the difficulties and expense of having a ship remain at the same location for a protracted period of time have prevented this study from being carried out.

IX. ATMOSPHERIC TIDES

As air, like all other matter. is subject to gravitational influence, there will be tides in the atmosphere possessing many features of similarity with those in the ocean. One of the characteristics of these tides will be a very small oscillatory variation in the atmospheric pressure at any place, and this may be regarded as the superposition of harmonic constituents with the ordinary tidal periods. By the systematic analysis of long series of regular barometric records, the principal lunar semidiurnal constituent M_2 of the barometric variation has been determined for a number of places, and found to have an amplitude of the order of .001 in. The dynamical theory of these tides has been the subject of considerable study. The derivation of the equations is not so simple as for ocean tides. one difficulty being that of taking account of the physical conditions in the upper regions. The equations which have been proposed are of the same general form as those for ocean tides, but the theory is still imperfect. The results of analysis for the S_2 constituent show a much larger oscillation with an amplitude of barometric variation of the order of .03 in. For this constituent, however, it is certain that thermal factors play a larger part than gravitational factors, and the theory is far from complete.

X. BODILY TIDES

The solid body of the earth, or lithosphere, suffers periodic deformation because of the tide-generating forces just as do the oceans and atmosphere. These bodily tides manifest themselves in the folloning ways: (1) a variation of the vertical, or plumb line, with respect to any solid structure imbedded in the earth's crust; and (2) a variation in the acceleration of gravity at any point due to the potential of the displaced matter in the earth's body, quite aside from the variation of gravity directly associated with the tide-generating forces.

The gravest free elastic oscillations of the earth's body as a whole have periods of the order of an hour, which is much less than those of the principal tide-generating forces. Therefore, it is probably correct to assume that the bodily tides will approximate closely to their equilibrium forms, or in other words, that they may be calculated on the principles of statics. Owing to the earth's rigidity, the vertical rise and fall of the earth's solid surface at any position on it is somewhat less than that based on the equilibrium tide. The fractional height of the equilibrium tide attained by this surface vertical displacement is practically independent of geographical location, and is designated by the symbol h. The potential of the displaced matter is additive to the tide-generating potential, its fractional contribution to the latter at any point on the earth's surface being designated by the symbol k. As in the case of h, k also is practically independent of geographical location. The numbers h and k were introduced by the theoretician in the field of elasticity, A. E. H. Love, and henceforth have been called the Love numbers.

The values of h and k depend on the geographical form of the disturbing potential, but it is common usage to consider only those values corresponding to a disturbing potential having the form of a spherical harmonic of the second degree, of which the semidiurnal equilibrium form is an example.

Various types of geophysical observations have been used to evaluate the Love numbers. For instance, it can be shown that the acceleration of the earth's gravity at the surface is altered by the amount

$$-\frac{2g\bar{\zeta}}{a}\left(1-\frac{3}{2}k+h\right)$$

where $\bar{\zeta}$ is the equilibrium tidal height at the place under consideration and a is the radius of the earth. A body of water whose natural period is short compared with the tidal periods will set itself so that its free surface is one of constant potential. If ζ' is the elevation of the water surface at a given position relative to the bottom, it can be shown that $\zeta' - (1+k-h)\bar{\zeta} = \text{const.}$ provided that the total volume of water in the basin remains constant. The yielding of the bottom tends to diminish the apparent tide while the additional potential of the displaced mass in the earth tends to increase it, hence the algebraic signs in the terms of h and k.

Thus it is seen that precise measurements of the acceleration of the earth's gravity at a point would give a determination of the quantity $1-\frac{3}{2}k+h$ while measurements of the water level in a long sheltered tube, free from winds and other disturbances would give a determination of the quantity $1+k-h$. This quantity also determines the position of the vertical as can be measured by a plumb line or a special instrument called the horizontal pendulum.

It should also be possible to determine the quantity $1+k-h$ by means of observations of the ordinary ocean tide, provided its dynamics were well understood. The long-period tides, especially the lunar fortnightly tide Mf, have usually been utilized for this purpose. It is generally assumed that the periods of these constituents are very much longer than those of all natural oscillations in the ocean basins, and that the equilibrium law would therefore hold. This assumption is certainly valid in the case of ordinary inertio-gravitational standing wave motion in the oceans. but serious objections have been raised on the basis of the possible existence of geostrophic or planetary wave modes characterized by steady or nearly steady ocean currents. There is a further serious difficulty in isolating the purely astronomical long-period constituents in analysis. and it may well be doubted whether reliable constants for the Mf constituent have ever yet been obtained from the records of observation. The values of h and k determined vary considerably depending on the type of observation used, and for this reason are subject to appreciable error. The value of h is somewhere in the vicinity of 0.6, that of k is near 0.3.

The above discussion of the bodily tide has omitted any reference to the complications introduced by the tides in the ocean. There are two effects: the warping of the earth's crust by the varying load on the ocean floor; and the contribution to the total gravitational potential by the displaced water mass. Generally, these effects are more serious closer to the coast and the greater the tidal range at the coast nearby. For this reason measurements of the bodily tide are usually attempted near the centre of large continents.

If the rigidity and density at all points in the earth's body were exactly known, it should be possible to calculate the Love numbers theoretically without need for recourse to observations. The internal constitution of the earth is not precisely known, but certain hypotheses concerning this internal constitution can be rejected on the basis of results of bodily tide observations. Lord Kelvin used the observed height of the fortnightly tide to show that the earth's rigidity, on the average, is greater than that of steel. See also references under "Tides" in the Index volume.

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(J. PR.; G. W. Gs.)

TIDORE (TIDOR), a mountainous island of the Moluccas, Indonesia, lying south of Ternate, nearly circular in shape, with an area of 45 square miles. The southern part is occupied almost entirely by an inactive volcanic peak (5,676 ft.). Below the 1,000 ft. level coffee, fruit and tobacco are cultivated, the soil being very fertile.

The northern half consists mostly of hills, though there are a few level strips along the coast. Pop., about 20.000. Tidore is part of the residency of Ternate, and, with neighbouring islands. comes under the resident of Ternate. The inhabitants are akin to the Ternatans. They dislike work, but sell fish and cultivate garden produce. Some Tidorese do smiths' work, in which they are proficient.

The other islands of the Ternate-Tidore group are Hiri, Mayu, Taifore, Maitara, Pilonga, Maré, Pasuraja. Moti, Makian. Waidoba, Taneti and the Kajoa and Goraityi groups All stretch along by the coast of Halmaheira towards Bachian. with the exception of Taifore and Mayu, which lie out in the Molucca passage. Kajoa (of coralline and crystalline rock formation), is nearly 10 mi. long and has a mountain range traversing most of its length. The people are Mohammedans, and grow rice and maize, and fish. Makian has a mountain of more than 4,000 ft., is well-wooded, volcanic, and has suffered from eruptions. It has a population of more than 8,000 Mohammedans, resembling the people of Ternate and Tidore, who weave, fish and grow tobacco, fruit, rice and sugar cane. Sago, the staple food, is imported from Halmaheira. Moti is surrounded with coral reefs. Maitara has mountains which attain an elevation of 1.266 ft.. and is well forested and fertile. Like Ternate. Tidore is the seat of an ancient and once powerful sultanate. The Portuguese established themselves there in 1521 and fought the sultan, whose capital they destroyed. Later, the Spaniards, when Portugal had become incorporated with Spain, obtained a hold which they retained until nell into the 17th century. aiding the Tidorese in maintaining their independence in Ceram, Halmaheira and other islands, against the sultan of Ternate and the Dutch. The latter, in 1654, conquered the island, but recognized the nominal power of the sultan. Japan occupied Tidore in 1942. (E. E. L.; X.)

TIDYTIPS, common name applied to *Layia* species, especially *L. elegans,* small North American herbs of the family Compositae, native to California. It is an attractive spring-blooming annual, about a foot high, bearing showy flowering heads, $1\frac{1}{2}$ in. broad, with sulfur-yellow rays tipped with white. This plant and other related Californian species, as L. *platyglossa,* are groun as garden annuals. The white daisy, *L. glandulosa,* found from British Columbia to Mexico, is also cultivated.

TIECK, JOHANN LUDWIG (1773–1853), German poet, novelist and critic, was born in Berlin on May 31, 1773, his father being a rope maker. He was educated at the Friedrich-Werdersche gymnasium, and at the universities of Halle, Gottingen and Erlangen. At Gottingen Shakespeare and the Elizabethan drama were the chief subjects of his study. In 1794 he returned to Berlin, resolved to make a living by his pen. He contributed a number of short stories (1795–1798) to the series of *Straussfedern,* published by the bookseller C. F. Nicolai and originally edited by J K. A. Musaus, and wrote *Abdallah* (1796) and a novel in letters, *William Lovell* (3 vols. 1795–1796). Tieck's transition to romanticism is to be seen in the series of plays and stories published under the title *Volksmarchen von Peter Lebrecht* (3 vols., 1797), a collection which contains the admirable fairy-tale *Der blonde Eckbert,* and the witty dramatic satire on Berlin literary taste, *Der gestiefelte Kater.* With his school and college friend W. H Wackenroder (1773–1798), he planned the novel *Franz Sternbalds Wanderungen* (vols i–ii 1798), which was the first expression of the romantic enthusiasm for old German art.

In 1801 Tieck went to Dresden, then lived for a time near Frankfort-on-the-Oder, and spent many months in Italy. In 1803 he published a translation of *Minnelieder aus der schwäbischen Vorzeit,* between 1799 and 1804 an excellent version of *Don Quzxote,* and in 1811 two volumes of Elizabethan dramas, *Altenglisches Theater.* The stories *Der Runenberg, Die Elfen, Der Pokal,* and the dramatic fairy tale, *Fortunat,* with earlier works, appeared in the collection *Phantasus* (3 vols., 1812–17). In 1817 Tieck visited England in order to collect materials for a work on Shakespeare (unfortunately never finished) and in 1819 he settled permanently in Dresden; from 1825 on he was literary adviser to the Court theatre, and his semipublic readings from the dramatic poets gave him a reputation which extended far beyond the Saxon capital. The new series of short stories which he began to publish in 1822 also won him a wide popularity. Notable among these are *Dze Gemalde, Die Reisenden, Die Verlobung, Des Lebens Überfluss.* More ambitious and on a wider canvas are the historical or semihistorical novels, *Dichterleben* (1826), *Der Aufruhr ın den Cevennen* (1826, unfinished). *Der Tod des Dıchters* (1834), *Der junge Tischlermeister* (1836; but begun in 1811), an excellent story written under the influence of Goethe's *Wilhelm Meister. Vittoria Accorombona* (1840), in the style of the French Romanticists, shows a falling-off. In later years Tieck carried on a varied literary activity as critic *(Dramaturgische Blätter,* 2 vols., 1825–26; *Kritische Schriften,* 2 vols., 1848); he also edited the translation of Shakespeare by A. W. Schlegel, who was assisted by Tieck's daughter Dorothea (1799–1841) and by Graf Wolf Heinrich Baudissin (1789–1878); *Shakespeares Vorschule* (2 vols., 1823–29); the works of H. von Kleist (1826) and of J. M. R. Lenz (1828). In 1841 Friedrich Wilhelm IV of Prussia invited him to Berlin where he enjoyed a pension for his remaining years. He died on April 28, 1853.

Tieck's *Schriften* appeared in zo vols. (1828–46); and his *Gesammelte Novellen* in 12 (1852–54). *Nachgelassene Sclzrijten* were published in z vols, in 1855. Of modern editions of *Ausgewählte Werke see* those by G. Klee (with an excellent biography, 3 vols., 1892), and G. Witkowski (4 vols., 1903). *The Elves* and *The Goblet* were translated by Carlyle in *German Romance* (1827), *The Pictures* and *The Betrothal* by Bishop Thirlwall (1825). See for Tieck's earlier life R. Kopke, *Ludwig Tieck* (z vols., 1855), for the Dresden period, H. von Friesen, *Ludwig Tieck: Erinnerungen* (2 vols., 1871); Also A. Stern, *Ludwig Tieck in Dresden (Zur Literatur der Gegenwart,* 1879); B. Steiner, *L. Tieck und die Volksbücher* (1893); H. Bischof, *Tieck als Dramaturg* (1897); H. Lucdeke, L. *Tieck und das alte englische Theater* (Frankfurt, 1922); A. E. Lussky, *Tieck's approach to Romanticism* (Borna-Leipzig, 1925).

TIEL, a town in the province of Gelderland, the Netherlands, on the right bank of the Waal (here crossed by a pontoon bridge), 25 mi. by rail west of Nijmwegen. Pop. (1957 est.) 16,870 (mun.). It possesses fine streets and open places, but of its fortifications the Kleiberg gate (1647) alone remains. The principal buildings are St. Martin's church (15th century), the town hall, courthouse and the historical castle of the family of van Arkel.

TIELE, CORNELIUS PETRUS (1830–1902), Dutch theologian and scholar of comparative religion, was born at Leiden on Dec. 16, 1830. He was educated at Amsterdam high school and afterward at the seminary of the Remonstrant Brotherhood. He served as pastor at Moordrecht and Rotterdam, then as professor at the Remonstrant seminary. In 1877 followed his appointment at the University of Leiden as professor of the history of religions, a chair specially created for him. During his tenure, which lasted until 1901, his influence on the developing study of comparative religion was great, most especially in the Netherlands. He died on Jan. 11, 1902.

Among the best known of Tiele's numerous learned works are *Outlines of the History of Religion* (1876; Eng. trans. 1877) and his Gifford lectures, published as *The Elements of the Science of Religion* (1897–99). He was also the author of the article "Religions" in the 9th edition of the *Encyclopædia Britannica.*

See S. Cramer in *Realencyklopadie fur protestantische Theologie und Kirche,* 3rd ed., vol. xix, pp. 766–775 (190.5).

TIEN SHAN (Russian TYAN'-SHAN; Chinese T'IEN SHAN, "celestial mountains"), one of the great mountain systems of central Asia. Situated in the Soviet Union and China, the Tien Shan is about 1,500 mi. long, trending generally west-southwest to east-northeast. The system is located between latitudes 40° and 44° N. and extends from the Samarkand area (67° E.) in the west to the Kansu border (96° E.) of China in the east. There is no general agreement as to its northern and southern boundaries. In the north, the Dzungarian Ala-Tau is sometimes regarded as part of the Tien Shan because it is linked to the system by the Borokhoro (Boro Horo Uula) range *(see* ALA-TAU). Others regard the Dzungarian Ala-Tau as an independent range, with the Ili valley as the northern border of the Tien Shan. In the southwest, the Turkistan, Zeravshan and Alay ranges are sometimes included in the Tien Shan because of geologic similarities. But on the basis of orographic and tectonic data, these ranges are excluded and the Fergana valley is regarded as the southwestern boundary of the system.

The Khan-Tengri (22,949 ft.), situated in a mountain knot on the Soviet-Chinese border, was long regarded as the highest peak of the Tien Shan system. In 1943, however, a Soviet expedition discovered a peak with an elevation of 24,406 ft., 13 mi. S. of

Khan-Tengri. and named the new summit Pobeda (Victory) peak in honour of Red army victories in World War II. From the mountain hub. subranges fan out toward the west into the Soviet section of the Tien Shan system, and toward the east into the Chinese section.

Western **Tien Shan.**—The western, or Soviet, section of the Tien Shan is complex in structure. It consists of a number of branches and subranges fanning out from the mountain hub of Khan-Tengri and Pobeda peak. The northern branch includes the Rungey Ala-Tau. which encloses the large mountain lake Issyk-Kul on the north. Parallel to the Kungey Ala-Tau in the north is the Trans-Ili (Zaili) Ala-Tau, rising to 16.243 ft. in Talgar peak. The Trans-Ili Ala-Tau continues westward in the Chu-Ili mountains. while the Kungey Ala-Tau extends on into the Kirghiz range. The central branch fanning out from the mountain hub consists of the Terskey Ala-Tau, which encloses the Issyk-Kul basin on the south. The southwestern branch is made up by the Kokshaal-Tau. These major branches of the western Tien Shan are tall, snow-clad ranges of an alpine character. In sharp contrast is the section bordered in the north by the Terskey Ala-Tau and in the south by the Kokshaal-Tau, where mountain ranges were eroded and converted into peculiar flat-topped summits known as *syrts*. These *syrts* are separated by broad valleys or tectonic depressions. While the outer alpine ranges rise abruptly for 10.000 ft. or more above the adjoining lowlands, the relative elevation of the *syrts* above the intervening valleys is only about 2,000–3,000 ft.

Eastern **Tien Shan.**—The eastern, or Chinese, section of the Tien Shan consists of two parallel series of subranges. The main southern series. extending eastward from the Khan-Tengri mountain hub, consists of the Khaliq-Tau (13,220 ft.) and the Boro Hatan (12,402 ft.) and terminates at the lake basin of Baghrash Kol.

The northern series of subranges includes the Borokhoro. the Bogdo Uula (17,946 ft.), the Bar Kol Tagh range (13,950 ft.) and the Karlik Tagh (14.090 ft.). South of the Bogdo Uula lies the Turfan depression. whose salt-marsh-covered floor lies at 427 ft. below sea level, the lowest point in China. The eastern Tien Shan, which divides China's Sinkiang Uigur Autonomous Region, into Dzungaria (north) and the Tarim basin (south) is characterized by an echelonlike arrangement of subranges and broad intermontane valleys and basins.

Geology. — The mountains of the Tien Shan are made up of sedimentary. metamorphic and igneous rocks of Paleozoic and Pre-Cambrian age. The most common rocks are schists, sandstone, limestone. marble. gneisses, granites and syenite-porphyries. The intermontane basins, on the other hand, are filled with unconsolidated continental sediments of Tertiary and Quaternary age, The northern ranges were originally uplifted during the so-called Caledonian revolution in the Lower Paleozoic period. while the southern ranges arose during the Hercynian revolution of the Upper Paleozoic. These initial ranges mere gradually eroded and converted into a peneplain by the Mesozoic and Tertiary eras. Toward the end of the Tertiary and early in the Quaternary, new uplifts took place to give the mountain ranges of the Tien Shan their present appearance. Downwarping associated with the uplifts produced intermontane valleys and basins. In the process of erosion of the mountains, these depressions became partly filled with eroded material.

Climate. — The climate of the Tien Shan is determined largely by its location in the interior of the Eurasian continent among arid desert lowlands of the middle latitudes. The climate of the region is sharply continental, but local contrasts in precipitation and temperatures are due to the great elevation of the Tien Shan and its complex relief. The piedmont plain and the foothills of the system have typically the same desert climate as the adjoining lowlands. Westerly Atlantic air masses carry most of the precipitation received by the Tien Shan system, discharging it mainly on the mest-facing slopes at middle and high altitudes. .Annual precipitation on these slopes reaches more than 30 in. On east-facing slopes and in intermontane basins. annual precipitation is only about 10 in. Precipitation reaches a maximum in the summer. In keeping with heavier precipitation on the western slopes, these slopes and westward-facing valleys have a heavier snow cover in winter. reaching almost 10 ft. The east-facing slopes and intermontane valleys have virtually no snow in winter. In general the snow line is much higher in the Tien Shan than it is in the European Alps or the western Caucasus. Even some passes of 13,000 ft. or more are known to be snow-free in summer. Average temperatures vary with elevation. In the valleys and on low-elevation slopes the July average is 70°–75° C., on medium-elevation slopes 55°–60° and on the mountain peaks near freezing. The large lake basin of the Issyk-Kul exerts a moderating influence on temperatures of nearby areas.

Glaciation. — The general trend of the mountain ranges of the Tien Shan is east-west, although some short ranges are also oriented north-south. Characteristic features of the Tien Shan are the so-called mountain knots from which short ranges fan out in several directions. Relatively humid air coming from the west condenses on the west-facing slopes of the north-south ranges and the mountain knots giving rise to valley glaciers. The principal glaciation centres are therefore the Khan-Tengri and Pobeda knot and the short north-south range of Akshiyrak. In the larger mountain knots. glaciers cover a total area of 10,000 sq.mi. The largest ones are the southern Inylchek glacier (37 mi. long), on the southern side of the Khan-Tengri; the northern Inylchek glacier (22 mi. long) on the northern side; and the 13-mi.-long Semenov glacier descending from Semenov peak (19,081 ft.), northwest of Khan-Tengri.

The Petrov glacier, on the west slopes of the Akshiyrak range, is 11 mi. long. In addition to the valley glaciers, glaciation is also in evidence on some of the flat-topped summits of the western Tien Shan, where peculiar ice shields are formed on the summits.

Hydrography. — The Tien Shan is mainly a region of interior drainage. whose rivers flow either into the desert lakes of central Asia or into mountain lakes without outlet to the sea. Most of the western Tien Shan is drained by the Syr-Darya (*q.v.*), one of the great streams of central Asia, which flows to the Aral sea. The principal rivers on the northern side of the Tien Shan are the Chu. which disappears in the desert west of Balkhash lake, and the Ili (*q.v.*), which flows to that lake. On the southeastern side of the Tien Shan, the drainage pattern is dominated by the Tarim (*q.v*), which also disappears in the desert sands near Lop-Nor (*q.v.*) lake. The river valleys of the Tien Shan tend to be broad except when they cut through transverse ranges. Rising generally at high elevations, the rivers of the Tien Shan are fed by glaciers and reach their high water stage in the summer, when they are most useful for the irrigation of crop lands in the piedmont plains. Some of the smaller rivers rising at lower elevations are fed by ground water, snow and rain. Several of the rivers are used to generate hydroelectric power, notably the Chirchik. a tributary of the Syr-Darpa; the Syr-Darya itself, and the Chu river. The Issyk-Kul, largest of the mountain lakes in the Tien Shan. occupies a broad tectonic depression.

Vegetation. — The vegetation of the Tien Shan follows a vertical zonation. The lower foothills are covered with desert vegetation. which dries up in about mid-May. Irrigated cotton and fruit trees dominate among the cultivated crops. At somewhat higher elevation, above 1.200 ft., an increase in precipitation assures a semidesert vegetation, such as wheat grass, which lasts until the end of June and can be used as spring and summer pastures.

Above the semidesert belt of the foothills lies the dry mountain steppe of feather grass and fescue, which serves as summer and fall pasture and for the cultivation of dry grains. At an elevation of 4,000 ft. begins the grassy steppe with bushes and patches of deciduous trees (walnut, apple, maple). This is a main area of unirrigated agriculture, used for hay and grains. The next higher zone of subalpine meadows also contains coniferous forests of spruce and fir as well as juniper groves. These meadows. which reach up to the snow line, are the principal summer pastures of the Tien Shan region.

Minerals. — Outflows associated with Hercynian magmatism have produced some highly mineralized areas in the Tien Shan, notably in nonferrous and rare metals. Among the most important Soviet mineral sites are the copper and lead-zinc ores of Almalyk of the Uzbek Soviet Socialist Republic, the antimony and mercury mines of Khaydarken in Kirghiz S.S.R. and the tungsten site of Chorukh-Dayron in the Tajik S.S.R. Jurassic coal of low caloric value is mined at Angren (Uzbek S.S R.) and on the periphery of the Fergana valley at Kyzyl-Kiya. Tashkumyr, Kok-Yangak and Sulyukta. The accumulation of sediments in the Fergana valley has also produced deposits of petroleum, natural gas. sulfur and ozocerite. Geologic exploration is still in its infancy in the Chinese portion of the Tien Shan, but oil fields are already in operation at Tushantze and Karamai in the northern foothills and several sites of nonferrous and rare metals are known.

Settlement and Transportation. — The heaviest population concentrations in the Tien Shan are found in the Tashkent (*q.v.*) oasis, the Fergana valley and the Chu valley of the Soviet Union, and in oases at the north foot (Urumchi) and south foot (Kashgar. Aqsu) of the eastern Tien Shan in China's Sinkiang (*q.v.*) The lower valleys and foothills of the Tien Shan, where irrigated agriculture (mainly cotton) is practised, were invaded by indigenous central Asian cultivators, such as the Uzbeks in the Tashkent and Fergana areas of the Soviet Union and the Uigurs in the oases at the southern foot of the mountain system in China. Among the pastoral peoples of the mountains are the Kirghiz in the western Tien Shan and the Kazakhs and Mongols in the eastern Tien Shan.

The population centres of the Soviet portion of the Tien Shan are reached by branches of the Soviet rail system, extending from Tashkent into the Fergana valley and through Frunze (*q.v.*) into the Chu valley and to Rybachye on the Issyk-Kul. A central Asian railroad linking China and the Soviet Union, completed in 1960, runs along the northern foot of the eastern Tien Shan and through the Dzungarian Gate. a natural passage way at the eastern end of the Dzungarian Ala-Tau. The higher valleys of the Tien Shan are served by roads, many of which can be used by motor vehicles. (T. SD)

TIENTSIN, an industrial and commercial city in the province of Hopeh, China. 70 mi. S.E. of Peking. Pop. (1953) 2,693,831 (1957) 3 220,000. The city is situated at the confluence of several streams on the lower coastal plain, 32 mi. by river from the Yellow sea. Until 1782 the place nas only a garrison tonn. but it became a treaty port in 1860, and began to grow rapidly A foreign settlement was located downstream on the right bank of the Hai Ho, and the entire city, native and foreign, suffered severely during the Boxer uprising (1900). After this the walls were razed. and the city was rebuilt on occidental lines. Originally covering only a small area, the former foreign concessions were integrated and the limits have since expanded steadily. The port area of Ta-ku and T'ang-ku was included within the city limits in 1949, and the area along the Hai Ho was annexed in 1953 to make the total area of the city 888 sq.mi. Tientsin, a chartered city since 1929, is an independent municipality administered directly by the central government from Peking.

Subject to flooding by the six small rivers coming together just west of the city, the main river below the city has long been shallow and subject to silting. The Communists have both maintained the earlier pattern of dredging the river, and have built a bypass flood canal around the city on the south side to relieve flood pressures. Though dredging can keep the river navigable for small ships. a new artificial port, Sinkang, able to take 10,000 ton ships at all times. was created at T'ang-ku. This is kept open for about two months during winter by icebreakers.

Tientsin is a leading seaport of China and a rail, an air traffic and a regional trade centre. Its industrial beginnings predate 1900, but it remained for some decades a centre of such light manufacturing as matches, bicycles, cotton and wool textiles, grain milling, tobacco manufacturing and simple chemicals. Gradually its variety of industry broadened as assembly operations, heavy machinery. iron and steel and the fuller range of chemical manufactures were added. Under the Communists its rank has increased as heavy manufacturing industries were located in the newer industrial areas toward the coast. In the mid-1950s marked expansion took place in iron and steel, and in heavy manufacturing. By the late 1950s Tientsin was the leading chemical manufacturing centre of China, and had become the third ranking industrial region. behind only Shanghai and the central Liaoning province region of southern Manchuria. It is the seat of Nankai university. (J. E. SR.)

TIEPOLO, the name of a family of Venetian painters comprising Giovanni Battista. by far the most important, and his two sons Giovanni Domenico and Lorenzo

GIOVANNI BATTISTA TIEPOLO (1696–1770), the greatest Venetian painter of the 18th century, was born on March 5, 1696. in Venice, the son of a merchant. He first studied painting under Gregorio Lazzarini, but quickly came under the influence of F. Bencovich and G. B. Piazzetta. His earliest known work, "The Sacrifice of Isaac" in the church of the Ospedaletto, Venice (1715–16). is sombre and still in the manner of Piazzetta. In 1717 his name first appears on the lists of the guild of Venetian painters, and for the next few years he concentrated chiefly on small easel paintings of classical and biblical subjects.

Throughout his life Veronese's was the pervasive influence on Tiepolo's art. The return of G. A. Pellegrini to Venice in 1721 was also crucial for Tiepolo's development, for his work inspired Giambattista to adopt a lighter and gayer palette. These two factors are apparent in his decorations for the Sandi and Dolfin palaces in Venice (both *c.* 1725, the latter now dispersed) and in those for the archiepiscopal palace and the cathedral at Udine (1726–27). In 1731 he was called to Milan to decorate the Archinti and Dugnani palaces (destroyed and damaged respectively, in 1943). In 1732–33 he frescoed the upper parts of the Colleoni chapel, Bergamo. By now he was widely recognized as the leading decorator in Italy. The Swedish envoy Tessin happily characterized Tiepolo's work as "full of spirit . . . of an infinite fire, brilliant colouring and an astonishing speed." Notable among his frescoes in the next 15 years were the ceilings in the Gesuati church, Venice (1737), the Palazzo Clerici, Milan (1740. destroyed 1943), the Scuola dei Carmini, Venice (1740–43). the Villa Cordellina, Montecchio Maggiore (1743), the church of the Scalzi, Venice (1743–44, destroyed 1915). the decorations of the Palazzo Barbarigo, Venice (1744–45. dispersed) and, probably about 1750, his most admired work in Venice, the scenes from the life of Cleopatra in the great saloon of the Palazzo Labia. He was also producing such masterpieces of oil painting as the huge "Road to Calvary" and its companion paintings the "Flagellation" and the "Crowning With Thorns" for S. Alvise as well as secular and religious paintings for patrons at home and abroad.

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART ROGERS FUND 1937

SKETCH FOR ALTARPIECE "INTERCESSION OF ST THECLA" BY TIEPOLO IN THE METROPOLITAN MUSEUM OF ART, NEW YORK CITY

In 1750 he was commissioned by the prince-bishop of Wiirzburg, Ger., to decorate the ceilings of the Kaisersaal and staircase of the new palace with historical and allegorical subjects. These huge frescoes, perhaps his greatest achievements, were completed in 1753. On his return to Venice. his outstanding decorations were the Villa Panigai, Nervesa della Battaglia (1754, now in Berlin), the ceiling of the church of the Pietà, Venice (1754–55), the Villa Contarini, Mira (1756, now in Paris), the Villa Valmarana, Vicenza (1757), the Palazzo Rezzonico, Venice (1758). the Palazzo Canossa, Verona (1761, destroyed 1944) and the Villa Pisani at

Strà (1761–62). The huge altarpiece of the "Intercession of St. Thecla" at Este, his most moving religious work, was completed in 1759. In 1761 he was invited to Spain by Charles III and in 1762, accompanied by his sons, he arrived in Madrid where he decorated three rooms in the royal palace (1762–67). He also executed seven altarpieces for S. Pasquale at Aranjuez (1767–69) and began the decoration of the vault of the apse of S. Ildefenso shortly before his death in Madrid on March 27, 1770.

Tiepolo's work is characterized by his skilled draftsmanship, the high key of his multicoloured palette, his mastery of composition and the extraordinary fertility of his imagination. Besides decorations and altarpieces he painted one or two portraits and a number of *Teste di Fantasia* ("imaginary heads") in the manner of Rembrandt. He produced vast numbers of sketches and finished drawings for collectors, to whom he also supplied numerous freely painted oil sketches—often reductions from larger works. Between about 1740 and 1760 he etched plates distinguished for their imaginative force and brilliance.

In order to achieve his enormous output Tiepolo employed assistants, among whom were Mengozzi-Colonna (for architecture) and his two sons, GIOVANNI DOMENICO TIEPOLO (1727–1804) and LORENZO TIEPOLO (1736–1776). Giandomenico, born in Venice on Aug. 30, 1727, was completely overshadowed by his father as a religious and decorative painter, but he had a real talent for genre painting, especially of scenes from contemporary life and of the popular theatre, such as the decorations of his own villa at Zianigo (1791–93).

Notable among his early works are the "Stations of the Cross" for S. Polo, Venice (1747–49), and the *chinoiserie* decorations of the guest wing of the Villa Valmarapa (1757). After his father's death Giandomenico returned to Venice where he executed a number of frescoes and easel paintings, especially of scenes from the *commedia dell'arte*. He, too, produced large numbers of drawings for collectors, besides nearly 200 etchings after his own and his father's designs. He died in Venice on March 3, 1804. Lorenzo, born in Venice on Aug. 8, 1736, seems to have specialized chiefly in genre scenes in pastel. He died in Madrid on Aug. 8, 1776.

See also Index references under "Tiepolo, Giovanni Battista" in the Index volume.

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TIERCERON, in architecture. an intermediate vaulting rib running from the spring of the vault to the ridge, at an angle between the cross rib and the diagonal or groin rib, or in cross vaults between the diagonal rib and the wall rib. Tiercerons came into use in the early Decorated period of English Gothic. Exeter cathedral (1308–67) shows the delicate beauty and lightness that tiercerons gives. *See* GOTHIC ARCHITECTURE; ARCH AND VAULT.

TIERRA DEL FUEGO, an archipelago lying between 52° 27' and 55° 59' S. lat. 'and 63° 43' and 74° 44' W. long at the southern extremity of South America, and separated from the mainland by Magellan's strait. In shape the main island is a triangle with its base on Beagle channel. The total area is 27.476 sq mi . about two-thirds of which is Chilean and one-third Argentine. The boundary agreed upon in 1881 follows the meridian of 68° 36' 38″ W. from Cape Espiritu Santo on the Atlantic. and the west-east Beagle channel. Lennox. Nueva. Picton and several small islands at the mouth of the channel are disputed between the tno republics. The western and southern. Chilean, part is known as the Tierra del Fuego department of Magallanes province, pop. (1952) 4.768; the eastern, Argentine, side is the province of Tierra del Fuego. pop. (1956) 10.596.

Physical Features.—The greater part of the main island north of the Almirantazgo sound-Lake Fagnano depression consists of Tertiary sediments and volcanic material, overlain north of the Inhtil-San Sebastián bays depression by glacial material deposited during the Pleistocene ice age. The distribution of land and nater and the major relief features in this area are the result of the location of great glacial lakes, the excavation of their overflow channels and the dumping of great moraines. The Altos de Boqueron, north of Inutil (Useless) bay, is one such undulating morainic plateau from which drain all the rivers of north Tierra del Fuego. Most of the northern area is, therefore, under 600 ft. in height and the Atlantic and Magellan strait coasts are low-lying.

The southern and western parts of the main island and the archipelago are a great contrast. Cretaceous foothills pass into the southern prolongations of the Andes with crystalline rocks, peaks exceeding 7.000 ft. and mountain glaciers. Mt. Sarmiento (7,333 ft.) and Mt. Darwin (7,005 ft.) are the highest summits. The western half of Magellan's strait, therefore, is bordered by the precipitous cliffs, rugged coasts and fiords of Desolación, Santa Inés, Clarence, Aracena and Dawson islands. South of the Beagle channel a similar group of islands, of which Hoste and Navarino are the largest, spread into the waters of Drake strait and terminate in the headland of Cape Horn, generally regarded as the southernmost point of South America, although the Diego Ramirez group lies 60 mi. to the southwest.

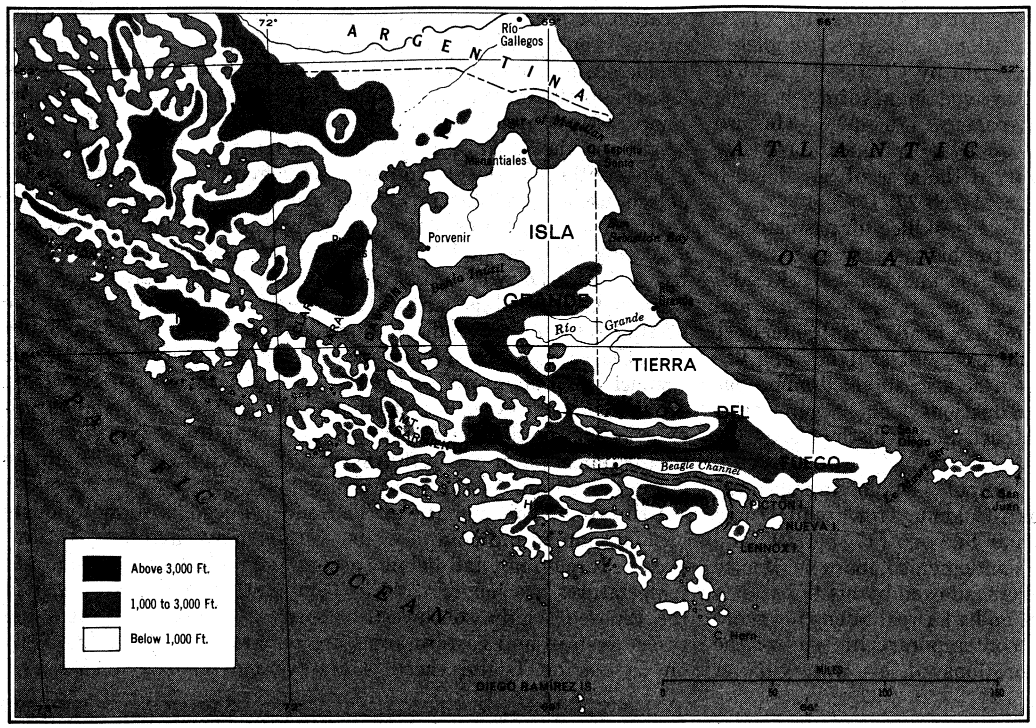
Climate.—The climate of Tierra del Fuego is monotonously cool in summer and cold in winter, although average temperatures even in July do not fall below freezing point, and average summer temperatures are below 52° F. Temperature ranges are least in the exposed windy southwestern areas. Rainfall contrasts between western and eastern areas are remarkable. At Bahia Félix on Desolación Island there is an average annual precipitation of 200 in, while at Rio Grande in Argentine Tierra del Fuego only one-tenth as much rain falls. The Beagle channel areas have usually less than 30 in. Three days out of four are wet in the west; one in four in the east.

E. AUBERT DE LA RÜE

AUSTRAL RAIN FOREST OF BEECH-LIKE TREES WITH YELLOW HANGING LICHENS ON NAVARINO ISLAND. TIERRA DEL FUEGO

Vegetation.—In the exposed. precipitous, southern and western areas vegetation is limited to mosses and stunted trees, but nhere terrain permits. evergreen beech clothes the islands, deteriorating upward into bushes. bare rock and ice and snow. The central part of the main island from the Atlantic to Inutil bay has deciduous beech forests, and the northern plains have a tussock grass cover.

History and Exploration.—Tierra del Fuego was discovered by Ferdinand Magellan in 1520 when he sailed through the strait named after him and called this region "land of fire" In 1578 Sir Francis Drake first sighted the point which in 1616 was named Cape Hoorn (anglicized into Horn) by the Dutch navigators Jacob Lemaire and Willem Schouten In 1619 the brothers Garcia and Gonzalo de Nodal first circumnavigated the archi-



SURFACE FEATURES OF TIERRA DEL FUEGO

pelago. No systematic exploration was attempted until the British admiralty undertook a thorough survey of the whole group by Philip Parker King and Robert Fitzroy during the decade 1826–36. They were accompanied on the voyage of the Beagle by Charles Darwin, then a young man. The present place names of the region are due in large measure to these surveys; although Chilean naval exploration and aerial mapping have filled in much detail. most hydrographic charts are based on King and Fitzroy's original work.

For 350 years after Magellan's voyage the region was left in the undisputed occupation of its indigenous peoples, but in the 1880s two events led to its colonization by European immigrants and Chilean and Argentine nationals. These mere the introduction of sheep farming, which in 20 years spread from Gente Grande bay to occupy all the grassland areas?and the discovery of gold along the eastern and southeastern coasts and on the beaches of the islands south of Beagle channel. In the 18'90s the gold rush spread to the northern rivers of the main island. The political result of this colonization was the partitioning of the island between Chile and Argentina, Porvenir on Magellan's strait becoming the main Chilean town and Ushuaia on Beagle channel the Argentine capital. The Ushuaia area together with Dawson Island, Rio Grande and Lake Fagnano became the main scene of missionary activity among the Indian peoples. Both Chilean and Argentine areas were at first territories administered by the central governments but they were raised to provincial status in 1929 and 1955 respectively.

The **People.**—Ona Indians occupied the pampa and deciduous forest belt of the north of the main island and were hunters of the guanaco and tucu-tucu (similar to a cavy). Yahgan Indians lived in the Fuegian archipelago, especially on Beagle channel, anchoring their canoes in the dense masses of kelp in those waters and gaining their livelihood from shellfish, seals and otters. Small groups of Alacalufs penetrated the northwestern channels from the fiords of western Magallanes. Few of these indigenous people now survive, as European settlement of their lands and the ravages of disease spelled their doom.

The present inhabitants of Tierra del Fuego are the immigrants and their descendants who were attracted by the pastoral industry, the gold rush, the discovery of oil and the general economic expansion of the region. In addition to Chileans and Argentinians, a great variety of European nationalities are represented. Yugoslavs are the predominant element derived from the gold-rush days. with Spaniards, British and Italians forming smaller minorities. Ushuaia still retains a penal settlement, and a colony of Italians was established nearby in 1948, Most of Tierra del Fuego's people live on the main island, but a subsidiary concentration is on Navarino Island where its sheep farms represent the world's southernmost land-based economic activity.

The Economy. — Pastoralism and petroleum exploitation dominate the region's occupational and commercial life. Enormous sheep farms were established in the favourable northern areas, one of which still exceeds 1,000,000 ac. in extent, while another carries 185,000 sheep. On the expiry of some of the leases in 1938 and 1957, subdivision of the farms was undertaken to increase the density of settlement. The discovery of petroleum at Manantiales in 1946 converted the northern part of Chilean Tierra del Fuego into that republic's only oil field; pipelines were laid to Magellan's strait for export of the petroleum to central Chile. A small refining plant on the oil field produces the needs of Magallanes province. There is also some lumbering in the forested areas of Beagle channel and Magellan's strait, fish and crayfish canning at Ushuaia and Porvenir, and fur hunting for nutria and seal. A meat refrigerating plant is located at Rio Grande but most surplus sheep are processed at mainland *frigoríficos.*

Road communications are poor. there are no railways but air services based on Punta Arenas and Rio Gallegos maintain links with the principal settlements in the Chilean and Argentine areas respectively. Sea communications are also of importance; a regular service plies between Porvenir and Punta Arenas, and naval vessels supply Navarino and Ushuaia.

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(G. J. B.)

TIFFANY, CHARLES LEWIS (1812–1902). U.S. jeweler who made a specialty of importing historic gems, jewelry and art works, was born in Killingly, Conn., on Feb. 15, 1812. He moved to New York city in 1837, and with John B. Young opened a fancy goods store. It became Tiffany, Young and Ellis in 1831 and. after branching out into jewelry manufacture, was reorganized as Tiffany & Co. in 1853. Tiffany adopted the standards of English silver in 1851, thereby establishing the term "sterling" in the U.S. and affirming the high prestige of his firm.

In 1858 Tiffany obtained a surplus section of the newly laid Atlantic cable. which he cut into pieces and sold as souvenirs with great success. At the beginning of the Civil War he turned most of his capital to the manufacture of swords, medals and other war material. In 1868 the company was incorporated and branches were established at London and Geneva. In 1887 he bought some of the crown jewels of France. He was made a chevalier of the Legion of Honour in 1878. He died in Sew York city on Feb. 18,

1902. He was the father of Louis Comfort Tiffany (*q.v.*).

See F. Heydt, *Charles L. Tiffany* (1893).

TIFFANY, LOUIS COMFORT (1848–1933), U.S. painter, craftsman and decorator, who is considered one of the leading original U.S. designers, was born in New York city on Feb. 18, 1848. the son of Charles L. Tiffany (*q.v.*). He became internationally famous for the inimitable glass which he named favrile, a neologism from the Latin faber. Tiffany began experimenting with glass in 1875 and could produce it reliably by the 1890s, when examples were donated to the Smithsonian institution and the Metropolitan Museum of Art; he won a grand prize at the 1900 Paris exhibition. Favrile glass, iridescent and freely shaped, was sometimes combined with bronzelike alloys and other metals; it enjoyed widespread popularity from 1890 to 1915, and again in the 1950s. Trained as a painter of narrative subjects in Paris, Tiffany visited Morocco; eastern and Amerindian influences mark his work. Returning to the U.S., Tiffany became a recognized painter. He established a decorating firm later known as Tiffany Studios, which served wealthy New Yorkers. redecorated the reception rooms at the White House. Washington, D.C., and was most active in church interiors. Stained-glass windows were its specialty, best known being the huge glass curtain (1911) at the Palacio de Bellas Artes in Mexico City. Tiffany, a director of his father's firm, established the Louis Comfort Tiffany foundation for young artists at his luxurious and celebrated Long Island estate (sold in 1946 to provide scholarship funds). He died, Jan. 17, 1933.

See R Koch, *Louis Comfort Tiffany, 1848–1933* (1958). (Er K)

TIFFIN, a city of northwestern Ohio, U.S., on the Sandusky river 40 mi. S.S.E. of Toledo; the seat of Seneca county. The present city began as Fort Ball, military depot in the War of 1812; the first settlement came in 1817 when Erastus Bowe built a tavern on the north bank of the river. In 1820 Josiah Hedges founded on the south bank another settlement, Tiffin, named for Edward Tiffin, the first governor of Ohio. Incorporated in 1835, Tiffin merged with Fort Ball in 1850. The discovery of natural gas in the vicinity in 1888 provided momentum for the growth of a community of well-diversified industries in a fertile agricultural region. Educational facilities include Heidelberg college, a coeducational liberal arts college opened in 1850 and supervised by the Evangelical and Reformed church (now the United Church of Christ). In Tiffin are a county historical museum, the national home of the Daughters of America and a state mental hospital. For comparative population figures see table in OHIO: Population. (C. G. K.)

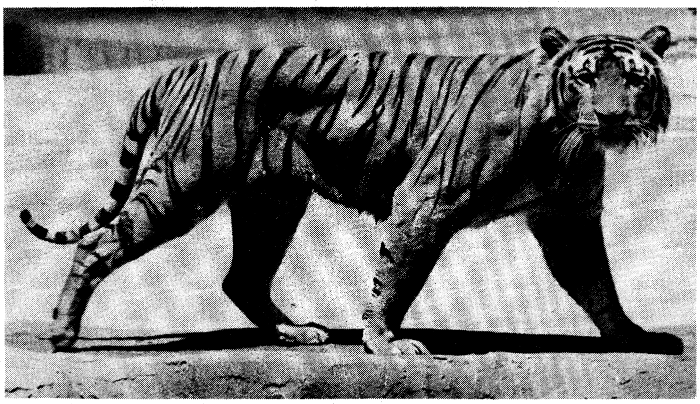
TIFLIS (renamed, as in Georgian, TBILISI, also TPILISI), the capital of the Georgian Soviet Socialist Republic, U.S S.R., and the chief town of Transcaucasia, situated on both banks of the Kura river. and on the railway linking the Black sea and the Caspian, in 41° 41' N., 44° 48' E. Pop. (1959) 694,000. It is sheltered by hills (1,500–2,400 ft.). Products include tobacco. vegetable oils. soap, cognac, leather goods, furniture, textiles and machinery. On the left bank of the Kura stands the Metekhi castle. formerly a palace of the Georgian kings. the foundation of which is ascribed to King Vakhtang Gorgasali (Gurgaslan) of Iberia (5th–6th century). The Sion cathedral traces its origin to the 5th century; other churches date from the 14th and 15th centuries, and the Armenian cathedral of Van rebuilt in the 18th century, from 1480. There are numerous museums and educational institutions. The tonn is at the southern extremity of the Georgian military road, which links it through the Darial gorge with Orjonikidze. The oriental markets and bazaars. where Iranians. Kirghiz. Tatars and peoples from the east congregate, display the work of Georgian silversmiths, gunsmiths and swordmakers; carpets, dried fruits and silken goods are important items.

The foundation of Tiflis dates from the 4th century A.D., but it succeeded Mtskhet as the capital of Iberia (eastern Georgia) in the 5th–6th century. After the temporary abolition of the Iberian monarchy, after 532. Tiflis was made the residence of the Iranian viceroys (*marzbans*). It then suffered successive plunderings at the hands of the Byzantines in 626, during the wars of the emperor Heraclius; the Arabs took it in the same century, and from the 8th century it was the seat of an Arab emirate until its incorporation into the kingdom of Georgia in 1122, by David II the Builder, and its installation as the national capital. In 1225–31 it was taken by the Khwarizm-Shah Jalaladdin and in 1234 by the Mongols. In the autumn of 1386 Tiflis fell to the Mongol conqueror Tamerlane, who led into captivity King Bagrat V of Georgia and his queen, Anne of Trebizond. Afterward the Turks seized it several times, and toward the end of the 17th century the Lesghians attacked it. In 1795 the shah of Persia, Agha Mohammed Khan, sacked and plundered Tiflis in the war intended as a reprisal for King Heraclius II's treaty of alliance with Russia of 1783. The Russian troops sent later to the aid of Georgia were instrumental, upon the death of the last king, George XIII, in 1800, in effecting the Russian annexation of that kingdom.

TIGELLINUS, TOFONIUS, minister and favourite of the emperor Nero, was a native of Agrigentum, possibly of Greek descent. During the reign of Caligula he was banished (A.D. 39) for adultery with the emperor's sisters, but recalled by Claudius (41). Having inherited a fortune, he bought land in Apulia and Calabria and devoted himself to breeding race horses. In this manner he gained the favour of Nero. In 62 he was promoted to the prefecture of the praetorian guards. The great fire of 64 broke out afresh in his gardens, and he was suspected of being concerned with it. In 65, during the investigation into the abortive conspiracy of Piso, he and Poppaea formed a kind of imperial privy council. In 67 he accompanied Nero on his tour in Greece. He deserted Nero at the last, and took the praetorians with him. Under Galba he was obliged to give up his command, but managed to save his life. Otho, on his accession (69), determined to remove him. While in the baths at Sinuessa, Tigellinus received the news that he must die, and, having failed to gain a respite, cut his throat.

TIGER (Panthera tigris), an animal rivaled only by the lion in size, strength and ferocity among the catlike beasts of prey (see CARNIVORA), the difference between the two lying mainly in the skin and its coverings. A tiger's skull may almost always be distinguished from that of a lion by the circumstance that the nasal bones extend higher on the forehead than the maxillae, instead of stopping on nearly the same line.

Although examples of both species do present considerable variations in size, the length of the largest Bengal tiger may exceed that of any lion. Ten feet from the tip of the nose to the end of the tail is no unusual length for a large male tiger. The female is somewhat smaller, and has a lighter and narrower head. The tiger has no mane, but in old males the hair on the cheeks is rather long and spreading. The ground colour of the upper and outer parts of the head, body, limbs and tail, is bright rufous fawn; and these parts are beautifully marked with transverse stripes of a



W. SUSCHITZKY

TIGER (PANTHERA TIGRIS), NATIVE OF SOUTHEAST ASIA

dark, almost black colour. The markings vary much in different animals. and even on the two sides of the same animal. The under parts of the body, the inside of the limbs, the cheeks and a large spot over each eye are nearly white. The tigers which inhabit hotter regions, as Bengal and the south Asiatic islands, have shorter and smoother hair, and are more richly coloured and distinctly striped than those of northern China and Siberia, in which the fur is longer, softer and lighter coloured. Black and white phases have been recorded, but they are rare. The tiger is exclusively Asiatic, but has a wide range in that continent, having been found in almost all suitable localities south of a line drawn from the Euphrates river, passing along the southern shores of the Caspian and Sea of Aral by Lake Baikal to the Sea of Okhotsk. Its most northern range is the territory of the Amur, its most southern the islands of Sumatra, Java and Bali. Westward it reaches to Turkish Georgia and eastward to the island of Sakhalin. It is absent, however, from the great elevated plateau of Central Asia, nor does it inhabit Ceylon, Borneo or the other islands of the Indo-Malay archipelago, except those named.

The principal food of the tiger in India is cattle, deer, wild hog and peafowl, and occasionally human beings. The regular "man-eater" is generally an old tiger whose vigour is past, and whose teeth are worn and defective; it takes up its abode in the neighbourhood of a village, the population of which it finds an easier prey than wild animals. Though chiefly affecting grassy plains or swamps, tigers are also found in forests, and seem to be fond of haunting the neighbourhood of old ruins. As a rule, they do not climb trees; but when pressed by fear, as during an inundation, they have been known to do so. They take to the water readily and are good swimmers.

The tigress gives birth to from two to six cubs, but three is the common number. She is an affectionate mother, and generally guards and trains her young with watchful solicitude. They remain with her until nearly full-grown, or about the second year, when they are able to kill for themselves. While they remain with her she defends them with courage and energy, but she has been known to desert them when pressed, and even to eat them when starved. As soon as they begin to require other food than her milk, she kills for them, teaching them to do so by practising on small animals.

Although the tiger is superficially distinct from the lion, both species are very closely allied anatomically and physiologically. Under certain conditions, as in enforced confinement in zoos, they occasionally hybridize. The offspring of such matings are called "tigons" when the father is a tiger or "ligers" when the father is a lion.

See Sir J. Fayrer, *Royal Tiger of Bengal (1875);* F. W. Champion, *With a Camera in Tiger Land* (1927); R. I. Pocock, *Fauna of British India, Mammalia,* vol. 1 (1939).

TIGERFLOWER, botanically *Tigridia,* a genus of tender herbaceous bulbous plants of the iris family (Iridaceae), natives of Mexico, Central America. Peru and Chile. They have long narrow plicately veined leaves springing from the bulb and a stem bearing two or three scattered smaller leaves and above a few flowers emerging from a spathe. The striking flowers are spotted (whence the name tigerflower or tiger iris) and have free segments springing from a tube; the three large broad outer segments are concavely spreading, the three inner are much smaller and more erect. T. *pavonia* (flower of Tigris or tigerflower) has large red flowers spotted with yellow and purple; however, many colourful variants exist in the garden varieties.

J. HORACE MCFARLAND CO.

TIGERFLOWER (TIGRIDIA PAVONIA)

TIGLATH-PILESER (Assyrian Tukulti-pal-E-sarra, "my confidence is the son of E-sarra," *i.e.,* the god In-Aristi), the name of several Assyrian kings. Their numbering is not certain.

TIGLATH-PILESER I, the son of Ashur-ris-isi, ascended the throne c. 1120 B.C., and was one of the greatest of Assyrian conquerors. His first campaign was against the Moschi who had occupied certain Assyrian districts on the Upper Euphrates; then he overran Commagene and eastern Cappadocia, and drove the Hittites from the Assyrian province of Subarti northeast of Malatia. In a subsequent campaign the Assyrian forces penetrated into the Kurdish mountains south of Lake Van and then turned westward, Malatia submitting to the invader. In his fifth year Tiglath-Pileser attacked Comana in Cappadocia, and placed a record of his victories engraved on copper plates in a fortress he built to secure his Cilician conquests. The Aramaeans of north Syria were the next to be attacked, and he thrice made his way as far as the sources of the Tigris. The command of the high road to the Mediterranean was secured by the possession of the Hittite town of Pethor at the junction of the Euphrates and Sajur, and at Arvad he received presents, including a crocodile, from the Egyptian king, and, embarking in a ship, is said to have killed a dolphin in the sea. He was a great builder, the restoration of the temple of Ashur and Hadad at Ashur being one of his works.

TIGLATH-PILESER II or III, son of Hadad-nirari II, appears to have reigned from about 950 to 930 B.C., but nothing is known about him.

TIGLATH-PILESER III or IV was a successful general who usurped the Assyrian throne on the 13th of Iyyar 745 B.C., after the fall of the older dynasty, and changed his name of Pulu (Pul) to that of the famous conqueror of earlier times. In Babylonia, however, he continued to be known as Pulu. He was a man of great ability, both military and administrative, and initiated a new system of policy in Assyria, which he aimed at making the head of a centralized empire bound together by a bureaucracy uho derived its power from the king. The empire was supported by a standing army and an elaborate system of finance. The first task of Tiglath-Pileser was to reduce the Aramaean tribes to order, and so win the gratitude of the Babylonian priests. Then he struck terror into the wild tribes on the eastern frontiers of the kingdom by a campaign which extended into the remotest parts of Media. Next came the defeat of a northern coalition headed by Sar-duris of Ararat, more than 72,000 of the enemy being captured with the city of Arpad, where the Assyrian king received the homage of the various Syrian princes. Arpad revolted soon afterward, but was retaken by a siege in 740 B.C. The following year Azariah of Judah appears among the enemies of Tiglath-Pileser, who had overthrown his Hamathite allies and annexed the 19 districts of Hamath. The conquered populations were now transported to distant parts of the empire. In 737 B.C. Tiglath-Pileser again marched into Media, and in 735 he invaded Ararat and wasted the country around the capital Van to a distance of 450 miles. In 734 B.C. he was called to the help of Yahukhazi (Ahaz) of Judah, who had been attacked by Pekah of Israel and Rezon (Rasun) of Damascus. Rezon, defeated in battle, fled to his capital which was at once invested by the Assyrians, while with another portion of his army Tiglath-Pileser ravaged Syria and overran the kingdom of Samaria. Ammon, Moab, Edom and the queen of Sheba sent tribute, and Teima in northern Arabia was captured by the Assyrian troops. In 732 B.C. Damascus fell; Rezon was put to death, and an Assyrian satrap appointed in his stead. Tyre also was made tributary.

The next year Tiglath-Pileser entered Babylonia, but it was not until 729 B.C. that the Chaldaean prince Ukin-zer (Chinzirus) was driven from Babylon and Tiglath-Pileser acknowledged as its legitimate ruler. In the early part of Tebet 727 B.C. he died, after having built two palaces, one at Nineveh, the other at Calah.

See also BABYLONIA AND ASSYRIA: *History.*

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TIGRANES (DIKRAN), king of Armenia (c. 140–55 B.C.), was the son or nephew of Artavasdes of Armenia, and a member of the dynasty founded by Artaxias. (See SELEUCID DYNASTY.) He was given to Mithradates II of Farthia as a hostage, and purchased his freedom by ceding 70 valleys bordering on Media.

Tigranes ascended the throne in 95 or 94 B.C. (Plut. Luc. 21), and immediately began to enlarge his kingdom. He deposed Artanes, king of Sophene, and entered into alliance with Mithradates VI Eupator of Pontus, whose daughter Cleopatra he married. In 93 he invaded Cappadocia in the interest of Mithradates, but was clriven back by Sulla in 92. During his first war with Rome, Mithradates nas supported by Tigranes. although he abstained from interfering openly. But he meanwhile began war with the Parthians. whose empire mas weakened after the death of Mithradates II (about 88) by internal dissensions and invasions of the Scythians. Tigranes reconquered the valleys which he had ceded, and laid waste a great part of Media; the kings of Atropatene Gordpene (now Bohtan), Adiabene (Xssyria) and Osroene (Edessa) became his vassals, who attended him like slaves wherever he went; he also annexed northern Mesopotamia. In 83 he invaded Syria, defeated the last successors of Seleucus and occupied Cilicia. In the war between Mithradates and Sulla he did not interfere, but after the death of Sulla (78) he occupied Cappadocia again and expelled King Ariobarzanes I, the vassal of the Romans. During the next years he had a nar in Syria, against Cleopatra Selene. and in Cilicia, nhere he destroyed the Greek tonn of Soli. Tigranes now had become "king of kings" and the mightiest monarch of Asia So he built a new royal city, Tigranocerta, on the borders of Armenia and Mesopotamia, between Mt. Masius and the Tigris, where he accumulated all his wealth and to which he transplanted the inhabitants of 12 Greek touns of Cappadocia, Cilicia and Syria (for the situation, which is much disputed, cf. Tac. *Ann.* xiv, 24, xv, 5, ed. Furneaux). He also transplanted many Arabic tribes into Mesopotamia. But the Romans could not tolerate encroachment upon their sphere of power, and in 69 Lucullus invaded Armenia. Tigranes was beaten at Tigranocerta on Oct. 6, 69, and again near Artaxata in Sept. 68. The recall of Lucullus gave some respite to the two kings, who even invaded Asia Minor again. But meanwhile a son of Tigranes and Cleopatra, called Tigranes, like his father, rebelled against him (as the old man had already killed two of his sons, he had reason enough to be afraid for his life) and found refuge with the Parthian king Phraates III, who sent him back with an army. The old king now gave up all hope of resistance; he put a price on the head of Mithradates, and when Pompey advanced into Armenia and united with the younger Tigranes, he surrendered (66 B.C.). Pompey now changed his policy; he received the old Tigranes graciously and gave him back his diadem. while he treated the son very coolly and soon made him prisoner. The younger Tigranes was led in triumph into Rome, where he found his death when he tried to escape from his confinement by the intrigues of P. Clodius in 58. The father after his defeat ruled about ten years longer over Armenia as vassal of the Romans. He died about 56, and was succeeded by his son Artavasdes. (See also MITHRADATES.)

See Lucian, *Macrob. 15*; Appian, Syr. 48; *Mithr.* 67, 104; Strabo, xi, 531 *seq.;* xii, 539; xvi, 745, *seq.;* Plut., *Luc., Pomp., Sulla;* Justin, xxxvii, 3; xl, i.

TIGRÉ (SHOA), a northern province of Ethiopia; one of the four former principal divisions of the country. Pop. (1956 est.) 1,000,000; area 26.500 sq.mi. Tigré contains the towns of Axum (Aksum, *q.v.*), capital of the ancient Ethiopic empire, and Adua (Aduwa, *q.v.*). (*See* ETHIOPIA.) Tigriña, the dialect spoken in Tigré and Lasta, is nearer the ancient Gîz than is Amharic, the official and more widely diffused language of Ethiopia.

See J. Schreiber, *Manuel de la langue tigrai* (Vienna, 1887–93); and L. de Vito, *Grammatica della lingua tigrigna* (Rome, 1895).

TIGRIS, the more eastern of the two rivers of Mesopotamia. It rises from two principal sources. The eastern branch rises from several streams to the south and west of Lake Van. The western branch rises about 10 miles south of Lake Geuljik. The upper waters of the Tigris therefore lie on the southern slopes of the Taurus the northern slopes of which are part of the basin of the Euphrates. The Tigris in its lower course seems to be particularly unstable. Although there is no evidence of any great change in the upper waters, from Kut al Amara onward the bed of the river has shown considerable variations. At the beginning of the second millennium B.C. the river appears to have been flowing along the Shatt al Hai; indeed the position of Lagash makes it almost certain that this was its normal course in Sumerian times. In Sassanid times it followed its present easterly course; during Arab times, however, it was apparently flowing along the Shatt al Hai. There are no ancient remains on the Tigris therefore below Kut al Amara, and owing to the changeable nature of the stream even few modern villages. In the alluvial area the Tigris lies lower than the Euphrates as far as the Shatt al Hai, and therefore in ancient times received the tailings of the canals, but did not supply water except locally for irrigation. It appears not to have deposited its silt as much as the Euphrates, probably due to the lack of suitable terrain for the formation of fresh water lakes, which are usually a silting ground for river deposits. Since its abandonment of the old channel the Tigris has probably contributed very considerably to the formation of new land at the head of the gulf. The upper drainage area also seems to have altered to a slight extent. The Arab geographers suggest that at one time at least part of the waters of the Khabur, a tributary of the Euphrates, flowed into the Tigris by a channel which was navigable when in flood. As late as 1832 Ormsby reported a stream from Jabal Sinjar which joined the Euphrates near Sharqat. This stream still appears to exist, but it no longer empties itself into the Tigris and in view of the waywardness of the rivers of Mesopotamia it is possible that Ormsby's observation was made at an unusual period.

Topography.— The Western Tigris, on whose banks lies the important town of Diarbekr flows east along the southern slopes of the Taurus and receives a number of tributaries of small size. The two main branches join at Til, from which point it runs in a southeasterly direction. It continues to receive a number of small tributary streams, mostly on the left bank. From the neighbourhood of Mosul to the confluence of the Greater Zab there lies a fertile triangle of land between the hills and the river. Nineveh lay on the left bank opposite Mosul. A little lower down the stream was the city of Kalakh. At this point two great barrages were erected in ancient times, which still effectively block the river for navigation. From a little above the confluence of the Greater Zab down to Tekrit the river flows through an uninhabited desert, the only important town being Kalaat Sharqat, the ancient Assur, which at present forms the railhead of the southern part of the Baghdad railway. About 30 miles below Sharqat the Lesser Zab joins the Tigris. From Tekrit, a city founded during the Persian domination, downwards, signs of ancient irrigation begin, although the alluvial plain is not entered until Samarra is reached. Below Samarra as far as Kut al Amara, a distance of about 200 miles, there was in ancient times a canal which served to straighten the course of the stream. The two principal tributaries in this region, the Adhem and the Diala, were also canalized, the Adhem reaching the main stream just below Samarra, the Diala below Baghdad. Close to the mouth of the Adhem are the ruins of an ancient city probably to be identified with Xenophon's Opis. Near this point the river makes a great bend and flows south to Baghdad (*q.v.*) at which point the Tigris and the Euphrates are only about 35 miles apart. In ancient times the two rivers ran close to one another and there are traces of numerous old irrigation canals connecting them. Below Baghdad lie the ruins of ancient Ctesiphon, on the left bank; opposite Seleucia on the other bank Kut al Amara marks the point where the Shatt al Hai leaves the present main stream. Below this point owing to the change in the course of the stream there are no ancient remains along the Tigris. The modern towns are Ali al Gharbi, Ali esh Sharki Amara, Qalaat Saleh and Kurna, below which point the two rivers unite to form the Shatt al Arab.

Navigation.—Although before World War I a launch navigated the river between Baghdad and Samarra (about 90 miles), and in 1838 a steamer went to within 28 miles of Mosul the upper Tigris is only navigable for native rafts. These rafts which may be as much as 35 tons burden are made of timber supported by inflated skins. During flood they cover the 27; miles between Baghdad and Mosul in three or four days. At their destination the wood finds a ready market in this treeless country, and the skins are carried back again on the backs of asses. No upstream traffic is carried on. The river flows over a bed of clay, sand or conglomerate, and is full of obstructions. Opinion has however been expressed that if these obstructions and the ancient barrages at Sharqat were cleared away, navigation to Mosul would be possible. In the lower part of the river there are bridges of boats at Baghdad, Gerara, Kut, Kut al Amara and Kale Sale. Between Baghdad and Kale Sale the Tigris is navigable all through the year by vessels drawing up to 5 feet of water. Below this point the river is in a bad condition, largely owing to the barrages built by native cultivators, but great efforts have been made to restore the channel. At low water it is generally estimated that only three feet of water is available. The low water period is reckoned from July to November, and high water from December to June, but the river is extremely liable to sudden floods.

The statistical details so far as at present recorded are as follows. From Baghdad to Kut the distance by river is 216 miles, the distance by land being 103 miles. At Baghdad the river is 114 feet above sea level, at Kut it is 57 feet, the fall in the river surface being 1 in 20,000. The width of the river is about a quarter of a mile, its depth at high water 26 feet, and at low 4½. The discharge in flood is 5,500 cubic metres a secbnd, dropping to as low as 300 cubic metres at low water. The velocity in flood is a little under 4 miles an hour, dropping at low water 1¼. At Kut the Shatt al Hai discharges about 1,000 cubic metres at high flood, but is dry at low water. Between Kut and Kut al Amara the river distance is 153 miles, and by land 119. The mean level at Amara is 28 feet, the drop between the two points being therefore about 19 feet, the gradient of the river level is 1 in 35,000. The average width of the river in this reach, which is singularly free from any obstacles for navigation, is about 365 yards, while the depth is 25 feet in flood and about 6 ft. 6 in. at low water, with a respective velocity of about the same as in the upper reach. The discharge at low water is similar but at high water about 1,000 cubic metres less at the head of the reach; owing however to branches at the lower end of the reach the discharge at high water only reaches about 2,500 cubic metres per second.

Between Amara and Kurna the river is affected by various channels which drain off much of the water. At Amara on the left bank the Chala, with a bed about 6 feet lower than the main stream, discharges about 1,000 cubic metres a second at high water falling to rather more than a tenth of that amount at low. Below this point first the Majar Kebir and then the Machera draw off about the same amount. Considerable changes take place therefore in the size of the stream between Amara and Kurna, at which point the level is 10 feet above sea level. The average width of the Tigris at this reach is a little under 200 yards, with a depth of 13 feet in flood and 6 ft. 6 in, at low water with a discharge of only 1,250 cubic metres per second and 150 at high water and low water respectively. Below Kale Sale although the depth is the same the average width is only 65 yards. Below Ezra's Tomb some of the lost waters return to the river from swamps and the stream becomes once more nearly 200 yards broad. The two rivers meet at Karmat Ali at which point the Tigris, full of dark marshy water, is more than 30 feet deep and more than 400 yards broad.

It will be seen from these details that the river presents great difficulties for navigation. In flood time it is liable to overrun its banks and convert the whole region into a vast lake. In addition to river steamers two types of native boats are used, a large coracle or Quffeh and river boats, *Safineh*, capable of carrying a cargo of as much as 100 tons. The coracles can only go downstream but the river boats are poled or towed upstream and are sailed or rowed with the current.

See Sir W. Willcocks, *The Irrigation of Mesopotamia* (1911), *Memorandum respecting the Navigation of the Tigris and Euphrates* (1913); *Colonial Office Reports* (annually). For ancient sites *see* S. Langdon, *Cambridge Ancient History* (1923) (Bibliography).
(L. H. D. B.)

TILAK, BALGANGADHAR (1856–1920), Indian nationalist leader, a Chitpavan Brahmin, was born at Ratnagiri July 23, 1856. At an early age he took the lead in providing education in Poona under Indian direction. In 1890 he was proprietor and editor of two weekly papers, Mahratta, in English, and *Kesari* (*Lion*), in Mahratti, which he used for antigovernment propaganda. His violent condemnation in 1897 of the plague prevention regulations resulted in his being convicted for sedition and sentenced to 18 months' imprisonment. For a similar offence he was sentenced in 1908 to six years' transportation, later commuted to simple imprisonment. After his release he took part in the home-rule campaign, and secured for his party control of the national congress. He died in Bombay Aug. 1, 1920. His formative part in the cult of Indian unrest is shown in the report of the Rowlatt sedition committee (1918). His speeches are collected in Lokamanaya B. G. *Tilak* (2nd ed. Madras, 1920).

TILBURG, a town, province of North Brabant, the Netherlands, and a junction station 13½ mi. S.E. of Breda by rail. Pop. (1954) 106,949. Tilburg rose to importance after the separation of Belgium from Holland as one of the chief industrial (mainly textile) centres of the south. In 1927 a Roman Catholic graduate school for business administration was established there. Tilburg was the favourite residence of King William II.

TILBURY DOCKS, on the north shore of the Thames, in Essex, Eng. They lie opposite Gravesend 25 mi. below London bridge and about the same distance from the Nore, being thus within the Port of London. They were constructed in 1886. but the rapid development of the Port of London necessitated many changes and they now accommodate the largest liners using the port. Railway communication provides direct connection for goods traffic with all northern lines. The system has a total land area of 72J ac. and a water area of 104 ac. It consists of a main dock with three branch docks, connected with a tidal basin. The principal entrance lock is 1,000 ft. long, 110 ft. wide, with a depth on the sills of 45½ ft. There are three small dry docks; a fourth is 750 ft. long and 110 ft. wide. A river cargo jetty, 1,000 ft. by 50 ft., was completed in 1921, while a passenger landing stage 1,142 ft. long, also in the river, with 3J ft. depth alongside at low water, was opened in 1930. The total length of dock quayage is nearly 4 mi. A new quay, 842 ft. long, and a passenger terminal with frontage of 550 ft. on the north side of the main dock was under construction in the mid-1950s. To meet the growing volume of road transport a new system of dock roads was built.

TILDEN, SAMUEL JONES (1814–1886), U.S. statesman, was born at New Lebanon, N.Y., Feb. 9, 1814. In 1834 he entered Yale university, but soon withdrew on account of ill health, and later studied in the College of the City of New York. He was admitted to the bar in 1841. In the financial troubles between 1850 and 1860 it is said that more than half the railways north of the Ohio river and between the Hudson and the Missouri rivers were at some time his clients. Tilden served in the state assembly in 1846 and in the state constitutional conventions of 1846 and 1867. In 1848 he participated in the revolt of the "Barn-burner" or free-soil faction of the New York Democrats, and in 1855 was the candidate of the "softshell" or antislavery faction for attorney general of the state. During the Civil War, although he opposed several of Lincoln's war measures, he gave the union cause his heartiest support.

In 1866 Tilden became chairman of the Democratic state committee, and soon came into conflict with the notorious "Tweed ring." As the "ring" could be destroyed only by removing the corrupt judges who were its tools, Tilden, after entering the assembly in 1872, took a leading part in their impeachment. By analysing the bank accounts of certain members of the "ring," he obtained legal proof of the principle on which the spoils had been divided. His fame as a reformer brought him to the governor's chair in 1874, and he gave his attention to breaking up the "canal ring," made up of members of both parties who had been robbing the state through maladministration of its canals.

In 1876 the Democrats nominated him for the presidency, the Republicans nominating Rutherford B. Hayes of Ohio. The result was the disputed election of 1876, when two sets of returns were sent to Washington from the states of Florida, Louisiana, South Carolina and Oregon. As the federal constitution contained no provision for settling a dispute of this kind the two houses of congress agreed to the appointment of an extra-constitutional body, the "Electoral Commission" (*q.v.*), which decided all the contests in favour of the Republican candidates. Tilden counselled his followers to abide quietly by the result. The remainder of his life was spent in retirement at his country home, Greystone, near Yonkers, N.Y., where he died Aug. 4, 1886. Of his fortune (estimated at $5,000,000) approximately $4,000,000 was bequeathed for the establishment and maintenance of "a free public library and reading-room in the City of New York"; but, as the will was successfully contested by relatives, only about $2,000,000 of the bequest was applied to its original purpose; in 1895 the Tilden Trust was combined with the Astor and Lenox libraries to form the New York public library.

See *Writings and Speeches of Samuel J. Tilden* (1885) and *Letters and Literary Memorials of Samuel J. Tilden* (1908), both edited by John Bigelow; also Bigelow's *Life of Samuel J. Tilden* (1895); and P. L. Haworth, *The Hayes-Tilden Election* (1927).

TILDEN, WILLIAM TATEM II (1893–1953), U.S. tennis player, first American to win the men's singles at Wimbledon, dominated tennis in the 1920s. Born in Philadelphia, Feb. 10, 1893, Tilden was 27 when he won his first national championship, in 1920. For 10 straight years he ranked at the top, winning seven national championships — six (1920–25) in a row and the last in 1929. He won the Wimbledon title in 1920, 1921 and 1930, was on 11 Davis cup teams and led the battle that kept the prized cup in the U.S. for seven straight years. He won a total of 70 U.S. and international championships.

Tilden had powerful shoulders, a light frame and long legs—the perfect tennis build; he was famous for his cannonball serve and a paralyzing forehand and backhand. He died in Hollywood, Calif., June 5, 1953. (J. D. McC.)

TILE, a thin, flat slab or block, usually of burned clay, glazed or unglazed, used either structurally or decoratively in building. The usage of the word varies widely; in connection with roofing, flat slabs of any material are sometimes termed tiles, as, for instance, the marble tiles of some Greek temples or the bronze tiles of ancient Rome. Similarly, stone slabs, used for roofing, as in certain parts of England, are termed stone tiles; slate, however, is never so called. Many forms of rough terra cotta used structurally in building are called tiles; thus an arch of hollow terra-cotta blocks between steel beams is known as a tile arch; partitions built of hollow terra-cotta blocks are known as hollow-tile partitions; rough terra-cotta pipes used for drainage are called drain tiles; and the steel forms used for casting certain types of reinforced concrete floors are frequently referred to as steel tiles.

The differentiation between tile, terra cotta (*q.v.*) and brick is thus exceedingly vague. (See BRICKWORK.) Modern usage extends the word "tile" to include blocks or panels made of plastics, glass and sound-absorbing materials.

Roofing Tile. — There is no evidence of the use of roofing tiles in the Mediterranean basin prior to the development of Hellenic civilization, but the most ancient examples of roof tiles show such highly developed forms that earlier usage must be assumed. The Greek form of temple roof which remained constant throughout the history of Greek architecture (*q.v.*) consisted of two types of tile, used together. First the roof surface was covered with tiles generally flat, but with adjoining edges raised, laid in overlapping courses, and all of equal size. Convex covering tiles, also overlapping, were then laid over the joints of the flat tiles below; in this manner an absolutely watertight roof could be produced. In order to make the architectural effect more delicate the ends of both lower tile and covering tile were rebated, so that the thickness of the overlapping portion was only half the thickness of the tile. At the bottom of each row of covering tiles was either a marble or tile upright, curved, decorative member known as an antefix.

In some cases the covering tiles were of pointed, straight-line section — the most common Greek type — in others a tile of semicircular section was used, easy to manufacture but lacking in the extreme refinement of the other type; in the simpler domestic work, the lower courses were also of curved section, a segmental concave shape replacing the flat tile with raised edges. The marble tile used in some Greek temples, as in that of Bassae (5th century B.C., by Ictinus), is universally of the type with flat under tile and pointed covering tile, although at times, in order to reduce the number of joints, the covering tile and the under tile are cut from the same piece of marble.

Two other types of roof tile were common in Roman architecture (*q.v.*) and probably represent common Mediterranean types of much earlier origin. One of these is the so-called "Spanish tile," also called "pantile," with a contour resembling the letter S, in which the convex part of each tile fits over the edge of the concave portion of the next. The other type is the shingle or flat tile found frequently in the Roman ruins of the northern provinces. These flat tiles are often of stone.

The usual material of all of these types of tile is burned clay, varying in colour from orange-yellow to purple-red. It is known, however, that bronze tiles were relatively common on the most monumental buildings of the Roman empire. Due to the rarity and value of bronze during the middle ages and the Renaissance, no examples of ancient bronze roof tiles are known.

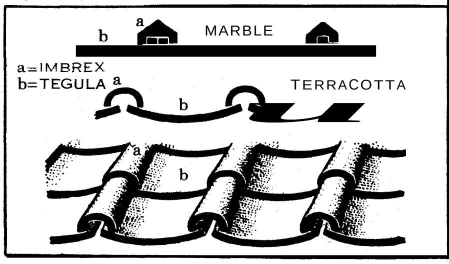
All of the classic forms of clay tile continued in use in various parts of the world during the medieval period, but their supremacy as a roofing material gradually yielded to lead and zinc for churches, public buildings, palaces, etc., and to slate, stone and thatch for the smaller private houses.

Clay roof tiles remain of substantially the same form; improvements have been only in methods of manufacture and not in design. The flat tile designed to hook over roof battens or boards is perhaps the most common type of small house-roof covering in England and parts of France, and the combination of concave under tile and convex over tile is almost universal on pitched roofs in Italy, Spain, Greece and Turkey. The S-shaped tile is also common around the Mediterranean. The curved tiles are almost always laid in a heavy bed of waterproofed mortar, with ridges and hips covered by courses of overlapping tiles, similarly bedded; with flat tiles, the use of mortar is restricted to the convex or pointed tiles covering the hips and ridges.

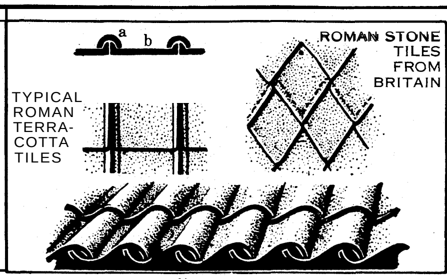
The best modern usage in laying tiles of this type demands the complete covering of the roof surface with a watertight material such as slaters' felt or heavy waterproofed paper before the tile is applied. The tiles themselves are held in place sometimes by copper nails which secure the under tiles direct to the roofing and the covering tiles to wood battens which run up the slope of the roof under each row of covering tiles, and sometimes by copper wire brought up through two holes in each tile and twisted together.

Although various attempts have been made to imitate clay tiles in stamped metal and concrete, these imitations are so lacking in the individual variation typical of ceramicware that their use has been restricted to the cheapest type of jerry-built construction; their use, even there, is seriously questionable. Quite different are the roofing tiles of reinforced and waterproof concrete, which are common in industrial buildings, especially in Europe. These modern, industrial tiles are usually of large size — sometimes running to four feet in length, and arranged to interlock, with the exposed surfaces grooved or channeled in such a way as to lead the water away from any joints. In these concrete tiles colouring matter is usually added in the material itself. (See also ROOF.)

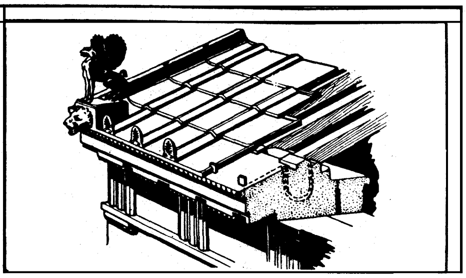
Roofing Tile in the Far East. — Although the principle of the roofing tiles of China and Japan is the same as that in the west, there are many differences in detail. Thus, in temples and palaces in China, the under tiles are slightly concave and overlap, much like those of classic roofs; the covering tiles, however, are made absolutely cylindrical in general contour, with rebated ends, so that they form long, unbroken lines of shadow down the roof. Moreover, instead of the upright antefix of the classic roof, the Chinese tiles have ornaments that project downward, in generally scalloped shapes, over the face of the cornice. There is also, particularly in north China, a tremendous elaboration of ridge and hip tiles, which are frequently of great height, with an elaborately molded section, carrying at their ends rows of animals — a great dragon or the like. At the ends of the ridge are large, grotesque beasts with their heads pointing inward; all these ornaments are modeled and baked in the tile itself. One of the chief glories of the Chinese roof tiles is their colour. This is produced by a shiny glaze that reveals the expected Chinese ceramic skill.



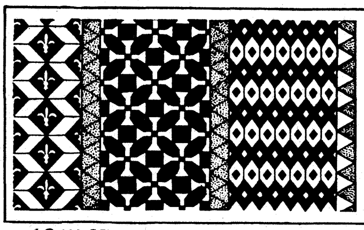
TYPICAL CLASSIC ROOFING TILES



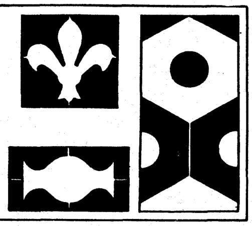
SO-CALLED "SPANISH" TILE USED IN LATIN COUNTRIES FROM ROMAN TIMES TO THE PRESENT



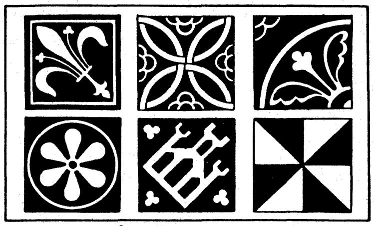
GREEK MARBLE TILE ROOF TEMPLE OF APOLLO BASSAE 5TH CENTURY B C



12TH-CENTURY TILE FLOOR FROM MONASTERY OF STE. COLOMBE (YONNE)

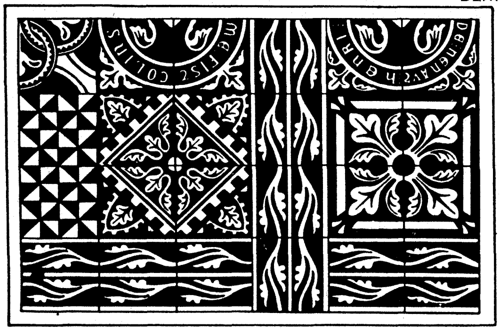


DETAILS FROM A SIMILAR FLOOR IN THE ABBEY OF ST. DENIS

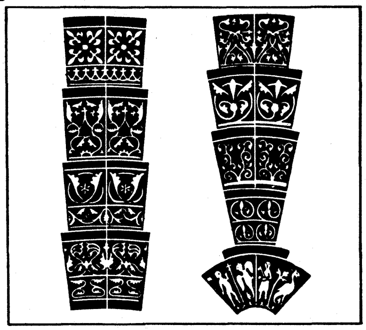


TYPICAL 14TH-CENTURY FLOOR TILES (VÉZELAY)

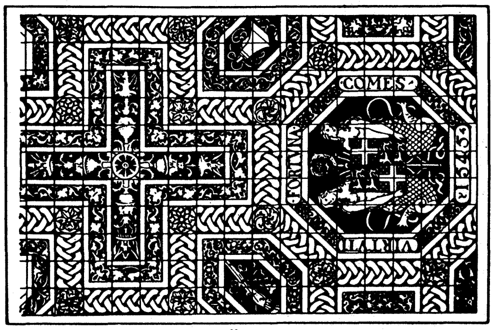
TYPICAL 13TH-CENTURY FLOOR TILES (AUXERRE)



FLOOR OF THE CHAPEL OF THE CHATEAU D'HAULSY (MARNE), 13TH CENTURY



PARTS OF A CIRCULAR PATTERN IN THE CHAPEL FLOOR FROM THE ABBEY OF CUNAULT, 13TH CENTURY



FRENCH RENAISSANCE FAÏENCE TILE FLOOR FROM THE CHATEAU OF POLISY (AUBE), 16TH CENTURY

CENTRE AND LOWER ROWS, FROM EMILE AMÉ, "LES CARRELAGES EMAILLES DU MOYEN-AGE ET DE LA RENAISSANCE PRECEDES DE L'HISTOIRE DES ANCIENS PAVAGES" (MONEL ET CIE)

The usual colour of temple and palace roofs is bright yellow, but other colours frequently occur. In central and south China, even temple roofs are frequently black. The cheap roof tile of the ordinary house is also almost black, but without lustre and with overlapping covering tiles like those of the west. (See also CHINESE ARCHITECTURE; TEMPLE.)

The same pattern of rebated, continuous, cylindrical covering tiles is common in the Buddhist shrines of Japan, but colours are rare, the ordinary tile being gray, with a very effective and artistic silvery lustre. (See also JAPANESE ARCHITECTURE.)

Floor Tile.—Except as small fragments of tile occur in classic mosaic (*q.v.*) and terrazzo, tile for floors does not seem to have been common in Europe prior to the 12th century. In the late 12th and 13th centuries, however. tile floors became usual in churches and other important buildings. The most common type consisted of square tile in two colours, usually a dark brown-red and a pale orange or brownish yellow. They were made by casting clay in such a manner that the parts to be in a lighter colour were sunk; when dry, these parts were filled with a clay of different composition which would bum to a lighter colour; the tile thus prepared was then burned. Patterns were formed of many tiles and consisted usually of circles or stars containing heraldic beasts, ecclesiastical symbols, etc.; in many cases the pattern was made with reversed colours, so that what was background colour in one tile was ornament colour in the one next to it. In the earliest examples designs were formed by a mosaic treatment in which the pattern was made by the shape and size of the individual tiles, as in the 13th century example found at Fountains abbey and at Prior Crauden's chapel at Ely (1321–41), both in England. Other common types of medieval pavement have the pattern merely incised, producing the artistic effect of a sketch.

The development of floor tiles in Gothic France was similar. The 12th-century examples are usually mosaic in type with black, dark green, light green and yellow as the predominating colours. The richest examples of these are in the abbey church of St. Denis, near Paris, where certain elaborate, chapel floor pavements still exist from the original building (1140–44) by Abbot Suger. By the end of the century, mosaic had yielded to two-coloured tiles of red and yellow, similar to the English tiles mentioned above. The same type remained constant until well into the 15th century, the designs becoming continuously thinner and more delicate; in the 16th century the art died out, superseded by the painted majolica pavements of the Renaissance.

The Gothic revival of the middle 19th century led, in England, to the revival of the designing and making of tiles of the medieval type and many modern pavements were placed in old churches as a result. Most of this tile has a simple lead glaze and is made not by casting damp, plastic clay, as in the medieval examples, hut by compressing po dered clay in steel dies so that shapes are more perfect and the rapidity of manufacture is vastly increased.

This type of tile, usually known as encaustic, is especially associated with the English ceramic works at Stoke-upon-Trent, particularly those of Minturn.

Meanwhile the Moorish skill in tilemaking had gradually come to be applied to floors. This type of majolica tile was adopted in early Renaissance churches, both in Italy and Spain, although not many examples remain, as the glaze was too soft. The decoration of the Italian majolica pavements consists of the same type of free and graceful classic arabesque trophies, acanthus ornament and coats of arms that is found on contemporary majolica.

In France not only were Italian tiles imported and used, but there soon grew up a local manufacture of similar painted floor tiles, especially at Rouen (established by Masseot Abaquesne, 1542–57), Nevers and Marseilles. With the increasing use of oak parquetry flooring for houses and marble for churches, toward the end of the 17th century, the use of tile diminished. There was similar importation of Italian and Spanish tiles into England during the early Renaissance and possible spasmodic attempts toward the making of certain types of this tile in England itself.

In the 18th century the use of plain, undecorated, square, red tiles, now commonly known as quarry tiles, became common all over northern and western Europe, and to a less extent in the American Colonies.

The greatest advances in modem floor tiles have been made in simple, vitrified, mosaic tiles for use in bathrooms, kitchens, swimming pools and public corridors. These are always machine-pressed and are made of fine clays, thoroughly vitrified and very hard. These are made in small squares, rectangles, hexagons and circles, in a few simple colours. Some, by the addition of gritty substances, such as alundum or carborundum, are given a surface which prevents slipping, even when the tile is wet.

Wall Tile.—Earthenware was used spasmodically for wall decoration by the Egyptians, as in the doorway of the Abusir pyramid of Neterkhet (3rd dynasty). More usually, however, they were in the form of mosaic (*q.v.*). Perhaps based upon earlier Egyptian examples, the people of Crete (*q.v.*) developed to an even higher degree the use of fai'ence for walls. Thus our knowledge of early Cretan houses is largely furnished by many fragments of small fai'ence plaques from the 18th century, B.C., which formed portions of a large, mosaic, fai'ence wall decoration. Moreover, there are in existence many modeled reliefs of fai'ence from the middle and late Minoan period which were apparently inserted in the plaster of walls.

Farther east, in the Tigris-Euphrates valley, a tradition of ceramic wall decoration was early established. (See PERSIA: Archaeology.) This took the form of glazed and enameled bricks rather than tiles proper. It is, nevertheless, important as being one of the first attempts to cover large and continuous wall surfaces with a decorative, ceramic material, and the friezes of marching beasts from Chaldean and Babylonian palaces, from the later Assyrian palaces and from their Persian successors, the famous friezes of the archers and the lions from the early 4th-century palace of Artaxerxes II at Susa, have remained models of this type of decorative work.

Moreover, the tradition of fine ceramic work continued vital throughout the stormy period of the fall of the Roman empire and the Islamic conquest. It is in Syria, the Tigris-Euphrates valley and Persia that wall tiles were, undoubtedly, first made. Thus tradition relates that the lustre tiles of the mosque of Sidi Okba at Kairouan were brought from Baghdad in 894, and it is certain that by the 13th century the manufacture of wall tiles for both exterior and interior use was well established in various centres in Persia, notably Rhages and Veramine. The exterior use of wall tiles was most highly developed, and in Persia, also, the transition from enameled and modeled brick to true, thin tile can easily be seen. By the 15th century tile decoration was supreme in Persia and the character had changed. Mosaics and moldings in relief yielded to a flat treatment with the richness entirely in the coloured, foliated ornament and the inscriptions painted on the tiles themselves. In later Persian art there is no distinguishable difference between the tiles of the exterior and the interior.

These Persian tiles governed the taste of the eastern part of the Islamic world; the same running patterns of leaves, palmettes, the carnation and other flowers that appear on Persian carpets decorate alike the interiors of mosques in Persia, Mesopotamia and Turkey, from potteries as far apart as Rhodes, Damascus and Kutayieh. In colour these have, universally, a blue-white ground with patterns predominantly blue and green, with lesser touches of vermilion and rose and occasional yellows. Several potteries in Asia Minor still operate and produce exquisite wall tiles in the traditional patterns and colours. Because of the gracious delicacy of the interlacing stems and the careful spacing of the leaves and flowers, together with a springlike clarity of the colours, these Turkish, Syrian and Persian wall tiles are among the most perfect wall decorations of their type.

Moorish *Wall* Tile.—Farther west, in Spain and North Africa, the Islamic potters were developing a new type of design which gave rise to the famous Spanish *azulejos*, whose decorative richness was such an important feature in the Alhambra (*q.v.*) at Granada (13th and 14th centuries), the so-called house of Pilate at Seville and similar buildings. Although transitional types occur, like the great plaque from Malaga at the beginning of the 15th century in the collection of M. de Osma, in which the patterns are of an almost Persian freedom, with twining foliage, in the greater number the design was almost purely geometric, being formed of interlacing lines than generate 8- and 10-pointed stars, octagons, irregular pentagons and similar figures. There are, in addition, a great many early tiles from the 13th and 14th centuries in which the influence of Christian heraldry is dominant. Even in the transitional plaque mentioned above, coats of arms appear and it is evident that the Islamic potters produced much purely heraldic tilework for Christian consumption. Many of these tiles are rich with metallic lustre decoration; the chief colours are blue, green and brown, with white lines, and in the later work a growing use of black and yellow.

The earliest examples of Moorish wall tiles produced their geometric patterns by a mosaic method in which each bit of separate colour is formed by a separate tile. In order to develop a more facile method of producing the same effect, the technique known as *cuerda* seca (dry cord) was developed, in which the tiles are rectangular, and the pattern on each tile is formed by raised fillets between the different colours, which prevented the adjoining enamels from running together. After the Christian conquest a third method was introduced, called *cuenca* (bowl), somewhat similar to the northern Gothic process in which the portions to be coloured were depressed and then filled with their enamels. These tiles, even in their old traditional Islamic patterns, were popular throughout the 16th century and even later for wainscots in Renaissance houses. The potters were evidently Moors; the great centres of manufacture remained as before in Malaga, Valencia, Granada and Seville.

In the 16th century the Italian majolica type of tile was introduced by Francesco Niculoso of Pisa, and these Spanish majolica tiles were much used, as in the door of the convent of St. Paula at Seville (early 16th century) or the exquisite altarpiece in the Alcazar at Seville made by the same artist in 1503, where the design is purely Italian. Both the cuenca and the *pisano* or majolica types of tile have been made in Spain almost continuously ever since. (See ISLAMIC ART.)

North European Wall Tile.—Meanwhile in Germany there had been developing a type of tile used principally for stoves, with ornament in relief and a glaze of green, yellow or brown. This tile was in widespread use as early as the 14th century and many examples exist throughout Germany, upper Austria and Switzerland, in which the ornament is of great richness, with Gothic architectural forms in the earlier types and Renaissance forms later.

The most important of the north European tiles are undoubtedly those made in Delft, Holland, from 1600 on. These are plain, square tiles, each containing a figure, a bit of landscape or a genre group, freely painted in a gray-blue upon a background of bluish-white. The little freehand sketches were so instinct with life, and the colour so subtly beautiful, that by the middle of the 17th century these tiles enjoyed a great vogue, not only throughout the Germanic countries, but in England and the American Colonies as well. Although outside of Holland they were chiefly used for fireplace and stove facings, in Holland itself they were often employed for wall wainscotings. Some of the later examples have the decorations in manganese purple instead of blue. During the 18th century many attempts were made to imitate the delftware and during the latter half of the 18th century, particularly in England, scenes printed from copper plates were used instead of the painted scenes.

Although many of the ancient pottery centres are still producing tiles in the traditional manner and although modern imitations of old wares are of excellent quality, the greatest modern contribution to wall-tile design was the development of square or rectangular tiles with relatively uneven surfaces and shapes on which colours and glazes of the greatest variety are unevenly flowed. so that each tile has marked individuality of colour and texture. All sorts of crackled and crystalline effects are common, as well as the blending of two or more colours. The scientific development of glazings and colourings gave the decorator an almost unlimited palette for either exterior or interior use. There was a corresponding development in the use of tile in relief, usually with the background sunk and glazed in a different colour.

During the late 19th century, light, flat tiles often provided an ideal material for vaults and domes. Their advantages over wood and stone had earlier been recognized by the Romans, who laid flat tiles verticallv and horizontallv between thick brick ribs in order to lighten vaults, keep them fireproof and gain both support and form for the concrete infilling poured between ribs. The biggest 19th-century innovation was the Guastavino vault, named for a Catalan engineer who developed a light, fireproof vault in which bonded layers of small, light and flat tiles were built into curved surfaces with a minimum of centring. Especially popular in the United States, examples of the Guastavino vault appear in New York's Carnegie hall and St. Thomas's church; St. Paul's chapel at Columbia university, New York city; Boston's public library; and the state capitol at Lincoln, Neb.

Cheaper materials compete with traditional kinds of tile and are called tiles even though some are not made of terra cotta. Fibreboard, sound-absorbing panels, referred to as "acoustic tiles," are used in modern ceilings. Glass block, sometimes called "Glasstile." appears in partitions. A wide variety of mass-produced ceramic veneers is available in different colours, finishes, textures and shapes, though figurative patterns are unusual.

Ceramic-glazed structural tile, hollow and approximately $33 \times 3\frac{1}{2} \times 11\frac{1}{2}$ in. in size, remains an attractive, economical and permanent material for partitions in schools, hospitals, railroad stations and cafeterias.

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TILEFISH (*Lopholatilus* chamaeleonticeps), a beautifully coloured fish of the family Latilidae, living in rather deep water in the western Atlantic. It was first discovered on a bank about 80 mi. S.E. of Boston, and proved to be a valuable food fish.

The tilefish is said to reach a weight of 50 lb., but about 10 lb. is more nearly the average size.

TILIACEAE, the linden family of trees, shrubs or (rarely) herbs, with 35 genera and about 300 species, found in most parts of the world, but largely tropical. Most of the genera are small, but *Grewia,* in the old world tropics, contains about 70 species. *Tilia,* various species of which are known as linden and as basswood (originally bast wood), is typical of the north temperate zone of both hemispheres. The bast of many representatives of the family is tough-and strong; Corchorus *capsularis* and C. *olitorius* being jute (*q.v.*) of commerce, largely produced in India. See LINDEN.

TILLAGE MACHINERY. Tillage includes soil management practices such as reducing residues of previous crops, plowing, harrowing, rolling and cultivating. The primary purposes of tillage are to prepare the seedbed, to retard weed growth and to improve the physical condition of the soil. Manures and fertilizers often are applied in connection with tillage operations.

The field operations that accomplish these purposes include: (1) crop-residue treatment; (2) primary tillage or plowing; (3) secondary tillage, or harrowing (refining the seedbed); (4) cultivation (primarily to retard weed growth); (5) fertilizing and manuring; (6) subsoiling or deep tillage. The kinds of machinery needed depend on the type or combinations of practices employed, and are dealt with under the following headings:

- I. Implements for Treating Crop Residues
  - 1. Stalk Cutters
  - 2. Rotary Cutters or Shredders
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I. IMPLEMENTS FOR TREATING CROP RESIDUES

Although most tillage implements mix crop residues with the soil, certain special implements are used for reducing the stalks of cotton, corn (maize) and other crops having heavy stalks.

1. Stalk Cutters. — These are made in animal-drawn and tractor-drawn sizes. The former has one section, of suitable width for cutting down the stalks of t o rows of corn or cotton; the latter employs two sections and covers four rows. The free-rolling cutting cylinder, with eight or ten sharp-edged knives mounted equidistant from their axis of rotation, is weighted to give a thorough cutting action as the cylinder rolls through the field. Some models have wheels for transport and depend for pressure upon a heavy compression spring. Others are transported by turning the unit upside down and using the transporting runners mounted on the upper side of the implement.

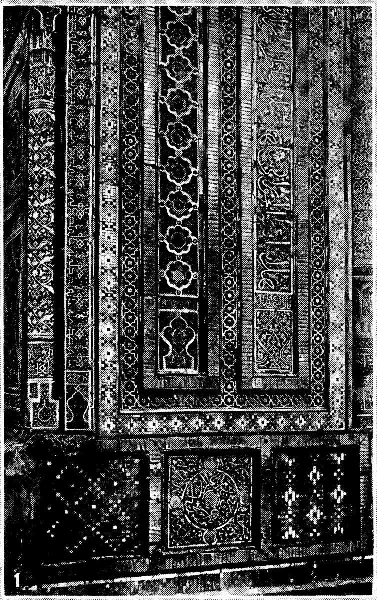
2. Rotary Cutters or Shredders. — Cutters or shredders are used for shredding stalks of cotton and corn, chopping prunings from orchards, cutting crops for silage and mowing pastures for weed control. These machines have many different names, including field shredder. brush beater, rotocycle and hammer knife mower. Tractor-mounted and -trailed models are available; both are driven by the tractor power take-off. One type uses a long horizontal shaft to which are attached flails or hammers. When rotated at high speed the pounding action reduces the stalks or trash to a fine mulch.

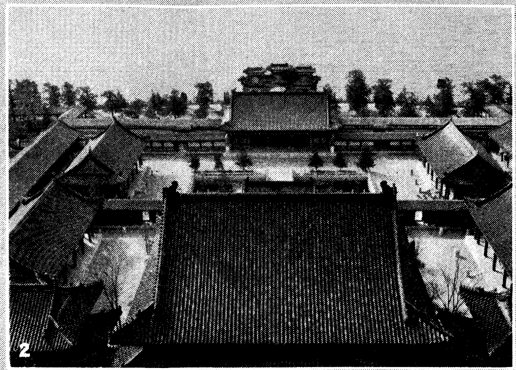
Other types have knives which cut rather than lacerate. Power-driven rotary cutters do more satisfactory work than the rolling stalk cutter.

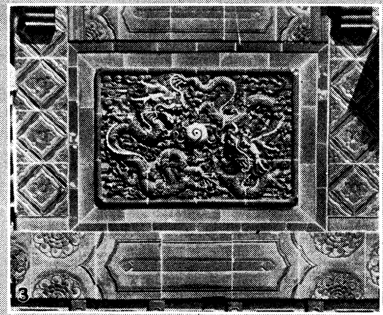
II. PRIMARY TILLAGE OR PLOWING IMPLEMENTS

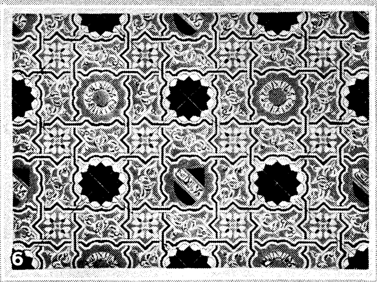
The main objectives of primary tillage are to loosen and aerate the soil, invert it to cover trash and weed seeds and expose a large area of fresh soil to weathering so it can be more readily harrowed into a good seedbed. The implements for primary tillage include moldboard plows, disk plows, listers, middlebusters or middle-breakers, one-way disk tillers and rotary tillers.

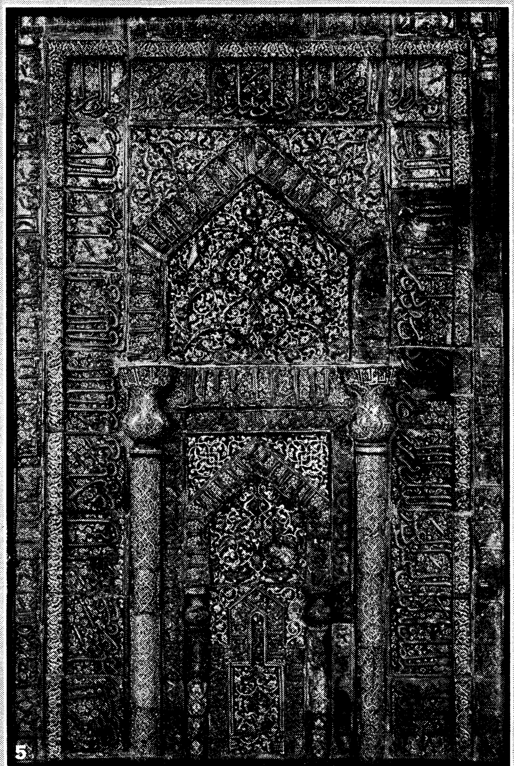
1. Moldboard Plow. — In its simplest form this is a single-furrow, animal-drawn implement held by the plowman who walks behind it. It consists of a beam to which is attached a pair of handles for controlling it; a bottom made up of a share (lay or sock) for cutting the furrow slice loose; the landside for taking the side thrust; a moldboard or breast for turning the furrow; braces; a colter for cutting a vertical side or wall of the furrow (this may

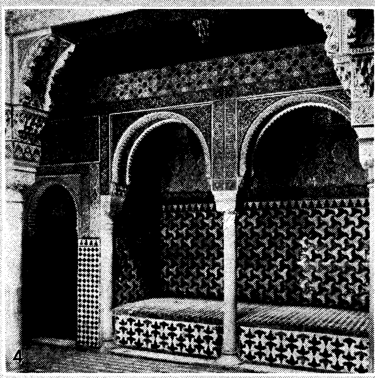


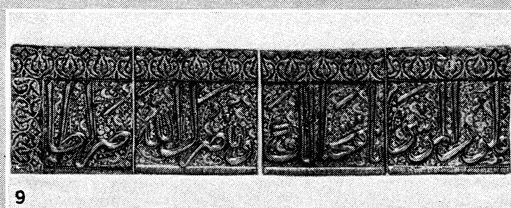










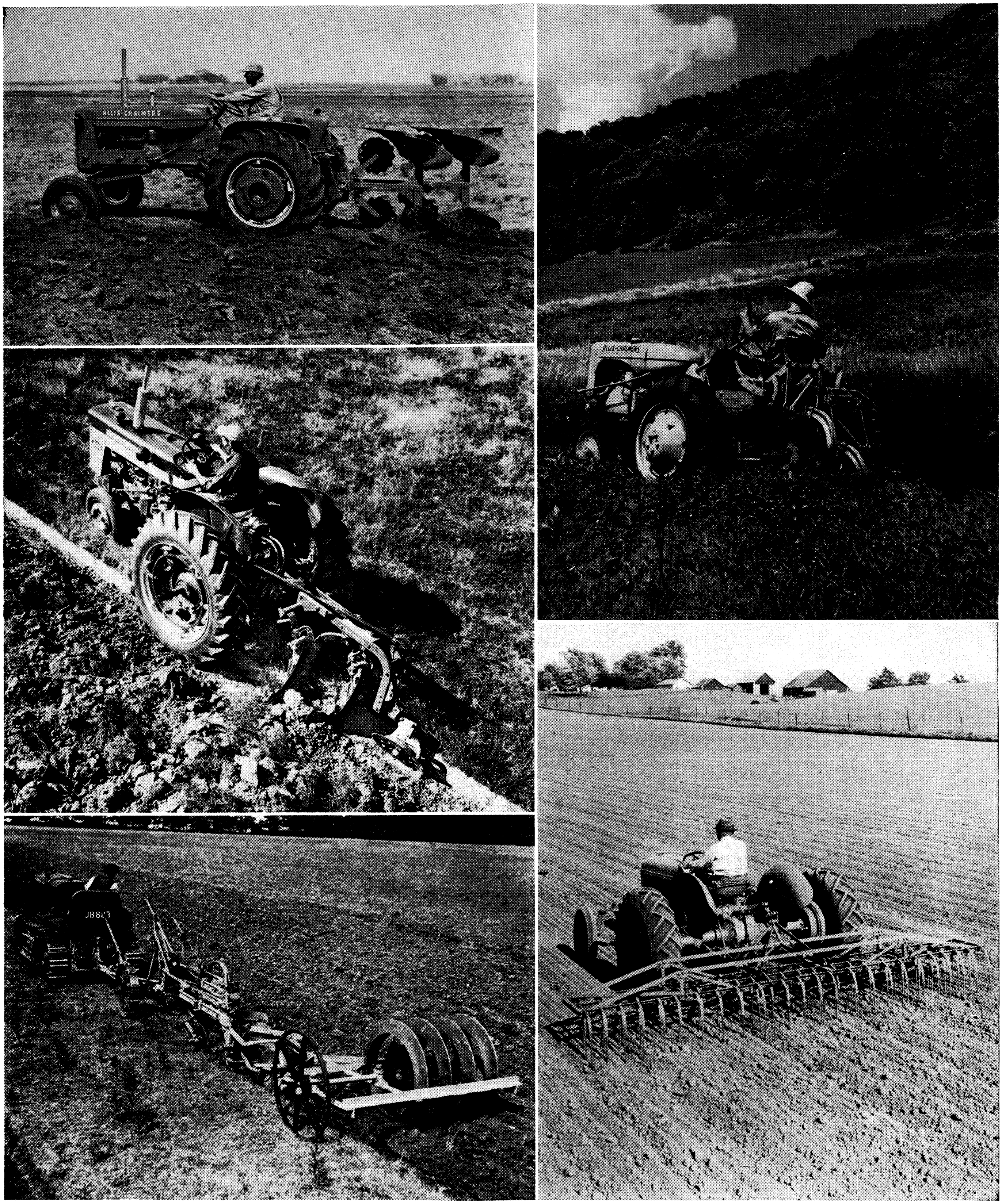


BY COURTESY OF (1) ERNST WASMUTH FROM SARRE, "DENKMÄLER PERSISCHEA BAUKUNST." (5) THE DIRECTOR OF THE KAISER-FRIEDRICH MUSEUM, (7, 8, 9, 10) THE METROPOLITAN MUSEUM OF ART, NEW YORK; PHOTOGRAPHS, (2, 4) EWING GALLOWAY, (3) HERBERT G. PONTING, F.R.P.S.

ARTISTIC EXAMPLES OF THE USE OF TILE

1. Elaborately designed tile wall decoration of Shah-Zinda, Samarkand
2. Roofs of the summer Palace of the royal family in Peking, China
3. Tile in the Hall of Classics, Peking, China
4. Court of Divans (cooling room of bath) in the Alhambra, Spain
5. Lustre tile Mihrab (niche in a mosque indicating the direction of Mecca, toward which Muslims turn when praying), from the Maidan Mosque, Kashan. Now in the Berlin Staatliche Museen, Islamische Abteilung
6. Painted tile in the floor of one of the alcoves of the Hall of Justice in the Alhambra
7. Tiles formerly around the fireplace of a Long Island home, built about 1745
8. Panel of wall tiles in Seville, Spain, of the 16th century
9. Persian frieze "Veramin," 13th century
10. Glazed blue and white Delft tiling

TILLAGE MACHINERY



BY COURTESY OF (TOP LEFT, TOP RIGHT) ALLIS-CHALMERS MFG. CO., (CENTRE LEFT) INTERNATIONAL HARVESTER CO. (BOTTOM RIGHT) HARRY FERGUSON, INC.; PHOTOGRAPH, (BOTTOM LEFT) ERIC GUY

MODERN TILLAGE MACHINERY IN OPERATION

Top left: Direct-connected, two-way (reversible) moldboard plow

Top right: Hillside plowing with two-way pickup plow which turns furrows uphill for better control of erosion

Centre left: Left hand plowing on the contour, with tractor-mounted two-way, two-disk plow. Disks are easily reversed to throw to the right on the return trip, thus eliminating back furrows and dead furrows.

Bottom left: Firming the soil with a land presser attached behind the plow

Bottom right: Spring-tooth weeder, used for destroying small weeds with shallow roots

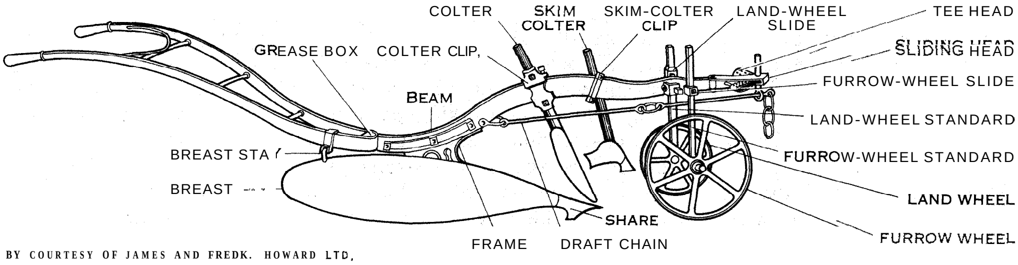


FIG. 1.—PARTS OF A SINGLE-FURROW WALKING HORSE-DRAWN PLOW WITH LEA BREAST

be a vertical knife, a circular knife or a rolling-disk colter); and an adjustable hitch. Most European and some U.S. plows have one or two gauge wheels at the front end of the beam that help keep the plow level, steady and at uniform depth. In oriental countries gauge wheels are not commonly used and depth control depends on adjustment of the clevis, or hitch (*see* fig. 2), at the front of the plow. This clevis also provides for adjusting the width of cut.

Fig. 1 is typical of an English walking plow and fig. 2 of a U.S. walking plox, and the essential parts are named there. The principal parts of moldboard plow bottotns are similar in walking plows and tractor plows. Because soil conditions vary greatly throughout the world, many different shapes of bottoms are required, and several different materials are used. The basic shapes are shown in fig. 3. Not shown is the breaker bottom with its long. easy-turning moldboard, adapted to virgin or tough sod. The English lea bottom (*see* fig. 1) is used mainly in sod and for fall plowing, and the English digger bottom—similar to the stubble bottom—is used for spring plowing.

Plain cast iron is preferred for sandy soils, which scour easily. Eut chilled cast iron. hardened by a special process, scours even better, resists abrasion well and is more widely used. Solid (crucible) steel is favoured where there are many rocks and stones because of its resistance to breakage. Soft-centre steel (two outer layers of hard steel cushioned by an inner layer of soft steel) is generally used in heavier soils.

Coverage of trash and weeds is improved by a rolling colter and skim colter, or jointer. Used together, they cut the edge of the furrow slice cleanly, tear off a corner of the slice with its projecting grass or weed growth and deposit it in the open furrow where it is well covered. These attachments may be used separately.

The width of furrow cut by single furrow plows varies from 6 to 12 in. These smaller sizes are commonly used in many countries—India, Mexico, Japan, China—where they are drawn by animals.

Moldboard plows, powered by farm tractors, vary in the width of furrow from 10 in. for a small, single bottom to 96 in. cut by six 16-inch bottoms of large tractor plows. Tractor plows are drawn behind the tractor or mounted on it. Smaller sizes with one or two bottoms are usually mounted, although available as trailed models also. Larger sizes with three or more bottoms are tractor drawn. They have wider bottoms. Some can plow 12 in. deep, although usually moldboard plowing is much shallower. An extremely large size is used in the western United States for making ditches and for mixing fertile subsoil with surface soil. Its huge. single moldboard turns a furrow six feet wide and three feet deep.

Tractor-drawn plows are attached with an adjustable hitch. This permits horizontal adjustment to insure correct width of the front furrow, and vertical adjustment to prevent nosing (downward tilting of plow points). which causes rapid wear of the underside of the share point and gives poorly turned furrow slices. A spring release or other protective device is incorporated in the hitch. This disconnects the plow when it strikes a firmly anchored obstacle. In some tractor plows the protecting device is applied to each bottom individually. as each bottom is held in working position by a heavy spring. Should it strike an obstruction, the spring permits the bottom to raise and pass over the obstruction.

Tractor-drawn plows have a lifting mechanism to raise them from or lower them to their working position. This may be either mechanical or hydraulic. The mechanical lift is controlled through a cord pulled by the tractor driver. The cord actuates a clutch usually located in the land wheel (the wheel that runs on the unplowed ground). The clutch connects or disconnects the motion of the wheel to a crank which raises or lowers the plow. Two principal levers may be furnished on tractor-draan plows, one for regulating depth and one for leveling the plow.

2. Tractor-Mounted Plows.—The tractor and the mounted plow are a compact unit, easily maneuverable and readily adjusted by the operator. Mounting plows, cultivators and other implements marked a milepost in the development of farm machinery. Prior to this development, the tractor was in a sense simply a mechanical draft horse.

The mounting of implements led to the development of hydraulic controls. The control levers are placed on the tractor itself rather than on the implements. Hydraulically controlled mounted implements showed so many advantages that in some countries—New Zealand, for instance—they became widely used within a very few years.

The hydraulic system consists of a pump driven by the tractor engine. an oil reservoir and distribution lines that convey the hydraulic liquid under pressure to a piston enclosed within a cylinder. The piston transmits the hydraulic force lo the leverage of the plow or other implement. Hydraulic cylinders are of two types, one-way and two-way. The one-way has a piston that can exert pressure in one direction only, the two-way piston may receive hydraulic pressure from either side and so can exert pressure in either direction and either lift a load or force it downward.

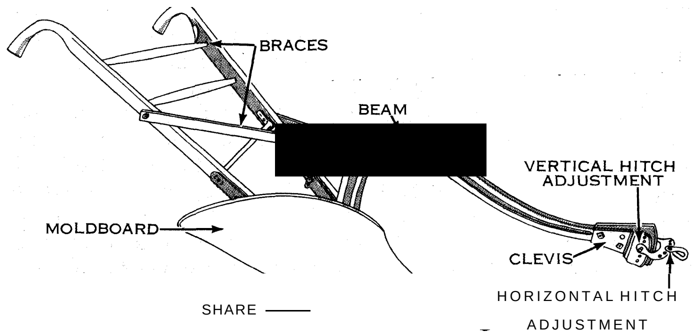
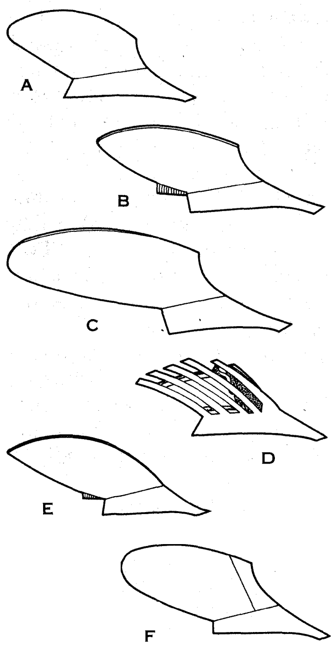


FIG. 2.—HORSE-DRAWN WALKING PLOW

Hydraulic power is applied to the control of many implements, both mounted and trailed. With trailed implements the hydraulic cylinder is placed on the implement Hydraulic liquid under pressure is conveyed to the cylinder through heavy hoses.

Mounting implements on the tractor also brought methods for quickly attaching and detaching such implements. The operator can attach or detach a plow or other implement without leaving the tractor seat. This convenience not only saves time but also lessens danger, since the operator need not stand behind the tractor when attaching an implement.

3. Two-Way Plows.—Two-way, or reversible, plows are used in hilly regions, in irrigated fields where dead furrows (open trenches) are a hindrance in controlling water and in irregularly shaped fields. They have a right- and left-hand plow bottom, one of each on animal-drawn plows and generally two of each on tractor plows. The operator can plow in either direction and throw all the furrows one way, thus eliminating all dead furrows, or he can throw all the furrows uphill to maintain soil in proper place for contour plowing. Two-way plows are available in walking models and in tractor-mounted and tractor-drawn models. The "turn-wrest" plow is a walking model used in India, where it is drawn



BY COURTESY OF JOHN DEERE

FIG. 3.—PLOW-BOTTOM TYPES

(A) Stubble; (B) general-purpose; (C) general-purpose, for clay and stiff-sod soil; (D) slat; (E) blackland; (F) chilled general-purpose

by two bullocks. After releasing a latch, the plowman can manually turn (wrest) the beam so as to alternately use the right and left bottoms.

4. Listers and **Middlebusters.**—The term middlebuster is used where crops are planted on beds. and the term lister where they are planted in the open furrow. Both listers and middlebusters have a right- and a left-hand bottom mounted back to back. They prepare ridges for cotton, potatoes, sweet potatoes and other crops that are planted on the tops of shallow beds. Listers and middlebusters are essentially the same. However, the lister moldboard is of the general-purpose shape, while the middlebuster moldboard is more like the black-land moldboard. The right and left moldboard on both listers and middlebusters are joined together so they throw furrow slices in both directions at one time. In semiarid regions the lister ridges the soil to preserve moisture and to lessen wind erosion. It is also combined with a planter which drops seeds into the open furrow to be covered by a planter attachment.

The listers and the middlebusters range in size and design from the single-bottom, animal-drawn units to the giant tractor models with six bottoms. A variety of bottoms can be used with a tractor employing the tool-bar method of mounting. The tool bar can carry different tillage tools. It is a heavy steel bar, usually square, mounted across the rear of the tractor. The bar itself is connected to the linkage operated by the tractor hydraulic system. Accordingly, implements attached to the tool bar are controlled by the hydraulic system. Also, the ground-working tools can be spaced horizontally on the tool bar as desired. Tool bars with their own wheels are also furnished as tractor-drawn units.

5. Disk Plows.—The disk plow has one or more concave disks varying in diameter from 20 in. for animal-drawn models to 40 in. for tractor models. Disk plows work well in dry, hard soils where moldboard plows penetrate with difficulty, and also in sticky soils where moldboard plows do not scour well. They also work satisfactorily in land having rocks or stones because the disks ride over such obstructions without breakage, and they are effective in loose soil and where there are many roots, shrubs and bushes.

Small tractor-mounted models may have only one disk; but large, tractor-drawn sizes may have seven or more. Most tractor models are controlled hydraulically, although some have a mechanical power lift.

The angle of the disks is adjustable vertically and horizontally. Adjusting the disk nearer to a vertical position makes it penetrate better. Adjusting it closer to a line perpendicular to the direction of travel makes it cut wider. In some models, the distance between the disks may be varied. Penetration depends upon field conditions, the diameter of the disk and the weight placed upon the disks. Accordingly, disk plows are quite heavy and wheel weights are often required to improve penetration.

6. Disk Tillers.—These ruggedly built tractor implements have the disks set at a fixed angle of about 45°, and the disks are smaller than those of the disk plow. They do not penetrate as deeply and they mix surface growth with the soil rather than invert it. They are used to mix the stubble of the previous crop with the surface soil, but leave enough stubble exposed to retard wind erosion and to improve water infiltration. Small sizes, about five feet wide, may be tractor mounted or semimounted. Large sizes, with sixteen 24-in disks spaced about 9 in. apart, may cut a 12-ft. swath. Hence, the rate of work is fast—up to 50 ac. per day. A special type, developed in Australia, is the stump-jump disk cultivating plow. The disks are assembled in pairs, each pair being held to its working position by spring pressure. When a solid obstruction is encountered a pair of disks can rise over the obstruction, against the spring pressure, without disturbing the rest of the implement. Modifications of this stump-jump plow are used in the range lands of the western United States.

Disk tillers are knoun also by other names, such as one-way disk, harrow plow, wheatland disks and vertical disk plow. Some may have a seeding attachment so that certain crops can be seeded at the same time the seedbed is prepared. (See also **PLANTING** MACHINERY.)

7. Rotary Plows.—Rotary plows have been used in Europe for many years. They employ an assembly of tines or knives mounted on a horizontal. power-driven shaft. The smallest sizes, powered by garden tractors, cut a swath of about 12 in.; larger garden tractor models cut a 30-in. swath. Large rotary tillers cut up to a 6-ft. swath, require up to 90 h.p., and may have a separate engine mounted on the tiller itself. Other models are mounted on farm tractors and driven by the power take-off.

In most designs the rotating knives cut on the downward stroke and mix the surface growth evenly throughout the seedbed Depth of cut can be varied through a wide range. Hence, rotary tillers are used not only for preparing seedbeds but also for surface cultivation.

Under favourable conditions rotary tillers prepare a seedbed in one trip over the ground. However, when conditions are difficult the rotary tiller can make a second trip over the tilled ground, which is not feasible with a moldboard plow.

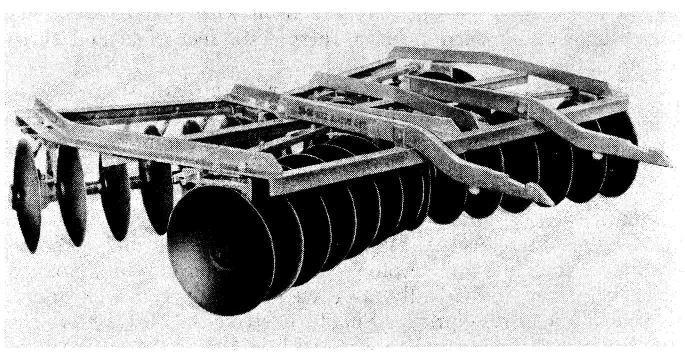
III. SECONDARY TILLAGE OR HARROWING IMPLEMENTS

Various types of harrows are used to refine the seedbed, to level the plowed soil, compact it and destroy weed seedlings.

1. The Disk Harrow.—A truly general-purpose implement, the disk harrow is sometimes used before plowing and quite generally after plowing. Disk harrows have gangs of disks assembled so that the side forces are balanced. One gang throws the soil to the right, the other to the left. Single-cut, animal-drawn disk harrows give a width of cut from four to six feet. Tractor disk harrows are usually of the tandem type having two gangs in front and two in the rear, thus giving a double action.

The offset tractor disk harrow has only two gangs; one is behind the other, somewhat like one-half of a tandem harrow. The two gangs throw the soil in opposite directions, the rear gang reworking the soil moved by the front gang so as to leave it quite level. This type is commonly used in orchards and vineyards because the operator can get under projecting branches and near to the trees or vines.

Penetration may be regulated by adjusting the angle of the disk gangs. In animal-drawn models this is accomplished by levers found on each gang. Tractor-drawn harrows may employ a power-angling device operated by movement of the tractor, or a hydraulic



BY COURTESY OF INTERNATIONAL HARVESTER CO

FIG. 4.—TRACTOR-MOUNTED. TANDEM DISK HARROW WITH FAST-HITCH CONNECTION

cylinder may be used to control the angle.

Some large tractor models are supported by transport wheels and the gangs are set at a fixed angle. Penetration is regulated by raising or lowering these transport wheels by hydraulic power.

Tractor disk harrows, five to eight feet wide, may be fully mounted, making them convenient for working in the corners of fenced fields. Larger tandem tractor harrows may cut a swath as wide as 14 ft. Special single-cut tractor harrows (up to 20 ft. wide) are used for controlling weeds on summer fallow and to reduce stubble and corn stalks previous to plowing.

2. The Spike-Tooth Harrow. — This implement aids materially in breaking up clods and leveling fields, and may be used for covering seed. It consists of a number of horizontal bars to which teeth or tines are attached. The teeth are spaced so that each tooth makes a separate cut through the soil; no one tooth trails another. With a typical five-foot section every two inches of ground is cut by a tooth. The number of sections used depends upon the power available. varying from perhaps only one section when drawn by an animal to eight six-foot sections for large tractors. Some tractor models are wheel-supported and the sections can be folded for transportation.

3. Spring-Tooth Harrows. — These also are made in sections with horizontal tooth-retaining bars. The flexible spring teeth are more widely separated than in the spike-tooth harrow. They resist damage from stones or other obstructions and penetrate well in hard ground. An implement of suitable width can be obtained for whatever power is available. Some models are carried on transport wheels that aid in regulating the depth. In others, depth is controlled by levers that change the position of the spri'ng teeth. With some types the operator can clear the teeth of trash without leaving the seat of the tractor.

4. Special Harrows. — Specially designed harrows are used for intensive grassland cultivation. Chain harrows, consisting of studded metal links fastened together like a net: brush harrows (made by drawing brushwood through a frame in such a way as to form a rough smoothing surface) or spike-tooth harrows are used in the spring for dragging out moss or matted undergrowth and dispersing lumps of manure, molehills. etc.

5. Clod Crushers, Packers and **Mulchers.**—These are used to break up lumps left by harrows and to compact the soil, thereby eliminating large air spaces. The plain roller is often used to compact grassland damaged by winter heaving. It is used frequently on alfalfa fields also. Corrugated rollers—single or tandem—crush clods and firm the soil after plowing. After wheat is sown, the corrugated roller compacts the soil around the seed to improve germination, and the corrugations left on the surface reduce soil-blowing.

Another effective clod crusher and packer is made of a series of sprockets loosely fitted at the hub and mounted on an axle between sharply ridged rollers. In moist soil the lagging of the sprockets lessens clogging of the ridged rollers. In England. land pressers or packers often are used. These have heavy wedge-shaped wheels about three feet in diameter. They are used in dry seasons to compress the soil at the bottom of the furrow; some designs may be hitched directly behind the plow to press down the freshly turned furrow slices.

IV. CULTIVATION OR HOEING IMPLEMENTS

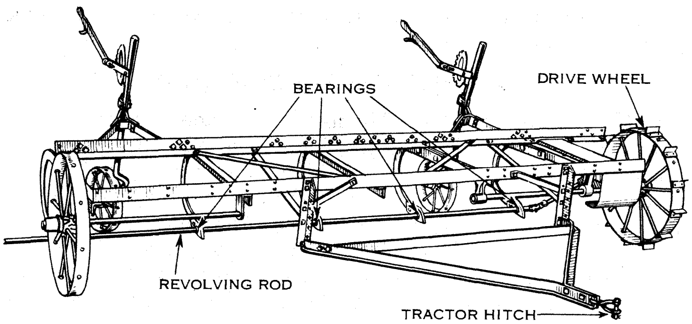
In general, weed destruction is the primary purpose of cultivation (hoeing). Cultivating implements can be divided into three main classes: (1) row-crop cultivators; (2) field cultivators; and (3) rotary hoes.

1. Row-Crop Cultivators. — These implements employ various shapes of steel shovels to work the soil. Typical shovels are short, narrow, slightly curved, pointed steel pieces with polished front surfaces that dig into the soil in proportion to the pressure applied. For very shallow cultivation, special shovels or sweeps (sometimes called duck-foot sweeps) are available in different widths.

Row-crop cultivators range in size from one-horse, between-row walking types to tractor models for cultivating (astraddle) six rows or more at a time. The kind and number of shovels used per gang depend on the crop and the soil characteristics. Shovels or sueeps are sometimes replaced by disks or disk hillers when a considerable quantity of soil is to be moved, or where trash and vines must be cut. The gangs carrying the shovels of a tractor cultivator may be front-mounted. centre-mounted or rear-mounted. Some designs combine a centre and rear mounting and others carry the cultivating steels on tool bars.

2. Field Cultivators. — These are designed primarily for open-field rather than row-crop cultivation. They are used also for controlling meeds in summer fallow, for renovating pastures and for stubble mulching. The large models are wheel-supported and hydraulically controlled. The cultivating tools may be spring teeth, shovels or sweeps. When equipped with spring teeth the larger. sturdier models penetrate deeply.

3. Rotary Hoes. — The rotary hoe works best when the tractor is operated at a fairly high speed. It is made up of gangs 42 to 46 in. wide. Within the gang a group of 14- to 20-in, hoe wheels. with radial projecting fingers. is mounted on a horizontal axle. Several gangs or sections are combined to make a tractor unit — sometimes 12 sections, which would cut a 40-ft. swath. Each section is of proper width to cover a typical corn row and has about seven hoe



BY COURTESY OF JOHN DEERE

FIG. 5.— TRACTOR-DRAWN ROD WEEDER

wheels. The rotary hoe is particularly useful in the early growth stages of corn and other row crops, and is effective in breaking crusts caused by hot sunshine after a hard rain. Sometimes the gangs are assembled in tandem to obtain double action.

When the rotary hoe is drawn backward the teeth do not penetrate. Instead, they give a treading action which crushes clods and pulverizes stalks and surface residue. One section may be used behind the plow to pack the freshly turned furrow slices.

Special rotary-hoe attachments are used with row-crop cultivators. These narrow attachments work directly on the row of plants, while the shovels work between the rows.

4. Rod Weeders. — The rod weeder is used for weed control in open fields where summer fallow is practised. Its working element is a square. horizontal rod driven by one of the supporting wheels and revolving one to five inches below the soil surface. Roots and weeds are caught on the rod and pulled out, but do not collect on it. Sizes vary from 8 to 12 ft. in single units up to combinations of sections sufficient to cut a 36-ft. swath.

5. Spring-Tooth Weeders. — These have light spring teeth designed for destroying surface needs only. They can be operated directly over the rows of growing plants because the light, wirelike teeth flick out the shallow-rooted weeds without injuring growing plants. These implements reduce the number of later cultivations because they destroy weeds effectively just as they emerge.

V. SUBSOILING OR DEEP TILLAGE EQUIPMENT

Heavy tillage implements are employed to encourage deeper root growth. to break up hardpan and compacted soils and to improve water infiltration, With tool bars, heavy ground-working tools can be used — large disks, heavy tines, shovels of various types, chisel points and subsoil blades. Such heavy equipment is often required for the hard, rough conditions frequently encountered in tropical agriculture.

1. The Subsoiler. — This implement employs a single long shank carrying a steel point. The various sizes and lengths of shanks permit penetration from 16 to 36 in. Draft of this implement is great, and larger sizes require a powerful tractor. The subsoiler opens a slit in the soil through which moisture can enter; it reduces compaction caused in some areas by implement traffic on the field. By improving water infiltration it reduces runoff and erosion.

A mole, shaped like a bullet or ball, is sometimes attached to the rear of the subsoil point. Such mole plows are used for draining land having a clay subsoil. The mole may be set to work at different depths and when drawn through the ground compresses the subsoil in its passage, leaving a drainage channel of its own diameter. The narrow slit cut by the subsoiler shank closes up and water then passes into the drain by percolation. Mole drains thus prepared should have suitable outlets and a natural gradiant following the contour of the land.

2. The Chisel Plow.—This plow has a number of shanks mounted on a transverse tool bar. Horizontal distance between the shanks may be adjusted, from 12 in. to 3 ft. apart, to suit field conditions. The work of the chisel plow is similar to that of the subsoiler, but shallower. Either rigid tines or spring-tooth shanks are used. They may penetrate as much as 18 in. and can also be used for shallow tillage. The shanks may be fitted with various shapes of steels such as narrow, double-pointed shovels, or wide sweeps for shallow tillage.

VI. FERTILIZER DISTRIBUTORS

I. Manure Spreaders.—The manure spreader carries manure, tears it up and spreads it on the field. The basic design has remained that of a four-wheeled wagon, although tractor models may have only two wheels and have the front of the spreader supported on the tractor. The distributing mechanism consists of a drag-chain conveyor at the bottom of the box. This carries the manure to the rear of the spreader where it is shredded and scattered. This is accomplished by an upper beater that levels and shreds the manure as it is driven into the lower spike-tooth beater, which tears it to bits. Wide rotating spiral fins complete the operation by spreading the manure widely in a uniform layer, the thickness of which is determined by the speed of the conveyor.

Both animal-drawn and tractor-operated spreaders are available. Some models have the distributing mechanism driven by the tractor power take-off; in others it is driven by the spreader wheels. Capacity is determined by the size of the box, which varies from 50 to 140 bu.

Loading manure spreaders by hand is a laborious and unpleasant task. Hence it is often done by tractor-operated loaders. These are powered by the tractor engine and controlled hydraulically.

2. Distributors for Commercial Fertilizers.—Commercial fertilizers are available in solid, gaseous and liquid form. Anhydrous ammonia, a popular source of nitrogen, is liquid under pressure but becomes a gas when it is freed from this pressure as it enters the soil.

Distributors for solid commercial fertilizers must give a uniform distribution whether heavy or light applications are being used. It is important that distributors can be easily cleaned because some fertilizers are highly corrosive. Solid-fertilizer distributors differ mainly in the method of distributing the material. Most designs have a wide hopper that carries the material. Wheels at the ends of the hopper serve for transport and also drive the distributing mechanism. Distribution in some models is effected by a roller at the bottom of the hopper. This revolves so as to work the fertilizer out backward as the machine advances. Other designs have agitators placed over holes in the hopper bbttom. Another uses an endless chain with projecting fingers which travel across the bottom of the hopper. Still another employs rotating fingers which work the fertilizer out. In several types the material falls straight down to the ground and is distributed along the full width of the machine. However, some designs use tubes for distributing the material in rons.

3. Broadcast Distributors.—These are quite different in design. They have a tub-shaped hopper from which the solid material falls on to two revolving disks. which are driven by the spreader wheels. The broadcaster may be drawn behind a motor truck or other vehicle, from which its hopper is filled. The revolving disks distribute fertilizer, lime or marl (clay and lime) in a broad swath, up to 20 ft. wide. Lime also is applied with an end-wheel type of distributor having a hopper about eight feet long.

4. Distributors for Anhydrous Ammonia.—These distributors require a heavy tank because this material must be stored under considerable pressure. Application is controlled by carefully designed valves and an accurate metering device. The ammonia passes through heavy tubing to applicator teeth that cut gashes four to six inches deep through the soil. When released at this depth the ammonia gas is sealed in by the soil falling above it. Anhydrous ammonia applicators may be obtained as tractor-trailed or -mounted models. Attachments are also available for row-crop planters.

5. Applying Fertilizer Solutions.—Water solutions of nitrogen and also solutions containing all three major plant foods—nitrogen, phosphorus and potassium—are available. Applicators may employ boom-type sprays with nozzles, as these solutions can be sprayed on pasture, small grain or the soil without loss of nitrogen to the atmosphere. Some applicators have a number of rubber or plastic hoses, attached to the ends of the boom openings, which drag on the ground and apply the solution to the surface. The rate of application is controlled by a metering device or by a positive type of pump that regulates flow from the tank. *See* also FERTILIZERS AND MANURES.

VII. SMALL-SCALE TILLAGE EQUIPMENT

For market gardeners, horticulturists, amateur gardeners and growers with small acreages a wide variety of tillage tools is available to fit practically every requirement. This includes garden tractors—both walking and riding—that are provided with tilling and cultivating implements suitable for many purposes. For the garden there are many hand-operated tools such as the push-hoe cultivator and seeder, as well as a wide assortment of tools.

Farm machinery dealers and hardware merchants can furnish information on practically any kind of tillage tool or advise customers where it can be obtained.

See also FARM MACHINERY; TRACTORS.

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(AR. A. S.)

TILLEMONT, SÉBASTIEN LE NAIN DE (1637–1698), French ecclesiastical historian, was born in Paris on Nov. 30, 1637. The boy was brought up in the little schools of Port Royal, and in 1660 he was made a tutor in the seminary of Buzenval, Jansenist bishop of Beauvais. Ten years later he came back to Paris, and became a chaplain at Port Royal. In 1679 the storm of persecution drove him to settle on his family estate of Tillemont, where he spent the remainder of his life.

Tillemont died on Jan. 10, 1698.

From the age of 20 he was at work on his two great books—the *Mémoires pour servir à l'histoire ecclésiastique des six premiers siècles,* and the *Histoire des empereurs* during the same period. Both works began to appear during his lifetime—the *Histoire* in 1690, the *Mémoires* in 1693—but in neither case was the publication finished until long after his death.

There is a full account of his life in the 4th volume of Sainte-Beuve's *Port Royal*.

TILLETT, BENJAMIN (1860–1943), British Labour politician, was born at Bristol, on Sept. 11, 1860. He started work in a brickyard at eight years. and was a "Risley" boy for two years He served six months on a fishing smack, was apprenticed to a bootmaker, and then joined the royal navy. He was. invalided out of the navy and made several voyages in merchant ships.

He then settled at the London docks and organized the Dockers' union of which he became the general secretary, taking a prominent part in the dock strike of 1889. He was one of the pioneer organizers of the General Federation of Trades, National Transport Workers' federation, National Federation of General Workers, International Transport federation, and of the Labour party.

For many years he was an alderman on the London County council, and was twice elected member of parliament by the Labour party. He died in London, Jan. 27, 1943.

His publications include *A Brief History of the Dockers' Union* (1910), and *A History of the Transport Workers' Strike* (1911).

TILLEY, SIR SAMUEL LEONARD (1818–1896), Canadian statesman, was born at Gagetown, New Brunswick, on May 18. 1818, the son of Samuel Tilley, an American Loyalist, who had settled in St. John in 1783. From 1860 to March 1865 he was premier of the province, and was prominent in organizing the conference on the union of the maritime provinces, which met at Charlottetown in 1864, and which soon widened into a discussion of Canadian federation.

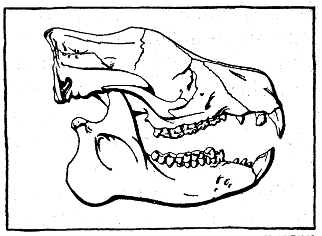
In 1865 he was defeated in a general election on the federation question, but returned to power in 1866, partly through an intrigue of the colonial office. From 1868 till November 1873 he held various portfolios in the Dominion cabinet; from 1873 to 1878 he was lieutenant-governor of New Brunswick, but in 1878 was agair elected as member for St. John, and entered the Conservative cabinet as minister of finance.

Later in 1878 he introduced and carried through parliament the "national policy" of protection, on which issue the election of 1878 had been won. The tariff so introduced became the basis of Canadian financial policy.

In Oct. 1885 ill health forced him to retire from the cabinet. He was again lieutenant-governor of New Brunswick from 1885 to 1893. He died on June 25, 1896.

His *Life*, by James Hannay (1907), forms one of the "Makers of Canada" series.

TILLODONTIA, a group of extinct mammals from the Eocene of North America and Europe. The average size was about that of a living brown bear. The canine teeth are very small, one pair of incisors in each jaw much enlarged and chisel-like. The general structure is very primitive, the brain small and elongate, the cheek teeth of generalized (tuberculo-sectorial) type, the feet plantigrade, with five toes. The skull is more carnivore- than rodent-like in general aspect. The best known genera are *Tillotherium, Esthonyx* and *Trogosus.* Despite the relative large size of its members, the group is probably more suggestive of the Insectivora than of any other established order and it is apparently an early, extinct, rather aberrant offshoot of the earliest stock of the placental mammals. (G. G. S.)



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

THE SKULL OF TILLOTHERIUM FODIENS, AN EXTINCT MAMMAL

TILLOTSON, JOHN (1630–1694), English archbishop, was the son of a Puritan clothier in Sowerby, Yorkshire, where he was born in October 1630. He was a fellow of Clare Hall, Cambridge, and about 1661 he was ordained without subscription by T. Sydserf, a Scottish bishop. Tillotson was present at the Savoy Conference in 1661, and remained identified with the Presbyterians till the passing of the Act of Uniformity in 1662. Shortly afterwards he became curate of Cheshunt, Herts., and in June 1663, rector of Kedington, Suffolk. He now devoted himself to an exact study of biblical and patristic writers, especially Basil and Chrysostom. The result of this reading, and of the influence of John Wilkins, master of Trinity College, Cambridge, was seen in the general tone of his preaching, which was practical rather than theological. In 1664 he became preacher at Lincoln's Inn. The same year he married Elizabeth French, a niece of Oliver Cromwell; and he also became Tuesday lecturer at St. Lawrence, Jewry. In 1670 he became prebendary and in 1672 dean of Canterbury. In 167j he edited John Wilkins's *Principles of Natural Religion,* completing what was left unfinished of it, and in 1682 his *Sermons.* With Burnet, Tillotson attended Lord Russell on the scaffold in 1683. It was partly through Lady Russell that he obtained influence with Princess Anne, who followed his advice in regard to the settlement of the crown on William of Orange. He possessed the special confidence of William and Mary, and was made clerk of the closet to the king and dean of St. Paul's. On his advice the king appointed an ecclesiastical commission for the reconciliation of the Dissenters. He was elected to succeed the Nonjuror Sancroft as archbishop of Canterbury, but accepted the promotion with extreme reluctance, and it was deferred from time to time, at his request, till April 1691. In 1693 he published four lectures on the Socinian controversy. He died on Nov. 22, 1694.

Ralph Barker edited his *Sermons* together with the "Rule of Faith" (14 vols 1695–1704). In 1752 an edition of his *Complete Works* appeared in 3 vols., with *Life* by Thomas Birch.

TILLY, JOHANN TZERCLAES, COUNT OF (1559–1632), general of the Catholic League in the Thirty Years' War, was born in 1559 at the château of Tilly in Brabant. He was destined for the priesthood and received a strict Jesuit education. But, preferring the career of a soldier, he entered a Spanish foot regiment about 1574 as a volunteer, and in the course of several campaigns rose to the command of a company. This being reduced, he again became a simple pikeman, and as such he took part in the famous siege of Antwerp by Parma. He distinguished himself by his bravery, and the duke of Lorraine gave him the governorship of Dun and Villefranche, which he held from 1590 to 1594. Henry IV. attempted unsuccessfully to induce him to enter the service of France. Somewhat later he left the Spanish service for that of Austria to fight against the Turks. In 1602 he became colonel in the imperial army, and raised a regiment of Walloon infantry which he commanded in the assault on Budapest, receiving a severe wound. In 1604 he was made general of artillery; having shown great capacity and devotion to the emperor and the Catholic religion, he was made a field-marshal in 1605 In 1610 he left the service of the emperor to enter that of Maximilian, duke of Bavaria, the head of the Catholic League. In 1620 he became lieutenant-general to Maximilian and commander-in-chief of the field forces.

With the victory of the White Mountain (1620) the new army and its leader became celebrated throughout Germany and the subsequent campaigns (*see* THIRTY YEARS' *WAR)* established their reputation. The battle of Hochst (1622) won for Tilly the title of count.

The defeat of King Christian was soon followed by the intervention of Gustavus Adolphus. The opening stages of the campaign did not display any marked superiority of the Swedes. At this time Tilly was commander of the imperial forces as well as of his own army. The first great contest was for the possession of Magdeburg (1631). Tilly has been blamed for the atrocities which accompanied the sack of this town after its fall (May 20). Yet his personal exertions saved the cathedral and other religious buildings from pillage and fire. Four months later Tilly and Gustavus, the representatives of the old and the new art of war, met at Breitenfeld (*q.v.*). The victory of Gustavus was complete, though the imperial general, although severely wounded, drew off his men in good order. On the Lech, a few months later, Gustavus was again victorious, and Tilly received a mortal wound. He died on April 30, 1632, in Ingolstadt.

See O. Klopp, *Tilly im 30-jährigen Krieg* (Stuttgart, 1861); K. Wittich, *Magdeburg, Gustav Adolf und Tilly;* also memoir of Tilly in *Allg. deutsche Bzographie;* Keym-Marcour, *Johann Tzerclaes, Graf v. Tilly;* Villermont, *Tilly, ou La Guerre de trente ans* (Tournay, 1859).

TILSIT, a town formerly in East Prussia. was renamed Sovetsk in the Kalinin *oblast,* Russian Soviet Federated Socialist Republic, G.S.S.R.

Pop. (1956 est.) 60,000.

Tilsit, which received civic rights in 1552, grew up around a castle of the Teutonic order, known as the "Schalauner Haus," founded in 1288. It owed most of its interest to the peace signed there in July 1807, the preliminaries of which were settled by the emperors Alexander and Napoleon on a raft moored in the Memel.

This treaty, which constituted the kingdom of Westphalia and the duchy of Warsaw, registered the nadir of Prussia's humiliation.

TIMAEUS (*c.* 345–*c.* 250 B.C.), Greek historian, whose writings shaped the tradition of western Mediterranean history, was born at Tauromenium in Sicily. He was expelled by Agathocles, the tyrant of Syracuse. and migrated to Athens where he studied rhetoric under Isocrates' pupil Philiscus and passed 50 years of his life. Whether he ever returned home is uncertain. The 38 books of his *Histories* went down to Agathocles' death in 289. but a separate work on Pyrrhus of Epirus seems to have reached the Roman crossing into Sicily in 264. Books 1–5 contained the early history of Italy and Sicily, books 6–33 the history of Sicily from the foundation of the Greek colonies to Agathocles' accession with digressions, sometimes touching on Greece, and books 34–38 a separate account of Agathocles. The *Olympionikai* ("Victors at Olympia") was probably a chronological study.

Timaeus was bitterly attacked by later historians, especially Polybius. Some of his faults, such as the composition of artificial rhetorical speeches, are common to the historiography of the age; but a somewhat naive attitude toward marvels reflects a genuine feeling for folklore. He was spiteful to those he disliked such as Dionysius and Agathocles, and he exaggerated the virtues of the Corinthian general Timoleon. Above all he showed the faults of the armchair historian. But his interests were wide; he was assiduous in assembling material, including inscriptions; and Polybius' charge of ignorance and willful dishonesty is unjust. Timaeus' system of reckoning by Olympiads furnished a valuable chronological tool for his successors, including Polybius. He employed a pleasing "Asiatic" style, nhich Cicero approved.

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TIMARU, a seaport of Geraldine county, New Zealand, on the E. coast of South Island. 100 mi. S.W. of Christchurch by rail. Pop. (1956) 23,308. The slight inward sweep of the coast forms the Canterbury Bight. The harbour is formed by breakwaters enclosing a space of 50 ac. The chief shipments from the port are wool. flour and frozen and chilled meat, and the town's industries arose chiefly in connection with these.

Timaru, the chief town in the South Canterbury district, is well served by rail and road; it is a popular seaside resort.

TIMBER. The terms "wood" and "timber" are not synonyms, for wood occurs in the veins of leaves and as strings in thick palm stems, as well as in thicker cylindrical form in twigs of shrubs and trees.

The term timber, synonymous with the North American term lumber, applies solely to wood of considerable dimensions produced by trees. (See LUMBERING.)

Two great classes of trees provide timber. (1) Conifers, including pines, spruces and larches, usually have more or less needle-like leaves, and their naked seeds are most frequently borne on cones; they yield the so-called softwoods. (2) Dicotyledons, including oak, ash, beech and teak, commonly have broader flat leaves, and their seeds are always produced in closed seedcases; they provide the hardwoods.

Origin and Structure of Timber.—The part of the tree above ground typically consists of a main trunk and the branch system, whose ultimate finest branches are the leaf-bearing twigs.

The trunk and branches grow in length solely at their tips, so that the oldest part of a trunk or branch is at its base and its slender tip is the youngest. Tree trunks and branches grow in diameter by the addition of new wood and bark by a microscopically thin layer of cells, the cambium, lying between the wood and the bark. The cambium deposits new wood on the outer side of the pre-existing wood and new bark on the inner side of the pre-existing bark, thus pushing the bark outward.

In temperate climates the cambium produces new wood only during spring and part of the summer and is inactive during autumn and winter; the mood produced first in each year is frequently (*e.g.*, in ash, oak, pine) different from that produced later in the year, so that a distinction is drawn between the early springwood and the later summerwood (frequently termed autumnwood). In such cases a cross section of the tree trunk will show a number of concentric annual rings, whose number is equal to the age of the region of trunk cut.

In the case of the beech and a number of other trees, the annual rings show no marked differentiation into springwood and summerwood but are recognizable because a very thin layer produced latest in the growing season differs in appearance from the rest of the wood. Finally many kinds of evergreen tropical trees (*e.g.*, mahogany) show no distinct annual rings.

In many species of trees (*e.g.*, pines and oaks) the inner wood becomes darker with age. This darker, central portion is called heartwood in distinction to the outer, lighter portion, called sapwood. In other species (*e.g.*, most spruces and firs) there is little or no difference in colour of sapwood and heartwood.

Structure of Wood.—With the aid of the microscope it can be seen that a softwood consists mainly of very narrow, hollow, spindle-shaped fibres (properly, tracheids), running parallel to the long axis of the trunk or branch. The solid wall of each fibre consists of wood substance and on at least two of its sides shows a series of thin round areas, the pits, through which water or sap can pass from fibre to fibre.

In addition to the fibres, certain softwoods, including those of true pines, have very thin resin-containing tubes, the resin ducts, which run parallel with the fibres. In structure each duct in microscopic miniature recalls a tall factory chimney, as its central tubular hollow is surrounded by microscopic, short, more or less brick-shaped cells, which are hollow and have thin walls. All commercial softwoods (excluding that of the yew) contain resin; but some of them (*e.g.*, California redwood) have in place of resin ducts merely resin-containing short cells.

Traversing the wood at right angles to the fibres are thin string-like or ribbonlike structures that run from the outside of the wood radially inward toward or actually to the pith. These are the wood rays, which are usually nearly or quite invisible to the naked eye in cross sections of softwoods. They consist of more or less brick-shaped cells, which in the sapwood contain albuminous substances and at times such other nutritive substances as sugar, starch or fatty oil; in the sapwood they consequently invite attack by animals and fungi. Softwoods that, like true pines, have resin ducts in the wood also possess these in the thicker rays.

The fundamental difference between softwoods and hardwoods is best understood if a number of the wider "water fibres" are imagined to be very greatly widened and strung end to end with their terminal walls absorbed, so that long continuous tubes. sometimes yards in length, are produced. These water-conducting tubes are termed wood vessels; in cross section they are often visible to the naked eye as "pores." All commercial hardwoods have wood vessels, which in the sapwood contain air with or without liquid sap. In addition to the vessels, the different hardwoods have "fibres" of various forms.

Wood rays also are present in all hardwoods, and in many of them are much thicker than in the softwoods, being distinctly visible to the naked eye in cross section. On radial longitudinal surfaces the rays occasionally are conspicuous and ornamental, being up to several inches wide in oaks and producing the so-called silver grain. The contents in the sapwood are similar to those of the softwoods.

Sapwood and Heartwood.—In the living tree the inner portion of the sapwood gradually changes into heartwood by the death of all remaining living cells and the infiltration of tannins, gums, resins and other materials, the exact nature of which is not fully known, into the cell walls and cavities. During this change the pores of some hardwoods also become plugged by bladderlike intrusions, tyloses, from the surrounding cells. Furthermore, many of the microscopic pits in the cell walls are reduced in size or closed. As a result of these changes, heartwood often is less permeable to liquids and gases than sapwood. Hence, sapwood is more easily impregnated by wood preservatives and other liquids and dries faster than heartwood. In some species of timber the materials deposited in the heartwood make it more resistant to decay (*see* DRY ROT) and insect attack, as is the case in certain oaks, cedars and redwood. Since the materials infiltrated into the heartwood are very small in amount, it is neither appreciably heavier nor stronger than sapwood. Some species characteristically have narrow sapwood (*e.g.,* larches, cedars and black locust), whereas others have wide sapwood (*e.g.,* maples, birches and ponderosa pine).

Grain of Timber. — Most frequently the fibres and other structural elements of knotless timber run parallel with the long axis of the trunk or branch, and the wood is described as straight-grained. If a plank or post is sawed in a direction not parallel to the axis of the trunk, the grain of the sawed article is not parallel to the sides of this and the plank or post is described as cross-grained. But not infrequently the grain of the trunk (or branches) runs in a spiral direction, as if the trunk had been twisted round its long axis; the grain is then described as spiral or torse, and the timber when cut up is inevitably cross-grained. There are yet other, especially tropical, woods in which the grain more or less swings from a left-handed to a right-handed spiral direction, so that the wood when cut into plain boards shows a double cross grain or interlocked grain and when cut along the radii of the trunk ("on the quarter," rift-sawed) shows roe figure, as in mahogany.

In addition to these deviations from the straight grain, the structural elements of the wood may pursue a wavy or sinuous course, as for instance in so-called rammy ash. When the waviness is irregular, the grain is said to be curly.

Knots, being the basal parts of branches that have become embedded in the thickening trunk, are naturally associated with a change of direction of the fibres. The wood of large excrescences on the trunks of certain trees known as burrs, or burls, exhibits structure similar to that which would be produced by many small crowded branches. Bird's-eye maple results from numerous conical depressions in the tree trunk.

The fibres of most timbers overlap and dovetail with one another at their ends, which are at different levels, and the wood rays as seen in circumferential or tangential views are arranged apparently irregularly or in spirals. But some woods when examined from the same viewpoints show very fine lines running across the grain and producing what is known as ripple marking; this is caused by either contiguous fibres ending at the same levels with little or no overlapping or wood rays placed at the same levels, so that the structure of the wood is tiered. Such structure is often shown by true American mahoganies.

Chemical Composition. — The wood substance composing the walls of the hollow structural elements that constitute the solid framework or skeleton of wood may, for the present purpose, be regarded as always being composed of two main constituents, lignin and cellulose. together with smaller quantities of additional more or less gumlike bodies.

The lignin can be removed from the wood by steam or warm weak acids and alkalies (and is so removed in the manufacture of chemical wood pulp), the cellulose remaining.

The various substances here described collectively as cellulose are carbohydrates, which may be popularly defined as sugars or substances capable of being converted into sugars. Thus cellulose of wood yields for instance a sugar, glucose, which by fermentation can produce ethyl alcohol (spirits of wine). Cellulose by appropriate treatment with nitric or acetic acid produces soluble compounds which when precipitated serve to make artificial silk, dopes. films (collodion, etc.) and, in the case of nitric acid, explosives.

The general agreement of all kinds of timbers as regards chemical composition is illustrated by the fact that all these under destructive distillation yield tar and tar derivatives, methyl alcohol (wood spirit) and acetic acid.

But the various kinds of wood also have additional chemical bodies which differ in the different species and include tanninlike bodies, resins, scented ethereal oils and colouring substances.

Physical Constitution. — Physically wood substance is a very stiff jelly or gel, and consequently is comparable with glue, gelatin or gums. Like these it is hygroscopic and swells as it absorbs water and shrinks as it dries. Wood substance can take up only a definite amount of water, which lies near 30% of its dry weight when the wood is in a saturated atmosphere. 4 piece of wood containing this maximum amount in its walls but none in its cavities is described as having reached fibre-saturation point. and has attained its maximum volume; when liquid water is added to it the water enters the cavities and no additional swelling ensues.

It is a familiar fact that when water is added to dry glue or gelatin these show a decline in hardness, strength and stiffness and a rise in flexibility and extensibility; as wood substance is a gel, the same changes in properties take place when water is added to a piece of dry wood until fibre-saturation point is reached. Moreover. just as when heat is applied together with water to glue this shows increased loss of stiffness (by "melting"), so when moist steam is applied to wood this can readily be bent for the manufacture of furniture and so forth.

The weight or heaviness of wood is recorded as the weight of a unit of volume of the wood, which is the density. The units employed in the British Commonwealth and the United States are cubic feet and pounds avoirdupois; elsewhere and in scientific work they are cubic centimetres and grams.

Since the fundamental chemical composition of wood substance approaches identity in all timbers, its specific gravity in these varies but slightly. lying near 1.55; that is, dry wood substance weighs slightly more than $1\frac{1}{2}$ times as much as water. Consequently when two perfectly dry pieces of wood of equal size differ in weight, the one is heavier than the other because it contains more wood substance; in other words the density of perfectly dry wood is a measure of the amount of wood in a unit volume. The various kinds of timbers differ in their densities; some woods, including ebony and box, even when fully seasoned, sink in water, whereas some balsawoods are lighter than cork. Consequently density facilitates identification of different woods.

Water Content. — The amount of water present in a piece of wood is of profound practical importance, since it determines the weight (consequently cost of transport), size, shape, heat-raising power, hardness, strength and stiffness of the piece. as well as the vulnerability of the wood to attacks by fungi and insects; it also determines the changes in these characters that will ensue when the wood is transferred to another place.

The water content of wood may be stated as the percentage of the weight of the wood and the contained water (always less than 100%) or as the percentage of the weight of the absolutely dry wood. Usually the latter basis is used. According to this method of recording. a log of wood is described as containing 200% of water when it contains 200 lb. of water to every 100 lb. of dry wood. Such a high water content does occasionally occur naturally, as for instance in freshly felled swamp (Louisiana) cypress; more frequently in freshly felled timbers it is around 100% in the sapwood. Heartwood usually contains much less. Here a popular error must be corrected: in cold-temperate regions the wood of a tree does not contain less water in winter than in summer; often the reverse is the case.

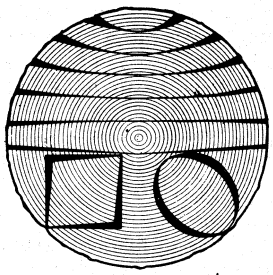
When exposed to the open air, preferably under cover, a freshly felled piece of wood dries and shrinks until the water content at its surface has a vapour pressure equal to that of the atmosphere. The water content of pieces of timber thus seasoned in the open air, and not too massive, varies according to the season and site between 15% and 20% in Great Britain but is much less in drier climates; in Egypt, for instance, it may be 6%.

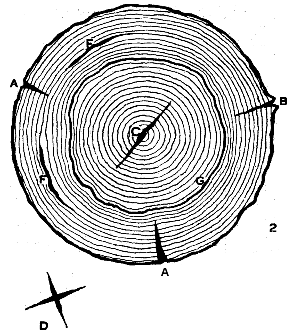
Brought indoors into heated workshops or rooms, further drying and shrinking take place, so that furniture in Great Britain contains about 7% to 9% and in drier parts of South Africa and the United States only 6% or less of water.

Placed in a drying oven at a temperature of 100° C., all the water, save that which is chemically combined, is regarded as having been dried out, and the wood is described as absolutely dry. When dry wood is once more exposed to moister air it reabsorbs water and swells. Under constant atmospheric humidity all species of wood attain about the same percentage of moisture based on their oven-dry weight.

Different kinds of wood undergo different changes of volume with the same percentage gain or loss of water. Heavy woods generally shrink or swell more than light woods, but shrinkage and swelling are not exactly proportional to wood density, for woods of the same density show considerable differences in this respect; for instance. Central American mahogany with changed water content undergoes comparatively slight change of size or shape

A piece of mood tends to shrink and swell unequally in different directions. Along the grain shrinkage and swelling are so slight that measuring rods made of well-seasoned wood are very reliable. Across the grain shrinkage and swelling are many times as great—in a radial direction 2% to 9% and tangentially (or parallel to the annual rings) 4% to 14%. Consequently when a piece of wood dries it undergoes greater or less change of shape. The accompanying diagrams show cross sections of pieces of wood respectively cut into boards, squares and cylindrical rods, and the change of shape caused by drying; the warping of boards cut off centre contrasts with the preservation of fatness of the board cut through the centre.





FIG, 1.—SHRINKAGE AND CHANGE OF SHAPE. INCLUDING WARPING
FIG. 2.— SHAKES AND SPLITS: (A) SEASONING SPLIT. (B) FROST RIB AND SPLIT, (C) SIMPLE HEART SHAKE. (D) DOUBLE HEART SHAKE. (E) STARLIKE HEART SHAKE, (F) PARTIAL CUP SHAKE. (G) COMPLETE CUP SHAKE

A piece of wood whose fibres, like those of very knotty wood or burrs, run in various directions obviously is especially liable to split when dried. It is partly for this reason that the burr wood used in the manufacture of beautifully figured furniture is cut into very thin sheets, termed veneers, which are glued onto straight-grained wood.

Plywoods (including the commonest of these, three-plywood) consist of thin veneerlike sheets glued together so that the grains of the successive sheets cross one another at a given angle (usually at right angles). with the consequence that plywood warps less and shrinks more uniformly than does plain wood and is less unequal in strength in different directions. (See PLYWOOD.)

Colour.—The different kinds of wood may be wholly white or in the heart may be black or have colours ranging from brown. yellow, red, green to violet, or mixtures of these. It is quite exceptional for one and the same wood when perfectly sound to show such a wide range of variation as does that of *Liriodendron* (English name Canary white wood and North American name yellow poplar); this wood varies in colour from light yellow to green and iridescent blue. The colour thus facilitates identification and helps to decide the decorative use to which a wood shall be put.

It is not true that dark-coloured woods are more durable than light-coloured. though this is true of the heartwood when compared with the' sapwood of the same timber. Abnormal discoloration of wood is very frequently caused by fungi attacking the wood or its contents. as is the case with the blue sap(wood) of softwoods, rusty red of woods attacked by various fungi (including some causing dry rot), black lines and white patches of many rotting timbers. and sometimes false heartwood in trees which normally lack a coloured heartwood.

Heating Power.— The heat-yielding power of a piece of wood decreases with increase of its water content; consequently the succeeding remarks refer to n-ood absolutely dry. During the combustion of wood the heat liberated is mainly derived from the wood substance; as the weight of this in a unit volume of wood is the density, it follows that the heavier a wood is the more heat it can supply: the presence of resin in wood, however, increases the heat-giving power.

When wood is used as fuel, however, the most important character often is the form in which the heat is liberated. Very heavy woods produce short or no flames and burn slowly, light woods can produce long flames and burn fiercely; consequently for fire lighting or steam producing the latter are used, whereas for keeping rooms warm, woods of intermediate density (*e.g.,* oak and beech) are most efficient.

Mechanical Properties.— The trunk and woody branches of a tree owe their strength and stiffness mainly to their wood. Accordingly, wood must possess strength to resist breakage or permanent damage by slow crushing, stretching, bending and twisting; it must also resist shock in the form of sudden application of these stresses; it must possess sufficient stiffness to give the requisite pillar strength to the trunk, and when a deforming stress is removed must return to its former shape.

In conformity with its difference of structure along and across the grain. wood differs in strength and stiffness in these two main directions. As regards crushing (compression) and stretching (tension) wood is strongest and stiffest along the grain and .weakest at right angles to this. As regards shear. however: it is strongest at right angles to the grain; a beam in bending is strongest and stiffest when the load is applied perpendicular to the grain. Consequently; joists, beams, floorboards, posts, ax handles, wheel spokes and so forth are strongest when their grain is straight and parallel to the sides of these objects, and they are weakened by cross grain and considerable knots.

The remarkable mechanical property of wood is its combination of strength and lightness; for instance, if the crushing strength is divided by the density in the cases of constructional wood and iron, steel and other metals, the resultant value is highest in wood. Severtheless, the tensile strength of steel or iron is so much higher than that of wood that one of the former is used in engineering construction for members required to resist rupture by tension, whereas wood is often used where resistance to bending or compression is needed. (See MATERIALS, STRESGTH OF.)

The peculiar elastic properties of wood render possible its employment as resonance wood, used for instance in the bellies of violins and in the sounding boards of pianos. Wood undergoing decay soon declines in strength and elasticity, and even when only partly decayed emits when struck a dull, in place of a sharp ringing sound.

Wood, thanks to its structure, elasticity, low tensile strength and relative softness. can be riven or cleft along the grain and yields a more or less smooth surface.

Defects of Timber.— Standing *Tree.*—Wood may have structural peculiarities that represent defects from the mechanical point of view but that may enhance the value because of the decorative effect. This is the case where deviations of the grain, such as wavy or curly grain, or abundance of knots weaken the wood.

Always decreasing the value of timber are long splits, termed shakes. directed along the grain of the standing tree. These in cross section may run parallel with the annual rings (or contour of the trunk) and are termed cup shakes. They may assume the form of short arcs or complete circles (ring shake); in the latter case when the log is sawed the central part separates from the outer part. But in cross section the shake may run in a radial direction; it is then a heart shake. Such a shake is widest toward the centre and tapers outward. and contrasts with the radial splits induced by drying of the felled timber which are wider at the outside and taper inn-ard.

Heart shake may assume the form. in cross section. of a single split traversing the centre. in which case it is described as simple; or this split may be crossed at right angles by another, thus producing double heart shake; or, finally a number of splits may radiate from the centre and thus constitute star shake. which is often associated with discoloration and decay. Radial frost shakes are frequently associated with frost ribs that are visible on the growing tree as ridges running down one or more sides of the trunk. With these shakes contrast the internal radially directed splits that first arise in felled timber which has been so rapidly dried that case-hardening has resulted.

In the resinous coniferous woods, such as the pines. lens-shaped, resin-containing cavities from less than an inch to several inches in width, known as resin pockets or pitch pockets, occasionally occur. Sometimes longer resin veins easily visible to the naked eye traverse the wood, or this may clearly show a general excess of resin in the absence of veins or pockets. In some cases excess of resin or abnormal development of the ducts is caused by injury to the cambium.

In hardwoods so-called gum veins are occasionally present in Australian species of eucalyptus, including jarrah, and in true mahoganies.

Felled Timber.—Tunnels or other cavities are also produced by animals in felled timber. In sea water they result from attacks by Mollusca (e g., shipnorms) or small Crustacea (cf. shrimps), and on land are caused by insects. Decay or rot of timber taking place in the standing tree or felled timber is always attributable to fungi (see DRY ROT), and is associated with discoloration and weakening of the wood but much less frequently with the production of internal cavities.

Opposed to the shakes already considered are cross shakes, which are cracks or splits running at right angles to the grain. In the overwhelming majority of cases they result from decay of the wood, caused by fungi, and consequent shrinkage (see DRY ROT). They render wood useless for mechanical purposes. But the logs of certain species of trees. including spruce, sabicu and some African mahoganies, occasionally show cross shakes even in freshly felled timber and when there is no trace of decay.

For a discussion of felling, forms and sizes see LUMBERING.

Special Softwoods.—The name cedar is given to various unrelated, usually fragrant, softwoods and hardwoods. The true cedars (Cedrus) are familiar as trees of three kinds: the Himalayan deodar, the cedar of Lebanon and the Atlas mountains cedar. Junipers (*Juniperus*) supply the pencil-wood 'cedar, the most important being the North American J. virginiana, though pencil slats are also made from another species growing in Kenya; the heartwood is durable, as the scented cedarwood oil is antiseptic and distasteful to insects.

Lawson's cypress (Chamaecyparis lawsoniana), indigenous in western United States, yields the valuable Port Orford cedar. Other Sorth American cedarwoods are produced by arbor vitae trees (*Thuja*), the durable red cedarwood (T. plicata) being used for shingles.

Bald, marsh or Louisiana cypress (*Taxodium distichum*) grows in swamps of southeastern United States and Central America; its durable wood is unsurpassed for conservatories.

The European larch (*Larix decidua*) is rather heavy and the red heartwood is very durable. The rather similar North American timbers are those of the tamarack (L. *americana*) and the western larch (L. *occidentalis*). Larch timbers find many of the same uses as hard pines (see below).

True Pine.—The name pine is given to a medley of softwoods but should be restricted to timbers belonging to the genus *Pinus*. Such genuine pine timbers may be ranged into two classes. hard pines and soft pines, the former of which are generally heavier.

Hard pines include one of the two most important softwoods of Europe; Baltic red deal (*Pinus sylvestris,* the Scots pine), which grows widely over Europe and is represented in North America by a very similar timber, red or Norway pine (P. *resinosa*).

The name pitch pine as applied to North (and Central) American timbers in Great Britain and the United States. respectively, is liable to cause confusion: in the latter country it refers to relatively poor wood of P. *rigida,* whereas in Great Britain and Europe it refers to pine timbers of the highest class produced by P. *palus*tris and two or three other species all exported from southeastern United States to England.

Soft pines include two North American species, eastern white pine (P. *strobus*), known in England as Weymouth pine and Canadian yellow pine. and western white pine (P. *monticola*), also called Idaho white pine. They are used for house construction, patterns, matches and packing boxes.

So-Called Pines.—A nide range of coniferous trees are known in Australasia as pines and include the kauri pine (Agathis *australis*) of Sen Zealand and huon pine (*Dacrydium franklinii*) in Tasmania. The Oregon or British Columbian pine is Douglas fir (*Pseudotsuga* taxifolia), which grows in the western portion of North America.

California redwood (*Sequoia sempervirens*) has a reddish heartwood, is light in weight, durable and used for building construction. tanks, wood-stave pipe, silos and coffins.

White deal is the wood of the Norway spruce (Picea excelsa), which is widespread over Europe. The white wood ranges in quality from the common grades used in packing cases, woodwork of houses and pulp. to mountain-grown wood of the highest quality which provides the best sounding boards of pianos. To similar uses the black, white, red and Sitka spruces (Picea spp.) are put in North America. (See SPRUCE.)

Special Hardwoods.—The ash tree (Fraxinus excelsior) is widespread over Europe and supplies the timber of commerce, which is almost solely sapwood, as any heartwood is produced late in life. The wood is remarkably tough and, after steaming, can be permanently bent without losing its shock-resisting power. It is used in the manufacture of fork handles, oars. baseball bats, tent poles and so forth. In North America six species of Fraxinus supply commercial timbers.

The beech timbers of commerce are the woods of *Fagus* sylvatica and F. *grandifolia* in Europe and North America respectively. The latter shows a distinction into white sapwood and reddish heartwood, but not so the former. which is of uniform reddish white. Being perishable out of doors beechwood is mainly made into articles used indoors, including furniture.

In addition to the softwoods enumerated a number of scented hardwoods from various countries are termed cedars; of these the most familiar is the tropical American cedar (Cedrela odorata) used in the manufacture of cigar boxes and small boats.

Very similar to the timbers of ordinary oaks are those of the true chestnuts, Castanea *vesca* of Europe and C. dentata of North America. but these lack wide rays and consequently display no striking silver grain, and they are weaker.

Species of Diospyros growing in tropical Asia and Africa supply the black ebonies of commerce. The black of the heartwood may be interrupted by patches of white (in Andaman marblewood) or brown (in calamander wood). The Japanese and North American persimmon woods also are species of Diospyros, but pieces of the latter have little or no black wood.

The commercial timbers are produced by several species of European and North American elm (*Ulmus*). They generally have heartwoods lasting well in permanent contact with water; the water pipes of London in old times were often made of hollowed trunks of elms.

Australia is the world's centre for the growth of eucalyptus trees. a number of which produce hard, heavy, strong timber of large dimensions, and include jarrah, karri, tallowwood and tuart.

Greenheart is a tropical South American wood, which is generally stated to be that of Ocotea *rodiaei;* it varies in colour from yellow-green to darker admixtures of colours. Resistant to shipworms, it is used widely for piling in docks; for fishing rods it is pre-eminent.

Commercial hickory woods of good quality are produced by a number of species of Hicoria in the United States. These find much the same uses as ash, since they are tough, but being stiffer they are used more for handles of striking tools, such as hammers.

The name mahogany is improperly given to a medley of woods which range from white to bluish red in colour and grow in various countries. The original mahogany was that of Swietenza *mahagoni,* growing in the West Indies; this species, together with the allied S. *macrophylla* growing on the mainland of tropical America. supply true American mahogany. These reddish-brown woods shrink and warp little, are durable, light and polish readily to yield beautiful decorative effects. Any other woods named mahogany should share these characters. Such is the case uith West African mahoganies produced by certain species of Khaya (belonging to the same family, Meliaceae, as Swtetenia), which are indistinguishable by most persons from the American mahogany. The West African Gaboon mahogany is a wood belonging to trees (or a tree) of an entirely different family. and is not a mahogany; neither are any of the so-called mahoganies of India, Australia, the United States and South America.

Maples, including the European sycamore, belong to the genus Acer and vield white firm woods that have a silverv sheen. North America supplies maples used in floorings. bowling pins, novelties and the beautiful bird's-eye maple used in furniture.

True oak timbers are produced by species of Quercus, which is a genus not growing south of the equator, and the commercially important ones are European, North American and Japanese in origin. The European timber is mainly derived from the wide-spread Q. *pedunculata* and Q. *sessiliflora,* and stands apart from the other commercial kinds in being the sole one that can be safely used alone in the construction of casks and barrels for the storage of beer, wines and spirits without causing deterioration of flavour of these. Great Britain produces a unique type, termed brown oak, which is used in the manufacture of panelling and furniture in Europe and North America, The European oak imported into England is known as Russian oak when exported from Baltic ports and as Austrian oak when exported from Fiume. North American commercial oak timbers are produced by a larger number of species of *Quercus* belonging to two groups. the white and red oaks, which contrast in structure, durability and uses.

Genuine lustrous satinwoods in origin are respectively East Indian (*Chloroxylon swietenia*) and West Indian (Xanthoxylum).

Teak timber is produced by Tectona *grandis,* which yields commercial supplies only in the Indian peninsula, Burma, Siam and Java. The valuable yellow to brown heartwood is hard, strong, stiff and very durable; moreover, unlike oak, it does not attack iron. As the wood also "stands" well, it is excellently suited for use in windowsills, ships and flooring. The wood shows annual rings and thus contrasts with such spurious teak timbers as West African teak (Chlorophora) and Indo-Malayan eng or yang teak (*Dipterocarpus*).

The two most important walnut timbers are those of *Juglans regia,* whose distribution stretches from England to northern India, and J. *nigra,* which is North American. The heartwood of both species is brown; that of the former species is often traversed by brown lines, while that of the American species is wholly of a blacker brown. Both woods are unrivalled for the manufacture of gunstocks and are excellent furniture wood; when it has been thoroughly seasoned and polished, it shrinks and swells very little. The wood has clearly marked annual rings and thus contrasts with two tropical spurious walnuts. the East Indian (Albizzia lebbek) and West African (Lovoa klaineana). 4 third misnamed wood is known in Great Britain as satin walnut (also as hazel pine) and in the United States. its native country, as gum (sweet or red).

Confusion frequently arises in England as to the identities of several woods that are more or less white. From the United States there are exported to England several kinds of wood having that character. One is named canary whitewood in Great Britain but yellow poplar in America; it is produced by the tulip tree (Lirio-*dendron tulipifera*) and ranges in colour from light yellow to iridescent blue. In addition are woods produced by true poplar trees (*Populus*), which are named cottonwoods in the United States. Third, there are woods known in England as lime and in America as basswood, that are produced by lime trees (*Tilia* spp.), which of course are very different from the limes (Citrus) producing the familiar juicy fruits.

The European sycamore is a maple, and when artificially coloured gray is marketed as hardwood. What is known as sycamore in the United States is the plane tree of Europe.

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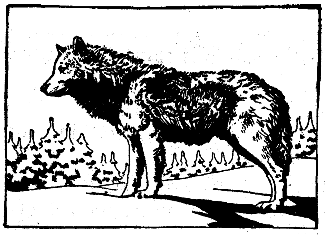
TIMBER LINE, the boundary above which there is no natural tree growth. In any elevated area in low or middle latitudes the line is generally clearly marked, but its height is dependent not only on general but also on local climatic and soil conditions. See SNOW LINE.

TIMBER WOLF, a name applied to the large wolf (*Canis lupus*) of the eastern and northern narts of North America. The colour is usually gray but ranges from black to white.



COURTESY NEW YORK ZOOLOGICAL SOCIETY
THE TIMBER OR GRAY WOLF

Timber wolves reach a length of 66 in., of which the tail is 12 in., and a weight of about 100 lbs. Over much of their former range. wolves have been exterminated.

See WOLF; CARNIVORA.

TIMBREL or **TABRET** (the *tof* of the ancient Hebrews. the *deff* of Islam, the adufe of the Moors of Spain), the principal musical instrument of percussion of the Israelites, identical with the modern tambourine.

The tabret or timbrel was a favourite instrument of the women, and was used with dances, as by Miriam, to accompany songs of victory, or with the harp at banquets and processions; it was one of the instruments used by King David and his musicians when he danced before the Ark.

TIMBUKTU (Fr. Tombouctou), chief town of a district of the Republic of Mali, 9 mi. N. of the main stream of the Niger in 16° N. and 5° W.

Timbuktu lies on a terrace formed by the southern scarp of the Sahara, about 800 ft. above sea level, surrounded by sandy dunes covered with mimosas and other spiny trees. Timbuktu communicates with the Niger by a series of marigots or channels nith alternating flow, which fill at flood time and empty themselves into the Niger when the dry season supervenes. In January, the maximum period the waters reach the walls of the town through the marigot from Kabara, which is the port of Timbuktu.

Timbuktu has been described as "the meeting point of the camel and the canoe," "the port of the Sahara in the Sudan." and (more correctly) "the port of the Sudan in the Sahara." It was formerly a much larger place than it was found to be at the time of its occupation by the French in 1893–1894. Extensive ruins exist north and west of the present town. The great mosque which at one time stood in the centre of the town now lies near the western outskirts, where its high but unsightly earth tower forms a striking landmark. The mosque of Sidi Yahia (in the centre of the town) and that of Sankoré in the north-east also possess prominent towers. Whereas in 1895 the town was little more than a vast ruin. under French protection the inhabitants, relieved from the fear of Tuareg oppression, set about repairing and rebuilding their houses; new streets were built; European schools, churches and other establishments were opened. But Timbuktu has not yet recovered; pop. (1955 est.) 7,468, including 68 Europeans. The majority are Songhoi. At the time of the commercial transactions from March to June, the population reaches 25,000. The industries of Timbuktu—cotton-weaving, earthenware, leatherwork and embroidery—are of subordinate importance, and the great bulk of the people are occupied exclusively with trade. The whole traffic of the surrounding lands converges on Timbuktu; two great caravans of 3,000 or 4,000 camels are yearly charged with salt from the Taudeni district.

Timbuktu, which possesses some valuable Arabic manuscripts —notably the Tarik *es-Sudan,* a 17th-century history of the Sudan written by Abderrahman Sadi of Timbuktu—and is a centre of Moslem teaching, is a converging point of the chief west Sudanese and Saharan races—Arabs or Arabized Berbers to the west; Sonrhaï in the immediate vicinity, and thence south-eastwards along the Niger; Ireghenaten or "mixed" Tuareg southwards across the Niger as far as the Hombori Hills and in the fertile Libbako plains beyond them; Fula, Mandingos, and Bambara in and about the city; and Imoshagh (Tuareg) belonging to the Awellimiden confederation mainly to the north and east.

The local administration—which French rule preserved—was placed in the hands of an hereditary *kahia,* a kind of mayor, descended from one of the Ruma families. (A. BE.)

History.—The history of Timbuktu is intimately connected with that of the city of Jenné and the Songhoi empire. The Songhoi are a negro race who are said to have come to the Niger countries from the Nile valley. In the 8th century they made themselves masters of a considerable tract of country within the bend of the Niger, and built the city of Gao (*q.v.*), zoom. in a direct line S.S.E. of Timbuktu, making it their capital. In the 11th century they were converted to Islam. Besides Gao, the Songhoi founded Jenné (*q.v.*), which early attained considerable commercial importance. Meanwhile (11th century) a settlement had been made at Timbuktu by Tuareg. Perceiving the advantages for trade with the north offered by this desert rendezvous, the merchants of Jenné sent agents thither (12th century), and Timbuktu shortly afterwards became known to the inhabitants of the Sahara and Barbary as an excellent market for their goods, and also for the purchase of the many commodities of the western Sudan. In the 12th or 13th century Timbuktu fell under the power of the Mandingo kings of Melle or Mali, a country lying west and south of Jenné. Its fame as a mart for gold and salt spread to Europe, "Timboutch" being marked on a Catalan map dated 1373. In 1353 it had been visited by the famous traveller Ibn Batuta. In 1434 the Tuareg made themselves masters of the city, which in 1469 was captured by the Songhoi king Sunni Ali. It was at this time (1470) that Timbuktu was visited by an Italian, Beneditto Dei. In the days of Sunni's successor Askia (1494–1529) the Songhoi empire reached its highest development, and Timbuktu rose to great splendour. The "university" of Sankoré became a chief centre of Mohammedan culture for the peoples of the western Sudan.

The riches of Timbuktu excited the cupidity of El Mansur, sultan of Morocco, who, in 1590, sent an army across the Sahara under an "Andalusian" Moor (that is, a Moor descended from those expelled from Spain), which captured Timbuktu (1591) and completely broke up the Songhoi empire. For about 20 years after the conquest the pasha who ruled at Timbuktu was nominated from Morocco, but the distance of the Niger countries from Marrakesh enabled this vast viceroyalty to throw off all allegiance to the sultan of Morocco. The Niger Moors, known as *Rumas* after El Mansur's musketeers, quarrelled continually among themselves, and oppressed the negro tribes. By the end of the 18th century two hundred years of oppression had reduced Timbuktu to comparative desolation and poverty. By this time the whole country was in a state of anarchy, and in 1800 the Tuareg swooped down from the desert and captured the place. They were in turn (1813) dispossessed by the Fula, who in 1840 gave place to the Tukulor. (See SENEGAL, History.)

At this period European interest in the region had revived. Maj. Gordon Laing, who had reached Timbuktu from Tripoli in 1826, had been murdered by order of the Fula; but Rent. Caillié, coming from the south, had been in the city in 1828 and had returned in safety. Heinrich Barth, an officially accredited representative of the British Government, reached Timbuktu from the Central Sahara in 1853 and some effort was then made to bring the place under British influence. El Backay (Bakhai), the sheikh who received Barth, gave him letters professing much friendship for the British, and in a letter to El Backay, dated April 15, 1859, Lord Clarendon, secretary of State for foreign affairs, said that "the friendship binding us shall not diminish through the centuries" and "as our Government is very powerful we will protect your people who turn to us." A nephew of El Backay's went to Tripoli, saw the British consul and was told that a British steamer was ascending the Niger and that the Government had recommended those on board "to make every effort" to reach Timbuktu. But no one from the lower Niger reached El Backay, whose influence appears to have declined after Barth's visit; and no further attempt appears to have been made by the British to keep in touch with Timbuktu. Indeed. between Barth's visit and the French occupation only one white man, Oskar Lenz, in 1880, reached Timbuktu and he crossed the desert from Morocco. It was in the following year, 1881, that the French. thrusting forward from Senegal, began the conquest of the countries of the Niger bend. When they reached Timbuktu in December 1893 they found that the town had again fallen beneath the rule of the Tuareg. The townsfolk, indeed, from the time of the decay of the Ruma power being at the mercy of all comers, were content to pay tribute to each in turn and sometimes to more than one simultaneously, for which they indemnified themselves by peaceful intervals of trade whenever the land routes were open and the Niger clear of pirates. But at times even the short tract separating the town from Kabara was so beset with marauders that it bore the ominous name of "Ur-immandess," that is, "He (God) hears not." Little wonder then that the townsfolk freely opened their gates to the French as soon as Lieut. Boiteux reached Kabara in command of a small flotilla.

The occupation of the town, against orders, was a daring exploit of a handful of marines. The force which "garrisoned" Timbuktu consisted of seven Europeans and twelve Senegalese. The somewhat larger body left with the gunboats was attacked by the Tuareg (Dec. 28) and suffered severely. Col. T. P. E. Bonnier, who was at Mopti, zoom. to the south-west, marched to the relief of Boiteux and entered Timbuktu without opposition on Jan. 10, 1894. He then set out with about 100 men to chastise the nomads. In the night of Jan. 14–15 his camp was surprised and the colonel and nearly all his men perished. The enemy did not follow up their victory, and within a short period French rule was firmly established in Timbuktu. In 1903 the French authorities placed commemorative tablets on the houses occupied by the four travellers, Laing, Barth, Caillié and Lenz, during their stay in Timbuktu. Under French rule the town has regained a measure of importance.

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TIMBY, THEODORE RUGGLES (1819–1909), American inventor, was born on April 5, 1819, in Dover, New York. His most noted invention was the revolving turret, which he first conceived in 1841. He first constructed a small model and displayed it in Washington. Later he built a steam-propelled model in Syracuse, N.Y. (1842). This he exhibited in the city hall, New York, where it was inspected by President Tyler and his cabinet. In 1843 he obtained a caveat from the patent office. During the Civil War, when the "Merrimack" had been constructed with heavy iron armour by the Confederate Government, it became evident that a new type of ship must be built to compete with it. At this juncture John Ericsson came forward with plans for a floating battery. These plans were presented to the naval department and promptly accepted. Immediately an organization known as the "Battery Associates" was formed to build armoured ships according to Ericsson's plans. When Timby heard of this Government contract, he presented the caveat for his patent on the revolving turret, which was to be the main feature of Ericsson's floating battery. The Battery Associates, recognizing Timby's claim, agreed to pay him $5,000 on each turret built. Soon afterwards. with Ericsson as engineer of the design and construction, the battleship "Monitor" was completed. When she met the "Merrimack" and gained her famous victory, Ericsson was given general recognition as the inventor of the revolving turret. No serious efforts were made to correct the misapprehension until Timby's death. From 1861 to 1891, Timby invented and patented, at home and abroad, a system of coast defences, such as the sighting and firing of heavy guns by electricity; the tower and shield; the cordon across a channel; the planetary and subterranean systems, and numerous modifications of the turret system. He died in Brooklyn, N.Y., on Nov. 9, 1909.

See the *Memorial to the 57th Congress for Recognition of T. R. Timby* by the Patriotic League of the Revolution (1902), and the *Memorial* to T. *R. Timby* (1911) *by* the Timby Memorial Trust.

TIME, the general term for the conscious experience of duration. For the distinction between man's subjective impression of time and an attempted scientific, hence entirely objective, description, independent of any observer, see SPACE-TIME. For the methods of reckoning time, see CALENDAR; DAY; MONTH; TIME MEASUREMENT; TIME, STAXDARD. See also Index references under "Time" in the Index volume. (H. B. LM.)

In Music. — Time is a term signifying the number of beats in a measure or bar. When there is an even number of beats, as two or four, the music is said to be in common or duple time. When there are three beats in a measure it is said to be in triple time. Further; when the beats are of the value of an aliquot part of a semibreve the time is termed simple. Thus four crotchets, or their equivalents, in a measure constitute simple common time. while three crotchets. or their equivalents, constitute simple triple time. When, on the other hand, the beats are of the value of dotted notes, and therefore not aliquot parts of a semibreve, the time is termed compound. Thus four dotted crotchets in a measure constitute compound common time. while three dotted crotchets in a measure constitute compound triple time. (X.)

TIME, STANDARD. In an isolated community clocks and watches would be set to the local mean time (see TIME MEASUREMENT), and before the period of railway communication the different towns as a rule kept local time. The need for a more systematic plan of standard times was chiefly felt in the United States. While the railways in England were run by Greenwich time and the railways in France by Paris time, it was not to be expected that railway systems in the middle and western states would adopt Washington, D.C., time. differing by several hours from the local time of the region which they served. Hence each railway had its own time. or, in the case of the longer lines, several different time zones, and great confusion arose at overlapping points. The question of bringing order out of chaos through a system of standard time was actively discussed in the principal commercial nations during the decade before 1880. Sandford Fleming in Canada and Charles F. Dowd in the United States being the principal proponents of the system. This involved adopting for the whole earth 24 standard meridians 15° apart in longitude, starting from Greenmich. These meridians were to be the centres of 24 time zones; in each zone the time adopted would be uniform, and it would change by one hour in passing from one zone to the next. After long discussion railway managers of the U.S. and Canada decided to adopt the system. Zone time based on the Greenmich meridian is now adopted almost everywhere. In most countries the time differs by an integral number of hours from Greenwich time, in accordance with the original plan; but in some countries a compromise involving half-hour differences was adopted. European countries are ranged in three groups, keeping respectively Greenwich time, mid-European time (one hour fast). east European time (two hours fast). In the U.S. there are four time zones: Eastern, Central, Mountain, Pacific, respectively 5, 6, 7, 8 hours slow on Greenwich time. A full list of standard times of the different countries, and of those on non-standard time is published yearly in the British *Nautical Almanac*.

The advent on an international scale of shipping and. later, of air travel has necessitated world-wide agreement on the 15° time zone system. Slight adjustments have been made in some of these parallels of longitude so that a particular standardization may cover a specific geographical area; for example in certain countries in east Asia (see map). The parallel of longitude at 180° (12 hours) is also known as the "date line" because just to the vest of this line countries are one calendar day ahead of Greeawich; again this line has been adjusted so that it does not pass through the middle of a country — in this case New Zealand. Some countries adopt. as an internal policy within their own borders, a zoning every $7\frac{1}{2}$°, giving time intervals of one-half hour; examples are India. Pakistan and other countries in the far east.

In the summer months some countries advance their time by one hour, or adopt the time of the next zone to the east. Thus legal time in Britain is Greenwich time in winter and mid-European time in summer. The advantage of summer or daylight saving (*q.v.*) time depends much on the latitude, and it is scarcely suitable for more northerly or southerly countries; it is unpopular in agricultural communities, but is widely favoured in urban areas.

The advantage of adopting a continuous reckoning of the hours from 0 to 24 instead of using the divisions A.M. and P.M. is obvious, and this reckoning has been adopted for many public services in some countries, but confusion has arisen through uncertainty as to when 0 hr. occurs. Astronomers from time immemorial have used a 24 hr. reckoning beginning at noon, but for civil purposes it has seemed more natural to count from midnight. At the meeting of the International Astronomical union in 1922 astronomers were recommended to use time beginning at Greenwich midnight from 1925, but no recommendation was given as to the name. In England it was believed that the intention was to use the name Greenwich mean time (G.M.T.) in a sense differing by 12 hr. from what it had previously meant. In other countries, however, other names were available for time counted from Greenwich mean midnight and these were used. At the meeting of the International Astronomical union in 1928 it was decided to use *temps* universe1 (T.U.) in France, universal time (U.T.) in England and *Weltzeit* (W.Z.) in Germany. The designation Greenwich civil time (G.C.T.), which had been used in England, France and the Gnited States, was dropped, and it was recommended that anyone who still wanted to use time counted from noon should call it Greenwich mean astronomical time (G.M.A.T.).

(A. S. E.; J. JN.)

See *The American* ***Ephemeris*** *and Nautical Almanac* (annual).

TIME MEASUREMENT. Time is a basic concept which deals with the occurrence of events. There is a definite order in which any two nonsimultaneous events occur. Thus, if *A* and B are such events, either *A* occurs before *B* or B occurs before *A*. Between two nonsimultaneous occurrences there is the lapse of an interval of time.

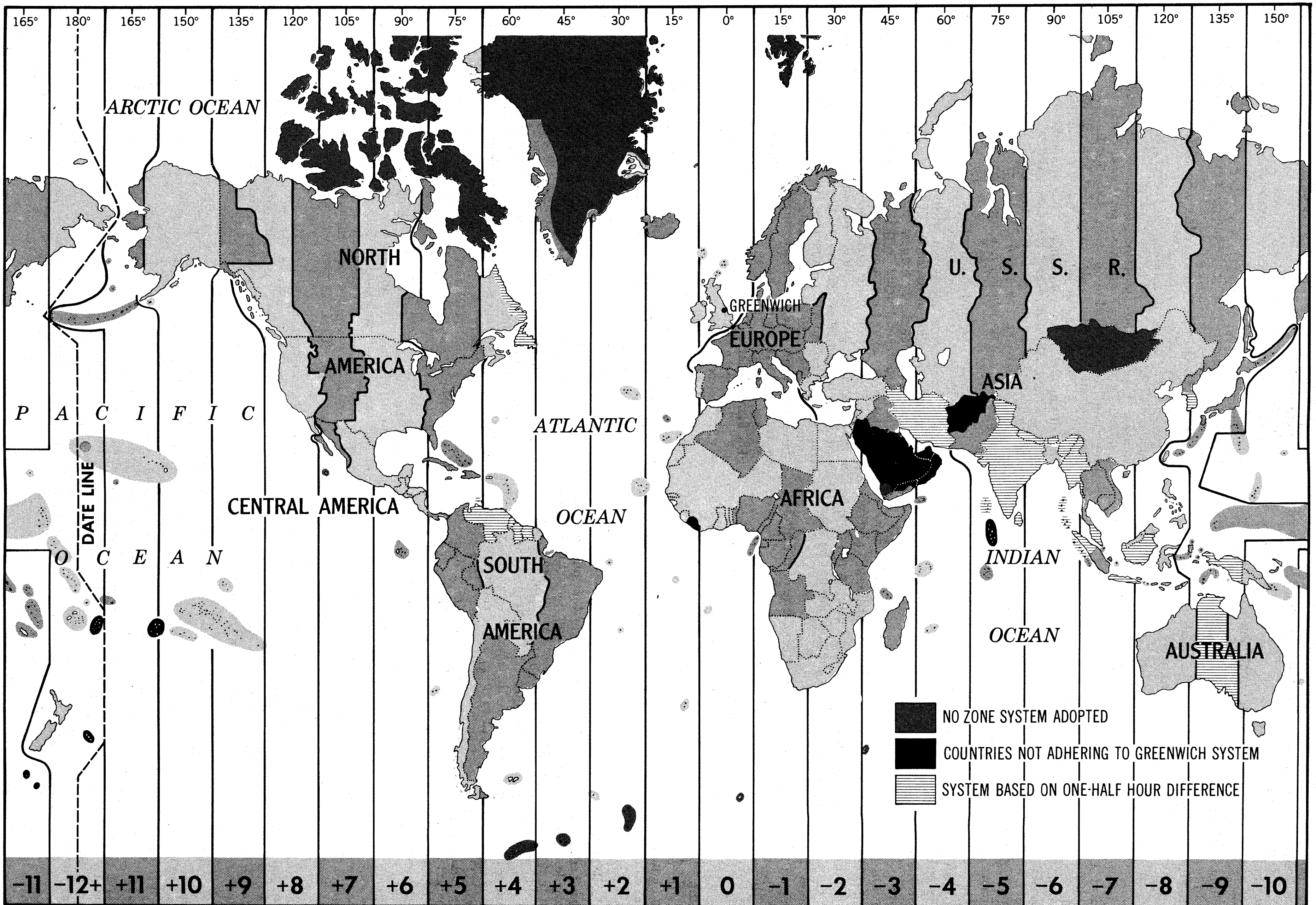
The measurement of time involves establishing a precise system of reference for specifying when any event occurs, that is, specifying the epoch, and establishing a standard interval of time. Astronomy and civil affairs are concerned both with epoch and with time intervals, whereas physics deals almost entirely with time intervals. The fundamental unit of time interval is the second. There is a similarity between time and length as dimensions, and also a difference. A unit of length may be made, and preserved in a vault. **A** unit of time: however, must be continually redetermined.

Analogous to equal intervals of length are equal intervals of time. The rhythm of music. the beat of a clock and the daily rising of the sun are recognized as manifestations of equal intervals of time. Our senses, however, are not a good judge of equal intervals, and if accuracy is required a clock of some kind must be used. A clock, in the general sense, may be defined as anything which can be used to measure an elapsed interval of time. We distinguish between two types. natural and artificial. The natural type is based on some process of nature, such as the rotation of the earth about its axis, the revolution of the moon about the earth or the decay of a carbon isotope. The artificial type consists of two parts, a constant frequency element and a counting element. Examples are the pendulum: quartz-crystal and atomic clocks.

The rotation of the earth was the sole standard of time determination until about 1940 when it became certain that the speed of rotation of the earth was not constant. Since mean solar time, which is based on the rotation of the earth, is nonuniform, a new kind of time which is uniform. called ephemeris time (E.T.), was introduced (see below). E.T. is defined by the revolution of the earth about the sun, but is obtained in practice from the motion of the moon about the earth. In 1955–56 the fundamental unit of time was redefined to be identical with the second of ephemeris time instead of the second of mean solar time, but mean solar time continued in civil use while ephemeris time is used for scientific and technical purposes whenever the requirement for accuracy in absolute time exceeded one part in 10,000.000 (1 in 10^7).

After an explanation of the basis of time measurement the above concepts are discussed in detail under the following headings:

I. Rotational (Nonuniform) Time
  A. Solar Time



BASED ON DATA FROM THE U.S. NAVY HYDROGRAPHIC OFFICE

TIME IS CALCULATED FROM THE MERIDIAN OF GREENWICH, ENG. THE MIDDLE OF THE ZERO TIME ZONE PASSES THROUGH GREENWICH WITH ITS EAST AND WEST LIMITS 7° 30′ ON EACH SIDE. EACH 15° ZONE EAST AND WEST OF THE INITIAL ZONE REPRESENTS ONE HOUR OF TIME. THE NUMBER OF HOURS THAT MUST BE ADDED TO OR SUBTRACTED FROM LOCAL TIME TO GIVE GREENWICH TIME IS INDICATED ON THE MAP FOR EACH ZONE

B. Sidereal (Equinoctial) Time
C. The Relation Between Solar and Sidereal Time
D. Time Cnits
E. Reckoning of Days and Hours
F. Practical Determination of Rotational Time (The Epoch)
Transit Instrument
Photographic Zenith Tube
Impersonal Astrolabe
G. Practical Determination of Time Intervals
Pendulum Clocks
Quartz-Crystal Clocks
H. Variations in Rotation of the Earth
I. Corrected Universal Time (UT2)
J. Dissemination of Time Signals
II. Uniform Time
A. Ephemeris Time
B. The Second
C. Atomic Frequency Standards
D. Gravitational Time and Atomic Time
E. Uses of Time Systems

Basis of Time Measurement.— Mechanical clocks might be used as a basis for a system of time measurement; however, they are affected by variations in friction. and are not suitable as a basis for accurate time determination. To be free of the effects of friction we may either utilize the motions of members of the solar system or of atoms. The astronomical basis of time measurement will be given first. the atomic basis later.

The motions of celestial bodies are predictable from the laws of celestial mechanics. Knowing the masses, co-ordinates and velocities of a number of bodies at one epoch, it becomes possible to find the co-ordinates for any epoch, t, by the solution of the appropriate differential equations.

The solution for some particular co-ordinate of one of the bodies, say x_1, may be written

$$x_1 = f_1\ (t; a_1, a_2, \ldots a_n), \qquad (1)$$

where f_1 is a function of t and the constants of integration a_1, $a_2 \ldots a_n$. By postulate, the t of equation (1) is uniform astronomical time.

A table which gives the predicted positions of a celestial body, based on an equation of the form (1). is called an ephemeris. For this reason the uniform time of celestial mechanics is called ephemeris time.

I. ROTATIONAL (NONUNIFORM) TIME

A. Solar Time.—The apparent daily motion oi the sun from east to west provides a measure oi time called apparent solar time, which is indicated by a sundial. The interval between two successive transits of the apparent sun across the meridian is called an apparent solar day.

The annual revolution of the earth about the sun causes the sun to appear to move eastward with respect to the stars. Hence, an apparent solar day is not equal to the period of rotation of the earth with respect to the stars. The apparent motion of the sun is 360° in a year, or nearly 1° per day, and an apparent solar day is almost 4 min. longer than the period of rotation.

The earth moves about the sun in an elliptical path in a plane called the ecliptic, which is inclined about $23\frac{1}{2}°$ to the equator. In consequence of these factors the component of the daily motion of the sun along the equator varies. As a result, apparent solar days are of variable length, and apparent solar time is nonuniform.

The development of clocks and watches in the 17th century made apparent solar time unsuitable ior civil use, and mean solar time was introduced. The mean solar day is the mean period of rotation of the earth with respect to the sun. Mean solar time is so defined as to be a measure of the rotation of the earth. The difference between apparent solar and mean solar time is called the equation of time. Its numerical value varies from 0 to about 16 min.

B. Sidereal (Equinoctial) Time.—For various astronomical purposes, such as locating a celestial object, the astronomer uses sidereal time. In the discussion given here astronomical co-ordinates, etc., are treated only briefly. For additional details see ASTRONOMY: *Modern Descriptive Astronomy*: *Time.*

The intersection of the true equator and the ecliptic provides a fundamental reference point called the true vernal equinox. Right ascensions are measureti along the celestial equator from the equinox. The interval between two successive meridian transits of the true equinox is called a true sidereal day. The hour angle of the true equinox, that is, the angle west of the meridian measured along the equator, is the true sidereal time.

The true equinox is not fixed with respect to the system of stars but moves very slowly in a retrocrade direction along the ecliptic, in a period of about 25,000 years. The secular, or steady, part of the motion is called precession and the periodic, or oscillating, part is called nutation. In consequence of nutation true sidereal days are of variable length. The maximum variation from the mean is only about 0.01 sec., but improvements in the pendulum clock made about 1925 required that uniform equinoctial time be introduced.

Uniform equinoctial time is defined as the hour angle of the mean equinox, that is, of the equinox freed of nutation. A mean equinoctial day is the interval between successive transits of the mean equinox.

The difference between apparent and mean sidereal time is called the nutation in right ascension, or the equation of the equinoxes. It varies from 0 to a little more than 1 sec.

C. The Relation Between Solar and Sidereal Time.— Mean solar time is dehned as 12 hours plus the hour angle of the fictitious mean sun. The latter is a point moving uniformly in the celestial equator with the mean speed of the apparent sun. In practice the right ascension of the fictitious mean sun is obtained from a formula, and the operational procedure is such as to keep mean solar time rigorously proportional to the speed of rotation of the earth.

Mean equinoctial time is also proportional to the speed of rotation of the earth, so that mean solar and mean equinoctial time are two iorms of time denoted as rotational. They would be uniiorm measures of time ii the earth rotated at a constant speed.

A clock keeping mean equinoctial time gains 3 min. 56.555 sec. of mean equinoctial time on a clock keeping mean solar time in one mean solar day. This relation holds irrespective of the speed of rotation of the earth.

Apparent solar time and apparent sidereal time have two sources of nonuniformity: (1) inequalities arising from the motion of the earth about the sun and from the motion of the equinox; and (2) variations in the speed of rotation of the earth. The inequalities due to (1) may be accurately calculated. To express the motion of the earth about the sun S. Nemcomb constructed a detailed mathematical development called the theory of the sun, based on the laws of celestial mechanics. A theory of the motion of the earth about its centre of mass, including precession and nutation, was developed, similarly. by E. W. Woolard. Such developments allow the inequalities due to (1) to be removed, giving mean solar and mean equinoctial time. The variations in speed of rotation of the earth include irregular changes of speed of unknown nature which cannot be determined, however, by computation. Hence, any system of time which involves the rotation of the earth cannot serve as a measure of uniform time.

D. Time Units.—A mean solar day is divided as follows:

1 mean solar day = 24 mean solar hours.
1 mean solar hour = 60 mean solar minutes.
1 mean solar minute = 60 mean solar seconds.

One mean solar day = 86,400 mean solar seconds. The other kinds of days are similarly divided, giving for example, the mean equinoctial (sidereal) second by subdivision of the mean equinoctial day.

E. Reckoning of Days and Hours.—From time to time changes were made in the notations concerning the reckoning of time. Definitions given below were in use in 1956.

Local mean time is the hour angle of the mean sun increased by 12 hours. Local mean time at Greenwich is called Greenwich Mean Time (G.M.T.) or universal time (U.T.). The designation G.M.T. is used in navigation. U.T. is the term used by astronomers. Standard time (zone time) differs irom U.T. by an integral number of hours.

The day begins at midnight and runs through 24 hours. In the 24-hour system of reckoning, used in Europe anti by military agencies of the United States, the hours and minutes are given as a four digit number. Thus 0028 means 28 minutes past midnight. and 1240 means 40 minutes past noon. Also, 2400 of May 15 is the same as 0000 of May 16. This system allows no uncertainty as to the epoch designated.

In the 12-hour system there are two sets of 12 hours; those from midnight to noon are designated A.M. (ante meridiem, beiore noon) and those from noon to midnight are designated P.M. (post meridiem, after noon). Neither A.M. nor P.M. may be used to designate either noon or midnight without ambiguity. To desinnate noon the word noon or 1200 should be used. To designate midnight without ambiguity the two dates between which it falls should be given unless the 24 hour notation is used. Thus, we may write midnight, May 15–16, or 0000 May 16.

Formerly, astronomers used a day which began at noon. Since 1925, however, the day used by astronomers commences at midnight, as does the day in civil use. It would be inconvenient to use local time strictly, ior no two places in different longitudes have the same mean solar time. The variation amounts to one hour for 15° of longitude, or about five sec. to the mile in middle latitudes. A system of zones was devised whereby within each zone the same mean time rules. but changes abruptly by one whole hour at its borders. Mean solar time, so regulated, is called zone time or standard time. (Srr TIME, STANDARD.)

Another convention regulates the date line, in travelling across which a calendar day is added to the reckoning in passing westward, or is dropped in passing eastward. (Src DATE LINE.)

During World War I clocks were advanced by one hour in summer in various countries in order to save fuel by reducing the need for artificial light. The advanced time is known as summer time in England and as daylight-saving time in the United States. Advanced time is adopted each year by many European countries. In the United States adoption is by local authorities, and coniusion often results because such adoption is not uniiorm.

During World War II England used "double-summer time" for part of the year, whereby the clock was advanced two hours ahead of standard time.

F. Practical Determination of Rotational Time.—The determination of time has become a highly specialized branch of astronomy which is usually carried out by a governmental observatory in each country. The basic definitions concerning time determination are standardized by the International Astronomical union (I.A.U.). Under the auspices of the I.A.U., the Bureau International de l'Heure (International Time bureau) at Paris makes comparisons of the various time determinations and serves to co-ordinate them.

The steps involved in the determination of universal time (U.T.) are as follows: (1) the transit of a star of known position is observed to determine local mean equinoctial (sidereal) time (L.S.T.); (2) the position of the mean sun is computed by means of a formula and L.S.T. is then converted into local mean time (L.M.T.); (3) the difference in longitude is added to convert L.M.T. into U.T.

Transit Instrument.—The apparatus required for time determination consists basically of a telescope and a clock. Specialized equipment of the highest precision is used. The telescope most commonly used is a transit instrument, which is constrained to move in the plane of the meridian. This is a small form of the transit circle. (*See* TRANSIT CIRCLE.) The reading of a clock being checked is recorded on a chronograph at the instant of transit as noted by the observer.

Transit circles which observe both the sun and the stars can, with the aid of a clock, determine the fundamental positions of the stars. Positions so obtained after many years of observation are used to form a fundamental catalogue. These positions are the ones used in time determination with transit instruments. The catalogue in use at mid-20th century was that of A. Kopff, designated FK3.

The positions in FK3 are for the standard epoch 1950.0. To obtain the apparent position at the moment of transit, corrections are made for proper motion, precession, nutation, aberration and, if sensible, parallax.

Let the clock used indicate, approximately, mean solar time. Observation of the transit of a star determines the mean solar time (except for the error of observation). The difference, computed time of transit minus reading of clock at transit, is called the correction to the clock. It is the quantity which is to be added to the reading of the clock in order to obtain the correct time as determined by observation. In practice the correction is obtained from the mean of observations of about 4 to 20 stars for a night.

A correction is obtained on each clear night, and a series of corrections establishes the rate of the clock. The word rate is customarily used to indicate the departure from the rate it is nominally keeping. Thus a clock which beats 86,401 sec. in a day is said to have a gaining rate of 1 sec. per day.

Knowing the correction to the clock for some epoch and its rate, the correction for any epoch may be computed and applied to the clock reading. In this manner a clock bridges the interval between observations and makes time continuously available.

Photographic Zenith Tube.—An instrument more accurate than the transit instrument for time determination is the photographic zenith tube (PZT), which was used for this purpose since 1934 at the U.S. Naval observatory. The PZT is fixed in a vertical position, and only stars which transit near the zenith are observed. A basin of mercury reflects the rays of light from the stars as the rays pass through the lens and defines the zenith, which lies in the meridian.

The plate is held by a carriage which is driven by a motor so as to track the star being observed. Four exposures of 20 sec. each are made of each star, and the lens and plate are rotated 180° as a unit between exposures. The motion of the carriage during the exposures initiates timing impulses which are read on the clock being compared with the stars. Through measurement of the positions of the star images it is possible to determine what the clock read when the star crossed the meridian. A comparison with the predicted time gives the correction to the clock.

The PZT was designed by F. E. Ross for the determination of the variation of latitude. Ross followed the design of Sir George Airy's reflex zenith tube, installed at Greenwich, Eng., in 1851. Ross improved on this obsolete instrument by placing what is known as the second nodal point outside of the lens and by making the instrument photographic. The photographic plate, which is small, is placed just beneath the lens at the nodal point. The position of the image of a star on the plate thus becomes insensitive to tilt of the lens, which is the essential feature of the design of the PZT by Ross.

This PZT, designated no. 1, was installed at Washington, D.C., in 1915 for the determination of the variation of latitude. It was adapted for the determination of time also in 1934 by F. B. Littell and J. E. Willis. A PZT of improved design was placed in operation in 1949 at a substation of the Naval observatory at Richmond, Fla. A similar PZT was installed at Washington in 1954 to replace PZT no. 1. By the latter 1950s a number of other observatories had placed or were placing PZTs in operation. These included Ottawa in Canada; Greenwich (at Herstmonceux) in England; Hamburg in Germany; Tokyo and Mizusawa in Japan; and Canberra in Australia.

Impersonal Astrolabe.—A. Danjon, of the Paris observatory, devised an accurate instrument for time determination which is quite different from those described. (The use of the word astrolabe in this connection should not be confused with the designation for the astrolabe of the days before the telescope.)

The astrolabe makes use of a reflecting basin of mercury and a 60°-prism to form direct and reflected images of a star. When the altitude of a star is exactly 60° the images coincide. In earlier forms of the instrument it was difficult to determine when coincidence occurred. Danjon introduced a Wollaston prism to obtain four images, two of which are suppressed. The observer manipulates a motor so as to keep the remaining images parallel to a spider thread, and the instant when the altitude is 60° is automatically recorded on a chronograph. Observations are made in various azimuths and both time and latitude are obtained.

G. Practical Determination of Time Intervals.—Artificial clocks used to measure elapsed intervals of time include:

Pendulum Clocks. Galilei Galileo discovered about 1581 that the time of swing of a pendulum was nearly independent of the amplitude of swing. Christiaan Huygens, in 1656, made a practical pendulum clock by adding an escapement (the counting element) to the pendulum (the frequency element). Numerous improvements were subsequently made, and pendulum clocks reached a high stage of precision in the years from 1900 to 1925. The most precise of these are the Riefler (German), the Leroy (French), and the Shortt (English). The last of these is noteworthy in that it forced the introduction of mean equinoctial time. The rate is constant to about 0.002 sec. per day. (*See* CLOCKS.)

Quartz-Crystal Clocks.—A quartz crystal if deformed, produces a difference in electric potential across certain of its faces. Conversely, a difference in electric potential produced across certain faces of a quartz crystal causes it to become deformed. This property, known as the piezo-electric effect, enables the quartz crystal to be incorporated in an electronic oscillator. The frequency of oscillation is controlled by the frequency of mechanical vibration of the crystal. (In physics, frequency is the number of occurrences per unit of time of a repetitive phenomenon. Frequency f and period p, of a cyclic occurrence are related by the expression $f = 1/p$.) The frequency of vibration is dependent on temperature, so that the crystal of the oscillator of a clock is kept at a constant temperature in a small oven.

The output of the oscillator, commonly 100,000 cycles per second, is reduced by a factor of 100 with a frequency divider. The resulting current of 1,000 cycles per second is used to drive a synchronous motor which in turn drives a seconds contact wheel and hands of a clock.

The frequency of an oscillator is often expressed as a deviation from some nominal value. Thus, if a quartz clock is gaining one sec. per day the frequency of the oscillator is said to be $1/86{,}400 = 1.157 \times 10^{-5}$ higher than nominal. The deviation is a ratio.

Quartz crystals tend to drift higher in frequency, that is, to vibrate more rapidly with age. This phenomenon, called aging, prevents the use of quartz crystals as absolute standards of frequency. For use in timekeeping it is necessary to determine for each crystal clock, from an extended series of observations, its law of drift and, for some epoch, the rate and correction of the clock.

Quartz-crystal clocks have been brought to a high stage of reliability and precision. Through their use it was possible to determine accurately the variations in speed of rotation of the earth of periods of a year or less. The day-to-day variation in frequency of the best crystal oscillators is about 2 parts in 10^{10}, which corresponds to 0.00002 sec. per day.

The use of quartz as a frequency control was described by W. G. Cady in 1922. In 1928 W. A. Morrison and J. W. Horton built the first quartz-crystal clock at the Bell Telephone laboratories. P. Sollenberger introduced a crystal-controlled clock for the automatic transmission of time signals at the U.S. Naval observatory in 1934. About 1942 timekeeping at the Greenwich observatory and at the Naval observatory was based on a combination of Shortt clocks and quartz clocks. A few years later the quartz clocks came into sole use at these observatories.

Two types of high precision crystals used at mid-20th century were the ring-crystal developed by L. Essen in 1938 at the National Physical laboratory (N.P.L.), Teddington, Eng., and the GT-plate developed by W. P. Mason in 1940 at the Bell Telephone laboratories. These are frequently used in a circuit designed by L. A. Meacham which uses a bridge to stabilize the amplitude of oscillation.

The Radio laboratories of the British post office supplied a number of ring-crystal oscillators to the Greenwich observatory, the U.S. Naval observatory, the Dominion observatory at Ottawa, and to other observatories. The U.S. national bureau of standards uses specially selected GT-crystals operated as resonators to obtain high precision.

By means of electronic devices known as oscilloscopes, decimal counters and beat counters, it is possible to compare quartz clocks with very high precision, about one part in 10^{12} in frequency and about one microsecond in time.

H. Variations in Rotation of the Earth.—The types of rotational time discussed above are nonuniform because of variations in the speed of rotation of the earth. These variations are of three types: (1) irregular; (2) seasonal; and (3) secular.

The irregular changes are of the order of 5×10^{-8}, or about 1.5 sec. per year. Because of these the earth, considered as a clock, wandered from the reading of a perfect clock by as much as 30 sec. during the past few centuries. This irregularity was detected through a study of the motions of the moon and planets.

About 1900 Simon Newcomb found that during the preceding two centuries the moon was sometimes ahead of its computed position and sometimes behind He suspected that this might be due to an error in the clock (the earth) instead of the lunar tables, but was not able to decide the matter Later studies by E W Brown in 1926 and W de Sitter in 1927, utilizing both the moon and planets, indicated that the rotation of the earth was not uniform Sir Harold Spencer Jones definitely proved that the rotation was nonuniform He showed that discrepancies in the orbital motions of the earth, Venus and Mercury corresponded to those shown by the moon, the apparent errors in position at any time were proportional to the mean motions.

It was formerly believed that the changes in speed occurred suddenly. About 1950, however, it began to he thought that the changes are the result of small random changes which gradually build up, and that large sudden changes do not occur

The seasonal variation in the speed of rotation consists of periodic terms whose periods are a year or less Such terms, annual and semiannual, were reliably ohtained by N Stoyko in 1937 at the Bureau de l'Heure. The total effect was such as to place the earth, as a clock, ahead or behind a perfect clock by about 0 060 sec. during the course of the year

Stoqko made use of a combination of pendulum and crystal clocks. His results were confirmed in 1949 by H Finch at Greenwich, who used only the precise crystal clocks available there, and by others For the year 1950, however, H M Smith at Greenwich ohtained an amplitude of 0 033 sec., and in succeeding years even less This led to questions as to the nature and stability of the seasonal term

A homogeneous solution made at the Naval ohservatory for the three years 1951 to 1954 showed that the seasonal variation was uniform for the years concerned; the amplitude was about 0.030 sec These results were based on observations made with the Washington and Richmond PZTs and two quartz resonators of the National Bureau of Standards Solutions made at other observatories for these years generally gave similar results.

Y. Mintz and W. Munk have calculated the effects of winds on the speed of rotation of the earth. There is a reasonable accordance of their results with astronomical observations for the annual term.

A study of records of ancient eclipses indicates a very gradual, secular diminution in the speed of rotation of the earth. This is accounted for by the effect of tidal friction acting in shallow seas. It was pointed out that the sun may act through atmospheric tides to increase the speed of rotation so as to offset tidal friction. It appears probable, however, that a secular decrease in speed is taking place.

I. Corrected Universal Time (UT2).—During the course of a year or so universal time is nonuniform because of the following effects: (1) polar motion; (2) annual and semiannual terms in speed of rotation of the earth; and (3) direct and indirect lunar terms. The International Astronomical union decided that as of Jan. 1, 1956, universal time would be computed so as to include corrections for (1) and (2); (3) is too small to he of effect. The time so computed is denoted UT2; it is relatively uniform time.

The complete notation adopted is as follows:

UT0 is classical universal time.
UT1 is UT0 corrected for (1).
UT2 is UT0 corrected for (1) and (2).

UT2 is the time given by radio time signals UT0 and UT1, used in precise surveying, differ from UT2 by less than 0 1 sec Corrections are furnished to make it possible to convert from one system to another.

Although the seasonal terms are not strictly repetitive and are largely empirical it was decided that a correction for these terms could be employed advantageously.

The polar-motion term arises from the motion of the pole of rotation in an approximate circle of about 30 ft. in radius (*see* GEODESY: VARIATION OF LATITUDE). The motion of the pole causes not only the latitude of an observatory but also its longitude to vary in a period of 14 months. The instantaneous value of the longitude must be added to the observed local mean time to obtain U.T. if U.T. is to be the same for all observatories. Formerly the polar motion was obtained much in arrears, but a Rapid Latitude service was established by the International Astronomical union in 1955 for the needs of time determination.

The Bureau de l'Heure computes and distributes the corrections ior variation of longitude, which differ for each observatory, and the correction for seasonal variation, which is alike for all observatories.

The moon affects the time determined in two ways, directly by altering the direction of the vertical and indirectly by tidal action on the earth's crust. A change in the form of the earth alters its moment of inertia and hence its speed of rotation. The period of the direct term is 0.5 day. There are two tidal terms of short periods, 13.6 days and 27.6 days. The amplitudes of all three terms are each about 0.001 sec. in time, and all three were detected with the PZTs of the Naval observatorq.

J. Dissemination of Time Signals.— Accurate time is needed in surveying and navigation, for the determination of longitude, and for other technical and scientific purposes. These needs are met by the transmission of time signals by radio stations, such as GBR and MSF in England and NSS and WWV in the United States. Corrections to the signals are issued periodically for use where great accuracy is required. Time signals direct from the Royal Greenwich observatory, are broadcast in England by the British Broadcasting company, and in the United States some commercial stations rebroadcast signals from NSS or WWV. In many cities of the world time may he ohtained automatically by telephone. The telegraph is used to distribute U.S. Naval observatory time to subscribers to this service.

II. UNIFORM TIME

A. Ephemeris Time.— The variations in the speed of rotation of the earth make universal time unsuitable for precise scientific purposes, so that ephemeris time (E.T.), which is uniform, was devised. It is defined in terms of the orbital motion of the earth about the sun, but is obtained in practice from the orbital motion of the moon about the earth. The moon can be used because the ratio of the periods of revolution of the sun and moon are known accurately. The moon is preferred because of its rapid angular motion.

An observation of the moon gives its apparent co-ordinates for an epoch recorded in universal time. The observed geocentric co-ordinates are obtained by corsecting for parallax. The computed geocentric co-ordinates of the moon are tabulated as a function of ephemeris time in the *Improved* Lunar *Ephemeris*. The Ephemeris is entered with the observed co-ordinates and the corresponding ephemeris time is taken out The difference between E.T. and U.T. is given by the formula $\Delta t = \text{E.T.} - \text{U.T.}$

The position of the moon was usually ohtained from observations of occultations and meridian transits. A dual-rate moon position camera developed at the U.S. Naval observatory in 1952 by W. Markowitz enables the position to be ohtained photographically. By means of a dark glass filter which tilts, the moon is held fixed relative to the stars in the background during a simultaneous exposure of 20 sec.

As long as the necessity for uniform time was limited to astronomical research, corrections for nonuniform rotation of the earth could be made several years in arrears. Developments in the field of electronics, however, required that uniiorm time should be immediately available, and formal action on the adoption of ephemeris time became necessary. The matter was considered or acted upon by the Conference on the Fundamental Constants of Astronomy, Paris, 1950; the International Astronomical union, Rome, 1952; and the Tenth General Conference on Weights and Measures, Paris: 1954.

B. The Second.— Until 1955 the fundamental unit of time was the second of mean solar time, defined as 1/86,400 of the mean solar day. Because of variations in the speed of rotation of the earth the second of mean solar time is not a constant unit of time. A redefinition of the second as 1/31,556,925.9747 of the tropical year for 1900 January 0 at 12 hrs. E.T. was adopted by the International Astronomical union in 1955, at Dublin, and by the International Committee on Weights and Measures in 1956, at Paris. This second is a fixed unit of time: and is identical with the second of ephemeris time. Technically, the use of the word second without a qualifying adjective is reserved for the ephemeris second.

The second of mean solar time may differ from the second of ephemeris time by nearly 1 part in 10^7. This difference is important in many scientific applications hut no account of it need be taken for ordinary purposes.

C. Atomic Frequency Standards.— The possibility of using the frequency of a spectral line to control a clock the rate of which would he absolutely constant was long considered. The frequencies corresponding to wave lengths of visible radiation (about 5×10^{-5} cm.) are too high to be generated electronically, being about 10^{15} cycles per second. The development, however, of methods of generating frequencies of the order of 10^{10} cycles per second opened up the possibility of utilizing spectral lines in the one-centimetre microwave region for frequency standardization.

R. V. Pound outlined in 1946 the use of spectral lines to stabilize an oscillator, and in 1947 W. V. Smith and co-workers confirmed the method of Pound by constructing an oscillator which was stabilized in frequency with the 3,3 inversion line of ammonia (NH_3). W. D. Hershherger and L. E. Norton stabilized a klystron oscillator with ammonia in 1948 H. Lyons and co-workers used an ammonia-controlled oscillator in 1949 to control a clock for brief periods.

In the preceding applications ammonia is used in absorption. Radio frequency (rf) energy is introduced into a cell containing ammonia and some of the energy is absorbed if the rf field matches the frequency at which the ammonia inversion occurs. The absorption of energy can be observed with a suitable detector.

A spectral line has a finite width so that transitions occur over a range of frequencies. Various techniques are employed to narrow the range, hut in the case of ammonia in absorption basic difficulties appeared to limit the degree to which this can be done.

C. H. Townes developed in 1951 a microwave amplifier called MASER which is stabilized in frequency by ammonia in emission. An intercomparison of two MASERs indicated a high degree of stability, but as of 1956 the MASER was not yet compared for stability with other standards of frequency although a number of MASERs were under construction and study.

Atomic frequency standards in 1956 were based on the transition of caesium designated $F\,m\ (4,0)\leftrightarrow(3,0)$. They employ an atomic beam technique developed by I. I. Rabi and co-workers in 1939. Caesium atoms emitted by an oven are subjected to an rf field. If the field is of the proper frequency a transition occurs which changes the magnetic properties of the atoms. Through use of magnets to deflect the atoms, and a hot-wire ionizer as a target, it is possible to determine when the rf field is at the proper frequency. A method, developed by N. F. Ramsey, of exciting the atoms with the rf field provides a spectral line with a sharp central peak. Early experiments with a caesium beam were made by H. Lyons and co-workers in 1952.

Many difficulties stood in the way of producing a practical atomic standard that would give measurable frequency with high precision. The production of a standard of this type was first accomplished by L. Essen and J. V. L. Parry in June 1955 at the National Physical laboratory. This standard, which employs caesium appears to be stable to about 1 part in 10^{10}. In co-operation with J. R. Zacharias, the National Company, Malden, Mass., placed in operation several caesium standards in Sept. 1956 in the United States.

The caesium standards described were operated as frequency standards and not as clocks. An atomic clock, however, may be obtained in effect by use of a quartz-crystal clock of high precision. The frequency of the crystal is regulated (about once a day) so that its frequency with respect to the caesium standard remains constant. The crystal clock will thus provide atomic time.

For additional information on atomic transitions *see* QUANTUM MECHANICS. Approximate values of frequencies utilized in atomic standards in 1956 were 23,870,130,000 cycles per second for ammonia and 9,192,631,800 for caesium.

D. Gravitational Time and Atomic Time.—The measure of uniform astronomical time is based on the motions of celestial bodies subject to the force of gravitation. The measure of uniform atomic time is based on the motions of atoms (or atomic particles) subject to electric and nuclear forces. The possibility exists that these two measures of time are different; they may be diverging.

'The nature of the possible difference may be understood from a description of the procedure used to test for its existence. By the latter 1950s the frequency of the caesium standard was being determined with respect to the second of ephemeris time, and a value accurate to about 1 part in 10^9 was expected to be available by 1960. A second determination made about 10 years later will give another value of the frequency. If the difference in the two values of the frequency is greater than can be accounted for by errors of observation then the gravitational and atomic time scales are diverging.

In addition to examining the relation between gravitational and atomic time scales the relation between various kinds of atomic time will also be examined. Thus, experiments will be made, for example, to determine if the frequency of ammonia with respect to caesium changes in the course of years.

E. Uses of Time Systems.—The construction of the atomic standard means that there is a choice of reckoning time on either an astronomical or an atomic basis. Astronomical time is closely related to civil affairs; it is based on units in common use such as the day and year. Atomic time provides the unit of time with high precision, but does not mark an epoch as does astronomical time. In the latter 1950s it appeared that physical measurements involving the unit of time with high precision would be referred to atomic time, but universal time (or standard time) would continue in common use.

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(W. Mz.)

TIMGAD, a ruined city 23 mi. S.E. of Batna in the department of Constantine. Alg. Timgad, the Thamugas of the Romans, was built on the lower slopes of the northern side of the Aures Mountains, and was situated at the intersection of six roads. It was traversed by two main streets, the Cardo Maximus running north and south, and the Decumanus biaximus east and west. The residential part of the town was on a lower level than the capitol and most of the other public buildings. The ruins of the capitol occupy a prominent position in the southwest of the city. Some of the columns of the façade (which are of the Corinthian order and 45 ft. high) have been re-erected. The dimensions of the capitol correspond with those of the Pantheon at Rome. Immediately north of the capitol are the remains of a large market; to the east are the ruins of the forum, basilica and theatre. The auditorium of the theatre, which held nearly 4.000 persons, is complete. A little west of the theatre are baths, containing paved and mosaic floors in perfect preservation. Ruins of other and larger thermae are found in all four quarters of the city, those on the north being very extensive.

Across the Decumanus Maximus just northeast of the market is the arch of Trajan— still erect, and restored in 1900. The arch is of the Corinthian order, and has three openings, the central one being 11 ft. wide. Each façade has four fluted columns 19 ft. high. The chief material used in building the arch was sandstone. The fluted columns are of fine white limestone and smaller columns are of coloured marble. At the other (eastern) end of the street are the remains of another triumphal arch. West of the capitol are the ruins of a large church, a square building with circular apse, built in the 7th century. There are also remains of six other churches. About 400 yd. south of the city, the walls nearly entire, is a ruined citadel, a quadrangular building 360 ft. by 295 ft.. with eight towers. It was built (or rebuilt) by the Byzantine army in the 6th century. Near the northern thermae is the house of the director of the excavations and a museum containing small objects found in the ruins.

Numerous inscriptions have been found on the ruins, and from them many events in the history of Thamugas have been learned. In the year A.D. 100 the emperor Trajan gave orders to build a city on the site of a fortified post on the road between Theveste and Lamhaesis. This city, called Colonia Marciana Traiana Thamugas (Marciana in honour of Trajan's sister) appears from the inscriptions to have been completed, as far as the principal buildings were concerned, in 17 years. In the 3rd century Thamugas became a centre of Christian activity, and in the next century espoused the cause of the Donatists. The city declined in importance after the Vandal invasion in the 5th century, and was found in a ruinous condition by the Byzantine general Solomon, who occupied it A.D. 535. It is believed that the Berbers from the neighbouring mountains destroyed the city, hoping thus to prevent it being used as a stronghold from which to harry them. Thamugas was, however, repeopled, and in the ith century was a Christian city. After the defeat of Gregorius, governor of Africa, by the Arabs in 647. Thamugas passes from history.

After centuries of neglect James Bruce, the African traveler, visited the spot (1765), made careful drawings of the monuments and deciphered some of the inscriptions. Bruce was follo ed, more than a century later (1875), by Sir R. Lambert Playfair, British consul general at Algiers, and shortly afterward (1875–76) Masqueray published a report on the state of the ruins. Since 1881 Thamugas has been systematically explored, and the ruins excavated under the direction of the *Service des monuments historiques.*

Among the objects discovered are a series of standard measures —five cavities in a stone slab. Seventeen miles west of Timgad, on the site of the Roman city Lambaesis, is Lambessa (*q.v.*).

See G. Boeswillwald. *R.* Cagnat and A. Ballu. *Timgad, une citk africaine sous l'empire romain;* and *A.* Ballu, *Guide illustré de Timgad* (Paris, 1903).

TIMISKAMING: *see* PRE-CAMBRIAN TIME.

TIMIŞOARA (formerly TEMESVAR), a city of western Rumania, in the region of the same name. Pop (1956) 142,257. On the Bega canal and the Bega river. it consists of the inner town, formerly strongly fortified, and of four outlying suburbs, the intervening space, formerly the glacis, having been laid out in park areas.

Timisoara is the seat of a Roman Catholic and a Greek Orthodox bishop. Among its principal buildings are the Roman Catholic cathedral, built (1735–57) by Maria Theresa, the Greek Orthodox cathedral; a castle built by John Hunyady in 1442, now used as an arsenal; the town and county hall, the museum and large barracks. In the principal square rises a Gothic column, 60 ft. high, erected by the emperor Francis Joseph in 1851 to commemorate the successful resistance of the town to the siege of 107 days laid by the Hungarian revolutionary army in 1849. Timisoara is a centre of commerce.

Timisoara is an old town, and although destroyed by the Tatars in 1242, it was a populous place at the beginning of the 14th century, and was strongly fortified by King Charles Robert of Anjou, who resided there several years The Hunyady family had also their residence there In 1514 the peasant leader. Gyorgy Dozsa, was defeated by the Transylvanian voivod, John Zápolya, near Timisoara, captured and executed. It was taken by the Turks in 1552, and recovered by Prince Eugene of Savoy in 1716.

After this it grew steadily in importance, serving as the capital of the whole Banat. It was again besieged by the Hungarians in 1849, and occupied by Serbia in 1919, but ultimately allotted to Rumania.

TIMKEN, HENRY (1831–1909), U.S. manufacturer and inventor, was born near Bremen, Ger., Aug. 16, 1831. He accompanied his family to the United States in 1838 and worked during his boyhood on his father's farm near Sedalia, Mo. At the age of 16 he went to St. Louis and apprenticed himself to a wagonmaker. In 1855 he established his own carriage factory in St. Louis, giving it up in 1860 to prospect for gold in Colorado. During the Civil War he served for three years as a captain in the 13th regiment of the Missouri militia. Returning to his business after the war, he invented a new type of carriage spring and patented it in 1877. It proved so successful that his carriage factory became primarily a spring-manufacturing plant. Timken retired in 1887 and went to California but returned to active business in St. Louis six years later. In 1898 he patented a tapered roller bearing that had even greater success than his Timken spring. He founded the Timken Roller Bearing Co. at Canton, O., to produce it.

He retired from business soon afterward and died at San Diego, Calif., March 16, 1909.

TIMMERMANS, FELIX (1886–1947), Flemish writer, an outstanding representative of regional literature, was born at Lier, July 5, 1886. He made his name with the novel Pallieter (1916; Eng. trans. 1924), an "ode to life" written after a moral and physical crisis. To express his praise of life, Timmermans depicted his native Brabant as a paradise and created a character, Pallieter, who has taken his place in literature as the embodiment of a typically Flemish enjoyment of living: at once sensual and mystical, because for him the world's joys are the gift of God. Timmermans was also a painter and illustrator, and found inspiration in old prints and the paintings of Brueghel. For his characters he drew on the people of his native town. His kindly, humorous style, succulent language, wealth of anecdote, sympathetically caricatured characters and pictorial skill hide his lack of depth. As well as many novels and short stories, he wrote romanticized biographies of Brueghel (1928), St. Francis (1932) and Adriaen Brouwer (1948), travel tales, autobiographical works and plays.

In 1935 he reached new heights with *Boerenpsalm,* a song of praise showing keen insight into life and a new lyrical strength. The lighthearted sensuality of Pallieter is modified by a deeper knowledge of suffering, and praise of nature gives way to praise of humanity represented by the peasant, Wortel, who feels that his life is in God's hands.

Warm colouring is the outstanding characteristic of Timmermans' manner. His expressive style is rooted in the language of the people and excels in the spontaneity and variety of its imagery. It is suited both to the treatment of sensual and spiritual subtleties and to the revelation of Timmermans' exuberant yet melancholy temperament. Another aspect of his art is shown in some prose works of great restraint (De *zeer schone uren* van *juffrouw Symforosa, begijntjen* [1918]; *Ik* zag Cecilia komen, [1938]) and in the few serene poems (Adagio, 1947) written shortly before his death at Lier, Jan. 24, 1947.

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TIMMINS, the principal town in the Porcupine gold mining area of northern Ontario, Can., is 268 mi. N. of North bay on the Mattagami river and the Ontario Northland railway. It was founded in 1911 by Noah Timmins to house employees of the Hollinger mine, but is not a company town. The town is laid out in grid fashion on sandy terraces overlooking the Mattagami river and prides itself on being the largest town in Canada—the population. 27,551 (1956), is larger than that of many Canadian cities.

The Hollinger Consolidated Gold Mines, Ltd. became the largest producer of gold in Canada. Mine shafts extend to depths of over 5,000 ft. and there are many miles of underground workings. By the 1950s about 1,000,000 tons of ore were mined each year, and the total annual gold production in the area amounted to about 1,000,000 oz., or one-quarter of Canada's total gold production. Hydroelectric plants at Wawaitin falls and Sandy falls furnish energy for the town and for the mines. Power is also brought from the Abitibi river. (F. A. CK.)

TIMOLEON (c. 411–c. 337 B.C.), of Corinth, Greek statesman and general. As the champion of Greece against Carthage he is closely connected with the history of Sicily, especially Syracuse (*q.v.*). He was driven into exile for 20 years by the anger of his family at his acquiescence in the death of his brother Timophanes, who had made himself tyrant. In 344 (Plutarch, Diodorus gives 343–342) he was chosen to go to Syracuse in answer to an appeal to Corinth for help against factions within and the Carthaginians without. He landed at Tauromenium (Taormina) and first attacked Hicetas, tyrant of Leontini, who was master of Syracuse at the time. Carthage first supported Hicetas, then abandoned him, and he was besieged in Leontini and surrendered. Timoleon then reorganized Syracuse on the basis of the constitution of Diocles, and introduced new settlers from Greece. About 340 Hicetas was reinforced by a new army from Carthage, which Timoleon defeated on the Crimissus, and a renewed attempt ended in Hicetas' final defeat and death in 338. A treaty was concluded confirming the dominion of Carthage to west of the Halycus. Timoleon then (337–336) retired into private life. He became blind some time before his death, but persisted in attending the assembly and giving his opinion, which was usually accepted as a unanimous vote. He was buried at the cost of the citizens of Syracuse, who erected a monument to his memory in their market place, and a gymnasium called Timoleonteum.

Lives by Plutarch and Cornelius Nepos; *see* also Diod. Sic., vol. xvi, pp. 65–90; monograph by J. F. Arnoldt (1850), which contains an exhaustive examination of the authorities; also SICILY: *History;* and SYRACUSE, with works quoted.

TIMON, of Athens, the noted misanthrope, celebrated in Shakespeare's play, lived during the Peloponnesian War. He is more than once alluded to by Aristophanes and other comedians. Plutarch introduces a short account of his life in his biography of Mark Antony (ch. 70), who built a retreat called Timonium (Strabo xvii, 794) at Alexandria. Timon also gave his name to one of Lucian's dialogues.

TIMON (c. 320–*c.* 230 B.C.), of Phlius in the northeastern Peloponnese, Greek skeptic philosopher and man of letters, was a pupil of Stilpo the Megarian and Pyrrho of Elis. Having made a fortune by lecturing (particularly in Chalcedon), he retired to Athens c. 275, where he died. Only fragments remain of his works, which included not only 20.000 lines of prose but also numerous tragedies, satyr-plays and comedies, poems in elegiacs and iambics and three books of silloi, or sarcastic attacks on dogmatic philosophers in mock-heroic hexameters.

For the fragments *see* F. W. *A.* Mullach (ed.), *Fragmenta philosophorum Graecorum,* vol. i (1860); and H. Diels (ed.), *Poetarum philosophorum fragmenta* (1901). *See* further W. Nestle, "Timon," Pauly-Wissowa, *Realencyclopadie,* 2nd series, Halbband 12 (1937).

TIMOR, the largest of the Nusa Tenggara Islands in the Malay archipelago, is divided from the main group by the Savu sea and Ombai strait and from Australia by the Timor sea. It is 294 mi. long and has a maximum width of 66 mi., extending from lat. 8° 19' to 10° 27′ S. and from long. 123" 27' to 127° 18' E. The northeastern part, with a small enclave (Oe-Cusse or Ocussi-Ambeno) on the northwestern coast is Portuguese (area 7,332 sq.mi.) while the southwestern section (formerly Dutch or Netherlands Timor) is part of Indonesia. Portuguese Timor had a population of 442,378 in 1950 (including only 568 Europeans); that of Indonesian Timor (1956 est.) 822,915. The adjacent islands of Roti and Savu, with west Timor part of the Indonesian Nusa Tenggara province, are considered here (see The People below).

Timor is on the outermost and apparently the first formed of the arcuate folds characteristic of the East Indian region. The great submarine ridge of which it is the crest lies near the Sahul shelf, the submerged extension of the Australian continental mass, and is roughly parallel to it. It is close to the area where alpine fold lines meet the Pacific marginal folds and where mountain-building is more active than anywhere else. The highly contorted and metamorphosed sediments, ranging in age from Palaeozoic to Mesozoic. show the intensity of these movements. The great volcanic activity in the islands to the north of Timor show that they are not yet over. In Timor there are no volcanic deposits later than Tertiary, but the presence of raised coral reefs of Pleistocene age at heights up to 4,500 ft. as well as many raised beaches at lower levels show how rapid and how extensive have been the changes of level on the island.

Timor is generally mountainous but cut by deep valleys. The highest points are. in Portuguese Timor, Tata Mailau (Mt. Romelau, 9,771 ft.) and, in Indonesian Timor, Mutis (7.759 ft.). both on the main central divide. A coastal range behind Dili (Dilli) reaches 4.650 ft. and there are extensive limestone plateaus behind the southern coastal plain. The climate is like that of northern Australia and different from that of Java and Sumatra in having a well-marked dry season in winter. There are wide local variations in annual rainfall from 30 in. on the north coast to 100–110 in. in the south and west.

The vegetation, too, is Australian in character with forests of *Casuarina equisetifolia* in the northern valleys and *Eucalyptus alba* on the southern coastal plains. Vegetation is scanty and scrubby generally, though the uplands yield fairly well under cultivation. The woodlands, which nonhere develop into good forests, contain much excellent sandalwood. The fauna of Timor is of special interest since it proves, conclusively. that Timor has never formed part of Australia within recent geological epochs. The deep sea channel between has proved such an obstacle that only one Australian type is found—the cuscus, a marsupial. whereas Asiatic types include the gray monkey, deer, wild pig, civet cat, shrew mouse, bat and a particular species of wildcat. found only in Timor and Roti. There is a slight preponderance of Asiatic birds over Australian. Among the insects are a few beetles. a rare rose chafer, such moths as the *Noctuae, Ophiodes, Remiga virbia,* and a humming bird moth *(Protoparce orientalis*), and many butterflies. Pieridae and Lycaenidae being common, others including the rare and beautiful swallowtails *Papilio aenomaus* and *P. liris,* and the deep purple-winged *Cethosia leschenaultiz.* The few land shells of Timor are allied to or identical with Moluccan and Celebes forms. There are snakes, and a species of crocodile. An interesting item in the fauna is the native pony, probably not however indigenous but certainly introduced before the arrival of the Portuguese.

The island has been little developed and has only one motor road in the Indonesian part. The staple crop is maize though rice is also gronn, sometimes on terraces. A little coffee, copra and rubber are produced for export and some sandalwood is also shipped. The presence of oil deposits has been known for many years and trial borings before World War II showed they had commercial possibilities.

Kupang (pop. 14.892) the main port of the island and the capital of Indonesian Timor stands on a bay at its western extremity. Dili (3,321) on the northern coast is the capital of Portuguese Timor. (T. Her.)

Beside the northeastern part of the island and Oe-Cusse-Ambeno, Portuguese Timor also includes the smaller islands of Atauro (Cambing) and Jaco. Until 1864 Portuguese Timor was administered from Portuguese India, from then to 1926 it was subordinated to Macao in China. It became successively a separate colony and (1951) an overseas province. In Feb. 1942 the island of Timor was occupied by the Japanese; it was liberated in 1946. Until about 1934 the administration was military, but by the mid-1950s many of the officials were graduates of the Escola Superior Colonial of the Technical university of Lisbon.

In addition to the municipality of Dili, there are five *circunscrições* (districts) with capitals at Lautem (Vila Nova de Malaca), Baucau (Vila Salazar), Manatuto, Aileu (Vila General Carmona) and Bobonaro. These are further subdivided into posts. Imports include cottons, wine and general merchandise. There are a few minerals. (H. V. L.)

History.—It was probably about 1520 when the Portuguese first began trading to Timor, principally for sandalwood. Missionaries soon came with the traders, but for many years the Portuguese based themselves on the island of Solor (100 mi. to the north) where a fort was built in 1566. At the beginning of the 17th century the Dutch appeared in the East Indies, capturing Solor in 1613 and landing on Timor shortly afterward. They established themselves at Kupang, and the Portuguese had to retire to the north and east of the island, with their capital at Dili.

In 1662 a treaty put an end to the long war between Dutch and Portuguese, but conditions in Timor remained far from settled. For over a century there was intermittent fighting between the Dutch. the white Portuguese, the "black" Portuguese of mixed race and the native Timorese, especially in 1749 when a combination of enemies attacked Kupang. but the Dutch succeeded in relieving the garrison and the Portuguese were almost annihilated. When the Netherlands passed under French domination in the revolutionary wars, the Dutch in Timor also beat off two British attacks made in the name of the exiled prince of Orange, but after the fall of Java they succumbed. Before Dutch Timor was handed back by the convention of 1814 the Portuguese seized the district of Atapupu, but were driven out again by the Dutch, and this led to many incidents and frontier disputes.

During the 19th century the problem of defining frontiers proved to be difficult, being complicated by claims for enclaves and by dissensions among the native chiefs concerned. who forcibly prevented the survey of territories in dispute between themselves. Attempts in 1851, 1859 and 1893 all failed to produce a final solution, and though a treaty was made in 1903, ratification was postponed until the frontier of the Portuguese enclave of Oe-Cusse was surveyed. After further frontier affrays in 1913 recourse was had to arbitration, and in 1914 the Swiss plenipotentiary at Paris, M. Lardy, a member of the Hague court of arbitration. decided in favour of the Dutch view of the track of the eastern frontier of the Oe-Cusse enclave; Portugal accepted it and the treaty of 1904 was then carried into effect.

After Japan's entry into World War II Great Britain asked Antonio Salazar for permission to occupy Portuguese Timor, but the Portuguese refused and decided to take on its own defense. On Feb. 20, 1942, the Japanese landed on Dili airfield and quickly occupied the whole island. After the Japanese surrender Portuguese troops reoccupied the eastern half of the island, but Dutch Timor soon became part of the new republic of Indonesia.

(K. H. D. H.)

The People.—The population of Timor in 1956 was estimated to be nearly 1,300,000, that of Roti in 1954, 68,330 and of Savu in 1954, 78,783'. It includes few Europeans and Eurasians, or foreign Asiatics (the latter being mostly Chinese, with a small number of Arabs). The natives are of mixed origin. The basic element is Papuan, a variety of the Oceanic negroid stock. but there has been a fairly considerable Indonesian (Mongoloid) admixture. In the interior there are traces of a negrito (pygmy) strain. and along the coasts Malay influence is marked. The people of Roti and Savu are lighter complexioned and have less Papuan blood; they have interbred to some extent with the natives of west Timor (Kupang, Semau. etc.). The Timorese proper are generally dark-skinned, lightly built and tall or medium in height. There are small communities of Christian converts, Roman Catholic and Protestant in Indonesian Timor, Roman Catholic in Portuguese Timor and a few Moslems along the coast. The people of Roti and Savu are largely Christian or Moslem.

Except along the coast, the Timorese have been comparatively little touched by civilization. They lead a primitive life and war between the small native kingdoms persists. The usual dress of the men consists of two pieces of patterned cotton material, with a decorated belt, often a sort of shawl, thrown over the shoulder when not in full use, and sometimes a kind of turban headgear, and a cloth wallet is carried. Women wear a sarong, also with a shawl, and they are fond of armlets of gold and silver, necklaces of glass, quartz or clay, and gold and silver chest plaques. Chiefs have special decorative garments. Tattooing is practised. Weapons are the bow and arrow, spear, shield and sword; and the blowpipe is used for hunting. The use of the gun is known, and the men are good horsemen. The usual Timorese house is built of wood, on piles, and is round in shape, with a roof of grass or palm-leaf thatch, and only one room (except in the case of chiefs); villages and houses are sometimes stockaded. There is a special hut in ahich the leader of a successful head-hunting expedition undergoes purification. to appease the ghosts of the slain. *Pomali,* or taboo, is prevalent, and apart from the custom of placing a palm branch. as a sign of taboo, before fruit trees, houses, crops. etc.. to protect them — villages have a regular *pomali* house, or *uma-luli.* It stands in a cleared space, within which not a stone may be overturned or a twig plucked. The presiding official at *pomali* ceremonies is known as the dato *luli,* and has great power. Certain relics are preserved in the *pomali* house where offerings are made to the *vatu luli,* or sacred stone. Some houses have a *luli* chamber, where sacrifices of animals (pigs) are made and where a bunch of rice is hung — to ensure a bountiful harvest. The dead are placed on a stage raised above the ground, sometimes covered with a roof, and kept until a burial feast can be arranged. Stone carved seats for graves are known in Roti, and stone graves in parts of Timor. The cult of a sun dweller is important. Polygamy and concubinage are practised.

Industry consists of weaving, plaiting and the making of ornaments and weapons. There are fishing and copra production along the coast. Trade is mostly in Chinese, Arab and Malay (Bugis) hands.

Many languages and dialects are spoken: Roti and Savu have languages of their own. (X.; B. A. L. C.)

TIMOSHENKO, SEMEN KONSTANTINOVICH (1895–), Soviet army officer, marshal of the Soviet union, was born in Furmanka, then Bessarabia, in 1895. Conscripted into the tsarist cavalry during World War I, Timoshenko was awaiting court-martial for striking an officer when freed at the outbreak of the Revolution. He joined the Red army and, aided by Stalin's friendship, became a cavalry division commander during the Russian civil war. Timoshenko's greatest contribution to the Red army was the system of training and rigid discipline he instituted after early Soviet failures in the Russo-Finnish War of 1939–40. Credited with the ultimate victory, Timoshenko was rewarded with the post of commissar of defense, an assignment he held until succeeded by Stalin after the U.S.S.R. entered World War II. After some initial success as a commander, Timoshenko failed in an important campaign and was relegated to a staff assignment at Stalin's personal supreme headquarters. After the war he served as a military district commander, never regaining his prewar prestige. He appeared to have little voice in the formulation of soviet postwar military policy. (H. E. KH.)

TIMOSHENKO, STEPHEN PROKOPOVICH (1878–), Russian-born specialist in mechanics, a leader in strengthening the teaching of mechanics in the United States. Born in Kiev. Russia, Dec. 23, 1878, he attended the Institute of Engineers of Ways of Communication, St. Petersburg, 1896–1901, and the University of Gottingen, Ger. (diploma engineer), 1905–06. He was assistant professor at the Polytechnic institute. St. Petersburg, 1903–06; professor at the Polytechnic institute, Kiev, 1906–11; professor at the Electrotechnical and Polytechnic institutes, St. Petersburg, 1913–17; professor at the Polytechnic institute, Zagreb, Tugos., 1920–22. He then moved to the United States and worked as a research and consulting engineer at Westinghouse Electric and Manufacturing Co., Pittsburgh, 1923–27. He became a citizen of the U.S. in 1927, the same year he became professor of mechanics at the University of Michigan. He m s named professor of theoretical and applied mechanics at Stanford university. Calif., in 1936, becoming emeritus in 1944. He wrote many papers on mechanics and leading U.S. texts on strength of materials and elasticity. His Collected Papers with a biographical sketch was published in 1953. (S. C. HR.)

TIMOTHEUS, Athenian statesman and general, son of Conon, the restorer of the ualls of Athens. From 378 to 356 B.C. he frequently held command in the war between Athens (in alliance with Thebes) and Sparta. In 375 Timotheus was sent with a fleet to sail around Peloponnesus by way of demonstration against Sparta. He gained over Cephallenia, secured the friendship of the Acarnanians and Molossians and took Corcyra, but used his victory with moderation. In 373 Timotheus was appointed to the command of a fleet for the relief of Corcyra, then beleaguered by the Spartans. But his ships were not fully manned, and to recruit their strength he cruised in the Aegean. For this delay he was brought to trial but acquitted. Having been superseded in his command he took service with the king of Persia. We next hear of him about 366, when, having returned to Athens, he was sent to support Ariobarzanes, satrap of Phrygia. But, finding that the satrap was in open revolt against Persia, Timotheus, in conformity with his instructions, abstained from helping him and turned his arms against Samos, then occupied by a Persian garrison, and took it after a ten months' siege (366–365). He then took Sestus, Crithote, Torone, Potidaea, Methone, Pydna and many other cities; but two attempts upon Amphipolis failed. During Athens' war mith its allies, Timotheus was sent with Iphicrates, Menestheus and Chares to put down the revolt. The hostile fleets sighted each other in the Hellespont; but a gale was blowing, and Iphicrates and Timotheus decided not to engage. Chares, disregarding their opposition, lost many ships, and in his dispatches he complained so bitterly of his colleagues that the Athenians put them on trial. Timotheus, disliked for his arrogance, was condemned to pay a heavy fine. Being unable to pay, he withdrew to Chalcis, where he died in 354.

TIMOTHY (TIMOTHEUS), **SAINT,** in the New Testament, was one of the younger companions of the apostle St. Paul (*q.v.*). He was connected with Lystra in Lycaonia, born of a pagan father and of a Jewish mother called Eunice, his grandmother being also a Christian. When the apostle came across him at home, he was still uncircumcised, but a full member of the church at Lystra (Acts xvi, 1 ff.; II Tim. i, 5 ff.). When the defection of Barnabas and Mark left St. Paul alone, he took Timothy with him as a colleague, first of all circumcising him out of respect to the prejudices of the communities in which he was to do mission work. This was a matter of convenience, not of principle. He accompanied St. Paul and Silas to Europe, where he was employed by them on various missions, especially among the Macedonian churches which he helped to found. But Gorinth as well as Thessalonike and Philippi drew out his activities as an "apostle" in the wider sense of the term (II Cor. i, 19, etc.). From Corinth he appears to have accompanied the apostle to Ephesus and Asia Minor (Acts xix, 22; I Cor. xvi, 10 ff.). He is then associated with St. Paul in his imprisonment, as the collocation of his name in the titles of Colossians, Philemon and Philippians indicates, whether that imprisonment was at Rome or elsewhere. In the Pastoral Epistles he is absent from his chief, in charge of work at Ephesus, and there is a notice of him in Hebrews (xiii, 23) which chronicles his release from imprisonment, though there is no clue to its date or place.

Tradition, probably based on inferences from the New Testament, made him bishop of Ephesus, where it is said he was martyred under Domitian, one legend asserting that he was clubbed to death by the mob for protesting against the orgies of Artemis worship. The Greek martyrology celebrates his death on Jan. 22, the Latin on Jan. 24. (J. MOF.)

TIMOTHY (HERD'S-GRASS; *Phleum pratense*) is an important and commonly cultivated hay and perennial pasture grass, either when grown alone or in combination with red clover or other grasses. It is better, however, as hay than for pasturage. (J. M. BL.)

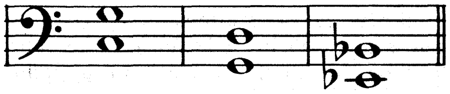
TIMOTHY, EPISTLES TO: see PASTORAL EPISTLES.

TIMPANI, the name given to the kettledrums in the orchestra (It. *timpano,* pl. timpani). Introduced in the orchestra in the second half of the 17th century, they first appear in scores of Matthew Locke (*Psyche,* 1673), Lully (*Thésée,* 1675) and Purcell (Fazry *Queen,* 1692), where they were used in pairs of one small and one large, each pair tuned to the tonic and dominant.

Each of the kettledrums consists of a bowl-shaped "shell" of copper. brass or other metal, over which is stretched a "head" of calfskin secured by a metal hoop. A hole is pierced at the bottom of the shell to avoid air concussion and the splitting of the head in *fortissimo* passages. The tension of the skin, and accordingly the pitch of the drum, is varied either by means of hand screws fixed to the shell or by a number of mechanical devices. These devices include a pedal or a hand mechanism that varies the tension of the head by means of rods connected to the hoop. The skin vibrates when struck with the drumsticks, the tone produced depending on the texture of the hard or soft felt or other substance forming the head of the stick. The tone also varies according to whether the drum is struck nearer the rim of the shell or the centre of the head. Occasionally the head is made to vibrate by means of the fingers, as in works of Constant Lambert and Benjamin Britten.

Two instruments, one tuned to the tonic and the other to the dominant, were normally used in 18th-century scores. In later scores three or more instruments were used with a variety of tunings. Sixteen kettledrums, requiring ten players, were used by Berlioz in his Requiem (1837).

The orchestral kettledrum has a practical compass of five full tones. The compass covered by a pair of timpani is normally an octave from F below middle C downward. The tuning of an orchestral set of three instruments generally covers the following ranges:



In certain cases this compass has been extended upward as far as B (in Stravinsky's *Le Sacre du printemps,* 1913) and downward to D flat (in the symphonies of Mahler).

The expressive resources of the timpani are by far the widest among percussion instruments. They include the reiteration of persistent rhythms, dramatic crescendos. sudden *sforzando* effects and atmospheric "rolls." Special effects include damped or muffled notes, as in Liszt's "Faust" Symphony, the striking of a note with two sticks, as in Alban Berg's *Wozzeck,* and a pedal glissando on a roll. used by Bartók. Occasionally muted timpani are used. as in Mahler's First Symphony, a strip of cloth being placed over the drumhead.

See also DRUM (J. BL.)

TIMROD, HENRY (1828–1867), U.S. poet. called "the laureate of the Confederacy," was born in Charleston, S C., on Dec. 8. 1828, the son of a bookbinder. He attended Franklin college (later the University of Georgia), Athens, for two years and for a short period of time read law in Charleston.

For a number of pears he worked as a tutor. and in 1860 a collection of his poems was published. During the Civil War he enlisted in the Confederate army but was soon discharged for reasons of health. Later he was an editor and part owner of the *South Carolinian* in Columbia. After the city was burned by Union forces, however, he suffered from poverty and chronic ill-health He died on Oct. 6. 1867.

In 1873 the southern poet Paul Hamilton Hayne, who was Timrod's lifelong friend, edited *The Poems of Henry Timrod.* Among Timrod's poems supporting the south were "Ode Sung at the Occasion of Decorating the Graves of the Confederate Dead." "The Cotton Boll" and "Ethnogenesis." *Katie,* a lyric poem to his wife. was published in 1884 and *Complete Poems* in 1899.

See H T. Thompson, *Henry Timrod, Laureate of the Confederacy (1928)*; G A Wauchope, *Henry Timrod: Man and Poet (1915).*

TIMUR (*Timur i Leng,* "the lame Timur"), commonly known as TAMERLANE (1336–1405). the renowned oriental conqueror, was born at Kesh (modern Shahr-i-Sabz. "the green city"), 50 mi S. of Samarkand in Transoxiana. The Timurid tradition (which is highly suspect) represents his father Taragai as head of the Barlas tribe and a descendant of a certain Karachar Noyan, described as the powerful minister of Jagatai, son of Genghis Khan, and a distant relative of the latter. The apocryphal *Memoirs* of Timur display him as a leader of expeditions during the disturbances that followed the death of Amir Kazgan, the governor of Transoxiana. in 1357. After the invasion of Tughlak Timur, the khan of Kashgar (1361), and his appointment of his son Ilyas Rhoja as governor of Transoxiana, Timur was selected as his minister, but shortly afterward he fled and rejoined his brother-in-law Amir Husain. the grandson of Razgan. After many wanderings and adventures they defeated Ilyas Khoja (1364) and set out to conquer Transoxiana. About 1370 Timur joined in a revolt against his ally Husain. besieged him in Balkh and, after his assassination, proclaimed himself sovereign of the Jagatai and restorer of the Mongol empire.

For the next ten years Timur was engaged in a struggle against the khans of Jatah (eastern Turkistan) and Khwarizm, finally occupying Kashgar in 1380. He then intervened in the conflicts between the rival princes of the Golden Horde in Russia; his protégé Toktamish defeated the ruling khan Mamai. replaced him as khan and, to avenge a defeat inflicted on Mamai by the prince of Moscow in 1380, occupied Moscow in 1382.

In 1381 Timur began his conquests in Persia with the capture of Herat. The political and economic situation of Persia at this time was precarious in the extreme. The signs of recovery visible under the later Ilkhans (*see* MONGOLS) had been followed by a setback after the death of the last Ilkhan, Abu Sa'id (1335). The vacuum of power was filled by rival dynasties, torn by internal dissensions. These warring principalities could put up no joint or effective resistance to Timur. Khurasan and all eastern Persia fell to him in 1382–85; Fars. Iraq, Azerbaijan and Armenia in 1386–87 and 1393–94; Mesopotamia and Georgia in 1394. In the intervals he was engaged with Toktamish, now khan of the Golden Horde, whose forces invaded Azerbaijan in 1385 and Transoxiana in 1388, defeating Timur's generals. In 1391 Timur pursued Toktamish into the Russian steppes, defeated and dethroned him. The khan again invaded the Caucasus in 1395, but was finally defeated on the Kur river. The revolts which broke out all over Persia during these campaigns were repressed with ruthless vigour.

In 1398, when Timur was over 60 years of age, he invaded India. He crossed the Indus on Sept. 24 and, leaving a trail of carnage, marched on Delhi. The army of Mahmud Tughlak was destroyed at Panipat (Dec. 17) and Delhi reduced to a mass of ruins, from which it took more than a century to emerge. By April 1399 Timur was back in his own capital beyond the Oxus. An immense quantity of spoil was conveyed away. Before the end of the same year Timur set out on his last great expedition. After restoring his control over Azerbaijan, he marched on Syria; Aleppo was stormed and sacked, the Mameluke army defeated and Damascus occupied (1400). In 1401 Baghdad was taken by storm, 20,000 citizens massacred and all its monuments destroyed. After wintering in Georgia, Timur invaded Anatolia, destroyed Sultan Bayezid I's army near Ankara (July 20, 1402) and captured Smyrna from the Knights of Rhodes. Having received offers oi submission irom the sultan of Egypt and from John VII, co-emperor of the east, Timur returned to Samarkand (1404) and at once began to make vast preparations for an expedition to China. He set out at the end of December, fell ill at Otrar on the Syr-darya west of Chimkent and died on Jan. 19, 1405. His body was embalmed, laid in an ebony coffin and sent to Samarkand, where it was buried in the sumptuous tomb called Gur Amir. Before his death he had divided his territories among his two surviving sons and his grandsons, and after years of struggle they were reunited by his youngest son Shahrukh.

During his lifetime Timur had a record kept of all his acts, and arranged ior the preparation of an official biography. This survived in the contemporary recension of Nizam ud-Din Shami, ed. by Tauer (Prague, 1937) and in the more florid version of Sharaf ud-Din Yazdi, trans. by F. Petis de la Croix (1723). The opposite point of view, bitterly hostile to Timur, is given by another contemporary, Ibn 'Arabshah, trans. by J. H. Sanders, *Tamerlane; or Timur, the Great Amir (1936).* The supposed *Memoirs* (*Malfuzat*), trans. by C. Stewart (1830), and *Institutes (Tuzukat)* of Timur are generally held to he iorgeries.

There are supposed paintings of Timur in Persian works; these are idealized Persicized portraits and in no way resemble the authentic description of him as very tall, with a large head, highly coloured and white-haired since childhood.

In the absence of a critical historical study of Timur the following works may be consulted: L. Bouvat, *L'Empire mongole, 2e phase* (1927); Ruy Gonzalez de Clavijo, *Embassy to Tamerlane,* trans. by G. Le Strange *(1928);* Harold Lamb, *Tamerlane; the Earth Shaker (1932).* (H. A. R. G.)

TIN is a metallic chemical element. symbol Sn. atomic number 50 and atomic weight 118.70. It has 10 naturally occurring isotopes (*q.v.*), more than any other element. The isotope with mass number 124 is radioactive. disintegrating by double β decay with a half life of about 6×10^{15} yr. By the mid-1950s 17 artificially radioactive isotopes had been prepared, either by nuclear reactions or in the fission of uranium.

History. — Bronzes containing tin were made more than 30 centuries B.C., but whether metallic tin was first isolated and then combined with copper, or tinstone was added to copper under reducing conditions is not known. In early Hebrew. Greek and Latin writings words that came to designate tin had a different meaning. making it difficult to establish with certainty when tin was first recognized.

The word "tin" in English Bibles, for example! corresponds to the Hebrew *bedhil,* which is a copper-tin alloy. Homer distinguishes between tin and bronze in his *Iliad* and Herodotus discusses the existence of the Cassiterides (*q.v.*), or tin islands. from which tin mas said to have been imported in his time. Pliny the Elder referred to tin as "white lead" and lead as "black lead." He also used the term stannum, but this apparently referred to a silver-lead alloy. An imitation stannum was made at that time which contained two-thirds "white lead." and by the 4th century the meaning of stannum had changed to tin.

The earliest known objects made of pure tin are a ring and a pilgrim bottle found in Egyptian tombs of the 18th dynasty (1580–1350 B.C.). However, tin ores are not found in Egypt. so the tin must have been imported. About 1000 B.C. the Cornwall (Eng.) deposits were worked by the Phoenicians. hut references to the Mediterranean tin trade of this era are scanty. The Cornish tin industry was dated back to 300–200 B.C. by the discovery of tin containing slag in excavations made at the castle of Chun near St. Just, and tin was imported from Cornwall into Italy after. if not before, the invasion of Britain by Julius Caesar.

That tin was known to the South American Indians prior to the advent of the Europeans was shown by the discovery of pure tin at Machu Picchu. Peru. Tin was not used by them for the manufacture of artifacts as such. however, but for the preparation of bronzes with compositions varied according to ultimate use. Hernan Cortes found small pieces of tin used as money among the natives of Taxco when he arrived in Mexico in 1519.

Geochemistry. — Tin,although not an extremely rare element. is nevertheless not as abundant as several less familiar elements such as lithium, vanadium and titanium. It occurs to the extent of 40 g. per ton in the earth's crust; while in meteorites the abundance is 100, 15 and 5 g. per ton in the iron-nickel. troilite and silicate phases. respectively. Because of the distribution in these meteorite phases, tin is classed as a siderophile, or iron lover. It is probable that tin is more abundant in the iron-nickel core of the earth than in the crust. When the earth's crust formed by crystallization of the molten rocks. the tin compounds were among the last to solidify.

In low temperature deposits the tin crystallized in sulphidic minerals, whereas in high temperature deposits the oxide crystallized. The tin deposits are in or closely connected with granite or acid-eruptive rocks of the same type. The minerals of tin are listed in Table I.

All the commercially important tin-bearing deposits contain cassiterite (*q.v.*), or tinstone, as the predominant tin mineral with the exception of the, Bolivian ores which contain both cassiterite and a variety of sulphidic ores.

TABLE *I.* — *Minerals of Tin*

Name	Formula	occurrence
Cassiterite	SnO_2	*See* text
Cylindrite	$Pb_3Sn_4Sb_2S_{14}$	Bolivia
Franckeite	$Pb_5Sn_3Sb_2S_{14}$	Bolivia
Stannite	Cu_2FeSnS_4	Bolivia, Cornwall, central Europe
Arandisite	$Sn_5(OH)_8(SiO_4)_8$	South West Africa
Canfieldite	Ag_8SnS_6	Bolivia, Saxony
Cuprocassiterite. . .	$Cu_2Sn(OH)_6.4SnO_2$	wit11 stannite (weathered stannite?)
Hulsite	$10(Fe,Mg,Ca)O.2Fe_2O_3.SnO_2.3B_2O_3.2H_2O$	Alaska
Native tin	Sn	Sew South Wales, Stromboli
Nordenskiöldine . .	$CaSn(BO_3)_2$	Norway
Paigeite	$30FeO.5Fe_2O_3.SnO_2.6B_2O_3.5H_2O$	Alaska
Plumhostannite. . .	$Pb_2Fe_2Sn_2Sb_2S_{11}$	Peru
Stokesite	$H_4CaSnSi_3O_{11}$	Cornwall (one specimen)
Teallite	$PbSnS_2$	Bolivia, Saxony

Mining and Metallurgy. — Tin deposits are of two kinds — the primary deposits found as veins traversing granite and related acid igneous rocks and the secondary. alluvial deposits formed by the disintegration of the primary deposits. Cassiterite is highly resistant to weathering and is found unaltered in the secondary deposits. The greatest part of the world's tin ore comes from secondary deposits which are worked by panning, gravel pump and open-cut mining and dredging, whereas the primary deposits, mainly the Bolivian ores, are worked by lode mining Subsequent treatment of the ore depends upon its other components. Those ores nhich contain only cassiterite, iron oxides and quartz feldspars are termed simple ores; nhile the sulphidic ores and other ores containing metals such as copper. iron, tungsten and lead are complex ores The ores generally contain 1% to 5% SnO_2 and must therefore be concentrated prior to reduction. The concentration processes are based on the high density, nonmagnetic character and nonreactivity of cassiterite.

The simple ores are dressed to a concentrate by multiple sluicing, followed. in some cases. by magnetic separation to remove tungsten minerals, iron oxides and other magnetic impurities. The complex ores require more extensive treatment to break down the sulphidic minerals and to remove a large part of the other metals present. This treatment involves grinding, roasting, gravity concentrations and magnetic separations.

Metallic tin is obtained by reducing the ore concentrate with coal in blast or reverberatory furnaces. Little preliminary treatment is required for the simple ore concentrates. but the complex ore concentrates still contain other metals which are removed in part by roasting and leaching prior to reduction. The crude tin which comes from the furnaces is purified by liquation, poling, tossing, boiling, electrolysis, or a combination of some of these processes. Liquation takes advantage of the low melting point of tin compared to the usual impurities to separate molten tin from the unmelted impurities. This is accomplished by slowly heating the crude tin to a temperature just above the melting point of tin and collecting the part that melts. Lead and bismuth melt with the tin and must be removed by subsequent treatment. Poling and boiling oxidize the impurities and part of the tin by a strong bubbling action caused by stirring the molten metal with poles of green wood or by agitating the metal nith compressed air. In tossing the oxidation is accomplished by pouring the molten metal from ladles at a height back into the kettles, so the impurities are oxidized by the air. In all these oxidation processes the oxidized impurities and tin oxide form a scum on the surface of the molten tin which is skimmed off and reprocessed During the smelting of tin much of the metal is either entrapped in the slag or reacts with the fluxes, because of the amphoteric nature of stannic oxide, and goes into the slag as tin compounds. Molten tin, moreover, is a mobile liquid and tends to escape from the furnaces through s all openings. Consequently, the recovery of tin from slags, furnace linings and drosses is an important phase in the metallurgy of tin, and these materials are always processed before being discarded.

In Malaya ore is smelted at Penang and Singapore and shipped as the metal; however, Bolivian and Thailand concentrates are shipped to the United States and the United Kingdom, Indonesian concentrates to the Netherlands and the United States, the Nigerian concentrates to the United Kingdom and the Belgian Congo concentrates to Belgium, Prior to World War II the main smelters were in the United Kingdom, the Netherlands, Malaya and Batavia. During the war the Japanese overran the Asian smelters and the Germans took over the continental European smelters. As a result the Longhorn smelter was constructed at Texas City, Tex.. in 1941 and extensive smelting was begun in the United States, mainly with Bolivian ores. After the war the continental European and Malayan smelters were again put into operation, but the Batavian smelters were not immediately reactivated.

The leading tin smelters in the mid-1950s were in the Federation of Malaya, the United States, the United Kingdom, the Netherlands and Belgium.

When supply and demand considerations make it profitable, the recovery of tin is of considerable importance. Some waste materials may be reworked by a combination of liquation and smelting; tin plate scrap is detinned, however. by electrolytic or chemical oxidation of the tin. Dry chlorine, which attacks tin more readily than iron, was largely replaced by hot oxidizing alkaline solutions for the latter. The secondary, or recovered, tin is obtained in the form of metallic tin or tin compounds and is generally sold in the form recovered.

Uses.—By far the largest part of the tin produced is used as the metal, the major uses being for plating and in alloys. Tin is less active than iron and will serve as protection only if it completely covers the iron object, whereas zinc, which is more active than iron, will protect the object even if the coat is not perfect. Tin plating, therefore, has to be more thorough than galvanizing to be effective. An object may be plated by electrolysis, chemical displacement or hot dip processes. The hot dip process gives, a heavier plate than the other methods; electrolytic plating gives a dull surface which has to be polished if a bright plate is desired. Terneplate, a protective coating of a tin-lead alloy applied by hot dip processes, is also used as a protective coating (see TIN PLATE AND TERNEPLATE).

The alloys of tin belong to two major classes, bronzes and white metals. In general, bronzes are copper base alloys which contain tin and smaller amounts of other elements to give alloys with specific properties (see BRONZE) while white metals are tin base alloys, such as Babbitt's metal, Britannia metal, pewter (*qq.v.*), antifriction metal (*see* BEARING METALS) and tin base die casting alloys, and alloys with other bases, such as type metal (*q.v.*), low-tin bearing metals, die casting alloys with lead or zinc bases and low melting alloys (*see* FUSIBLE ALLOYS). Solder (*see* SOLDERING) is an alloy of tin and lead containing from 20% to 80% tin.

TABLE 11.—*Composition of Typical Tin Alloys*

Alloy	% Tin	% Copper	% Lead	% other elements
Bronzes				
Bell metal	15–25	85–75		
Gun metal	8–14	92–86		
Coinage bronze	4	95		Zinc 1
White metals				
Britannia metal	90–94	3–1		Antimony 8–5
Babbitt's metal	90	3		" 7
Pewter	82			" 18
Bearing metal	75	12.5		" 12.5
Fine solder	60		40	
Eutectic fusible alloy	50		32	Cadmium 18
Plumber's solder	33.3		66.7	
Type metal	26	1	58	Antimony 15
Wood's metal	12.5		25	Bismuth 50, Cadmium 12.5

Tin metal is also used in the construction of block tin stills and tin pipes for the distillation and circulation of distilled water, for thin foil to wrap various objects and for collapsible tubes to dispense tooth paste, ointments, etc. Conservation measures instituted during World War II, when tin was in short supply, resulted in the substitution of other metals for tin in some applications and the use of much thinner plate on cans. Aluminum foil and tubes in large part supplanted tin foil and tubes for most uses, but in some cases, such as the packaging of alkaline substances, aluminum is not satisfactory. Lead is also substituted for tin. but it is not a satisfactory replacement in many instances because of its toxicity.

Compounds of tin used commercially represent less than 1% of the tin consumption. The main uses are in textile manufacture, dyeing and in glasses. ceramics and porcelains. The compounds used industrially are SnO_2 (tin ash), $SnCl_5.5H_2O$ (butter of tin), $SnCl_2.2H_2O$ (tin salt), $(NH_4)_2SnCl_6$ (pink salt). $Na_2SnO_3.10H_2O$ (preparing salt), $SnSO_4$, SnC_2O_4, $SnC_4H_4O_6$, $Sn_3(PO_4)_2$ and $Sn_3(PO_4)_4$.

Physical Properties.— Tin is a soft, ductile, white metal which is readily extruded, drawn, stamped and spun. Although it does not work-harden appreciably, it has a low elastic limit. When bent. the cast metal emits a creaking sound called the "cry of tin". This is thought to be caused by the grinding of crystals of the metal against one another when the bar is bent. The metal has at least two allotropic modifications. In the usual commercial form it is a white massive metal, but, when exposed to temperatures below

TABLE 111.—*Some Physical Properties of Tin*

Property	Value	Remarks
Melting point	231.9° C.	National Bureau of Standards standard
Boiling point	2,270° C.	
Transition temperature	13.2° C.	gray to white
	161° C.	white to γ (?)
Critical temperature	3730° C.	
Critical pressure	650 atmospheres	
Density	7.311 (20°/4°)	white
	5.85	gray at 15°
Hardness	1.8	white on Von Moh scale
	14.0	silver = 100
		silver = 100
Coefficient of linear expansion	2.03×10^{-5}	white, 8°–95° C.
Heat of fusion	14.2 cal./g.	
Heat of vaporization	525 cal./g.	
Heat of transition	4.2 cal./g.	gray to white
	0.02 cal./g.	white to γ
specific heat	$0.0534+0.0000348t$ (t=0 to 100° C.)	cal./g. White
Ionization potential I	7.30 e.v.	
II	14.5 e.v.	
III	30.5 e.v.	
IV	39.4 e.v.	
Electrode potential Sn–Sn^{++}	0.136 volts	
Sn^{++}–Sn^{4+}	−0.15 volts	
Radius Covalent	1.40 Å (1 Angstrom—	single bond
	1.30 Å 10^{-8} cm.)	double bond
Sn^{++}	0.93 Å	
Sn^{4+}	0.74 Å	

13° C. for sufficient time, it becomes brittle and may be readily crushed to a gray powder. Tin objects eventually crumble to this gray powder spontaneously if kept in a cold climate for years. Before the change was understood, it was named tin pest or tin disease, for the transformation appears to be contagious. It is autocatalytic, and a single grain of the gray form in contact with a piece of white metal below the transition temperature will start the transformation. The gray and white modifications have been designated α tin and β tin. Another modification, termed γ tin, was reported to form at 161° C. and exist up to the melting point, but authorities disagreed as to its existence. It is not generally accepted as an allotrope of tin.

Chemical Properties.— Tin is a member of group IV of the periodic table (see PERIODIC LAW, THE), being associated with carbon, silicon, germanium and lead. It falls between germanium and lead in atomic weight and resembles these two elements the most closely. The four valency electrons of tin occupy the $5s^2$ and $5p^2$ orbitals and consist of two sets from the consideration of the energy required to remove each electron. Accordingly, tin forms two series of compounds, the stannous tin(II) series in which tin has an oxidation number of +2 after losing only the 5p electrons, and the stannic tin(IV) series with an oxidation number +4 corresponding to the loss or sharing of all four outer electrons. Tin also forms a few compounds in which it can be considered to have the oxidation number −4. In these compounds the outer electron shell is built up to eight electrons by sharing electron pairs with other more electropositive atoms. The electrode potentials show that tin is oxidized to Sn^{++} by the hydrogen ion, but that hydrogen is oxidized to the hydrogen ion by Sn^{4+}.

TABLE IV.—*Some Chemical Reactions of Metallic Tin*

Reagent	Product	Conditions of reaction
Air	superficial tarnish	room temperature
	SnO_2	high temperatures
Oxygen	SnO_2	accelerated by water and heat
Hydrogen, nitrogen	no reaction	
Fluorine	SnF_4	100° C.
Chlorine, bromine	$SnCl_4$, $SnBr_4$	room temperature
Hydrofluoric acid	feeble attack	
Hydrochloric acid	$SnCl_2$	slow if dilute, more rapid if hot, concentrated
Hydrobromic, hydriodic acids	$SnBr_2$, SnI_2	hot
Chloric acid, aqua regia	$SnCl_4$	room temperature
Sulphuric arid	$SnSO_4$	cold, dilute (slow)
	$Sn(SO_4)_2$	hot, concentrated
Nitric acid	$Sn(NO_3)_2$	dilute
	$SnO_2.5H_2O$	concentrated
Alkali hypochlorites	basic stannic chlorides	
Sulphur	SnS or SnS_2	heat
Hydrogen sulphide, Sodium sulphide, or Sulphur dioxide	SnS	heat
KOH	$K_2Sn(OH)_4$	heat

The simple cation Sn^{++} exists in moderately acidic solutions; but there is some question about the existence of the simple cation Sn^{4+} because of extensive hydrolysis. In most solutions the stannic ion is undoubtedly present as some kind of complex ion because it has a high charge density, but there is some evidence that Sn^{4+} may be present in certain sulphuric acid solutions. For the most part, however: compounds containing tin(IV) are either covalent in nature or else contain tin in a co-ordinated cation or anion. In both oxidation states tin is amphoteric, but $Sn(OH)_4$ is a stronger acid than $Sn(OH)_2$ as would be expected for the smaller, more highly charged tin(IV) ion. Although it has been customary to write ions such as SnO_3^{--} in the stannate solutions, the salts isolated from such solutions retain their original nature only when dehydrated as far as the composition illustrated by $K_2SnO_3.3H_2O$. Further dehydration, which is more difficult, gives salts which have lost ready solubility in water; so it is probable that the stannate ion is $Sn(OH)_6^{--}$. The stannites are much less stable than the stannates and are efficient reducing agents. They also tenaciously retain sufficient oxygen and hydrogen to indicate that the stannite ion is $Sn(OH)_4^{--}$.

Binary compounds of tin in both oxidation states have been prepared with the halogens. oxygen, nitrogen. sulphur, selenium and tellurium. The hydride and phosphide of tin(IV) are also known. The salts of the common oxyacids have been reported, for the most part in both series, although the tin(IV) salts are more difficult to prepare because of hydrolysis and in some cases have not been isolated. Co-ordination compounds containing tin generally have a co-ordination number of four for tin(II) and six for tin(IV); however, a few compounds with co-ordination number six for tin(II) and eight for tin(IV) are known. Some examples of compounds of these kinds are $K_2SnCl_4.2H_2O$ and $(NH_4)_2SnBr_4$ [tin(II), co-ordination number four], $Na_2SnBr_6.6H_2O$ and $K_2Sn(OH)$, [tin(IV), co-ordination number six], $(NH_4)_4SnBr_6.H_2O$ [tin(II), co-ordination number six] and $H_4Sn(C_2O_4)_4$ and $Sn(C_{32}H_{16}N_8)_2$ [tin(IV), co-ordination number eight].

The stereochemistry (*q.v.*) of the various tin compounds is, in general, what is expected from bonding considerations. In those compounds with four covalent bonds linked to tin(IV), such as $SnCl_4$ and the organotin(IV) compounds, the bonds are directed to the four corners of a tetrahedron as with carbon and other elements which form compounds using sp^3 orbitals for bonding. The resolution of methylethylpropyl tin iodide into optically active isomers is classical evidence for the tetrahedral structure of these tin compounds. In compounds such as K_2SnCl_6 the six chlorine atoms are arranged in octahedral fashion about the tin atom in the same way the chlorine atoms are arranged around the platinum atom in K_2PtCl_6. The configuration in $K_2SnCl_4.H_2O$ is that of infinite chain ions of composition $SnCl_4^{--}$ formed by $SnCl_6$ octahedra sharing two opposite edges. In the gaseous state. molecules such as $SnCl_2$ are angular in shape, a configuration to be expected because the 5*s* electron pair is still present in the outer electron shell of tin. so the *p* orbitals, which are at a 90° angle, determine the configuration. Stannous oxide, SnO. also shows the effect of this inert pair of electrons. It has a layer structure in which four oxygen atoms are arranged in a square bonded to one side of the tin and the inert pair occupies the other side. thus forming the apex of a tetragonal pyramid. The oxide SnO_2 has the rutile structure in which the tin atoms are surrounded octahedrally by six oxygen atoms. gray tin has the diamond lattice and white tin has a metallic lattice.

Table V.—*Some Properties of Typical Tin Compounds*

Formula	Melting point	Boiling point	Density	Colour	Solubility
SnO	decomposes	>385° C.	6.9	black	alkali, acid
Precipitated SnO_2	1,132° C.		6.6–7.0	white	alkali, acid
$SnCl_4$	−33° C.	114° C.	2.3	colourless	water, organic solvents
SnF_4	sublimes 750° C.		4.8	white	water
$SnCl_2$	246.8° C.	603°–606° C.	2.6	white	water, organic solvents
SnF_2				white	water, alkali, fluoride
SnS	880° C.	1,230° C.	5.1	brown	concentrated HCl, $(NH_4)_2S_x$
SnS_2	decomposes		4.5	yellow	basic sulphides, concentrated HCl
$K_2SnCl_4.H_2O$			2.5	white	water
$(NH_4)_2SnCl_6$	decomposes		2.4	white	water
$Sn(C_2H_5)_4$	−112° C.	181° C.	1.2	colourless	organic solvents
$(CH_3)_2SnI_2$	43° C.	228° C.	2.9	white	hot water, organic solvents
$Sn(C_6H_5)_4$	226° C.	>420° C.	1.5	colourless	hot organic solvents
SnH_4	−150° C.	−52° C.		colourless	concentrated H_2SO_4, concentrated alkali

Under the proper conditions compounds corresponding to stannic acid can be isolated. Two stannic acids, one prepared by the acidification of stannate solutions and the other by the action of concentrated nitric acid on tin, have been said to exist and were named a and β stannic acids or stannic and metastannic acids, respectively. Stannic acid prepared by the two methods differs in properties (the α form is readily soluble in acids and bases, whereas the β form is difficultly soluble in these reagents), but the reason for the differences has not been definitely established. X-ray diffraction patterns for the two forms are the same and identical with that of cassiterite: so the difference is not one of isomers. It is probably essentially one of particle size and amount of adsorbed water, with the β form a modification with larger particles. The conversion of α to β occurs readily, whereas the reverse transformation is more difficult. Treatment of a stannic acid with hydrogen peroxide yields a peroxyacid of tin with the formula $H_2Sn_2O_7.3H_2O$. Sodium and potassium salts of this acid are also known.

Stannic sulphide also possesses amphoteric properties, being soluble in basic sulphide solutions to give thiostannates, but stannous sulphide is so much less acidic than the tin(IV) compound that it is insoluble in basic sulphide solutions.

Tin resembles silicon and germanium in the compounds it forms which are analogous to the extensive series of organic compounds of carbon. The hydride SnH_4 (see Hydrides) is the only gaseous binary hydride known to be formed by tin. but chains of tin atoms occur in the organometallic compounds with the formula $(CH_3)_3Sn[Sn(CH_3)_2]_nSn(CH_3)_3$ in which n may be 0, 1 or 3. A large number of organotin compounds have been prepared in which tin is bonded to from one to four alkyl or aryl groups. In those compounds containing tin(IV) the other bonds may be to halogens, hydrogen or oxygen. A few organotin compounds have been prepared which contain tin(II), but they disproportionate fairly easily to tin and tin(IV) compounds. Metallic tin dissolves in a liquid ammonia solution of potassium to give a blood-red solution which contains the polystannide ion Sn_9^{4-}. In this ion there are eight tin atoms associated with a Sn^{4-} ion. The tin hydride, SnH_4, and this unusual polystannide ion are two of the few compounds containing tin in the −4 oxidation state.

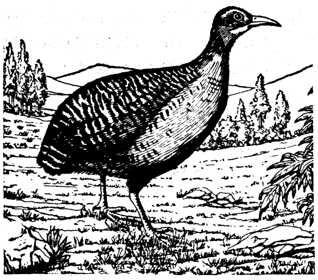
Stannic oxide, SnO_2, is prepared commercially by the high temperature ignition of metallic tin. The reaction of chlorine with tin at low temperatures supplies $SnCl_4$ from which the hydrates and $(NH_4)_2SnCl_6$ are made by subsequent treatment with water or ammonium chloride. Tin is treated with moist hydrogen chloride to make $SnCl_2.2H_2O$ and dissolved in dilute sulphuric acid to make $SnSO_4$. $Na_2SnO_3.10H_2O$ is made by the fusion of metallic tin with Chile saltpetre and caustic soda. On a laboratory scale tin compounds are made from tin by dissolving it in an acid or base and treating the resulting solution with the proper reagents for the usual metathetical preparations. Some of the compounds of tin are water-sensitive and must be prepared under anhydrous conditions. The organotin compounds are prepared by the reaction of tin halides with the Grignard reagent or organozinc compounds. To prepare metallic tin in the laboratory an insoluble compound is fused with potassium cyanide and carbon or a solution of a soluble compound is treated with zinc.

Analysis.—In the field cassiterite is usually recognized by its high density and extreme hardness. A chemical test that distinguishes it from those minerals with which it might be confused is the treatment of the mineral with cold dilute hydrochloric acid or sulphuric acid in the presence of zinc or iron. This reduces the surface oxide to a gray coating of metallic tin which can be washed and rubbed to a silvery surface. The minerals most frequently confused with cassiterite are zinc blende, ilmenite, rutile, haematite, wolframite, tantalite. columbite. zircon, garnet, tourmaline and axinite. In the usual wet qualitative analysis scheme both Sn(II) and Sn(IV) are separated as insoluble sulphides in dilute hydrochloric acid. The sulphides are then dissolved in a basic sulphide solution containing polysulphide to oxidize Sn(II) to Sn(IV). Arsenic and antimony are the only elements of those considered in most qualitative schemes which go into solution with tin. These elements are recovered as sulphides. and tin sulphide is then separated from the arsenic and antimony sulphides by various procedures, most of which depend upon the solubility of stannic sulphide in concentrated hydrochloric acid, the stability of the oxalate complex of tin. or the selective reduction of tin(IV) to tin(II). Several spot tests have been suggested for tin. the most satisfactory of which are reported to be the violet colour formed by Sn(II) with cacotheline. the blue colour imparted to a colourless Bunsen burner flame when hydrogen generated from zinc and hydrochloric acid in the presence of tin compounds (except highly refractory compounds) is burned. and the blue colour formed by the reduction of molybdophosphoric acid by Sn(II). Quantitatively, tin is determined gravimetrically as the ignited oxide after the removal of other ions or as the electrolytically deposited metal. Titrimetric determinations are made by the iodometric titration of Sn^{++} or $K_2SnS(C_2O_4)_2$ with iodine in the presence of starch. The titrimetric method is generally considered the superior quantitative procedure.

Deposits and Production.—The important tin deposits are confined to the following geographical locations: (1) Burma. Thailand. Malaya and Indonesia, (2) Bolivia. (3) Nigeria and the Belgian Congo, (4) west England, Brittany and the Erzgebirge and (5) Australasia. The major ore producing areas in the mid-1950s were Malaya, Indonesia. Bolivia, Belgian Congo. Thailand and Nigeria. The deposits at Cornwall, Saxony and Bohemia. major producers in the 18th and 19th centuries, were almost depleted and are mainly of historical interest, although some ore was still obtained from them. Other sources of lesser amounts of tin ores are Portugal, Spain, the Union of South Africa. Burma. China and Australia. North America is the only continent which does not have commercially important deposits of tin ores. Both Canada and Mexico produce small tonnages. but North America depends almost entirely on imports for its tin.

Bibliography.—A thorough treatment of the industrial and historical aspects of tin may be found in *Tin: Its Mining, Production, Technology, and Applications* by C. L. Mantell, 2nd ed. (1949). The chemistry of tin is discussed in N. V. Sidgwick, *The Chemical Elements and Their Compounds,* pp. 551–627 (1950). (B. P. B.)

TINAMOU, the name of a group of birds peculiar to South America. having some superficial resemblances to the partridge. The elongated bill. small head and slender neck are diagnostic. The plumage is some shade of brown, variously barred with darker tints. The wings are short and rounded, and the male incubates the highly burnished eggs. They are exceedingly stupid and are excellent to eat. More than 60 species are recognized. They are considered a group of palaeognathine birds and form the family Tinamidae. The little tinamou *(Crypturus pileatus)* ranges from the Amazon to Mexico, while the rufous tinamou *(Phychotus rufescens)* inhabits southern Brazil and Paraguay.



RUFOUS TINAMOU

TINDAL, MATTHEW (d. 1733), English deist. the son of a clergyman, was born at Beer Ferrers (Ferris), Devonshire, probably in 1653. He studied law at Lincoln college, Oxford, under the high churchman George Hickes, dean of Worcester; in 1678 he was elected fellow of All Souls college. About 1685 he became a Roman Catholic, but returned to the Church of England at Easter, 1688. His early works were an *Essay of Obedience to the Supreme Powers* (1694); an *Essay on the Power of the Magistrate and the Rights of Mankind in Matters of Religion* (169;); and *The Liberty of the Press* (1698). The first of his two larger works. *The Rights of the Christian Church Asserted Against the Romish and All Other 'Priests Who Claim an Independent Power Over It*, pt. i, appearing anonymously in 1706 (and ed., 1706; 3rd, 1707; 4th, 1709), is a forcible defense of Erastianism. Author, publisher and printer were prosecuted, but this did not prevent the issue of a fourth edition and gave the author the opportunity of issuing *A Defence of the Rights of the Christian Church,* in two parts (and ed., 1 jog). The book was burned by order of the house of commons, along with Henry Sacheverell's sermon, by the common hangman (1710). It was the object of denunciation for years, and Tindal scented in a pastoral letter by Edmund Gibson, bishop of London, a charge of having undermined religion and promoted atheism and infidelity. He replied in the anonymous tract, *An Address to the Inhabitants* of *London and Westminster* (2nd ed., 1730). In this he defends the deists, and anticipates his *Christianity as Old as the Creation; or, the Gospel a Republication of the Religion of Nature* (London, 1730; 2nd ed., 1731; 3rd, 1732; 4th, 1733), which was regarded as the "Bible" of deism.

Tindal died at Oxford Aug. 16, 1733.

TINEA VERSICOLOUR (Pityriasis Versicolour) is a harmless skin disease caused by the deposition of a fungus of the ringworm group. *Microsporon furfur.* It thrives on the trunk of adults and forms slowly spreading brown patches with fine branny scaling. Sunshine bleaches the brown patches. and after continued exposure the normal skin becomes darker than the bleached spots because the fungus colonies hinder the penetration of the tanning sun rays; hence the name "versicolour," which means changing colour. The fungus deposits itself only on the skin of a few specifically susceptible persons and is not transierable by contact. (S. Ron.)

TINGUIAN, a tribe of north Luzon, in the Philippines. of Malayo-Indonesian stock; more brachycephalic and probably belonging to a later wave of immigration than the Igorot (*q.v.*) group, and showing stronger traces of Indian influence on culture; probably traceable to Sumatran origin. The same influence appears in rice cultivation methods, and irrigated terraces are less elaborate than those of the Igorot, who do not use the buffalo. Marriage restrictions are based on blood relationship only, not on clan; and the polity is democratic.

A creator is believed in. and spirits of various functions, good and bad, some of which inhabit guardian stones. The home of the dead, where life goes on as on earth, is sometimes placed in a mountain. The dead are dried before burial. Mediums, usually female, communicate with spirits.

See Fay Cooper Cole, *The Tinguian* (1922).

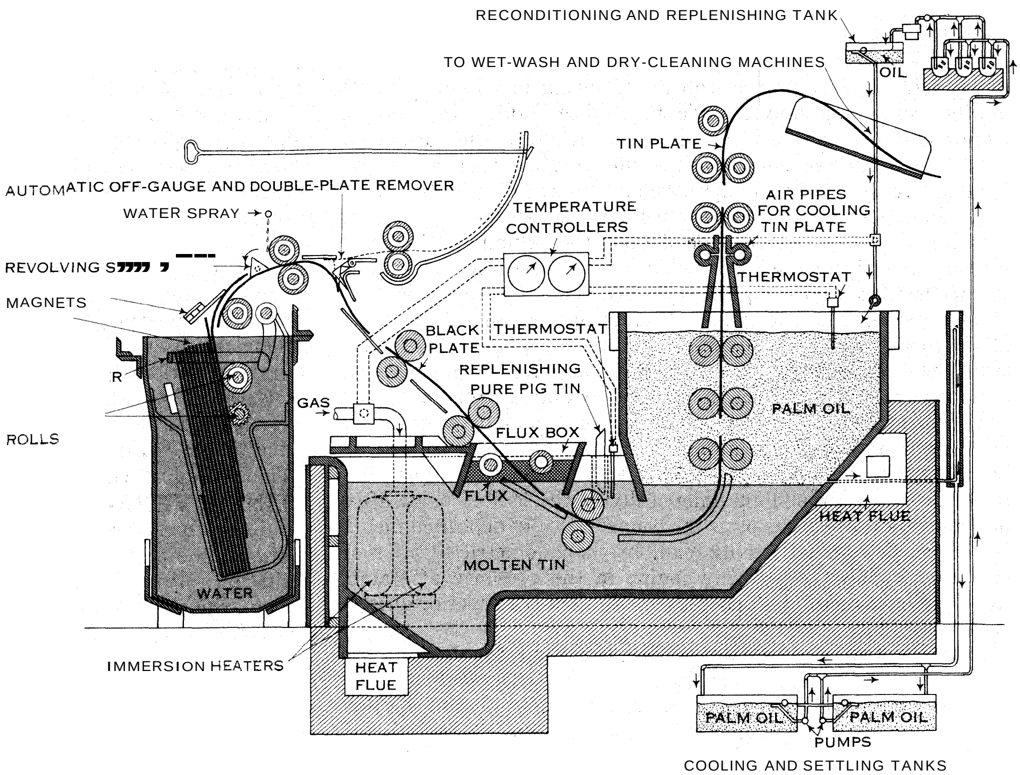
TIN PLATE AND TERNEPLATE. Tin plate is a low-carbon steel sheet or strip thinly coated with commercially pure tin. thus comprising in one inexpensive material the strength and formability of steel and the corrosion resistance, solderability and good appearance of tin. Tin plate is made by rolling mild steel to a finished gauge of about 0.01 in. and then applying a coating of pure tin by dipping in molten metal or by electrodeposition. Tin plate is available in various grades ranging from thinly coated electrolytic tin plate carrying coatings as thin as 0.000015 in. to thickly coated hot-dipped tin plate carrying coatings of 0.0001 in. to 0.0008 in.

Terneplate is a low-carbon steel sheet or strip coated with terne metal, which is an alloy of lead and tin. Lead alone does not alloy with the iron but when 7% to 12% of tin is incorporated in the alloy, the tin readily wets the steel and forms a solid solution with the lead. Terne sheets are seldom manufactured of thinner gauge than 0.014 in.. thicker than 0.125 in. or wider than 48 in. The clean cold-reduced mild steel sheet or strip is coated by a hot-dip process similar to that used in the tin-plate industry with the exception that the coating is applied at a higher temperature. Terneplate is sold on the basis of a coating weight of 0.3 to 1.45 oz. per square foot.

Tin-Plate Manufacture.—The base sheet for tin plate is made principally from open-hearth steel, hot-rolled' to strip (0.07 × 36 in.), pickled continuously in hot dilute sulfuric acid, cold-reduced to finished gauge (0.01 in.), then annealed and temper-rolled to impart the required hardness and surface finish.

(See IRON AND STEEL: *Mills for Semi-Finished Materials.*) The tin coating is applied either by hot-dipping in molten tin or by electroplating from tin-bearing electrolytes. About 30% of world tin-plate production is hot-dipped and 70% electroplated.

Hot-Dip Tin Plate.—In a modern tinning plant (see figure), the cold-reduced steel is sheared to sheet length and passed through a pickling unit attached to and driven synchronously with the tinning units. The tinning unit comprises a thermostatically controlled vessel of molten tin held at about 600° F. In the molten tin is submerged a mechanism of rollers and guides for conducting the pickled sheets downward through a layer of zinc chloride flux into the tin and then upward and out of the tin through a thick covering layer of palm oil. The sheets are subjected to the squeegeeing action of tinned steel rollers which serve to regulate and control the final thickness of coating on the sheets. The tinned sheets are cooled by an air blast and then cleaned and polished, usually by a combination of alkaline detergent washing and dry absorbent cleaning with bran or wood meal to absorb the oil. A conveyor automatically separates the sheets into prime sheets (free from defects), seconds (slightly defective but usable) and menders (to be retinned).



BY COURTESY OF WHEELING STEEL CORP.

SCHEMATIC DIAGRAM OF SINGLE SWEEP TIN POT

Electrolytic Tin Plate.—The world's first commercial electrolytic tin-plate line was installed at the United States Steel Corp.. Gary, Ind.. in 1937. The cold-reduced steel is handled as a continuous strand through all operations of preparation and tinning. In a typical electrolytic line the following operations follow in sequence: decoiling and welding of the trailing end of the previous coil to the leading end of the following coil; electrolytic cleaning in dilute sulfuric acid; light pickling; electrolytic deposition of the tin from alkaline or acid tin-containing electrolytes; melting of the dull matte coating to give it a brilliant surface; chemical dipping in chromate solutions; oiling; shearing; inspection and piling. Five grades of electrolytic plate are available, viz., $\frac{1}{4}$ lb., $\frac{1}{2}$ lb., $\frac{3}{4}$ lb., 1 lb. per basis box and differential plate with 1 lb. on one side and $\frac{1}{4}$ lb. on the other. The basis box is the unit of area and consists of 112 sheets each 20 × 14 in. equivalent to 31,360 sq.in. of tin plate.

Where the can manufacturer is equipped to accept tin plate in coils (36 in. wide, 20,000 lb. in weight), the final shearing and classification operations are omitted. Utilization of tin plate in coils may well become general practice.

Terneplate Manufacture.—The process of coating terneplate is quite similar to that for tin plate. A more active flux consisting of zinc chloride and hydrochloric acid is used, and the terne metal is maintained at about 700° F. In some cases. an additional machine operation with palm oil substituted for the flux is used which allows complete control of coating weight over a wide range.

Applications.—Tin plate is very ductile and can be bent, drawn and folded into complicated shapes without risk of failure. The tin coating follows, to a remarkable degree, the movement of the steel base when tin plate is formed into useful shapes. The coating is very adherent, and spalling or peeling of the coating from the base is almost unknown. It protects the steel from corrosion and is resistant to the wide range of processed foods and other merchandise which is packed in tin plate. The coating renders the material easily solderable at high speeds and imparts a surface which can be readily decorated, painted, enameled or lacquered. Tin and iron are nontoxic and are safely used in all applications where contact with foods or beverages occurs.

The uses of tin plate are varied and widespread. The choice between hot-dipped tin plate and electrolytic tin plate is dictated by technical and economic factors.

Hot-dipped tin plate is used for the severer and more corrosive packs, typified by certain acid fruits and baby foods. Heavily coated stock is used for hardware, kitchen utensils, gas meters, toys and returnable containers. Electrolytic tin plate ($\frac{3}{4}$ lb.) is widely used for packaging evaporated and condensed milk and for certain closures. The thinner coated tin plate ($\frac{1}{2}$ lb. and $\frac{1}{4}$ lb.) is used for a wide variety of general line containers, caps and closures, for packaging dehydrated and dry goods and cigarettes and nonfood products. Internally lacquered $\frac{1}{4}$ lb. electrolytic tin plate is used for canned beer and dog food.

Terneplate has good forming properties. It is used for roofing, and is ideal for fabrication into automobile gasoline tanks, fireproof doors and door frames and for lining caskets. It is used extensively for packaging paints, lubricating oils and greases.

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TINTAGEL, a village in the Camelford rural district of Cornwall, Eng., 20 mi. N. of Bodmin by road. Pop. (1951) 1,451. It stands by the sea on a bare upland, to the south of Tintagel head, a rugged promontory united by a narrow isthmus to the shore. The village is sometimes known as Trevena. Below is Tintagel haven, or Porth, a small cove surrounded by cliffs of almost black slate. Great numbers of visitors are attracted to Tintagel by the castle, with its romantic associations as the reputed birthplace of King Arthur, and its striking situation. The ruins stretch from the precipitous cliff across the isthmus to the mainland. The castle was built in the 12th century on the site of a Celtic monastery and this settlement appears to have existed from *c.* A.D. 350–850. The earls of Cornwall occupied the castle in Norman times and built the chapel. The parish church of St. Merteriana, isolated on a high cliff west of the castle, shows traces of Saxon workmanship.

There is much Norman masonry and 12th-century iron hinges to the north door. The church contains an inscribed stone, probably Roman and referring to the emperor Licinius. Many of the gravestones in the churchyard are buttressed against the violent storms that sweep this coast at times. The church once belonged to Fontevrault abbey in Normandy, but Edward IV made it over to the collegiate church of Windsor. The old post office, a 14th-century stone house built like a medieval manor house with a large hall, stands in Tintagel village; it belongs to the National Trust.

Bossiney, part of the civil parish, appears in Domesday Book as *Botcinnii.* It surrendered its charter to Charles II and obtained a new one in 1685. In 1784 the vicar of Tintagel, as mayor and only qualified elector, enjoyed the probably unique privilege of returning two members to the house of commons. In 1832 there were ten resident voters within the borough and nine outvoters. The Reform act transferred their votes to the county, and Tintagel is included in the North Cornwall division.

TINTERN ABBEY, in Monmouthshire, one of the most famous ecclesiastical ruins in England, on the river Wye. The abbey was founded by Walter de Clare in 1131 for Cistercian monks. The existing church, however, dates from the latter part of the 13th century; it is unroofed, and the nave is imperfect, but many of the finest details of a style transitional from Early English to Decorated are preserved. The church is cruciform. Cloisters and other monastic buildings, of which there are considerable remains, lay to the north of the church. The foundation was dissolved by Henry VIII.

TINTORETTO (Jacopo Robusti) (1518–1594). Italian painter who was the greatest Mannerist painter of Venice and one of the giants of late Renaissance art, was the son of Battista Robusti. a Venetian dyer *(tentore),* hence his nickname of "little dyer," *tentorello* in the Venetian dialect (It.. *tintoretto*). An early bent for drawing was noticeable, and Jacopo's biographer, Carlo Ridolfi. relates that he was apprenticed to Titian. who after ten days dismissed him from the studio because he did not like the boy's drawing methods. The effect upon the lad was dismaying in the extreme. and in later years there was never any cordiality between the two men, although Tintoretto. ever the conscious professional, sedulously collected works by Titian. Ridolfi says that after the expulsion Tintoretto was self-taught by means of studies from life and from casts after the antique. Michelangelo and Sansovino, and that he evolved his style as a conscious synthesis of Michelangelo and Titian. "Michelangelo's drawing and Titian's colour" is the motto he is said to have put on his wall. Ridolfi's story, that the young Tintoretto haunted the colour shops and sought walls upon which to work for nothing, may well be correct. Ridolfi also mentions, in passing, that Tintoretto worked with Bonifazio Veronese and Andrea Schiavone.

Attempts to reconstruct Tintoretto's earliest works remain unconvincing. Either much later works are dated too early, or the works of others are confused with his early manner. An "Apollo and Marsyas" in Hartford, Conn., has been plausibly (if not certainly) identified with a ceiling painted for Pietro Aretino in 1545. An unfinished and mostly wrecked "Christ Among the Doctors" in the Opera del Duomo, Milan, may also be put at this time, and, possibly, an altarpiece with "Three Male Saints" in the former cathedral at Korcula, Yugos.

The first certain work is the "Institution of the Eucharist," signed and dated 1547, on the north wall of the chancel of S. Marcuola. In this work are the hallmarks of Tintorettos style: consummate draftsmanship; brilliant brushwork, in which the brushstrokes in broken colour are made into a decorative as well as a functional pattern (an innovation of Tintoretto's); a sensitive use of colour and light for dramatic emphasis; and a conscious borrowing from the antique.

The young man's reputation was made by his obtaining the commission for the "Miracle of the Slave," done for the Scuola di S. Marco in 1548. The work is lucidly composed and brilliantly painted with an emphasis upon colour, sun and shade, texture and dramatic cogency. There are evidences of his awareness of other painters, Paris Bordone for one. and Cecco di Salviati for another, from whose works in S. Giovanni Decollato, Rome, he seems to be copying. This may be taken as internal evidence of a trip to Rome for which no direct evidence is available. In 1549 Tintoretto completed an "Apotheosis of St. Marziale" for the church of S. Marziale. This work shows Tintoretto's a areness of some of Michelangelo's Sistine chapel figures (more evidence to support a putative Roman journey), Raphael's "Sistine Madonna," which he could have seen in Vicenza, and the "Assumption" which Titian had painted for the high altar of the Frari in Venice. The canvas is, however, no mere pastiche but, rather, a simple and heroic work. In 1549 Jacopo also received a major commission for the church of S. Rocco, the large horizontal decoration of "St. Rocco Visiting the Plague-Stricken." This work carries forward the brilliant invention of the S. Marco picture and the technical distinction of the S. Marziale canvas. In it he introduces a nocturnal scene with as much mastery as Raphael had shown in his Vatican decorations.

Tintoretto's reputation and financial position were now secure, and in 1550 he married Faustina de' Vescovi, the daughter of a Venetian banker. The couple occupied a house on the north side of Venice near the church of the Madonna dell'Orto, Tintoretto's home parish.

In 1552 Tintoretto executed a masterly pair of canvases for the Magistrato del Sale, "SS. Andrew and Jerome," and "SS George and Louis and the Princess." These works are brilliant in tonality and execution, and in construction Jacopo anticipates the baroque in his broken picture surface with pictorial elements thrust out at the spectator. In the same year he executed in the simplest terms and cheapest pigments the organ shutters for Sta. Maria del Giglio. These works show his most glittering brush technique and again borrow from the Sistine ceiling. Between 1550 and 1553 he executed a cycle of "Creation" for the Scuola della Trinità. in which his bravura style is slightly modulated by a note of elegiac poetry, especially in his treatment of landscape.

By 1556 Tintoretto completed the organ shutters for his home parish of the Orto. showing on the front "The Presentation of the Virgin" (with reminiscences of Sebastiano del Piombo, and, more surprisingly, of Lotto's "Presentation" in Bergamo, even to the point of a similar colour scheme). "St. Peter's Vision of the Cross" and the "Death of St. Andrew." These show his varied ingenuity of design and. more important, his narrative ability. They also show early evidence of the hands of helpers. In 1559 he painted the "Miracle of the Paralytic" for the church of S. Rocco. This design he adjusted, Ridolfi says, to that of the Pordenone work opposite, and this fact may account for the crowding of forms and colours and the increased mannerist emphasis.

Tintoretto began his long association with the Scuola di S. Rocco in 1564. As a building it is deficient in natural illumination, so that it required brilliant tonalities in its decoration and careful placement of the pictures. A competition was announced, and four of the five who were invited to compete presented sketches on the appointed day, while Tintoretto. who had contrived to have his full-sized work installed in place, uncovered a finished piece. to the fury of some members of the governing confraternity. Tintoretto then presented the picture to the *scuola,* aware that its constitution forced it to accept all offered gifts. Thus. Tintoretto began an association to last the rest of his life. In 1577 he contracted to deliver three pictures a year for 100 ducats. and by the end of his life he had received almost 2,500 ducats.

The work of 1565 was the "Crucifixion." in which the painter is seen at his most awe inspiring. showing unparalleled brilliance of invention and execution, but reflecting various celebrated, works, including the statue of Bartolommeo Colleoni of Verrocchio and the Gattamelata of Donatello. Of this work John Ruskin observed that it "is beyond all analysis and above all praise." The other works for the confraternity, which continued for 30 years. are of the greatest variety of design and concept, and certain of them, such as the "Temptation," with its borrowings from the Grimani marbles and dazzling bravura execution, almost blind the spectator to the fact that Tintoretto is perhaps as great a storyteller as Giotto, and that as an analyst of human motivation he is without equal.

In the 1560s Tintoretto also carried out three more works for the Scuola di S. Marco, the "Finding of St. Mark's Body" (Milan), the "Theft of St. Mark's Body" and the "Saving of the Saracen at Sea" (both Venice). These display Tintoretto's technique at its best, with an unsurpassed integration of architecture and figures, and an atmospheric presentation the equal of anything in El Greco. To these years also belong the first works for the ducal palace. This set of commissions occupied Tintoretto till 1594 and his studio still longer. The work became especially heavy after the fire of 1577 when the bulk of the commissions for a few years were distributed between Tintoretto and his colleague and intimate friend, Veronese. These commissions included such large set pieces (machines) as the "Excommunication of Barbarossa," the "Capture of Zara" (1584–87), the "Glorification of N. Da Ponte" (1581–84), "Venice. Queen of the Seas," and the last large work, the "Paradise" (1588) (which was to have been done by Veronese, who died before he could accept the commission) and such decorative masterpieces as the "Bacchus and Ariadne" and its three pendants.

Tintoretto died on May 31. 1594, and was buried in the Madonna dell'Orto next to his favourite child, Marietta, who had died about four years earlier. Tintoretto left his son Domenico. a most accomplished painter, in charge of the studio, as well as another painter-son, the brilliant and apparently erratic Marco, and his son-in-law, Sebastiano Casser, who kept the studio open till 1627. Among other students and helpers were Martin de Vos, Leonardo Corona and Andrea Vasilacchi called l'Aliense.

A basic problem with Tintoretto is that the works which he executed for patrons outside of Venice were almost always done by studio members. Even work in Venice shows strong traces of helpers. especially in the later years. He seems to have felt a curious indifference about the final execution of a great amount of his studio's work. This in itself relates to the methods of the studio. Though a vast store of drawings still exist which came from the studio and the master himself, there are almost no sketches by him; indeed, the only absolutely certain ones are a large one in Paris and a small one in Providence, R.I. Apparently Tintoretto outlined his compositions through the use of an illuminated shadow box with small modeled figures set behind a grid of string. If it were an out-of-town commission, he then would have members of the studio finish it, even though he might add some finishing touches of his own. This procedure accounts for the uncanny brilliance of certain designs and the rather inferior quality of the finish of the same pictures, such as the Dresden "Arsinoe." which is surely Tintoretto's invention and almost just as surely Aliense's execution. The same thing seems to be true of the "Bacchus and Ariadne," "Three Graces," "Minerva and Mars" and "Forge of Vulcan" in the ducal palace which are certainly Tintoretto's design and concept, but which must have been largely executed by his son Domenico.

The case of the portraits is even more extreme. Except for a very few which are surely autographic the calibre is not what one would expect. His two great self-portraits (1548 and 1590/94) show a degree of penetration and distinction which looks straight to the romantics. Certain others, the "Senator" (Eastman house, Rochester, N Y.) and the "Andrea Capello," one of the most awe-inspiring images of a sick man ever painted (Venice), rank with the greatest portraits of the 16th century. The usual portraits from the studio, however, are dull, even though the brilliant and difficult Marco has been accounted in his own day as a fine portraitist.

The Venetians said in Tintoretto's own day that he had three styles, one of gold, one of silver and one of iron. This obviously refers to the quality and autographic extent of execution as much as to matters of tonality. The sobriquet *il Furioso* summarizes his capacities but it does not indicate their full extent. The various versions of the "Last Supper" in Venice (S Giorgio, S. Marcuola, S. Polo, Scuola di S. Rocco, S. Simeone. S. Stefano and S. Trovaso), like the "Annunciation" in Scuola di S. Rocco, were at times criticized for their frenzy and sometimes for their unbiblical character. This latter censure is undiscerning, as Tintoretto seldom sought to be merely a historical narrator. Rather, he usually

ALINARI

"BACCHUS, WITH ARIADNE CROWNED BY VENUS" BY TINTORETTO. IN THE SALA DELL' ANTICOLLEGIO. DUCAL PALACE. VENICE

gives a good bit of theological exegesis. For example, the "Annunciation" is more than an illustration of the Gospel; it also is a commentary upon the Virgin as the new Eve. The "Last Supper" in S. Giorgio shows the light shining in darkness and epitomizes the new dispensation, just as its pendant, the "Fall of Manna," shows shadows upon a field of light and symbolizes the old dispensation.

Together these pictures can only properly be seen by the celebrant at Mass for whom they form pendants to a continuing mystery, just as the personages in the Orto "Presentation" may be taken to symbolize the Old and New Testaments.

Tintoretto is the major figure of the Mannerist epoch in Venetian painting. In his work amazing intimations of the baroque are fully visible. He is a perfect exemplar of the method and theories of the Counter-Reformation as it evolved in Venice. He also is probably the greatest dramatic decorator of western painting. His work is almost impossible to see outside of Venice, for prime examples of it are rare, and works given to him outside his native city are shop productions of variable interest. The works in Venice have all darkened, some of them disastrously. This is partly, as Goethe shrewdly noted, because of Tintoretto's fondness of using a dark priming on his canvas without preliminary heightening with white, and it is partly the result of dirt and bad varnish. The evidence indicates that when his great works were new they owed much to the technique of fresco painting, at which he was adept in his youth. Also the technique paralleled that of the scene painter. When one adds the bad light which prevails for most of Tintoretto's work still in place, the resulting image is far from clear, and Tintoretto's position as a great and epoch-making colourist seems hard to understand. If the viewer will try to recall the purposes, both theological and dramatic, for which these works were done, and if he will try to visualize their vanished pristine state, he then, perhaps, can get some inkling of the true stature of Tintoretto.

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TIPASA, a town and commune on the coast of Algeria, in the *département* of Alger, 30 mi. W. of the capital. Pop. (1954 census) 671 (town); 6,210 (commune). The modern village, founded in 1857. is a favourite tourist spot, with Roman and Byzantine ruins (the former are more interesting), and summer resort with its beach and pleasant situation, facing across a bay the small summer resort of Chenoua Plage at the foot of the impressive Chenoua mountain.

The Roman ruins are on the western edge of the town. Mosaics of artistic interest may still be excavated. The Byzantine ruins are just to the east of the town. Of the houses. few traces remain, but there are remains of three churches, two cemeteries, baths, theatre, amphitheatre and nymphaeum.

Tipasa was founded by the Phoenicians, was made a Roman military colony by the emperor Claudius and afterward became a municipium. Christianity was early introduced, and in the 3rd century Tipasa was a bishop's see. In 484 the Vandal king Huneric (477-484) sent an Arian bishop to Tipasa; whereupon a large number of the inhabitants fled to Spain, while many of the remainder were cruelly persecuted. After this time the city disappears from history.

See S. Gsell, *Promenades archéologiques aux environs d'Alger* (1926), *Les Monuments antiques de l'Algérie*, 2 vol. (1901), and *Atlas archéologique de l'Algérie* (1911).

TIPPERA, a district in the Chittagong division of East Pakistan. Area, 2.531 sq.mi.; population (1951) 3,797,310. The administrative headquarters are at Comilla, pop. (1951) 47,195. The district has a fat and open surface, with the exception of the isolated Lalmai hills (100 ft.), and is for the most part laid out in well-cultivated fields! intersected by many rivers and creeks.

The principal rivers are the Meghna, or estuary of the Brahmaputra, Gumti, Dakatia and Titas.

TIPPERARY, a county of Ireland in the province of Munster, bounded northwest by Galway, northcast by County Offaly, east by Leix (Laoighis) and Kilkenny. south by Waterford and west by Cork. Limerick, Clare and Galway. Tipperary is the sixth in size of the Irish counties, having a land area of 1,051,292 ac. or 1,642.6 sq.mi. Pop. (1956) 129,415. The northern and western parts of the county are flat and generally fertile. with a group of prosperous market towns including Nenagh, Thurles and Tipperary; the southern portion. along the Suir valley, is also fertile and includes Clonmel. The central part of the county consists mainly of the Galtee mountain range. Sandstone heights stand out above the limestone plain; the Knockmealdown mountains on the southern border reach an elevation of 2.597 ft.; to the north are the Galtee or Galty mountains (Galtymore 3.018 ft.); to the east. bordering Kilkenny. are the Slieveardagh hills, and near Templemore the Devil's Bit mountains (1,577 ft.) with a curious gap on the summit; in the northwest is Keeper hill, 2,278 ft. The folded character of the Carboniferous Limestone is seen in the anticlinal boss on which stands the acropolis of Cashel. The Suir has its source in the Devil's Bit mountains? and flows southward and eastward by Templemore, Thurles. Cahir and Clonmel. The Nore, which also rises in the Devil's Bit mountains, soon passes into County Laoighis and the Shannon forms part of the western border. The Mitchelstown stalactite caverns, in the extreme southwest of the county. were discovered accidentally in 1833 and explored by M. Martel in 1895. The subsoil in the loner grounds is limestone: which is overlaid by a rich calcareous loam. The Golden vale. the most fertile district in Ireland. stretches from Cashel to the town of Limerick. There is some mining, and anthracite mines at Ballingarry have been reopened. The lead ore mined for many centuries at Silvermines south of Nenagh is silver bearing and is associated with zinc blende. Indications of ore have been traced along the junction of the limestone with the older rocks. Good slates are quarried in the Silurian area in Clashnasmuth townland on Slieve-na-Man. The county has a considerable number of meal and flour mills. It has benefited considerably from the electric power stations built along the lower Shannon.

Tipperary is one of the counties generally considered to have been formed by King John in 1210; in 1328 Edward III made it a county palatine in favour of the earl of Ormonde. In 1372 the grant was confirmed to James Butler, earl of Ormonde, the lands belonging to the church retaining, however, a separate jurisdiction and being known as the county of Cross Tipperary or the Cross of Tipperary. The Protestant see of Cashel was in 1833 united with those of Emly. Waterford and Lismore. The Roman Catholic see of Cashel, with its seat at Thurles. is an archbishopric, comprising the dioceses of Cashel and Ernly. It has eight suffragan dioceses, in Cloyne, Cork, Kerry, Killaloe, Limerick, Ross, Waterford and Kilfenora.

From the 19th century County Tipperary has been prominently connected with the revival of traditional sports and games, especially through the Gaelic Athletic association. It was the scene of the abortive Young Ireland insurrection in 1848. which collapsed at Ballingarry. and later it was an active centre of the Land league and of the Sinn Féin conflict with British forces prior to the treaty of 1921. The administrative counties of Tipperary North Riding and Tipperary South Riding together return seven members to *dail eireann.*

TIPPERARY, a town of County Tipperary, Ire., near the Slieve-na-&luck or Tipperary hills. a branch of the Galtee range, 113 mi. S.W. of Dublin by road. Pop. (1956) 4,790. Its butter market ranks next to that of Cork. Condensed milk is manufactured. The town first acquired importance through the erection of a castle by King John. of which there are no remains. A monastery founded for Augustinians by Henry III gave a second impulse to its growth. The gatehouse is all that remains of this foundation. Formerly Tipperary was a corporation from a grant made in 1310 by Edward II. New Tipperary was founded outside the town in 1890.

TIPTON, a municipal borough in the Rowley Regis and Tipton parliamentary division of Staffordshire. Eng., 4 mi. S.E. of Wolverhampton. Pop. (1951) 39.382. Area 3.4 sq.mi.

The modern town sprang up around Tibbington, mentioned in Domesday, and the parish registers, dating from 1513, are the oldest in England. The borough was incorporated in 1938. The industries include engineering, iron founding, the making of electrical appliances and many more. The borough has 12 mi. of canals and 7 railway stations.

TIPU SAHIB (1750–1799), sultan of Mysore, son of Hyder Ali (*q.v.*). was born in 1750. He was instructed in military tactics by French officers in the employment of his father. In 1767 in the invasion of the Carnatic he commanded a corps of cavalry and fought against the Marathas on several occasions between 1775 and 1779.

On the outbreak of the second Mysore War in 1780 he mas put at the head of a large body of troops and defeated Brathwaite on the banks of the Coleroon in Feb. 1782. He succeeded his father in Dec. 1782, and in 1784 concluded peace with the British and assumed the title of sultan. He subjugated the Nairs of Malabar in 1787-88 and in 1789 provoked British invasion by ravaging the territories of the rajah of Travancore. When the British entered Mysore in 1790. he retaliated by a counterinvasion, but was compelled by Cornwallis' victory near Seringapatam to cede half his dominions (March 16, 1792). When the British renewed hostilities in March 1799 he was shut up in Seringapatam and killed during the storming (May 4, 1799).

TIRADENTES (JOAQUIM JOSÉ DA SILVA XAVIER) (1 748–1792), Brazilian patriot and martyr, was born at Pomhal, Minas Gerais. With indifferent results he tried a number of professions, including dentistry, from which he derived his sobriquet "tooth puller" (*tiradentes*). Enlisting in the Portuguese army, he rose quickly to the rank of lieutenant of the cavalry but was unable to gain further promotion.

In 1788 he took a prominent part in a conspiracy. the so-called *Conjuração mineira,* inspired partly by the example of the United States and aiming at Brazilian independence from Portugal. Betrayed the following year, the leaders of the plot were arrested and tried. Tiradentes was executed: the others were exiled. Three decades later. after Brazil gained independence, Tiradentes became a national hero.

Tiradentes appears to have been motivated by a combination of personal and patriotic aims: frustration in his career and resentment against the advantages enjoyed by Portuguese-born officials, as well as a desire to end Portuguese domination so that Brazil's great wealth might be employed for the benefit of the Brazilian people' His political ideas were poorly defined hut he anticipated future developments nith his call for the abolition of slavery, improved educational opportunities and social assistance to large families. (R. E. P.)

TIRAH, a mountainous tract on the Afghanistan-Pakistan frontier, west of Peshawar, West Pakistan. It lies between the Khyber pass and the Khanki valley and is inhabited by the Afridi and Orakzai tribes. It is chiefly notable as the scene of the Tirah campaign of 1897–98. It is a cul-de-sac in the mountains, lying off all the roads into Pakistan, comprises an area of between 600 and 700 sq.mi. and includes the valleys lying round the source of the Bara river. The five chief valleys are Maidan, Rajgul, Waran, Bara, Mastura. The chief passes are Sampagha pass (6,500 ft.), separating the Khanki valley from the Mastura valley; the Arhanga pass (6,995 ft.), separating Mastura valley from Maidan; Saran Sar (8,650 ft.), leading from the Zakka Khel portion of Maidan into the Bara valley; the Tseri Kandao (8,575 ft.), separating Maidan from the Waran valley; and the Sapri pass (5,190 ft.), leading from the east of the Mastura valley into the Bara valley in the direction of Mamanai.

Tirah Campaign. — This was an Indian frontier war in 1897–98. The Afridis had for 16 years received a subsidy from the Indian government for safeguarding the Khyber pass, and the government had maintained for this purpose a local regiment composed of Afridis. Suddenly, however, the tribesmen rose, captured all the posts in the Khyber held by their own countrymen and attacked the forts on the Samana ridge near Peshawar. It was estimated that the Afridis and Orakzais could, if united, bring from 40,000 to 50.000 men into the field.

The general commanding the Tirah expedition was Gen. Sir William Lockhart, commanding the Punjab army; he had under him 34,882 men, British and Indian, in addition to 20,000 followers. The frontier post of Kohat was selected as the base of the campaign, and it was decided to advance along a single line. On Oct. 18 the operations commenced. The Dargai heights, which commanded the line of advance, were captured without difficulty, but abandoned because of lack of water. On Oct. 20 the same positions were gallantly stormed by the Gordon highlanders and 3rd Sikhs, with a loss of 199 killed and wounded. The progress of the expedition, along a wretched track through the mountains, was obstinately contested on Oct. 29 at the Sampagha pass leading to the Mastura valley, and on Oct. 31 at the Arhanga pass from the Mastura to the Tirah valley. The force, in detached brigades, then proceeded to traverse the Tirah district in all directions and to destroy the fortified hamlets of the Afridis. The two divisions available for this duty numbered about 20,000 men. A force about 3,200 strong, commanded by Brig. Gen. Richard Westmacott, was first employed to attack Saran Sar, which was easily carried, but during the retirement the troops were hard pressed. On Nov. 11 Saran Sar was again attacked by the brigade of Brig. Gen. Alfred Gaselee. The traversing of the valley continued, and on Nov. 13 Brig. Gen. F. J. Kempster's brigade visited the Waran valley via the Tseri Kandao pass. On Nov. 16, during the return march, the rear guard was hotly engaged all day and had to be relieved by fresh troops next morning. The casualties numbered 72. Almost daily the Afridis, too wise to risk general engagements, waged a guerrilla warfare. On Nov. 21 a brigade under Brigadier General Westmacott was detached to visit the Rajgul valley. The road was exceedingly difficult and steady opposition was encountered. The last important work undertaken was the punishment of the Chamkannis, Mamuzais and Massozais. This was carried out by Brigadier General Gaselee, who joined the Kurram movable column ordered up for the purpose. The Mamuzais and Massozais submitted immediately, but the Chamkannis offered resistance on Dec. 1 and 2. The Kurram column then returned to its camp, and Lockhart prepared to evacuate Tirah, dispatching his two divisions by separate routes — the 1st under Maj. Gen. W. Penn Symons to return via the Mastura valley, destroying the forts on the way, and to join at Bara, within easy march of Peshawar; the 2nd division under Maj. Gen. Yeatman Biggs, and accompanied by Lockhart, to move along the Bara valley. The base was thus to be transferred from Kohat to Peshawar. The return march began on Dec. 9. The cold was intense. The movement of the 1st division, though arduous, was practically unopposed, but the 40 mi. to be covered by the 2nd division were contested almost throughout. The actual march down the Bara valley (34 mi.) commenced on Dec. 10 and involved four days of the hardest fighting and marching of the campaign. The road crossed and recrossed the icy stream, while snow, sleet and rain fell constantly. On the 10th the casualties numbered about 20. On the 11th about 50 or 60 casualties were recorded among the troops, many followers were killed or died of exposure and quantities of stores were lost. On the 12th the column halted for rest. On the 13th the march was resumed in improved weather, though the cold was still severe. The rear guard was heavily engaged and the casualties numbered about 60. On the 14th, after further fighting, a junction with the Peshawar column was effected. The 1st division, aided by the Peshawar column, then took possession of the Khyber forts without opposition. Negotiations for peace were begun with the Afridis, who at length agreed to pay fines and to surrender the rifles demanded. The expeditionary force was broken up on April 4, 1898.

See C. E. Callwell, *Tirah* (1911) ; H. D. Hutchinson, *The* Campaign in *Tirah (1898).* (C. J. B.; X.)

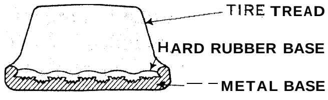
TIRANE (Alb. TIRANË), the capital of Albania, lies at the southern end of the fertile plain of Kruje, 20 mi. inland from the Adriatic coast, on the Ishm river. It is beautifully situated at the foot of the wooded highlands. It was founded early in the 17th century by a Turkish general, Barkinzadeh Suleiman Pasha. At the beginning of the 20th century it had about 15,000 inhabitants; nearly three-quarters of the total were Moslem, the remainder being Orthodox or Roman Catholic. In 1955 the population was 108,183.

Tirane was chosen as capital of independent Albania in 1920 by a congress of Albanian patriots held at Lushnja. Under the reign of King Zog I considerable new quarters were built by Italian architects with government offices around Skanderbeg square. The biggest of the city's many mosques is the Haji Ethem, completed in 1821. Tirane was occupied by Italy in April 1939, at which time it had about 35,000 inhabitants, and was recovered by the Albanians from the Germans on Nov. 17, 1944. On Jan. 11, 1946, a people's republic was proclaimed there. New residential districts were built and about 20 factories erected by Russian specialists. In 1950 a hydroelectric power station was completed nearby, supplying the capital with electric power and water. In 1951 Tirane was linked by rail with the port of Durazzo (Durres). In addition to elementary and secondary schools, there are vocational schools and six institutions of higher education. There are also four museums, a national theatre and a concert hall.

TIRARD, PIERRE EMMANUEL (1827–1893), French politician, was born at Geneva, Switz., on Sept. 27, 1827. Elected mayor of the 2nd *arrondissement* in 1870 and representative of the Seine *département* in the national assembly in Feb. 1871, he withdrew to Versailles after the outbreak of the Commune. In 1876 he was returned for the 1st *arrondissement* of Paris to the chamber of deputies. He held office in a series of ministries between 1879 and 1885, and when Sadi Carnot became president of the republic in 1887 he asked Tirard to form a ministry. His refusal to proceed to the revision of the constitution of 1875 led to his defeat on March 30, 1888. He returned to power the next year, but resigned on March 15, 1890, on the question of the Franco-Turkish commercial treaty. He replaced P. M. Rouvier in the A. F. J. Ribot cabinet (1892–1893) as minister of finance, and died in Paris on Nov. 4, 1893.

TIRE. The tire of a wheel is the outer circumference portion that rolls on the ground or on a track prepared for it. Railway vehicle wheels usually have hard steel tires, which together with the hard steel rail give high endurance and low rolling resistance. The common tire for the exterior rim of nonmotor road vehicles which serves to hold together the parts of the wheel is ordinarily made of steel or iron in the form of a flat hoop fitted tightly over the exterior of the wheel. Its chief attributes are strength, durability and resistance to wear. On airplanes, bicycles, automobiles and other motor-driven vehicles in which freedom from shock is sought, pneumatic rubber tires are almost universally used. Solid rubber tires are employed mostly on industrial trucks for use in warehouses and factories.

The principle of the pneumatic tire was patented by Robert William Thomson in England in 1845, in France the following year and in 1847 in the United States. Thomson's patent substantially covers the tire as it is known today. It showed a nonstretchable outer cover and an inner tube of rubber to hold air. An early set of tires made on this basis covered 1,200 mi. when placed on an English brougham.



BY COURTESY OF THE B F GOODRICH CO
FIG. 1.—CROSS SECTION OF SOLID TIRE

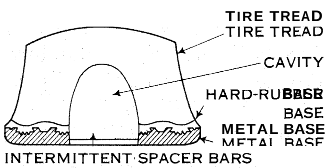
Almost half a century later, when the bicycle became popular, pneumatic tires were revived by John Boyd Dunlop of Belfast, Ire. He obtained patents in England in 1888 and 1889 on bicycle tires, which served as the foundation of the Dunlop company. This company early acquired the patents of Charles K. Welch in England (1890) and of A. T. Brown and G. F. Stillman of Buffalo, N.Y. (1892), pertaining to a method of fastening the tire by wires running through thickened edges of the fabric, engaged by a channeled metallic rim. The Brown and Stillman patent became the basis for the Dunlop company's tire business in the United States and for licences by Dunlop to other rubber companies to make wired-on tires.

In 1890 the first "clincher" tire, held in position by inwardly curved flanges of the wheel rim, was patented by William Erskine Bartlett in England, and in 1892 by Thomas B. Jeffery in the United States. The thread or cord tire was patented by John Fullerton Palmer in England and in the United States in 1893. Pneumatic tires were first applied to motor vehicles by the French rubber manufacturers Michelin and company. Rubber tires were adopted by Panhard and Levassor and other French automobile manufacturers about 1895. The first tires used in the U.S. on commercial motor vehicles were made by the B. F. Goodrich company in 1896 for Winton cars manufactured in Cleveland, O. These were single-tube tires.

TYPES OF TIRES

Rubber tires are of two types: (1) solid or cushion tires, in which the rubber portion functions to carry the load, to absorb shocks and to resist cutting and abrasion; and (2) pneumatic tires, in which the load is carried and the shocks are absorbed mainly by compressed air. The structure of the pneumatic tire is designed to provide a nonextensible but flexible cover with impermeable lining to contain and restrain the compressed air. This cover is provided with a rubber tread portion designed to withstand the cutting and abrasive wear of road contact and to protect the tire against puncture and loss of air. Such a structure has, as distinct from a solid rubber or cushion tire, no capacity in itself either to carry load or to absorb shocks. It is entirely dependent on the contained compressed air to enable it to function, and is therefore correctly named a pneumatic tire.

Solid Tires.—Introduced in 1881 on the wheels of hansom cabs in London and formerly used for many types of road vehicles, these disappeared from highways, mostly because of legislation that discouraged their use because they were hard on roads. Large sizes were supplanted by large pneumatic tires (truck and bus casings), but small solid tires came to be used extensively on industrial trucks and tractors. Some of these are made with metal base bands to which the rubber (and in some cases, rubbery polyurethan compositions) is firmly attached. (See fig. 1.) These bands are the full width of the base of the tire and are often dovetailed to secure firm anchorage of a hard-rubber layer interposed between the metal and the soft rubber constituting the main portion of the tire. Alternatively, the soft rubber may be adhered directly to the base either by means of brass plating or an adhesive layer. This type of tire is forced over the periphery of the wheel in a hydraulic press and remains fixed for the period of its life. In other cases the tire is vulcanized directly to the rim of a metal wheel instead of to a separate band.



BY COURTESY OF THE B. F. GOODRICH CO
FIG. 2.—CROSS SECTION OF SEMI-CUSHION SOLID TIRE

Cushion Tires.—There are a number of variations of the solid tire which are designed to provide greater deflection under load and increased cushioning against shocks. These objectives are attained by the use of softer rubber compounds and by insertion of cavities in the tire. (See fig. 2.)

Pneumatic Tires.—The simplest form of pneumatic tire is that known as the single-tube tire. It consists of an endless tube of rubber-coated fabric having on its inner face an impermeable rubber lining and on its outer surface a covering of rubber to protect the fabric from wet or damage, with an additional thickness of rubber on the tread portion to resist road wear. In the C.S. the use of single-tube tires for bicycles, which prevailed for many years, gradually diminished because of the difficulty in repairing them. Single-tube tires, which were discontinued for automobiles about 1900, persisted in low-speed services as on wheelbarrows and hand trucks.

The necessity for a ready means of repair resulted in tires taking the form of a separate inflatable inner tube with a detachable outer cover. Out of a multitude of types of detachable covers introduced in the early 1890s two emerged: the wired-on or straight-side type and the beaded-edge or clincher type.

The wired-on type quickly secured a dominating position in cycle tires, whereas clincher tires were used extensively for several years on automobiles but were dropped as original equipment by U.S. automobile manufacturers in 1923.

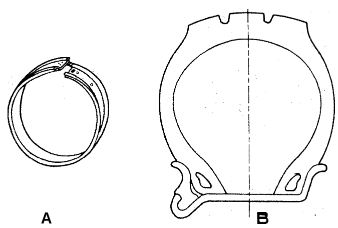
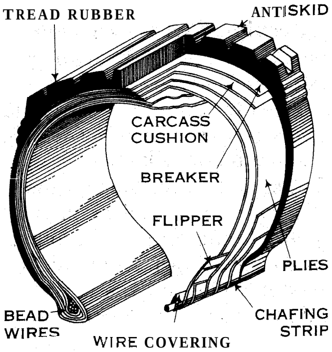


FIG. 3.— (A) TRANSVERSELY SPLIT RIM. (B) WIRED OR STRAIGHT-SIDE PNEUMATIC TIRE ON FLAT-BASE RIM WITH DETACHABLE FLANGE

With the development of pneumatic tires the design of rims also underwent change. In the U.S. the straight-side rim of the flat-base type came to be most commonly used for trucks and motor coaches. Its construction varies principally in the method of mounting the tire and in attaching the rim to the wheel. Some of these rims are made with a loose flange of a self-locking type; some have two loose flanges with a separate locking ring; and there is also the transversely split type. They all require the use of a flap or band of rubber to cover the line of contact between the beads and the rim to prevent chafing of the inner tube. For passenger-car tires. a rim, continuously used for cycle tires and known as the well-base or drop-centre rim, mas universally adopted for automobiles both in England and in the U.S. These drop-centre rims enable the tires to be very readily and easily mounted and dismounted. The method, well known to motorists may be briefly described as depressing the endless wired edge of the tire into the well of the rim at one point in its circumference, thus allowing the wired edge of the tire to be lifted over the edge of the rim at the opposite point of its circumference.

Cord and Canvas Tires.—The bodies of pneumatic tires are made universally of parallel cabled cords which are the load-supporting elements of the tire carcass. This form of fabric reinforcement replaced the square woven fabrics of earlier days in which the warp and filling were substantially equal in size and strength. In canvas tires these cross threads under flexure were abraded against each other so that tires developed failures of the carcass (the foundation structure) at low mileages. In cord tires the cords, nhich are surrounded by rubber to protect them against abrasion, are usually made of rayon or nylon. For certain kinds of service, steel cords are used. Cords in bicycle tires are usually made of cotton.

High-Pressure and Low-Pressure (or Balloon) Tires.—The superior performance of cord tires over canvas tires led to developments in which the cross sections of tires were considerably increased, and with these larger sections came the transition to tires with lower inflations to support a given load. These low-pressure (balloon) tires, with cushioning properties superior to the high-pressure tires, became standard equipment on automobiles in the United States after 1933. About 1947 U.S. manufacturers began to furnish automobiles equipped with extra low-pressure tires and to advertise the easier riding quality of cars thus equipped. The table shows the dimensions and air pressures for these three types of tires for approximately the same load-carrying capacity, 900 lb.



BY COURTESY OF U. S. RUBBER CO

FIG. [illegible] STEP-DOWN SECTION OF BALLOON PASSENGER-CAR TIRE

The designation of tire size indicates the type of tire. For example, all high-pressure tires are described by placing first the over-all wheel diameter and second the tire height in inches, thus 32 × 4 in.; in balloon sizes the tire width (sectional diameter) is placed first and rim diameter in inches second, thus 6 × 16 in.

In order to impart to vehicles stability against side sway there has been a consistent trend toward increase in the width of the rims. Thus 6 × 16 in. tires are mounted on rims measuring 4 in.

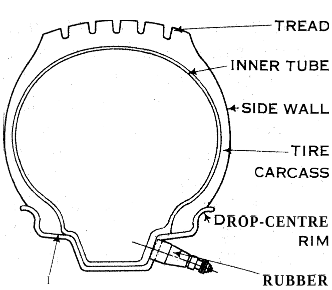
Type	Year	Size designation (in.)	Sectional diam. (in.)	Rim diam. (in.)	Rim width (in.)	Max. tire diam. (in.)	Inflation pressure (p.s.i.)
High pressure	1924	32 X 4	c. 4	24	[illegible]	[illegible]	[illegible]
Lowpressure	1936	6.00×16	6	16	4.00	28.4	[illegible]
Extra low pressure	1947	6.70×15	6.7	15	5.00	28.0	24
	1957	7.50×14	7.5	14	5.50	27.2	22

between flanges instead of 2.97 in., the width of the rims for high-pressure tires, which they superseded. All passenger-car tires are mounted on drop-centre rims. (See fig. 5.)

All rims and tire dimensions and their designations are regulated in the U.S. by the Tire and Rim association, which co-operates with similar groups in other countries with a view to establishing international standards for tire and rim dimensions.

Aircraft Tires.—Modern high-speed airplanes, particularly jet fighters, operating from hard-surfaced runways, have take-off and landing speeds in excess of 200 m.p.h. The stresses set up in the tires on landing and during braking are severe. Moreover, stowage space for the landing gear in the wings is very restricted. Tire designers have met these demands by building small tires of natural rubber tread and carcass stocks reinforced with nylon cords which operate at very high inflation pressures, in the range of 250 to 350 p.s.i. (pounds per square inch). As an example, a 26 × 6.6 tire weighing only 29 lb., inflated to 265 p.s.i. pressure, has a load-carrying capacity of 12,000 lb. and can be used on aircraft with landing speeds up to 250 m.p.h. Under average service conditions, the tread on this tire affords ten take-offs and landings. With the introduction, in 1958, of fabric-reinforced treads by B. F. Goodrich company tire designers, landing speeds up to 300 m.p.h. have been attained.

Farm Tractor and Implement Tires.—Pneumatic tires have become standard equipment on agricultural vehicles, especially in the U.S. and Great Britain. Such tires offer two definite advantages over steel tires: (1) much lower rolling resistance over soft, uneven ground permitting haulage of heavier loads with lower fuel costs; (2) ability to run directly from the farms onto public roads without the fitting of special road bands as were required with the steel tires formerly in use.



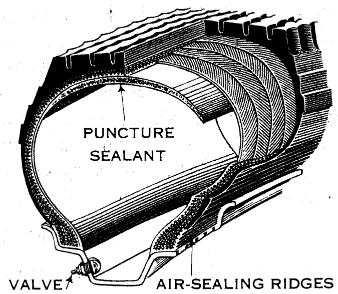
BY COURTESY OF THE B. F. GOODRICH CO.

FIG. 5.— PNEUMATIC TIRE ON WELL-BASE RIM

Off-the-Road Tires.—Most spectacular in appearance are the large pneumatic tires fitted on the earth-moving machinery used in modern road building, airport and dam construction. The larger ones stand up to 8½ ft. high and weigh about one ton apiece. They provide the necessary grip and mobility demanded by 500-h.p. scrapers that can scoop up 40 tons of earth, sand and rock in a minute, transport this load at speeds to 30 m.p.h. and redistribute it at the desired location.

Rigid Breaker Tires.—Sometimes called restricted periphery tires, these (exemplified by the X-type made by the Michelin Co. of France and used to some extent on passenger and sports cars and on trucks and buses) are characterized by extremely flexible side walls but with a tread area as rigid as a steel hoop. These characteristics, quite different from those of ordinary tires, are obtained by altering both the number and distribution of the carcass plies and by altering the angle of the cords with relation to the axis of the tire. Though textile materials can be used, the cords in X-type tires, especially those in the breaker strips, are usually of steel wire. In general, rigid breaker tires have excellent cornering power and excellent tread life in high-speed operation. At low speeds on uneven roads, these tires do not run so smoothly as conventional ones and they tend to be heavy in parking. They show to best advantage on cars which have especially designed suspension and steering systems.

Tubeless Tires.—A puncture-sealing tubeless tire, developed about 1947 and widely sold in the United States, combines a thin lining of butyl rubber as a barrier against diffusion of air into the tire casing with a layer of puncture-sealing material in the crown area. Multiple sealing ridges molded integrally with the bead are compressed against the rim flanges under inflation pressure to form an effective seal without the need for an inner tube. (See fig. 6.)



BY COURTESY OF THE B F. GOODRICH CO.

FIG. 6.— PUNCTURE-SEALING TUBELESS TIRE

Success in the use of tubeless tires led to their adoption as original equipment on the 1955 models of U.S. automobiles. These original-equipment tires were not provided with a puncture-sealant layer. The advantages to motorists of the tubeless type over the inner-tube type of tires include lower unsprung weight on the wheel assembly, less variation in static and dynamic balance, the almost complete elimination of blowout hazards and increased mileage in service. Tubeless tires also find use on airplanes and in truck and bus service.

TIRE CONSTRUCTION

See Rubber: Production and Manufacture for materials used in the industry.

Casings.—The assembly of pneumatic tires consists of a series of steps: the preparation of the cord material, either from viscose rayon (Tyrex) or nylon yarns by twisting (doubling) into cords and in some cases by weaving them into cord fabric; the application of a suitable adhesive treatment to the cords, usually an aqueous dispersion of resins and rubber; drying; and calender coating the cord fabric on both sides with a thin coat of rubber composition at the calender rolls. These rubberized strips are then cut into bias strips of suitable widths and brought to building machines on which the casing is built up, and the wire rings (bead wires) which retain the finished tire upon the rim are enclosed within the edges of the casing. Various parts of rubberized fabric and rubber are added in the form of chafing strips, filler strips, rubber insulation plies and fabric breaker strips, and finally the tread and side-wall coverings are added with care to exclude trapped air or other inclusions between any of the plies. The early practice of building this structure over a core of approximately the finished shape of the tire was generally discontinued.

In the second half of the 20th century tires were built in the form of wide, flat endless bands which, before vulcanization, were subjected to a shaping process either by producing a vacuum outside the band in a forming box or by applying pressure against the inner surface of the band. The tires thus formed may be mounted on expansible rubber bags and placed in steel molds for vulcanization.

For many years it was common practice to stack the molds containing the tires one above another on a hydraulic ram inside a vertical cylindrical steam-pressure vessel. After the cover of the vessel was closed the ram was raised, forcing the halves of the molds tightly together around the tires, and heat was supplied by steam outside the molds while the bags inside the tires were expanded with air, steam or hot water or combinations of them.

Hot water or steam furnished heat from the inside in addition to that supplied by the steam surrounding the molds In some factories the tires and their enclosed bags were each placed and cured in individual, steam-jacketed molds. In later practice the enclosed bags were eliminated entirely by the use of a curing press in which is provided a cylindrical diaphragm (bladder) of special rubber which is inflated by steam to conform the tire casing to the mold during the cure.

This process of vulcanization under pressure results in the molding of the tire into its finished form, uniting all parts firmly, and produces within the rubber mass certain reactions between the rubber and the sulfur and other ingredients which have been previously incorporated in the rubber, resulting in a tough and durable product.

Inner Tubes. — These are to hold the air inside the tire casings. The early practice of vulcanizing straight tubes on cylindrical mandrels and afterward splicing their ends together was abandoned in favour of vulcanization in circular, steam-jacketed molds while the rubber is expanded by air or steam against the mold surface. All tubes are, of course, fitted with nonreturn valves.

Metal valve stems, once universally used, were largely supplanted by flexible rubber stems with metal inserts. Inner tubes are made 15% to 20% smaller in volume than the casings into which they fit. When inflated they expand to fill the inside of the casings. Most inner tubes are made of butyl rubber because it has unusual resistance to air diffusion.

FUNCTION OF TIRES

Cushioning. — When a tire strikes an obstacle protruding above the road surface, the road and the tire both experience shocks, shock impact to the road and shock reaction to the vehicle. In the case of steel-tired wheels or even with solid rubber-tired wheels, these shock reactions are severe at any ordinary speed because the vehicle tends to ride up over the rough spots .in a road. But pneumatic tires, especially the Ion--pressure type. have a high degree of compliance, which is unique, and they cushion the ride by enveloping the road inequalities, permitting the high-speed travel common in the second half of the 20th century.

Avoidance of Slipping. — Depending on the material and smoothness of road surfaces and on weather conditions, the coefficient of friction between tires and road may range widely—from 0.02 to 0.70. Nonskid designs are formed on treads during the vulcanization process when inflation inside the tires expands them against an engraved mold presenting the desired design in reverse. The designs most effective in preventing slipping and skidding on wet. hard surfaces are those that nipe the water from the highway under the tread, permitting the rubber to grip a nearly dry surface. On dirt roads traction and steadiness are enhanced by deformation of the road material as it sinks into depressions in the tire tread. This condition is encountered with farm tractors that are used over plowed ground. Tires for such equipment and snow tires for automobiles are consequently made with sturdy, thick crossbars of rubber.

Cornering Power, Cushioning and Durability. — Directive control of an automobile driven at the prevailing speeds can be achieved sdequately by no other mechanism than the pneumatic tire. The "roadability" of the modern motor vehicle is dependent upon cornering power, the lateral force directed at each In- stant at right angles to the path of travel of the tire and vehicle. Steel-shod wheels, for example, slip and slide if maneuvered at relatively high speeds.

Factors that contribute to the cornering power (sidenise push of the tire against the roadway) of tires are the camber of the wheels, the radial load, the speed, the inflation, rim width, tire size and cord angle. The cushioning properties and durability of tires are also of importance because of considerations of comfort and cost. In the design and construction of tires the elements contributing to cornering power, cushioning and durability have to be reconciled by compromise because they are to a large degree antithetical.

At one time the useful life of tires was limited by failure of the fabric in the carcass. After about 1930 the carcasses of tires usually outwore the tread even though the durability of treads had been greatly improved. The practice of retreading or of recapping tires, often advantageous, was of strategic importance during the years of World War II. Truck tire carcasses of rayon or nylon cord proved remarkably durable and were able in some instances to wear out the original and two or more recapped treads in highway service. In recent years the use of nylon cord in replacement tires for passenger cars has become widespread. The use of natural rubber for truck, bus and airplane tires is standard practice because of its low hysteresis; but smaller-size tires for passenger cars are mostly made of SBR (styrene-butadiene rubber), especially in the U.S. Adoption of the newer oil-furnace carbon blacks (grades HAF and ISAF) in tread compounding has greatly improved abrasion resistance, and some of the newer synthetic rubbers, notably cis-1,4-polybutadiene, promise further improvements in tread durability.

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(W. H. P.; J. W. Sc.; H. L. Tl.; E. B. Nn.)

TIREE, an island of the Inner Hebrides, Argyllshire, Scot. Pop. (1951) 1,216. Area (including Skerryvore) 29.5 sq.mi. It lies 2 mi. S.W. of Coll; its length from northeast to southwest is nearly 12 mi.; its breadth varies from $\frac{3}{4}$ mi. to 6 mi, Between Coll and Tiree lies the Isle of Gunna. Tiree is composed of rocks of Lewisian gneiss mostly covered with blown shell sand (machair). Ben Hynish (460 ft.) is its highest point. The machair, when dressed with cobalt, makes fertile arable land. Clydesdale horses are bred on the island. Green-spotted pink marble is mined. The vast beaches and the lakes, especially Loch Bhasapoll, attract thousands of ducks! terns and other birds on migration. Steamers from Oban call regularly at Scarinish and there is a daily air service from Glasgow. Skerryvore lighthouse, on a lonely rock in the Atlantic about 12 mi. S.W., was completed in 1844.

TIRIDATES or TERIDATES, a Persian name, given by Arrian in his Parthica (preserved by Photius, cod. 58, and Syncellus, pp. 539 ff.) to the brother of Arsaces I, the founder of the Parthian kingdom, whom he is said to have succeeded. But Arrian's account seems to be quite unhistorical (cf. PARTHIA).

The king commonly called TIRIDATES II was set up by the Parthians against Phraates IV in 32 B.C., but expelled when Phraates returned with the help of the Scythians (Dio Cass., vol. li, p. 18; Justin, vol. xlii, pp. 5 ff.; cf. Horace, Od., vol. i, p. 26). Tiridates fled to Syria, where Augustus allowed him to stay, but refused to support him. During the next years Tiridates invaded Parthia again; some coins dated from March and May, 26 B.C., with the name of a king Arsaces Philoromaios. belong to him; on the reverse they show the king seated on the throne, with Tyche stretching out a palm branch toward him. He was soon expelled again, and brought a son of Phraates into Spain to Augustus. Augustus gave the boy back to his father, but declined to surrender "the fugitive slave Tiridates" (Justin, vol. xlii, p. 5; Dio, vol. liii, p. 33; cf. *Mon. Ancyr.*, 5:54; in vol. li, p. 18, Dio wrongly placed the son's surrender in 30 B.C.).

TIRIDATES III, grandson of Phraates IV, lived as a hostage in Rome and was educated there. When the Parthians rebelled against Xrtabanus 11 in A.D. 35, they applied for a king to Tiberius, who sent Tiridates. With the assistance of L. Vitellius, Tiridates entered Seleucia. but could not maintain himself long (Tacitus, *Ann.*, vol. vi, pp. 32 ff.; Dio Cass., vol. lviii, p. 26). (ED. M.)

TIRLEMONT (Flemish THIENEN), a town in the province of Brabant, Belg., 11 mi. S.E. of Louvain. Pop. (1947) 22,383. It still preserves its enceinte, 6 mi. in circumference. The principal church, Our Lady of the Lake, begun in the 12th century and enlarged in the 15th, is still unfinished. The church of St, Germain, also 12th century, contains a fine altarpiece by Wappers.

TIRMIDHI (ABU ISA MOHAMMED IBN ISA UT-TIRMIDHI) (d. 892), Arab traditionalist, was born at Tirmidh on the Jihun. He travelled through Khurasan, Iraq and Hejaz. His *al-Jami us-Sahih* (published at Bulaq, 1875) is one of the six canonical collections of traditions. He included every tradition that had ever been used to support a legal decision. He also wrote the *Kitab ush-Shamail* (printed at Calcutta, 1846) on the character and life of Mohammed.

TIROL or TYROL, a province of Austria, 135 mi. long, with an average width of 35 mi. and an area of 4,882 sq.mi. It is wholly alpine and consists of the basin of the Inn river together with the upper Lechtal.

Physiography. — The province includes three east-west belts — the North Tirolean Alps, the Inn valley and the northern slopes of the Central Alps. The northern ranges and the Lechtal constitute a limestone region characterized by jagged skylines, deeply cut valleys and high plateaus. It is a barren, unproductive and thinly populated region. The Inn from Landeck to Innsbruck follows the lithological boundary between the limestone regions and the crystalline band of the Central Alps. East of Innsbruck the southern highlands are of shales and slates, and the *Almen* provide rich pastures. The river finally cuts north through the limestone country at Kufstein, having traversed from Landeck a sheltered and agriculturally rich valley nearly 100 mi. long and averaging a mile broad. The river is incised in a rather flat floor bordered by terraces which are intensively cultivated, both wheat and maize growing well. There are also many orchards. An almost continuous line of village settlements runs along the middle terraces where soil and drainage are good; they are above the winter fogs, receive abundant sunshine and enjoy the benefit of the *Fohn* winds (43 days, average at Innsbruck).

On the crystalline hills south of the valley, life is of the classical alpine type, based on cattle rearing and dairying with transhumance. The highest part of Tirol lies south of the Inn, along the ridge of the Central Alps — the Ötztal Alps (Wildspitze. 12,382 ft.), the Stubai and Zillertal Alps, descending to the lower Kitzbühl Alps; with another ridge running east and south along the Hohe Tauern (Grossglockner, 12,461 ft.) to the Pusertal. (See also ALPS; AUSTRIA.)

The climate of Tirol is bright and sunny. The abrupt scarps of the limestone country overlooking the Inn valley shut out cold northerly winds. Rainfall is only half that of the Bavarian foreland north of the ridge, and temperatures are appreciably higher. Sunshine records at Innsbruck are nearly three times those of Vienna.

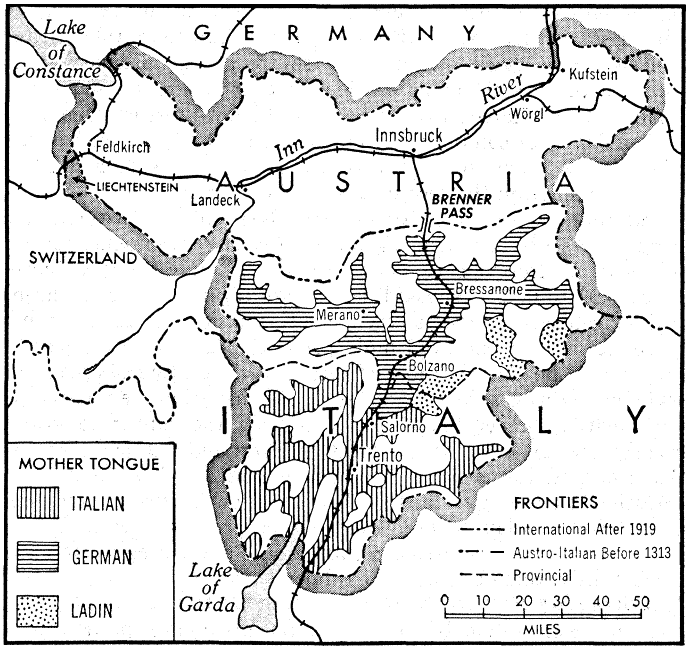
Population. — The population (1951 census, 426,271) is almost entirely German in speech and Roman Catholic in religion. It is surprisingly dense along the Inn (250 per square mile) in comparison with the rest of Austria (214 per square mile for the whole country); but Tirol as a whole has the least dense population of all the provinces. Quite one-third of the population lives at altitudes of more than 2,400 ft.; and tiny hamlets are found up to nearly 6,000 ft. Innsbruck (*q.v.*) is the only large town, with a population (1951) of 95,055.

Industry. — In the early and middle ages Tirol was an important mining area, more particularly for silver (at Schwaz) and copper, but its mineral output is now insignificant. Salt, brought from the Salzberg as brine, is still worked at Hall, and cement is manufactured at Wörgl and Kufstein. The many streams provide abundant opportunities for hydroelectric power plants. The main railway line from the Arlberg tunnel to Vienna is electrified. The most important industry in the Tirol, however, except for agriculture, is the tourist industry, for the grandeur of the mountain scenery is enhanced by the sunny climate. (T. HER.)

HISTORY

In 15 B.C. the Rhaetians, who inhabited the country later known as the Tirol, were defeated by Drusus and Tiberius, the stepsons of Augustus, and their territory became the Roman province of Rhaetia separated from Italy by a frontier which crossed the River Isarco (Eisack) at Chiusa (Klausen). The Christianization of the territory began about A.D. 400. After 600 years of Roman rule the modern Austrian *Land* of Tirol-Vorarlberg was occupied by the Baiovarii (Bavarians) who flowed over the Brenner into South Tirol, the modern Italian province of Bolzano (Bozen) or Alto Adige. About the same time the province of Trent (Trentino) to the south was occupied by the Lombards and therefore remained of the same language and culture as the rest of Italy, whose originally German-speaking Lombard conquerors had been assimilated by their Italian subjects.

Bavaria and Lombardy were absorbed into the Carolingian empire in the 8th century and later passed to the German kings who succeeded in part to that empire. In 1004 the Saxon emperor Henry II gave land in the Brenner area to the bishop of Trent, and in 1027 Conrad II enlarged this fief by the counties of Bozen and Vintschgau, bestowing the counties north of this line on the bishop of Brixen (Bressanone). It was at this time the imperial policy to make the church the instrument of royal, as distinct from princely, control; and these bishops held their lands directly from the emperor, not from the dukes of Bavaria. However, they delegated their secular rule, mainly to the counts of Tirol. who took their name from the castle of Tirol near Merano but who gradually extended their rule over the whole of Tirol. The lands ruled by the counts of Tirol were eventually inherited by Margaret Maultasch (*q.v.*). On the death of her son in 1363 Margaret made over Tirol to the duke of Austria, Rudolph IV, and from that time until the breakup of the Austrian empire at the end of World War I Tirol was a Habsburg possession. In the 16th century the doctrines of the Reformation made considerable progress in Tirol and were largely responsible for a formidable peasants' revolt in 1525. But Protestantism was completely stamped out in the area in the second half of the century. In 1803 Tirol (entirely German in speech with the exception of some surviving Ladin in the south) was enlarged by the addition of the Italian-speaking province of Trentino, which had remained until then an independent prince-bishopric of the Holy Roman empire.



TIROL AND SURROUNDING AREAS, SHOWING THE DISTRIBUTION OF PRINCIPAL LANGUAGES AT THE ITALO-AUSTRIAN FRONTIER

Tirol was a land of intense provincial pride, with a strong feeling for its own institutions and local government, its people thinking of themselves as Tirolese rather than Austrian. Accordingly when in 1805 after the treaty of Pressburg, Napoleon established French and Bavarian rule in the area, the people found it intolerable. Bavaria meddled with matters that Vienna had wisely left to Tirol itself. Consequently in 1807 there was a rising under Andreas Hofer (q v.) during which a surprising number of defeats were inflicted on the occupying troops. But after the peace of Schonbrunn (1809) had given Tirol mainly to Bavaria (the south went to Italy and Lienz to Illyria, then French), the revolt was ruthlessly crushed. Hofer was shot in Mantua on Feb. 10, 1810, it was said, by Napoleon's express order. The treaty of Paris (1814) reunited Tirol and restored it to Austria. Northern Tirol was well pleased, but the Italian-speaking province of Trentino became a focus of irredentist claims against Austria, an irredentism which grew steadily stronger from 1870 until the outbreak of World War I in 1914.

The South Tirol Question. — From the beginning of World War I the Italian government negotiated both with Austria and nith the Allies on a price for Italy's co-operation. Austria was prepared to cede Trentino, but would yield nothing further. Italy thereupon signed the secret treaty of London (1915) with the Allies by which it was promised among other rewards the Brenner frontier. In 1919 the treaty of St. Germain fixed the Italo-Austrian frontier on the Brenner and handed over to Italy not only Italian-speaking Trentino, but the whole of South Tirol (5,420 sq.mi.), called by Italians the province of Bolzano, where, according to the Austrian census of 1910, there were 215,796 German-speaking Tirolese against 16,510 Italians and 5,990 Ladins. (These last speak a Rhaeto-Romanic language similar to the Romansh of Switzerland.)

Italy was bound by no treaties for the protection of minorities such as were signed by lesser states in 1919, and, although its ministers declaimed in 1919 that Italy was under a moral obligation to apply the provisions of the minorities treaties, a disregard for the rights of a minority developed into an oppressive tyranny with the advent of the Fascists to power in 1922. Efforts were made to stamp out the German language by educational measures, by putting Italian-speaking officials in administrative posts and by settling Italians, largely from the overpopulated regions of south Italy, in the towns.

On Oct. 21. 1939, Germany and Italy signed an agreement under which the South Tirolese were to opt once and for all for transfer to Germany or for the retention of Italian citizenship. Of the 267,000 German-speaking Italian subjects in the provinces of Bolzano. Trentino. Belluno and Udine 185,365 opted for Germany, including 166,500 (73%) in the province of Bolzano. Since half the population were engaged in farming and most of these families had been settled on their farms for centuries the size of the vote for migration to Germany showed the strength of the hatred of Italian rule. About 70,000 actually left Tirol, mostly people from the towns.

In 1945 there was a strong feeling in Great Britain as well as in Austria that an injustice had been done in 1919. The history of the area suggested that a strategic frontier might have been found further south of the Brenner, where the deep Salorno gorge forms a natural barrier and that a line might have been drawn along the Italian provincial boundary betneen Trentino and Alto Adige, this line uould also largely have coincided with the ethnic boundary. (See map.) The strongest point, however, in the Italian case for the retention of Alto Adige lay in the economic development of the province betneen 1919 and 1939. By 1939 Alto Adige had become one of the chief sources of the hydroelectric poner essential to the industries of the north Italian towns. Other industries, particularly the chemical and aluminum, had also been developed in Bolzano.

The Council of Foreign Ministers finally decided in 1946 that there would be no change in the Italo-Austrian frontier. But article 10 of the Italian peace treaty of 1947 bound Italy to make arrangements with Austria to guarantee free movement of passenger and freight traffic between North and East Tirol, and took formal note of the agreement made between Italy and Austria in Paris on Sept. 5. 1946. This agreement promised complete equality of rights to the German-speaking inhabitants of Alto Adige and of the neighbouring bilingual townships of the province of Trentino and undertook to grant a measure of legislative and executive autonomy to the population.

By a decree of Feb. 2, 1948, the Italian government made it possible for Tirolese who opted for Germany to return and recover their Italian nationality. By Sept. 30, 1952, 28,593 applications had been made of which 1,012 were refused on the ground of the applicants' past associations with Naziism.

The Italian constitution of 1948 recognized Trentino-Alto Adige as one of the five special regions which should have a considerable measure of legislative and executive autonomy. But, as the region included Trentino as well as Alto Adige, there was an Italian majority in the region as a whole. According to the census of 1951, the autonomous region had a total population of 728,604. An Italian source gave the estimate of the population of the Alto Adige on Oct. 31, 1953, as follows: German-speaking inhabitants 214,257; Italian 114.568; Ladin 12,696. Further, the powers of local government within the region granted to the provinces of Bolzano (Alto Adige) and Trentino were narrowly limited, and the German-speaking population consequently felt that the Italian interpretation of the 1946 agreement was not wholly satisfactory. At the general election of June 7–8, 1953, the Sudtiroler Volkspartei obtained 122,474 votes and gained three seats in the Italian chamber of deputies.

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TIRPITZ, ALFRED VON (1849–1930), German admiral and chief builder of the German navy at the turn of the century, was born on March 19, 1849, at Kiistrin, Brandenburg. He entered the Prussian navy in 1865 and became an officer in 1869. In the 1880s he was the fleet's outstanding torpedo specialist. After serving during 1892–96 as chief of staff of the navy high command, he commanded the far eastern cruiser division and selected Tsingtao, China, as a future German naval base. On June 16, 1897, he was appointed secretary of state for the navy, his position for almost 20 years. Created a noble in 1900, he attained the rank of admiral in 1903 and of grand admiral (*Gross*-admiral) in 1911.

On the evaluation of his personality, of his aims, unflinchingly set on a definite course, and of his successes and failures largely depends the historical judgment on the short period of German imperialism; for. with the gifted but erratic and dilettante emperor William II, Tirpitz was its dominant figure. The association of these two personalities was the fateful coincidence which determined the splendour and the fall of the German empire. The military prerogatives of the emperor under the Bismarck constitution, combined with the naval mania and ambition of William II, had led in 1889 to the splitting up of the admiralty into the *Reichsmarineamt* (office of the secretary of state fr the navy) for administration, the *Oberkommando* der *Marine* (navy high command) for plans and operations and the imperial *Marine-Kabinett,* a counterpart to the royal (Prussian) military cabinet, for officer personnel. This arrangement immensely strengthened the direct influence of the monarch on navy matters.

To transform a coast defense force into a high seas battle fleet in less than two decades was an achievement comparable only with the creation of the Russian fleet by Peter the Great. Tirpitz was a born, sometimes an overbearingly ruthless, leader. His qualities are beyond question: fervent patriotism, cleverness, administrative ability in the technical domain and in the domain of organization, capacity for detailed work as well as for plannicg on a grandiose scale, inexhaustible energy and indefatigable industry. He could be aggressive and conciliatory, pressing and patient. None of his co-actors on the political scene — three chancellors of the reich and seven secretaries of state of the foreign ministry among them — equalled him in strength. Bismarck and Tirpitz represent the two different eras of imperial Germany. When visiting Bismarck in 1897. Tirpitz felt that the founder of the German empire still lived with the idea of Germany in 1871 and of England in 1864.

Naval Program.—Modern imperialism found its military expression in the "new navalism" of the 1890s, and Germany was no exception. Tirpitz brought Germany within 16 years from the sixth place among sea powers to the place next to Great Britain.

As chief of staff of the navy, Tirpitz developed the principles of offensive navy tactics under the recognizable influence of convictions held by Gen.-Adm. Albrecht von Stosch, chief of the admiralty, 1872–83, his venerated mentor. His tactical memorandums applied the offensive idea of land warfare to the navy, deriving the necessity of offensive action from the strategic defensive.

The *Flottennovelle* of 1898 created the basis for building a fleet according to a plan fixed by law; it provided for a navy of 17 battleships and a cruiser force of 9 large and 26 small cruisers to be built in six years. Such a navy was regarded as strong enough for limited offensives in a war against France and Russia. The navy law of June 14, 1900, expanded the building plan and set 1917 as the year of completion. By this time the German battle fleet provided by the 1898 bill was to be doubled. Supplementary laws of 1904, 1906, 1908 and 1912 were further steps in expanding the navy. The fleet of 1920 was to comprise 41 battleships and 20 large and 40 small cruisers, the battle fleet consisting of three active battleship squadrons.

Political Aspects.—Seen in retrospect, the navy law of 1900 appears as Germany's declaration of "cold war" against Great Britain. For the real goal of Tirpitz was not so much the defense of the German coast or protection of German overseas trade; it was nothing less than a change in the distribution of world power, although conceding a certain margin of naval superiority to Britain. Germany's bold attempt to intrude in the sphere of naval supremacy led to catastrophe. German statesmen did not grasp the political significance and potentialities of naval power or realize that the building of the German navy radically changed the Bismarckian concept of Germany's position in the world. They clung tenaciously to the alliance with Austria-Hungary and Italy, adding prestige liabilities by their Turkish policy. German naval policy was not supplemented by an appropriate revision of Germany's alliance policy.

Tirpitz favoured a pro-Russian orientation, believing that by coalition with other navies a certain new balance of power on the sea, comparable with the continental balance of power, could be established. German imperialism made its cardinal mistake by overestimating German strength, thus simultaneously provoking British enmity by building a competitive navy and Russian hostility by clashing with Russian interests by an active near east policy.

The Germans bitterly resented Winston Churchill's statement (Feb. 9, 1912) on the German *Luxusflotte,* but the British stand in the naval competition could hardly have been defined more precisely: "The purposes of British naval power are essentially defensive . . . The British navy is to us a necessity, and from some points of view the German navy is to them more in the nature of a luxury."

Tirpitz coined the phrase of the temporary "danger zone" which Germany had to pass through in its relationship to England during the construction of the navy, until it became a *Risikoflotte; i.e.,* a navy of such strength that war against it would endanger the superiority of even the strongest navy. The theory of the *Risikoflotte* hypnotized the German people. Based on the assumption that French and Russian enmity against Great Britain could be regarded as permanent factors in international relations, it became invalid when Great Britain's previously isolationist position was changed by the alliance with Japan and the entente with France and Russia. Both slogans, the danger zone and the *Risikoflotte,* proved to be fallacious; the danger zone became unending. since in the Anglo-German naval rivalry a static relationship of mutual strength over a long period of time never was established.

A master propagandist, Tirpitz wielded influence on the kaiser through the naval attachés, his devoted aides. Through his press office, through the *Nauticus* yearbook and the Navy league (Flottenverein, since 1898) he influenced the *Reichstag* and the general public Anglophobically, creating a general sentiment which limited the freedom of responsible German statesmen to negotiate an accord with England. The German Colonial league and the Pan-German league served as propaganda auxiliaries.

Pushing the construction of the battle fleet, Tirpitz before 1914 was opposed to large-scale submarine and naval airship building, lest the navy become a "museum of experiments."

The "Dreadnought" (1906) revolutionized naval architecture and strategy and sharpened the Anglo-German conflict. A new phase in the armament race started when the Germans immediately took up construction of the same type of giant battle ships. Between 1908 and 1912, a period of frantic but futile search for a mutually acceptable formula of armament limitation, Tirpitz exercised decisive influence on Anglo-German relations—an influence heightened by the emperor's siding with Capt. Wilhelm Widenmann, the naval attaché in London, against the ambassador, Count Paul Wolff-Metternich.

War and Postwar Activities.—Seldom has the combination of fierce economic rivalry, unbridgeable political positions, an atmosphere of deep-seated mutual suspicion, misunderstandings, miscalculations, misinformation and provocative utterances on both sides led to more tragic consequences, culminating in 1914 in the Anglo-German war. But the war brought about Tirpitz' deepest disappointment: the mighty weapon which he had forged was not employed. His repeated efforts to obtain command of the navy and exercise decisive influence on its use. either by the creation of a supreme navy command or by becoming himself commander of the high seas naval forces. were rejected. While the army was defeated in applying "the recipe of victory of dead Schlieffen" (Tirpits), he was refused opportunity to try out his plan for victory on the high seas. To subjugate England he became an early advocate of mercantile submarine warfare, which, after his resignation, brought the United States into the war, making inevitable Germany's ultimate collapse.

Snubbed by the government in the deliberations about submarine warfare, Tirpitz resigned on March 1S, 1916, from the navy secretaryship.

In retirement he was identified with rightist movements such as the annexationist Vaterlandspartei in 1917–18. A member of the *Reichstag,* 1924–28, for the Deutschnationale Volkspartei, he persuaded the reluctant Paul von Hindenburg to accept the nomination as candidate for the presidency in 1925.

Tirpitz died in Ebenhausen, near Munich. on March 6. 1930.

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TIRSO DE MOLINA (pseudonym of the Spanish dramatist, GABRIEL TÉLLEZ) (*c.* 1584–1648), who was born at Madrid, studied at the University of Alcalá and was professed in the Mercenarian order of which, as its official historian, he wrote the *Historia de la Merced,* and in which he was a theologian of repute. Guided to drama by an inborn sense of the theatre, and inspired by the achievements of Lope de Vega. he built on Lope's national foundations to Lope's free-and-easy prescriptions, sometimes accentuating the religious and philosophical aspects that attracted his theological interest, sometimes drawing on his own topographical and historical knowledge, stored while travelling on the business of his order through Spain, Portugal and the West Indies, sometimes borrowing from the vast common stock of Spanish stage material and sometimes relying on his fantastic imagination.

Three of his dramas appear in *Los Cigarrales* de *Toledo* (1621), a set of verses, tales, plays and critical observations which, arranged after the Italian fashion in a picturesque framework, affect to provide a series of summer recreations for a group of friends. Otherwise his extant output of about 80 dramas, a fragment of the whole. was published chiefly in five *Partes* between 1627 and 1636.

Part ii, containing several of his famous pieces, presents apparently insoluble problems of authenticity, and the authorship of certain others outside this *Parte* has also been disputed.

The most powerful dramas associated with his name are two tragedies: El *Burlador de Sevilla* and *El Condenado por desconfiado*. The first. introducing the hero-villain, Don Juan; himself derived ultimately from popular legends but recreated with Tirsian originality. rises to a majestic climax of nervous tension where the libertine is confronted with the statue-ghost of the man he has killed, and deliberately chooses to defy this emanation of his diseased conscience. El *Condenado por desconfiado* exteriorizes a startling theological paradox by opposing to the case of a notorious evildoer who has kept and developed the little faith he had. and is granted salvation by an act of divine grace, the example of a hitherto good-living hermit. eternally damned for allowing his one-time faith to shrivel. Among the psychological conflicts and contradictions involved in these master characters Tirso is at his best. At times he reaches Shakespearean standards of insight, tragic sublimity and irony. The same qualities are found in isolated scenes of his historical dramas, for instance in *Antona Garcia,* notable for its objective analysis of mob emotionalism; in *La Prudencia en la mujer*, with its modern interpretation of ancient regional strife; in the two parts of *Don Alvaro de Luna*, with its study of the clash of personal and political interests in the friendships of public men; and in the violently realistic scenes of the biblical *La Venganza de Tamar*.

On such occasions Tirso, even against the talented background of Spain's golden age, stands out uniquely. When inspired, he had the rare gift of dramatizing personality, and his best characters are also memorable as individuals. He is more stark and daring than Lope. and less ingenious; more spiritually independent than Calderón. and less poetic. Where he approximates to the golden age norm his plays of types and manners. like El *Vergonzoso en palacio*, are animated, varied in mood and usually lyrical. But his style is erratic and can be trite. In pure comedy he excels in cloak-and-sword situations. and in. for example, *Don Gil de las calzas verdes,* he manipulates a complex, rapidly moving plot with exhilarating vitality. He is famous, in both tragedy and comedy, for his clowns, whose wit has a tonic air of spontaneity. Naturalness .in diction suited his dramatic purpose better than the ornamental rhetoric which was then coming into vogue, and generally he avoided affectations, remaining in this respect nearer to Lope than to Calderón. He is not as consistently brilliant as some of his dramatic contemporaries, but at his greatest, even in comedy, the Spanish speciality, he can rival them, and in tragedy he towers above them all.

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TIRUNELVELI (formerly TINNEVELLY), a town and district of Madras state, India. The town is on the left bank of the Tambraparni river, on the other side of which is Palamcottah. the capital of the district. Pop. (1951) 73,476. It is on the South Indian rail ay, 444 mi. S.W. of Madras. A branch line was opened to Tiruchendur in 1923. Its most noteworthy building is a beautifully sculptured temple of Siva.

The DISTRICT OF TIRUNELVELI has an area of 4,344 sq.mi. It is for the most part a plain with an average elevation of zoo ft., sloping to the east with slight undulations. It is watered by numerous short streams, the principal being the Tambraparni with a length of 80 mi. The chief irrigation work is the Srivaikuntam anicut or dam on this river.

In the north the scenery is unattractive and the soil poor; in the south red sandy soil prevails in which little save the palmyra palm will grow. This palm yields toddy as well as a coarse sugar. Along the banks of the rivers are rice fields. cotton, millet, pulse and oilseeds are grown, and cloth, mats. lace and sugar manufactured. There is a trade in cotton stuffs, and fishing is carried on.

The district contains many ancient and magnificent buildings. The population was 2,506,275 by the 1951 census.

The Society for the Propagation of the Gospel and the Church Missionary society have important stations at Tirunelveli town and Palamcottah, as also have the Jesuits.

It was there that St. Francis Xavier began his preaching in India.

The early history of Tirunelveli is mixed up with that of Madura and Travancore. Down to 1781 it is a confused tale of anarchy and bloodshed. In that year the nawab of Arcot assigned the revenues to the East India company, which then undertook the internal administration. Several risings subsequently took place, and in 1801 the whole Carnatic. including Tirunelveli, was ceded to the Eritish.

TIRUPATHI (Telugu "venerable lord"; vulg. TRIPETTY), a famous holy place in Chitoor district, Andhra Pradesh. India, 67 mi. W.N.W. of Madras. The sacred hill range, Tirumalai, has at its base the main town of Tirupathi (pop., 1951, 25,207), noted for brasswork and wood carving, and, above, Upper Tirupathi, the centre of pilgrimage.

There. near Seshachalam (serpent hill): one of the range's seven sacred peaks, is the great temple. No European visited Tirupathi till 1870; none has entered the temple. The cult is of Vishnu. overlaid with non-Aryan ritual elements.

Women undertake at Tirupathi certain ceremonies to ensure fertility and in thanksgiving for childbirth or deliverance from sickness; that girls serve there for several years as "wives of the god" has been alleged.

See A. F. Cox, *Manual of* N. *Arcot District,* p. 146 ff. (Madras, 1881); W. Crooke in *Encyclopaedia of Religion and Ethics,* ed. *by J.* Hastings, xii, *s.v.* "Tirupati" (Edinburgh, New York, 1921).

TIRYNS, a prehistoric fortress and afterward a small Greek city, on an isolated ridge of rock near the east side of the plain of Argos in Peloponnese, about 3 mi. from the coast and from the port of Nauplia. There is a railway station close to the site. In Greek legend it was founded by Proetus, brother of Acrisius, king of Argos. His successor, Perseus, founded Mycenae about 10 mi. farther inland. Later, Heracles there served Eurystheus in many "labours," and Tydeus and his son Diomedes held it. After the Dorian conquest *(see* DORIANS) Tiryns. like Mycenae, declined as Argos grew; it sent its small contingent to fight at Plataea (*q.v.*) in 479, but about 460 it was destroyed by the Argives. Pausanias (*c.* A.D. 170) was shown there the "palace of Proteus," and the "chambers of his daughters." and wondered at the "Cyclopean" walls, the τίρυνς τειχιόεσσα of Homer. *Il.*, ii. 559. The same walls in 1884 attracted the attention of Heinrich Schliemann, the excavator of Troy (1871) and Mycenae (1875), who uncovered, with W. Dorpfeld. a prehistoric "palace" remarkable for many points of resemblance to the house of Odysseus in the *Odyssey;* Schliemann however made only a few soundings into the stratified remains under its floors. These were carefully examined from 1908 onward by members of the German Archaeological Institute in Athens, and though their conclusions were not fully published, the outline of the archaeology of Tiryns as described below is assured.

The natural ridge on which Tiryns stands is about 330 yd. from north to south and 112 yd. at widest from east to west; the greater heights of its southern half now is mainly due to superstructures. From about 2000 B.C. a small unfortified settlement can be traced on and also around this ridge, with three superposed layers of mud-brick houses; on what was probably the summit (under the later *megaron*) was a remarkable round building, nearly 90 ft. across, also of mud brick but roofed with slates and tiles, probably for some public or official use.

About 1600 B.C. the southern half of the ridge was heavily fortified with rude but massive walls, to protect a new "palace" of which the plan is obscure (for it lies underneath its successor), but the arts and industries are derived. like those of the contemporary shaft graves at Mycenae, from the Middle Minoan culture of Crete (*q.v.*). The settlement which it dominated extended several hundred feet south and east of the ridge. Communication was by a gateway in the east wall, underneath the later propylaea. About ½ mi. away, on the hill called St. Elias, cist graves and rock-chambers are found, of various dates, and on the same hill is a ruinous "beehive tomb" like those at Mycenae, Heraeum and Midea, and probably contemporary with them; but nothing has survived from its contents.

The "early palace" perished by violence and was succeeded, about 1300 B.C., by another, which occupied the whole area of the early citadel, and was in turn defended by the massive but rudely-fashioned walls which are now conspicuous. These considerably enlarge the area of the fortress and enclose also the whole of the northern half of the ridge. The latter, however, was not occupied by buildings (except a pot kiln and some workshops) but was levelled upwards with debris as a place of refuge for dependants and their cattle. The same principal entrance, heavily fortified, in the middle of the east side, served both this "lower citadel" and the "upper" section south of it, which was further protected by an inner gate with bolted doors, as at Mycenae, within which a covered porch (*propylaea*) panelled with wood above a stone plinth, gave access to a level outer court occupying the whole of the south end, and sustained by very thick substructures. These contain, on their east and south frontages, the famous "galleries" which served as store rooms in peace, and as casemates in war. As the "later palace" within these fortifications was not itself designed for defence, its construction was slighter, and it has perished above plinth level. Its plan, however, which has attracted the attention of commentators on Homer, since Schliemann's time, is completely traceable. The outer court gives access, through a second porch, to an inner one, about 53 ft. by 70 ft., containing a domestic altar, furnished to east and west by colonnades. and giving access northward through a deep portico with two columns to a vestibule (with three doors outward and one inward) and so to a great hall to which the Homeric name *megaron* is commonly applied. This hall, about 40 ft. by 30 ft., has a central hearth, between four column bases, which supported a roof with some kind of louvre or clerestory to let out the smoke. On the cement floor, which is ornamented with painted panels of octopus and dolphins, a space is marked out between the hearth and the east wall, as the place of honour; but there is neither dais nor any other doorway but that of the vestibule. From the latter a small door leads west to a bathroom, of which the floor is a single limestone slab draining to the main sewer, as at Cnossus (see CRETE: *Archaeology:* Palatial Architecture); in this room were found the remains of a clay bathtub.

This "later palace" also perished by violence, and parts of its mud-brick walls were so calcined that at first sceptical scholars acclaimed them as Byzantine, and there was, in fact, a small Byzantine church (now removed), with a graveyard near the south end of the site. As it evidently lay long desolate, little remains of its decorative splendour except fragments of fresco, and of an alabaster frieze inlaid with blue enamel like the θριγκὸς Κυάνοιο of *Od.* vii. 87. The pottery is of degenerate Late Mycenaean style.

The frescoes of the "earlier palace," with rich spiral and floral designs, resemble those of contemporary Cnossus (*L M.*, i. ii); those of the "later" included a majestic procession of women bearing offerings, an elaborate hunting scene, in which a boar is attacked by hounds and men, and other animals are represented; an assault on a palace; a chariot procession; and bull-baiting gymnastic of the Cnossian kind. A small painted plaque shows the worship of an armed goddess; and a fragment with ass-headed personages may be a masquerade.

To the centuries after the destruction of the palace belong a series of graves with pottery of "geometrical" style, safety pins, and other objects of the Early Iron age. In the 7th century a temple was dedicated to Hera on the site of the Mycenaean *megaron*, and furnished with rude terracotta offerings.

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TISA (Ger. *Theiss*), tributary of the Danube, rises in the northeastern Carpathian mountains in Ruthenia at a height of about 6.300 ft., and is formed by two streams, the Black Tisa (Cerna Tisa) and the White Tisa (Bila Tisa) which unite above Rachovo where the mountain valley begins to widen. A few miles below Rachovo the river takes a generally westerly direction and makes a great curve around the Nyirség plateau entering Hungary near the top of the curve and then continuing southwest to Szolnok. From there its course across the Hungarian plain is parallel to the Danube, which it enters near the small plateau of Titel, 20 mi. E. of Novisad. The winding course is 509 mi. long and the basin, covering an area of 56,600 sq.mi., is shared by Czechoslovakia, Hungary, Rumania. Yugoslavia and the Soviet Union. Two of its tributaries, the Szamos and Maros, coming from the impermeable rocks of Transylvania, bring a great volume of water, but these and the main stream quickly lose their velocity on reaching the plain where the fall is less than 3 cm. per kilometer. Two periods of high water occur on the middle and lower Tisa, one in spring due to snow melting, the other in June following the summer rain; to this the Koros is a big contributor. The spring flood coincides with that of the Danube which. having a quicker flow, dams back the Tisa and causes extensive flooding sometimes felt as far as Szolnok.

Huge canalization and diking works have been undertaken to protect the surrounding lowland. The Tisa is navigable for steamers as far as Szolnok, 197 mi., or as far as Tiszafhred. 2jj mi., depending upon the stage of the water, and for rafts and floating timber almost anywhere. It is joined to the Danube by the Francis Joseph canal and its tributary the Bega, and is canalized to Timişoara.

TISCHBEIN, a Hessian family of artists. Throughout three generations more than 20 members of the family embraced artistic careers of one sort or another, though their greatest successes were achieved as portrait painters.

JOHANN HEINRICH TISCHBEIN the Elder (1722–89), who studied with Charles Andrew Vanloo and in Venice with G. B. Piazzetta, was active after 1752 as court painter in Cassel, Ger. In addition to painting portraits of members of the court, Tischbein created mythological canvases and conversation pieces. Best known is his "Gallery of Beauties," a series of portraits of ladies of the court, at the palace of Wilhelmstal, near Cassel.

JOHANN VALENTIN TISCHBEIN (1715–68) and ANTON TISCHBEIN (1730–1804) were portrait painters of lesser importance who worked at some of the smaller courts of the old German empire.

JOHANN FRIEDRICH AUGUST TISCHBEIN (1750–1812), the representative painter of the second generation of his family, studied with his father. Johann Valentin, and later in Paris and Italy. The artist's duties as court painter to the prince of Waldeck were light and allowed him to spend considerable time in Holland. His experience with social life in Holland gradually induced him to turn away from court life and devote his talents to painting wealthy burghers in the grand style of English society painters. Many of these portraits may be seen in German and Dutch museums.

JOHANN HEINRICH WILHELM TISCHBEIN (1751–1829), a grandson and a pupil of Johann Heinrich and a cousin of Friedrich August, began his career by painting portraits at the Prussian court in Berlin. In 1779 he went to Italy and in 1789 succeeded in being appointed director of the art academy in Naples. Forced to leave in 1799 because of war, the painter retired to north Germany. Tischbein's most famous picture is that of "Goethe in the Campagna," painted in 1787 at the time the two men traveled from Rome to Naples. While Goethe had induced the artist to turn his interest toward the classical movement, Tischbein later became interested in the ideas of German romanticism. (Hs. H.)

TISCHENDORF, LOBEGOTT FRIEDRICH KONSTANTIN VON (1815–1874), German biblical critic, was born on Jan. 18, 1815, at Legenfeld, near Plauen, in the Saxon Vogtland. He was educated at the Gymnasium of Plauen and the University of Leipzig, where he qualified as a lecturer in 1840 with a dissertation on the recensions of the New Testament text. These studies convinced him of the absolute necessity of new and exacter collations of manuscripts.

From Oct. 1840 to Jan. 1843 he was in Paris, studying in the great library, eking out his scanty means by working for other scholars and for the publisher Didot. The great triumph of these laborious months was the decipherment of the palimpsest Codex Ephraemi Syri Rescriptus, abandoned as illegible by earlier collators. The New Testament part was printed before he left Paris and the Old Testament in 1845. From Paris he had paid short visits to Holland (1841) and England (1842).

In 1843 he visited Italy, and after a stay of 13 months went to Egypt, Sinai, Palestine and the Levant, returning by Vienna and Munich. (*See* his *Reise in den Orient*, 1845–46.) From Sinai he brought a great treasure, 43 leaves of what is now known as the Codex Sinaiticus. He kept the place of discovery a secret, and the fragments were published in 1846 as the Codex Friderico-Augustanus, a name given in honour of the king of Saxony. He now became professor extraordinarius in Leipzig, and married (1845). In the same year he began to publish an account of his travels in the east (2 vol., 1845–46). In 1850 appeared his edition of the Codex Amiatinus and of the Septuagint version of the Old Testament; in 1852, among other works, his edition of the Codex Claromontanus.

In 1853 and 1859 he made a second and a third voyage to the east. In the last of these, in which he had the active aid of the Russian government, he at length acquired access to the remainder of the precious Sinaitic codex, and persuaded the monks to present it to the tsar, at whose cost it was published in 1862 (in four folio volumes).

In 1859, Tischendorf had been made professor of theology and biblical paleography. The manuscripts brought to Europe on the first two journeys were catalogued in the *Anecdota sacra et profana* (1855; enlarged, 1861). *See* also the *Monumenta sacra inedita* (1846), and *Nova collectio* of the same (1855–69). The third volume of the *Nova collectio* gives the results of his last eastern journey. Side by side with his industry in collecting and collating manuscripts, Tischendorf pursued a constant course of editorial labours, mainly on the New Testament, until his health failed in 1873.

Tischendorf died on Dec. 7, 1874, at Leipzig.

Four main recensions of Tischendorf's text of the New Testament may be distinguished, dating respectively from his editions of 1841, 1849, 1859 (ed. vii), 1869–72 (ed. viii). The edition of 1849 may be regarded as historically the most important from the mass of new critical material it used; that of 1859 is distinguished from Tischendorf's other editions by coming nearer to the received text; in the 8th edition the testimony of the Sinaitic manuscript received great (probably too great) weight.

His edition of the Roman text, of the Septuagint, with the variants of the Alexandrian manuscript, the Codex Ephraemi and the Friderico-Augustanus, was of service when it appeared in 1850, but, being stereotyped, was not greatly improved in subsequent issues.

Beside this may be mentioned editions of the New Testament Apocrypha (*De Evangeliorum apocryphorum origine et usu* [1851]; *Acta Apostolorum apocrypha* [1851]; *Evangelia apocrypha* [1853; 2nd ed., 1876]; *Apocalypses apocryphae* [1866]) and various minor writings, in part of an apologetic character, such as *Wann wurden unsere Evangelien verfasst?* (1865; 4th ed., 1866), *Haben wir den echten Schrifttext der Evangelisten und apostel?* (1873) and *Synopsis evangelica,* 7th ed. (1898).

See in addition to the handbooks on New Testament criticism, Carl Bertheau's article on Tischendorf in Herzog-Hauck, *Realencyklopädie,* 3rd ed. (1907).

TISELIUS, ARNE WILHELM KAURIN (1902–), Swedish chemist, born at Stockholm, Aug. 10, 1902, was awarded the 1948 Nobel prize for chemistry for his researches on electrophoresis and adsorption analysis. especially for his discoveries concerning the complex nature of the serum proteins.

He received his early schooling at Gothenburg and then studied chemistry at the University of Uppsala, where he obtained his doctorate in 1930. He was assistant to T. Svedburg in the Physical Chemical institute at Uppsala (1925–32) and lecturer in chemistry (1930–38). In 1934–35 he worked at the Institute for Advanced Studies at Princeton university, and on his return to Uppsala in 1937 a professorship of biochemistry was created for him and a new institute was built to house his department. He was chairman of the Swedish State Council for Research in Natural Science from 1946 to 1950 and became vice-president of the Nobel foundation in 1947.

The method of electrophoresis, which consists in the measurement of the displacement of dissolved molecules under the influence of an electrical charge. offers a means of separating substances which differ only slightly in their chemical constitution. The separations obtained are indicated by changes in the refraction of light.

The method is extremely delicate and can be used not only for the separation of complex substances but also for the detection of minute impurities. One of its most important applications is the analysis of normal and pathological sera. Equally important is Tiselius' work on the related methods of chromatography and adsorption analysis. (W. J. Bp.)

TISSAPHERNES (Pers. CITHRAFARNA), Persian soldier and statesman, son of Hydarnes. In 413 he was satrap of Lydia and Caria, and commander in chief of the Persian army in Asia Minor.

When Darius II ordered the collection of the outstanding tribute of the Greek cities, he entered into an alliance with Sparta against Athens, which in 412 led to the conquest of the greater part of Ionia. But Tissaphernes was unwilling to take action and tried to achieve his aim by astute and often perfidious negotiations; Alcibiades persuaded him that Persia's best policy was to keep the balance between Athens and Sparta. and rivalry with his neighbour Pharnabazus of Hellespontic Phrygia still further lessened his energy.

When, therefore, in 408 the king decided to support Sparta strenuously, Tissaphernes was removed from the generalship and limited to the satrapy of Caria, whereas Lydia and the conduct of the war were entrusted to Cyrus the Younger. On the downfall of Athens, Cyrus and Tissaphernes both claimed jurisdiction over the Ionian cities, most of which acknowledged Cyrus as their ruler; but Tissaphernes took possession of Miletus, where he was attacked by Cyrus, who gathered an army under this pretense with the purpose of using it against his brother Artaxerxes II. The king was warned by Tissaphernes, who took part in the battle of Cunaxa, and afterward tried to destroy the Greek mercenaries of Cyrus by treachery.

He was then sent back to Asia Minor to his old position as general in chief and satrap of Lydia and Caria. He now attacked the Greek cities, to punish them for their allegiance to Cyrus. This led to the war with Sparta in 399.

Tissaphernes, who once again had recourse to subtle diplomacy, was beaten by Agesilaus on the Pactolus near Sardis (395); and at last the king yielded to the representations of Pharnabazus, strongly supported by the chiliarch (vizier) Tithraustes and by the queen mother Parysatis, who hated Tissaphernes as the principal cause of the death of her favourite son Cyrus. Tithraustes was sent to execute Tissaphernes, who was lured to Colossae and slain in 395. (Ed. M.)

TISSERAND, FRANÇOIS FÉLIX (1845–1896), French astronomer best remembered for his theoretical researches and for his excellent textbooks, especially his *Traitk de mdcanique ckleste* (4 vol., 1889–96), was born at Nuits-Saint-Georges, Côte-d'Or, on Jan. 13, 1845. Having studied science at the École Normale supérieure in Paris, he was appointed assistant at the Paris observatory under U. J. J. Leverrier in 1866. He went to direct the observatory at Toulouse in 1873, but five years later returned to Paris to succeed Leverrier in the Académie des Sciences, subsequently entering the *bureau des longitudes.* In 1892 he became director of the Paris observatory on the death of Adm. A. E. B. Mouchez, and died in Paris on Oct. 20, 1896.

Tisserand went to Malacca to observe the total solar eclipse of Aug. 1868, and made expeditions to observe the transits of Venus of 1874 and 1882, the first to Japan. the second to Martinique. On becoming director of the Paris observatory he took over the task of completing the reobservation of the Lalande catalogues and the organization of the work on the great international photographic catalogue known as the *Carte du Ciel*, besides continuing his *Traité de mécanique céleste*. This latter work may be compared, as a comprehensive compilation, with a similar study by P. S. Laplace nearly a century earlier, and it is still read with profit by students of this branch of astronomy. Tisserand also founded the well-known astronomical journal *Bulletin astronomiqzte* (1884), mhich contains his work on the theory of the capture of periodic comets. (J. JN.)

TISSOT, JAMES JOSEPH JACQUES (1836–1902), French painter and illustrator, was born at Nantes, Oct. 15, 1836. After studying under Louis Lamothe (Edgar Degas' master) and H. Flandrin, he began in 1859 to exhibit at the Salon, his genre being that of the amusements of the young and well dressed. After joining the Commune (*see* COMMUNE [OF PARIS, 1871]). he went to London in 1871, continuing his genre subjects and in 1875 taking up drypoint etching and book illustration.

At this time he produced works as varied as the "Ball on Shipboard" (Tate gallery. London) and the portrait of the balloonist Frederick Burnaby (National Portrait gallery. London), and ten plates illustrating the Goncourts' *Renee Mauperin*. His last 15 years, clouded by the death of a mistress in London, mere spent in Palestine and France and devoted to biblical illustration. The first volume of his *Life of Christ* (865 plates) appeared in 1896. Tissot died at Buillon, Doubs, Aug. 8, 1902.

See J. Laver, *Vulgar Society: the Romantic Career of James Tissot, 1836–1902* (1936). (D. C. T. T.)

TISSUE CULTURE: *see* ANIMAL CELL (TISSUE) CULTURE; PLANT CELL (TISSUE) CULTURE.

TISTA, a river of northern India, which rises on the edge of the Tibetan plateau, has a tumultuous course southward through the mountain gorges of Sikkim and Darjeeling and flows through West Bengal and East Pakistan for another 170 mi. till it joins the Brahmaputra in the district of Rangpur.

In the 18th century the course of the Tista was due south to join the Ganges; but in 1787 great floods diverted the stream toward the southeast, and it made its way by a new channel into the Brahmaputra.

"TITANIC" DISASTER. On April 14–15, 1912, one of the greatest disasters in maritime history occurred about 95 mi. S. of the Grand Banks of Newfoundland when the 46.000-ton White Star liner "Titanic" struck an iceberg on her maiden voyage and sank with the loss of 1,513 lives. The great ship, at that time the largest and most luxurious afloat, had a double-bottomed hull divided into 16 watertight compartments. Since four of these compartments could be flooded without endangering the liner's buoyancy, it mas considered "unsinkable." Shortly before midnight on April 14, however, while steaming at 22 knots, too fast for existing conditions, the ship collided with an iceberg which ripped a 300-ft. gash in the left side of the liner, ruptured five of her watertight compartments and caused her to sink at 2:20 A.M. the following morning. The Leyland liner "Californian," which might have aided the stricken luxury vessel, was less than 20 mi. away all night, but its radio operator was asleep. Only the arrival of the Cunard liner "Carpathia" 20 minutes after the "Titanic" went down prevented further loss of life in the icy waters. As a result of the disaster, inquiries were held in the U.S. and Great Britain and in 1913 the first International Convention for Safety of Life at Sea was called in London. The convention drew up rules requiring that every ship have lifeboat space for each person embarked (the "Titanic" had only 1,178 boat spaces for the 2.224 persons aboard); that lifeboat drills be held during each voyage (none was held on the "Titanic," leading to confusion on the fateful night); and, because the "Californian" had been deaf to the distress calls of the "Titanic," that ships carry enough radio operators to maintain a 24-hour radio match. Another important innovation was the establishment of the international ice patrol (*see* SHIPPING ROUTES) to warn ships of ice in the North Atlantic shipping lanes.

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TITANIUM, a metallic element, changed after 1947 from a rare metal to an important structural metal. Because of its light weight (0.163 lb. per cubic inch) and high strength particularly in alloy form, it is in demand for use in structural parts in high-speed airplanes. Because of its excellent corrosion resistance. it is used in many applications in the chemical industry. No other structural metal has been studied so extensively nor has advanced in technical stature so rapidly as titanium. This rapid advance in the technology of titanium began with development by the U.S. bureau of mines of the process for refining titanium, first disclosed by Wilhelm Kroll in 1936. A laboratory curiosity became the raw material for a commercially feasible process.

A multitude of problems arose in handling titanium: new melting techniques had to be developed; standard fabrication and processing methods had to be modified; and an understanding of the metallurgy of titanium had to be disseminated to the users of the new metal. To assist in the development of the technology of titanium, the U.S. department of defense contracted for a titanium metallurgical laboratory at Battelle Memorial institute, Columbus, O., in 1955, to provide a central facility available to both industry and government for the collection, storage and dissemination of information on titanium; to provide engineering assistance on problems encountered in the production. fabrication and application of titanium; and to provide technical data and advice to the department of defense.

History. — Titanium was named by M. H. Klaproth, a German scientist, who, in 1795. when studying the mineral rutile. discovered the new element. He named it for the mythological first sons of the earth, the Titans. an allusion to the incarnation of natural strength in the metal. In 1797. Klaproth found that titanium also was present in the mineral ilmenite and recognized that it was the same element discovered by William Gregor in England in 1791 that he had called menachanite (or menaccanite) after the Cornish town Manaccan near which he discovered it. Not until over a century later did anyone succeed in isolating elemental titanium. Between 1797 and 1910 many investigators attempted to isolate it, but the metal-appearing products were usually compounds of titanium with nitrogen, carbon and oxygen, for all of which titanium has a great affinity. In 1910, M. A. Hunter succeeded in isolating titanium by reducing titanium tetrachloride with sodium in an airtight steel cylinder. After Hunter's work, titanium remained a laboratory curiosity until 1946 when the U.S. bureau of mines, using Kroll's process. succeeded in producing titanium on a pilot plant scale by the magnesium reduction of titanium tetrachloride.

Occurrence. — Titanium occupies the ninth place in abundance in the earth's crust, exceeded only by oxygen, silicon, aluminum, iron, calcium. magnesium, sodium and potassium It has been found in 98% of all rocks examined in a study of the relative abundance of elements and occurs in practically all sand. clay and other soils. Also, it has been found in oil, coal, natural waters. vegetation. animal flesh and bones, volcanic ash, deep-sea dredgings and meteorites and stars. Despite this widespread distribution there are numerous deposits of highly concentrated titanium minerals mhich are readily accessible and easily mined. Many minerals contain titanium, but only two are of prime commercial importance, ilmenite and rutile. Ilmenite, the more abundant of the two minerals, is a combined iron-titanium oxide usually expressed as iron titanate ($FeO\text{-}TiO_2$) although its composition varies considerably. Usually, ilmenite contains about 32% titanium and 37% iron. Ilmenite occurs frequently with hematite and magnetite (iron bearing ores) in rock formations and in sand in beaches and rivers. Rutile, which in pure form is titanium dioxide (TiO_2), is richer in titanium content than ilmenite but is generally diluted with other minerals either in rock formations or beach and river sand. Known deposits of rutile are not so extensive as ilmenite.

The important sources of titanium ore in North America are the Allard lake district of eastern Quebec; Sanford lake, N.Y.; Iron

Mountain. Wyo.; and Pablo Beach. Fla. Of these, the Allard lake district contains the largest known ore reserve, two large high-grade deposits estimated to contain many hundreds of millions of tons of ore. Known deposits of titanium ores are located in Virginia, Minnesota, Rhode Island, Montana, California, Oklahoma, Colorado and New Mexico, although the extent and usefulness of these deposits was not fully known in the second half of the 20th century. Titanium ores are also abundant in Australia. Brazil. India, Malay States, Norway, Russia. Sweden, Finland. Portugal and various places in Africa. Travancore, India, has been one of the major sources of titanium orcs because of its high TiO_2 content. Much of the titanium ores imported by the Cnited States for production of titanium dioxide pigments has come from India.

Production. — Titanium is produced by a chemical process in which titanium tetrachloride ($TiCl_4$) is reduced with magnesium or sodium. The Kroll process, which is used in the United States, consists of reacting four parts by weight of liquid $TiCl_4$ with one part by weight of molten magnesium in an iron reactor at about 850° C. to form one part of titanium and four parts of magnesium chloride. The sodium-reduction process, used principally in Great Britain. requires two parts by weight of sodium to reduce four parts by weight of $TiCl_4$ and produces one part of titanium and five parts of sodium chloride. Both processes are conducted in large reactors producing about 1,000 to 2,000 lb. of titanium per batch. An argon atmosphere is used within the reactor because all air must be excluded from the reaction to prevent oxygen, nitrogen and hydrogen contamination of the final product. Both of these methods produce titanium in the form of a sponge with magnesium chloride or sodium chloride entrapped in the pores. This sponge is crushed to a suitable size for handling and then leached with water and acid or heated in a vacuum to remove the entrapped chlorides. Titanium sponge is the raw material used for melting ingots of titanium and titanium alloys. Its purity is dependent on the purity of the TiCl, from which it was made, the purity of the magnesium or sodium reducing agent and the purity of the atmosphere during the reduction process. Common impurities in sponge titanium are oxygen, carbon, nitrogen, hydrogen and iron.

Extremely pure titanium can be made by the thermal decomposition of titanium tetraiodide and by an electrorefining process. Both of these processes use impure sponge titanium as the starting material, so they cannot be considered as primary production processes. Much research had been directed toward the development of an electrolytic process for producing titanium in the second half of the 20th century, and although considerable success had been obtained on a laboratory scale, no one had been successful in scaling the process up to a production scale.

Properties. — Titanium in pure form is a soft ductile metal. It has a density of 4.5 g. per cubic centimetres (0.163 lb. per cubic inch) which is about midway between aluminum (2.702 g. per cubic centimetres) and iron (7.9 g. per cubic centimetres). It has a silvery gray colour and can be polished to a high lustre. However, it is not so lustrous as chromium or stainless steel.

Titanium melts at 1.670° C. (3,040" F.). Common impurities, carbon, oxygen and nitrogen, raise the lnelting point while most metallic impurities. such as iron, manganese, chromium and copper. lower the melting point. There are two crystal structures of titanium. At temperatures below 882° C. (1.620" F.) titanium has a hexagonal close-packed structure known as the alpha phase, while at temperatures between 882° C. and its melting point titanium has a body-centred cubic structure known as the beta phase. Titanium is paramagnetic. and has very low electrical a'nd thermal conductivity. Its atomic number is 22 and atomic weight is 47.9. It occurs in three valence forms, 2, 3 and 4, the most stable of which is 4, thus forming compounds of the type TiO, Ti_2O_3 and TiO_2.

Perhaps the most important property of titanium is its ability to be alloyed. Titanium can be alloyed with most of the other metals and many of the nonmetals. Alloying additions increase the strength of titanium both at room temperatures and elevated temperatures. Pure titanium has a tensile strength of about 40,000 lb. per square inch (p.s.i.). By alloying titanium, tensile strengths as high as 200,000 p.s.i. can be obtained. It is this property of titanium that has made it useful as a structural metal.

Like stainless steel and aluminum. titanium has excellent corrosion resistance in many environments because of the formation of a passive oxide surface film. Titanium resists corrosive attack by oxidizing acids such as nitric acid and aqua regia, organic acids, moist chlorine gas, chloride solutions. dilute solutions of sulfuric acid and hydrochloric acid, and dilute solutions of alkalies. It will ignite and burn in dry chlorine gas and is attacked by hydrofluoric and phosphoric acids and moderate concentrations of the alkalies. In fuming red nitric acid, titanium is severely attacked. Several instances of pyrophoric reactions, including explosions. have occurred when titanium has been exposed to red fuming nitric acid. In marine atmospheres and sea water the corrosion resistance of titanium is outstanding. No noticeable corrosion of titanium has been found after exposure to sea water for over three years. Although at room temperatures titanium is resistant to oxidizing atmospheres, at elevated temperatures titanium reacts with the oxygen in the air. At temperatures as low as 500° F. the surface of titanium becomes tarnished, forming an oxide film which ranges in colour from blue to gold. At higher temperatures a thicker oxide film or scale is formed which is yellow-brown. The rate of oxidation increases as the temperatures are increased but it is not until temperatures above about 1.200" F. are reached that oxidation becomes a problem if long-time exposures are involved. At temperatures between 1.200" and 2,200" F., short-time heating can be done in air. Forging and fabrication of titanium alloys are done at these temperatures with no detriment to the properties so long as the oxide scales are removed after fabrication. However, in the liquid state, titanium is very reactive and reduces all known refractories.

Titanium-Base Alloys. — The major alloying elements that are added to titanium are aluminum, vanadium, molybdenum, manganese, iron and chromium. All of the titanium-base alloys contain one or more of these elements. The gaseous elements, carbon, oxygen. nitrogen and hydrogen, are present in almost all titanium alloys in small quantities. The tensile strengths of titanium alloys vary from about 120,000 p.s.i. to over 200.000 p.s.i.

Titanium alloys can be classed in three basic types: alpha, alpha-beta, and beta alloys. Alpha alloys contain elements that dissolve in the hexagonal close-packed alpha phase. Alpha-beta alloys contain limited quantities of elements that dissolve in the body-centred cubic beta phase resulting in a two-phase alpha-beta alloy. Beta alloys contain large quantities of elements that dissolve in the beta phase resulting in all beta structure. Alpha alloys have medium strengths (120.000 to 150,000 p.s.i.) and good elevated-temperature strengths. can be welded and are used mostly as forgings. Alpha-beta alloys are the most versatile. In the annealed condition, they have medium strengths but can be heat treated to very high strengths. These alloys have good forming characteristics and can be used in both sheet and bar stock form. Generally they are not weldable. Beta alloys have medium strengths and excellent forming characteristics, but contain large quantities of high-density alloying additions. Compositions and properties of typical alloys of the three types are listed below:

Type of alloy	Composition (balance titanium)	Teniile strength, p.s.i.	Elonsation %
Alpha	5% 41, 2.57, Sn	130,000	15
Alpha-beta	8% Mn	120,000	10
Alpha-beta	2% Fe, 2% Mo, 2% Cr	140,000	15
Alpha-beta	6% Al, 4% V	150,000	15
Alpha-beta (heat-treated)	6% Al, 4% V	180,000	7
Beta	13% V, 11% Cr, 3% hl	150,000	15
Beta (heat-treated)	13% V, 11% Cr, 3% Al	200,000	6

Titanium in Other Metals. — Titanium has long been used as a deoxidizer in steel where it is added as a ferrotitanium or a ferrocarbontitanium alloy. More recently, it has been used as an alloying addition to many steels to reduce grain size and control carbon content in stainless steel. In aluminum, it is used to refine the grain size, while in copper it produces a precipitation-hardening alloy. In high-temperature nickel-cobalt-chromium alloys, titanium is added to produce a precipitation-hardening reaction providing high strengths at temperatures up to 1,500° F. Titanium is used in permanent magnet alloys of the iron-cobalt-nickel-titanium type.

Uses. — The greatest use for titanium metal is in structural parts in high-speed military aircraft where high strength and low density are important. Titanium and titanium alloys can be used at temperatures up to 800° F., several hundred degrees higher than the useful temperature range for aluminum. It is used in the compressor section of jet engines, in airframe construction, aircraft skins, fire walls and as fasteners (nuts and bolts). In other military applications, it may prove useful for armour plate because of its toughness, and for structural components of equipment that may be carried by air because of its light weight. In naval applications its excellent corrosion resistance to marine atmospheres makes it suitable for special applications, such as heat exchanger tubes, superstructure parts, valves, propeller blades and armour plate.

In corrosion-resistant applications, titanium is used in valves and pumps for corrosive chemicals and in wire cloth for filtering equipment, screens and other equipment. It is used to line pulp bleaching equipment in chlorine dioxide environments. It has been used in centrifuges, condensers, filter presses and heat exchangers where corrosion is a problem. In the electroplating industry, titanium has been found to be excellent for anodizing racks, It is used in prosthetic devices because there is no reaction between titanium and fleshy tissues or bones.

A list of the potential applications for titanium would be lengthy for its combination of high strength, low density and excellent corrosion resistance would find a multitude of uses. However, the high cost of titanium ($2.75 per pound for sponge, $8 00 to $20.00 per pound for mill products) precluded its use in many applications. Continued decrease in price (the price fell steadily after 1947) to a competitive level with other metals would make it probable that large quantities of titanium would be used in transportation equipment. Such use would include not only aircraft but automobiles, trucks, busses, railroads and boats and ships.

Compounds.—The most important compound of titanium from the point of view of consumption is titanium dioxide (TiO_2), which is used extensively in the pigments industry because of its excellent hiding power or opacity. Titanium dioxide, a pure white compound having high reflectivity, is ideal for use in white paints, enamels and lacquers and can be used in conjunction with other pigment compounds in coloured paints. It is also used in pigments for rubber, paper, oilcloth, leather, textiles, inks and cosmetics. Titanium dioxide is produced from rutile or ilmenite by dissolving the ore in a sulfuric acid solution and precipitating the iron compounds. The solution is then hydrolyzed, producing a hydrous titanium oxide, which is mashed and calcined.

Titanium tetrachloride, the raw material for producing titanium metal, is the next most important compound. It is produced by chlorinating TiO_2 or titanium ores in the presence of carbon. The minor amounts of iron, silicon, oxygen and other impurities present after chlorination are removed by fractional distillation. Other uses for titanium tetrachloride are as a catalyst in many chemical reactions along with titanium dioxide and as a smoke-producing compound for skywriting or smoke screens. Titanium carbide, a compound produced by reacting carbon with a titanium compound, is used in conjunction with tungsten carbide in cutting tools and dies. Many other compounds of titanium exist, but their uses are limited. See also Index references under "Titanium" in the Index volume.

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TITANOTHERE, the common name for any member of the family Brontotheriidae, extinct, hoofed, herbivorous mammals of the order Perissodactyla, which also includes the horses, tapirs and rhinoceroses. Titanotheres range from Early Eocene to Middle Oligocene in age and are known from North America, Europe and Asia. From small. hornless ancestors, the latest titanotheres became as large as elephants, with a transverse pair of great, bony, hornlike knobs above the nose (most genera) or a battering-ram extension of the nasal bones themselves (the Asiatic *Embolotherium*).

See PERISSODACTYLA. (G. G. SI.)

TITANS, in Greek mythology, the children of Uranus (Heaven) and Ge (Earth). The Greek name is Τιτᾶνες, the etymology of which is uncertain. According to Hesiod *(Theog.*, 133), the male Titans were Oceanus, Cocus, Crius, Hyperion, Iapetus and Cronus; the female, Thea, Rhea, Themis, Mnemosyne, Phoebe and Tethys. Later authors add other names. After the rebellion of Cronus and the birth of Zeus *(see* CRONUS), a struggle ensued between Zeus and Cronus in which the Titans nearly all sided with the latter but were finally defeated and imprisoned in Tartarus (Hesiod, *Theog.*, 153–210, 617 *et seq.)*.

TITCHENER, EDWARD BRADFORD (1867–1927), English-U.S. experimental and systematic psychologist and leader of the structural school, was born in Chichester, Eng., Jan. 11, 1867. He was educated in the English public schools; at Brasenose college. Oxford (A.B., 1890); and at Leipzig university, where he went to study with Wilhelm Wundt (*q.v.*). After receiving his Ph.D. degree in 1892 he returned to Oxford as an extension lecturer. In 1893 he went to the United States as an assistant professor of psychology at Cornell university, Ithaca. N.Y., and he remained there until his death, being promoted in 1895 to the Sage professorship in psychology and in 1909 to a professorship in the graduate school.

During his service at Cornell Titchener published eight books on psychology, many of which went through several revised editions and were translated into numerous languages; 11 translations of German psychological textbooks into English; and many (216) psychological articles. He edited the *American Journal of Psychology* for 31 years and founded (1904) the Society of Experimental Psychology. He died on Aug. 3, 1927.

In addition to his three elementary textbooks. Titchener's outstanding works are: *Experimental Psychology,* one of the most thorough and encyclopaedic handbooks ever published, the first two volumes covering qualitative (1901) and the last two covering quantitative psychology (1905); *Lectures on the Elementary Psychology of Feeling and Attention* (1908); *Lectures on the Experimental Psychology of the Thought Processes* (1909); *A Textbook of Psychology* (1910); and *Systematic Psychology: Prolegomena,* published posthumously in 1929.

See biographical sketch by E. G. Boring in the *American Journal of Psychology,* 38:489 ff. (1927). (K. M. D.)

TITHES, a form of tribute consisting of a tenth of a man's property or produce, connected politically with taxation, and religiously with the offering of first fruits to deity. This custom was almost universal in the ancient world, and can be traced in Babylonia, Persia, Arabia, Egypt, Greece, Rome and even in China. The tax probably originated in a tribute laid by a conqueror or ruler on his subjects; and it may be assumed that the custom of dedicating a tenth of the spoils of war to the gods led to a religious extension of the term, the original offerings to deity being first fruits. Among the early Hebrews, for example, the king could exact a tithe from cornfields, vineyards and flocks (1 Sam. viii, 15, 17); and on the religious side the oldest laws (*e.g.,* Exod. xxxiv, 26) speak of bringing the first fruits of the land to the house of Yahveh. By the 7th century (Deuteronomy) the word "tithe" had come to be used regularly for religious dues. But the analysis of tithe legislation in the books ascribed to Moses is a complicated problem, owing to the way in which strata of legislation belonging to different periods are combined in the Pentateuch as we now have it; and for detailed investigation reference should be made to the works mentioned below. Ultimately the tithe system became a means of contributing to the regular support of the priests, as ministers of the public ritual.

Tithes in Christendom. — The earliest authentic example of anything like a law of the State enforcing payment appears to occur in the capitularies of Charlemagne at the end of the 8th or beginning of the 9th century. Tithes were by that enactment to be applied to the maintenance of the bishop and clergy, the poor, and the fabric of the church. In course of time the principle of payment of tithes was extended far beyond its original intention. Thus they became transferable to laymen and saleable like ordinary property, in spite of the injunctions of the third Lateran Council; and they became payable out of sources of income not originally tithable.

The Council of Trent definitely enjoined payment of tithes, and excommunicated those who withheld them (Sessio xxv. 12). In England the earliest example of a legal recognition of tithes appears to be in a decree of a synod in 786 (quoted by Selden, *History of Tithes,* ch. viii. 2). Other examples before the conquest occur in the laws of Alfred, Athelstane, Edgar, and Canute. It was Selden's denial of the divine right of tithes which brought down the wrath of the Star Chamber upon his head (1618), and he was forced to retract his opinion.

Tithes in English Law.—Two chronological divisions may conveniently be made.

(i.) Before the Commutation Acts (1836 sqq.). Tithes were classified by origin, as "praedial," or arising immediately from the ground, *e.g.,* grain of all sorts, hay, wood and the like; "mixed," or arising from things immediately nourished by the ground, *e.g.,* colts, lambs, eggs and the like; or "personal," namely, of profits arising from the honest labour and industry of man, and being the tenth part of the clear gain, *e.g.,* fishing, mills and the like; or according to value, as great, *e.g.,* corn, hay and wood; or little, which embraced all others. Of common right tithes were only payable of such things as yield a yearly natural increase and generally only once a year. They were recoverable by a writ against the owner of the tithable property usually brought in the ecclesiastical courts, the jurisdiction of which in this respect was confirmed by the statutes *Circumspecte agatis* (13 Edw. I.), *Articuli cleri* (9 Edw. II.), and others of Henry VIII. and Edward VI.; and an act 2 and 3 Edw. VI. made any person refusing to set out tithes liable to pay double the value in the ecclesiastical court or treble in a common law court. At the time of the Commutation Acts, it was common for a tithe-owner to accept a fixed sum of money or fixed quantity of the goods tithable in place of the actual tithes, whether in respect of a whole parish or only of particular lands within it; and this could be sued for in the ecclesiastical courts. In the City of London there were customary tithes; in other towns and places there were compositions for tithes which were confirmed by local acts of parliament; and according to a return presented to the House of Commons in 1831, there were passed between 1757 and 1830 no less than 2,000 local acts containing commutation clauses.

(ii.) The principle of the Tithe Commutation Acts (1836–1860) is to make permanent and general the system which had been only partial or temporary (in most cases), and to substitute a corn rent (known as a tithe rent charge), permanent in quantity and payable in money, but fluctuating in value, for all tithes, whether payable under a *modus* or composition or not, which may have heretofore belonged either to ecclesiastical or lay persons (Phillimore, *Eccles. Law,* ii. 1161). Commissioners (now the board of agriculture) are appointed to execute the acts; a rent charge on all lands liable to tithes at the time of the passing of the first act is substituted for those tithes, of which the gross amount is ascertained either by voluntary parochial agreement. or, failing that, by compulsory award confirmed by the commissioners; and the value of the tithes is fixed in the latter case by their average value in the particular parish during the seven years preceding Christmas 1835, without deduction for parochial or county and other rates, charges and assessments falling on tithes, the rent charge being liable to all the charges to which tithes were liable. The rent charge is apportioned on all the lands liable in the parish, and such apportionment may be altered or a new one made; and the value of the rent charge is fixed at the value (at the time of confirmation of the apportionment) of the number of imperial bushels and decimal parts of bushels of wheat, barley and oats as the same would have purchased at the prices so ascertained by the advertisement (of prices of corn) to be published immediately after the passing of the act 6 and 7 Will. IV. c. 71, in case one-third part of such rent charge had been invested in the purchase of wheat, one-third part in the purchase of barley, and the remaining third part in the purchase of oats; and the respective quantities of wheat, barley, and oats so ascertained shall be stated in the draft of every apportionment. The price at which the conversion from money into corn is to be made at the time of confirmation of such apportionment, according to the provisions of the said act, are 7s. $0\frac{1}{4}$d. for a bushel of wheat, 3s. $11\frac{1}{2}$d. for a bushel of barley, and 2s. 9d. for a bushel of oats (7 Will. IV. and 1 Vict. c. 69); the average price of the bushel of each grain is now computed by substituting for the "advertisement" above the statement of the septennial average price of the imperial bushel of British corn made under the Corn Returns Act, 1882; and thus the value of the statutory amount of corn is now fixed for each year at the beginning thereof at the average price of the three components of corn for the previous seven years.

The method of recovering rent charge under the Commutation Acts was distraint where the rent charge is in arrear for 21 days after the half-yearly days of payment, and entry and possession with power of letting if it is in arrear for 40 days. This power of distress and entry extends to all lands occupied by the occupier of the land whose tithe is in arrear as owner or under the same landlord; but no action lies against the owner or occupier of the land personally. If a tenant quits leaving tithe unpaid, the landlord may pay it and recover it from him. The tithe-owner cannot recover damages from the tithe-payer for not cultivating the land. Special provision is made for the recovery of the rent charge in railway lands.

The act of 1891 shifted the responsibility from the occupier to the landowner by making the latter solely responsible. The landowner became liable to pay the rent charge in spite of any contract to the contrary between him and the occupier; the rent charge if in arrear for three months is recoverable by an order of the county court, whatever its amount may be; if the land is occupied by the owner, the order is executed by the same means as those prescribed in the Tithe Acts; but if it is not, then by a receiver being appointed for the rents and profits of the land. Appeal lies to the High Court on points of law; and a remission of rent charge may be claimed when its amount exceeds two-thirds of the annual value of the land. The act does not apply to the particular kinds of rent charges mentioned above.

The Tithe Acts do not apply to the city of London, which has always had its own peculiar customary payment regulated by episcopal constitutions of 13 Hen. III. and 13 Ric. II. and statutes of Henry VIII. confirming a decree of the privy council, under which the rate of tithes was fixed at $16\frac{1}{2}$d. for every 10s. rent, and at 2s. gd. for every 20s. rent of houses, shops and the like by the year. Provision was made by statute after the fire of London for certain annual tithes to be paid in parishes whose churches had been destroyed. Parliament in 1936 passed an **act** for the extinction of tithes.

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TITHING. Formerly throughout England, except in the north and west, every man had to be enrolled in a group of ten men, called a tithing, who were responsible for his appearance in court if he were accused of any offence. This was known as the system of frankpledge (*q.v.*). If the offender was not forthcoming, inquiry was made whether he was in frankpledge; if he were not, and had no right of exemption, the township was amerced, but if he were in a tithing, then it was upon the tithing that the amercement fell. South of the Thames the tithings were districts normally identical with the township which discharged the duties of the frankpledge. Some townships, however, contained more than one tithing. There are also indications that in the ancient kingdom of Mercia the tithing was originally a district and not a mere association of persons.

TITHONUS was, in Greek legend, according to Homer, the son of Laomedon, king of Troy and husband of Eos (the Dawn). In the Homeric Hymn to *Aphrodite* Eos is said to have carried him off because of his great beauty. She entreated Zeus that he might live for ever; this was granted, but she forgot to ask for immortal youth for him. He became a hideous old man; Eos then shut him up in a chamber; his voice "flowed on unceasingly," but his limbs were helpless.

A later development is the change of Tithonus into a grasshopper, after Eos had been obliged to wrap him like a child in swaddling clothes and to put him to sleep in a kind of cradle. In some versions she is said to have carried him away to the land of Ethiopia near the ocean streams.

See O. Gruppe, *Griechische Mythologie,* i, 313, *n.* 16, who attributes a Milesian origin to the story; also the classical dictionaries.

TITI, a name properly applied to the small South American monkeys of the genus Callicebus. The titis, of which there are numerous species, inhabit the forests of Brazil and the neighbouring countries and feed on fruits, insects and even small birds. The tail is long and bushy, and is not prehensile. They are very vociferous, though less so than the howler (*q.v.*) monkeys of the same region. The name titi (also spelled teetee) is also sometimes used for the squirrel monkeys ***(Saimiri),*** small, richly coloured, largely insectivorous forms, inhabiting Central and South America. See SQUIRREL MONKEY.

TITIAN (TIZIANO VECELLI or VECELLIO) (c. 1490–1576), Italian painter universally recognized as the greatest painter of the Venetian High Renaissance. His prominence during his lifetime was acknowledged by the government of his city, by the neighbouring courts of Ferrara, Mantua and Urbino, by the pope and by Emperor Charles V and his son Philip, king of Spain. Titian's exceptionally long life enabled him to reflect the evolution of Italian art through the larger part of a century and at the same time to set a pattern according to which the lives of many creative artists were enacted. First, there were the years of apprenticeship in which the achievements of the past were absorbed. Second, with a bound, all of his contemporaries were left behind and a miraculous 'outburst of inventive power directed every branch of painting into new channels, demanding greater material size for greater spiritual expression. Third, there followed a calming-down period when the artist had reached his 40s and his interest turned to refinement and detail. Fourth, there was another crest of the wave: a return to the youthful conceptions of his heroic era, but the conception as such had lost its original importance in favour of changed interpretation. Fifth and last, in the isolation and loneliness of the old, he rejected all compromise with the demands of his period. The fame which he had gained during his earlier manhood lived on, but his direct influence on ascending contemporary artists had lessened and finally stopped. Younger patrons withdrew, and there was a rumour of decay. This art of Titian's old age, which disregarded his patrons' tastes, became the pure expression of the master's intentions. This work does not show decay. It is his fulfillment.

What is known of Titian's life is derived mainly from the writings of three contemporaries: Lodovico Dolce, Pietro Aretino and Giorgio Vasari. Dolce and Aretino lived in Venice and were intimate friends of the master. Vasari favoured Florence and Michelangelo and was thus prejudiced against Titian, although not openly inimical. Born in Arezzo and a compatriot of Pietro Aretino, Vasari was influenced by Aretino's high appreciation of Titian. Carlo Ridolfi, writing in 1648, elaborated Vasari's statements, sometimes incorrectly, and collected everything that was known about Titian in Venice in the middle of the 17th century. A source of a quite different nature is Sir Anthony Van Dyck's sketchbook (c. 1624, Chatsworth house) which in drawings preserves much of Titian's work in Italy. or rather what was believed to be by Titian in Van Dyck's time.

The year of Titian's birth is not known, but indirect evidence points to about 1490. His birthplace was high in the Alps, Pieve di Cadore, to which Titian often returned. In drawings he seems to have thoroughly studied his native mountains since he often inserted their majestic views in the background of his paintings. His family had resided in Pieve di Cadore for centuries, their male members having followed a military or a judicial career. It may be assumed that the boy had shown an inclination for painting early; otherwise he would not have been sent to Venice at the age of nine to be trained as a painter. There, probably after a short apprenticeship with Sebastiano Zuccato, a poor craftsman, he entered the workshop of the government's official painter, Gentile Bellini, and shortly afterward that of Giovanni Bellini. If a modern interpretation of Vasari's text is correct, Titian had a hand in furthering his master's important commission for Alfonzo d'Este, duke of Ferrara, the "Feast of the Gods" (National gallery, Washington). The first reliable information about Titian concerns his share in the frescoes which Giorgione was commissioned to paint on the walls of the Fondaco dei Tedeschi (the warehouse of the German merchants in Venice, 1507–08). In the damp Venetian atmosphere the frescoes soon perished except for two fragments now in the Academy in Venice; the compositions of several others are preserved in engravings dating from the 17th and 18th centuries.

Three murals representing deeds of St. Anthony, which Titian painted in the Scuola del Santo in Padua, are documented by the receipt for his fee dated Dec. 2, 1511. In the mural representing St. Anthony bringing to life a woman murdered by her jealous husband, Titian shows his independence by relegating the culminating episode of the legend to the background and making the dramatic episode of the murder the main scene.

After Giorgione's death, Titian returned to Venice. Marcanton Michiel's notes on Venetian art treasures state that Titian finished several of Giorgione's pictures. His own work was strongly influenced by Giorgione in this period which ended about 1515. The most famous examples are the "Flora" (Uffizi, Florence) and the "Sacred and Profane Love" (Borghese gallery, Rome); opinions about the authenticity of the "Concert" (Pitti, Florence) are divided.

Before 1513 Titian designed the mighty series of woodcuts, "Triumph of Faith," "Sacrifice of Abraham" and "Destruction of Pharaoh's Host in the Red Sea." They represent a revolution in the history of woodcuts, for they did not vie with miniature painting, as earlier graphic art in Venice had done, but rather with murals. In the "Destruction of Pharaoh's Host in the Red Sea" the drowning horses in their violent poses were most impressive. Titian, conscious of having achieved something that no other artist in Venice could have accomplished, let this sureness set the tone of his application to the government for the commission for the "Battle" in the Sala del Gran Consiglio (Great Council hall in the Ducal palace) in 1513, in which horses were to be the main actors. The first decoration of this hall, representing legendary themes, was replaced by a series for which Titian painted the "Battle of Spoleto." After this series was destroyed by fire in 1577, another series was begun in which the battle of Spoleto was not included as a theme, and even its name was lost; later writers referring to Titian's great work spoke of it as the "Battle of Cadore." A painted copy in the Uffizi, two engravings, a preparatory drawing of the whole composition in the Louvre and a study for one of the riders in the Uffizi are all that are preserved of Titian's greatest profane painting, which required a quarter of a century to complete. After receiving this commission, as well as the position of official government painter in 1516 after Giovanni Bellini's death, Titian accepted many other commissions.

The high altar painting "Assumption of the Virgin" for the church of Sta. Maria Gloriosa dei Frari was the sole commission which he completed on schedule (ordered in 1516, unveiled in

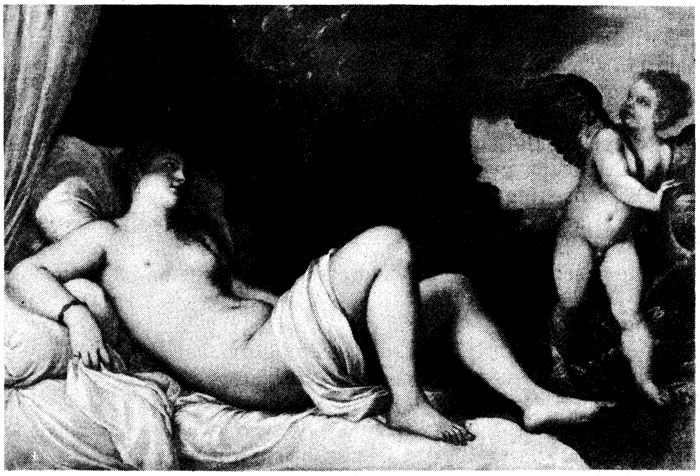
March 1518). This work, abundant with figures and bursting with vitality, was a frightening surprise for the Franciscan monks. Venice, bound by its Byzantine heritage and therefore more conservative than any other cultural centre in Italy, with this painting stepped to the front of the new movement called High Renaissance.

The second of Titian's great religious classics is the altarpiece for the Pesaro family, also found in the Frari. The payments ran from April 1519 to May 1526, and on Dec. 8, 1526, the festival of the Immaculate Conception, the painting was unveiled. This composition, although not so energetically dedicated as the "Assumption" to unprecedented arrangement, nevertheless again introduced an unprecedented scheme. Instead of the usual frontal position, the construction has been shifted to an oblique angle; furthermore the scene is set not within the usual church interior or in the open with a landscape view, but in a kind of portico with t o huge columns heightening the impression of spaciousness. The group of donors, including ancestors and living members of the family, are intermingled with the saints, so that the saints become endowed with human vitality and the humans with saintly bliss. The third of Titian's religious classics, the "Martyrdom of St. Peter Martyr," painted between 1525 and 1530 for the church of S. Giovanni e Paolo in Venice and destroyed by fire in 1867, is preserved in many copies. The union of figures and landscape, striving with all their force to the single effect of the drama of the assassination, made this work a landmark in the history of painting. This "Peter Martyr" brought to Titian the acclaim of his contemporaries as the greatest landscape painter of his time.

Alfonso d'Este commissioned three mythological paintings from Titian that are worthy parallels to the three great religious works. Executed between 1517 and around 1523, they also introduced a new style in their field. The correspondence between the duke's agent in Venice, Titian and the court of Ferrara indicates how frequently Titian was interrupted and how the duke urged the execution of these works. The themes of the "Worship of Venus" and the "Andrians" (both in the Prado. Madrid) were taken from descriptions by the late classical writer Philostratus; the one of "Bacchus and Ariadne" (National gallery, London) from Ovid's *Metamorphoses*. There are some striking analogies between the religious and mythological works (*e.g.,* in the "Assumption" and the cupids in the "Worship of Venus"); the tense movement of Bacchus and its alert reverberation in his suite find their parallel in the main figural drama of the "Peter Martyr" and its resonance in the tree trunks and swishing branches.

Titian's mood in his turbulent youth was not appropriate to portrait painting. After the few small and subdued portraits from his Giorgionesque period, Titian chose a larger format. Otherwise they resemble in their solemn rigidity the portraits of the donors in the religious paintings.

In the period of relaxation which followed Titian's first creative outburst he painted so many portraits that Aretino said in a letter of Nov. 9, 1537, that Titian was believed to have become a mere portrait painter. The large output of these portraits in the 1530s was rather uneven; outstanding were those of "Cardinal Ippolito de' Medici in Hungarian Costume" (1533; Pitti), the emperor "Charles V With Dog" (1532; Prado), "Xlfonso d'Avalos, Marquess del Vasto" (1532; private collection, Paris) and "King Francis I" (1538; Louvre). The portraits of the emperor and the French king have in common that they were not painted from nature but from models. That of the emperor is an exact copy from a painting of the Austrian court painter Jacob Seisenegger; that of the French king is from a medal. Titian s eminence as a portraitist is proved in these works: the dry work of Seisenegger has been developed into a deep and noble conception of the strange personality of this lonely man; and the medal's abstract profile has become the means of expression, the pose alone bringing to life the king's "chivalrous gaiety, his sex-appeal and exuberant vitality." The emperor appointed Titian as his court painter and promoted him to count palatine. The latter promotion enabled Titian to legitimate his two sons born before his marriage. Typical works from Titian's intimate period are the small painting in the Louvre, "Madonna With the Rabbit" ($26\frac{3}{4} \times 33$ in.) and



ALINARI

"DANAË" BY TITIAN. IN THE NATIONAL MUSEUM, NAPLES, ITALY

the somewhat larger one, "Madonna and Child With Saint John and Saint Catherine" in the National gallery, London ($39\frac{1}{8} \times 55\frac{1}{2}$ in.). Both claim the same documentation, a letter from 1530 mentioning a "Madonna With St. Catherine" for the court of Mantua. Although the Louvre painting, an "idyllic scene in format, composition and spiritual content is a little Titian, its colour scheme makes it worthy to rank among his great masterpieces."

The "Presentation of the Virgin in the Temple." painted between 1534 and 1538 for a wall in the Scuola della Carità, is still at its original location above two doors where the Accademia (the Museum of Venice) has grown around it. At first sight its composition looks traditional; but the perspective construction has been unobtrusively developed into a motif of expression. The woman with the basket of eggs against the stair wall, seemingly a mere genre figure traditional in Venetian paintings of this subject, is monumentalized by Titian to a heroic dignity which fits well with the antique torso on the other side of the door.

Titian visited Rome in 1545, at which time Paul III Farnese and his two nephews sat for a group picture. This Farnese group (Naples), a feast in flaming reds, was never finished. Titian brought with him as a present a picture of "Danae." This precious gift, now in Naples. is an evolution of the motif of the "Nude Woman Lying Down," the first version of which goes back to Giorgione. Titian had further developed this motif in the "Urbino Venus" (about 1538; Uffizi). Shortly afterward. he adapted this genrelike version, using the same youthful girl to model for a "Danae" (private collection, New York) and later for the fully blooming woman of the Naples painting. Even while in Rome Titian tried to obtain the emperor's invitation, offering him a "Venus" painting as a present. In 1547 he brought it to Augsburg where Charles V held his diet. This Venus has not been identified; it might have been a version of the two shop productions of this subject in the Prado. The most important work of Titian's first stay in Augsburg was the portrait of the emperor as victor of the battle of Miihlberg, which took place on April 24. 1547. The emperor is shown in the armour he wore that day as he rode into battle. The painting (1548; Prado) sets the pattern for all subsequent representations of princely portraits. The "Gloria" (1554; Prado), also called "Last Judgment," is the last great painting Titian delivered to Charles V. The emperor took it with him when he retired to Yuste after his abdication in 1555. After 1554, Titian began to deliver his paintings to Philip II. Charles' successor. On Dec. 22. 1574, he sent a list of those which he had shipped to Spain during the previous 25 years. Most of them represented mythological subjects—Titian called them *poesie*—and were developments of earlier conceptions. These can best be studied in the "Danae" versions of this late period (*e.g.,* in the Vienna gallery), which enhance the decorative side at the expense of the spiritual content. The woman whose passion had heightened her into a goddess became a fixture within a harmonious construction. Seen from another angle, such change denotes the wise and tenderly sad resignation of old age.

Titian's son Orazio, other members of the family and German painters who had joined the shop fulfilled the incoming orders and manufactured the goods which Orazio shipped to places where sales were likely. Titian may—or may not—have retouched them before they left the studio. The assistants based their fair copies on models kept in the studio. Titian himself had done these models, consisting of portraits from nature, final conceptions of his *poesie* and devotional pictures. Serving originally as a basis for further production as Titian developed or modernized them, they now served for reproduction by the assistants. Some of these *modelli* go back into Titian's youthful years. Vasari, when visiting Titian in 1566, found the house in the Birri full of them. After Titian's death Pomponio, his second son, had them retouched and finished to make them salable. Most of them came to the Hermitage (St. Petersburg) in the 19th century, and to the United States in the 20th century. Four were bought by Tintoretto in their original state (one of these, "Christ Crowned With Thorns," is in Munich). These *modelli* had not been conceived for sale; they anticipated the unrestrained boldness that is typical of the master's late works, with which they are often confused. The very impressive late "Pietà" (Academy, Venice), which Vasari had seen in the studio and with which Titian had planned to adorn a chapel in the Frari, was finished by Palma Giovane after Titian's death in Venice on Aug. 27, 1576.

Orazio died from the plague several weeks after his father. He had been his father's right hand for many decades, and Titian had tried to introduce him as his heir to King Philip of Spain and to the Venetian government. Since all the work of Orazio, except for a small Crucifixion that was rediscovered in 1956 in the Escorial in Spain, has been inseparably incorporated into that of his father, nothing of his own style is identifiable.

See H. Tietze, *Titian,* 2nd ed. (1950), which has a good bibliography. (E. T.-C.)

TITICACA, LAKE (LAGO TITICACA), in the Andes of South America on the border between Peru and Bolivia, is the world's highest large lake. Its area of 3,141 sq.mi. is divided into two parts by the Strait of Tiquina. The northwest part, Lake Chucuito, is the larger, 85 mi. long by 35 mi. wide; the smaller southeast part, Lake Uinamarca, is 15 mi. long by 35 mi. wide. The whole lake, including the strait, is 110 mi. long. Its northeast shore is along the base of the towering Cordillera Real with peaks 21.000 ft. or more in height. Spurs of the mountains extend into the lake as rocky promontories. There are also high mountains to the southwest. Between the promontories, and at either end of the lake, the shores are marshy. The water level is 12,497 ft. above sea level. The lake is very deep—1,214 ft. Consequently the water temperature remains quite constant at about 51° F. The lake receives its water, which is only slightly brackish, through many short streams descending from the snow-capped mountains on either side. In addition there are three larger rivers draining a wide area of the Peruvian highlands—the Río Ramis, the Río Coata and the Río Huenque. The lake's outlet to the southeast is through the Rio Desaguadero into Lake Poopó.

One of the earliest civilizations of the Americas developed around the shores of Lake Titicaca. Archaeological remains of old cities, dating back to the time before Christ, are found on Titicaca Island and Coati Island, on the Copacabana peninsula, and at Tiahuanaco southeast of the lake. The Aymara Indians who still live in the Titicaca basin are the descendants of native peoples who were conquered by the Incas from Cuzco. They maintained their language and their way of living in spite of this conquest. Later, when conquered by the Spaniards, they were able to maintain their hold on the land regardless of the superior technology of the people from Europe. The Aymaras catch fish in the lake, and plant potatoes, quinoa. barley and maize on terraced fields around the shores. Their land is generally accepted as the place where the potato was first planted as a crop. Railroads connect Puno on Lake Titicaca with Mollendo and Matarani on the Peruvian coast, and Guaqui at the southeast end of the lake with La Paz in Bolivia A regular steamer service connects these two lake ports. *See* also BOLIVIA; *PERU.* (P. E. J.)

TITLE INSURANCE COMPANY is a company that issues policies indemnifying owners, mortgagees, lessees and others having particular interests in real estate against loss by reason of defects in title. Title insurance is strictly an American institution, having originated in Philadelphia, Pa., in 1876. The only comparable system of title assurance is a method of title registration devised in 1858 by Sir Robert Torrens in Australia, under which a certificate of title is issued by a public officer. With some variations in operation, the Torrens system has been adopted in a number of British colonies, some Canadian provinces, London, England, and a few states of the U.S. In some parts of Europe land records for many years have been kept by a system of judicial registration. In some countries there is neither registration of titles nor any provision for recording deeds; title papers aye preserved and passed from one owner to another when title is transferred.

In every state of the United States there are statutes providing for recording deeds, mortgages and other instruments relating to real estate. These statutes serve the dual purpose of preserving the records and of giving notice to all persons of their contents. There are also other public records of taxes, wills, court proceedings, judgments and mechanic's liens which affect title. In the course of time these records have become so voluminous that the process of re-examining title every time it is transferred has become increasingly laborious and complicated for lawyers. The problem of improving methods of transferring interests in land has long engaged the attention of lawyers, legislators and bar associations, but despite limitation statutes barring ancient claims, curative laws correcting minor flaws in public records, and adoption of title examination standards for guidance of lawyers, no substantial progress has been made. The title insurance business has thrived in offering a solution to this complex title problem. Upon transfer of a title that has been insured, the insuring company does not re-examine the entire history of the title, but merely considers matters affecting the title since the prior policy was issued.

There are about 160 title insurance corporations in the United States. Most of these offer title service only in the state of incorporation through a home office and agents, who may be abstracters or lawyers experienced in real-estate matters, designated "approved attorneys." A few of the larger companies insure titles in many states. Title insurance is available everywhere in the United States either from a local company or through an agent of a national company. Title insurers have a trade association, the American Title association, organized in 1907, whose membership includes title insurance companies, abstracters and attorneys specializing in real-estate law. There are also 32 state title associations.

Title insurance companies are subject to regulation and supervision, the extent of which varies in different states. In most states they are governed by an insurance code, which covers also other familiar kinds of insurance—life, fire, accident and public liability. Regulation often includes minimum capital requirements, supervision of policy forms and premium rates, maintenance of loss reserves, and periodical examination of company records by state officials. Most states require a substantial deposit of securities with a state officer to protect policyholders.

Title insurers issue two basic types of policies—an owner's policy and a mortgage policy—the forms of which differ among companies. They issue also a standardized form of mortgage policy, known as the American Title Association Standard Loan policy, whose coverage is substantially broader than most mortgage policies. The cost of title insurance depends upon the amount of the policy, the scope of coverage and the work involved in searching and examining title.

Many reasons account for growth of title insurance in the United States: insurance-mindedness of Americans; preference for title insurance over other forms of title evidence because protection includes indemnity against loss and defense against adverse claims; escrow and other services rendered by title insurers in connection with closing of real-estate transactions. (C. F. GR.)

TITLE TO LAND. Title is a legal conclusion concerning the ownership of land drawn from facts which, if proved, will enable an "owner" to obtain or retain possession of it. A complete understanding of land titles requires comprehension of the number and nature of interests in land recognized by the legal system where the land is located, the rules which the system provides to determine priority among two or more claimants to the same land and the procedure for obtaining and preserving the necessary title evidence.

The Anglo-American law of real property recognizes a complicated mass of interests which may coexist in a parcel of land. Several estates, several concurrent owners of undivided interests and several persons having different rights to use and enjoyment may all exist with respect to any given parcel. Fragmentation of ownership thus complicates land titles. but the rules concerning priorities may determine how many of the fragments other than those presently created are factors in the title.

It would have been possible to have had a priority rule that anyone who buys and takes possession in good faith obtains an absolute title to land even though the possessor from whom it was obtained was not himself the owner. Gnder such a rule a thief could pass title to an innocent purchaser. Mercantile law applies this precept to certain kinds of negotiable instruments such as currency, notes or checks, so that an innocent person who purchases such property from a thief acquires a title prior to or better than the person from whom the instrument was wrongfully taken (see COMMERCIAL PAPER). This rule, however, has never been applied to land; in fact, the early common law had almost an exactly opposite rule of priority. first in time is superior in right no matter how innocent a later purchaser may be. This rule, together with the fact of land's permanence and the prevalence of many interests in land, gives land a long title history which must be proved. A buyer of land must often examine the entire history of a parcel of land in order to determine whether the present seller is the successor of an earlier person who was first in time. Thus a seller must show that he got it lawfully from someone else and the latter from someone else and so on. Except for ancient and modern statutes of limitations designed to prevent a person, however rightful he may be. from asserting his claim after the lapse of a number of years, this proof would require that title be traced back to a discoverer, conqueror, sovereign or some other "first" person (see PRESCRIPTION).

The basic problem in land titles is one of proof. How does a seller go about furnishing proof that he or his predecessors were first in time? In primitive society neighbours knew firsthand and from received tradition who owned what parcel. If ownership was to be transferred from one person to another, it was done with the utmost publicity in the neighbourhood—by a symbolic delivery of the land in the presence of neighbours. As society became more complicated such direct knowledge was not enough. and each government eventually provided procedures for preserving the evidence of title histories. In much of England this is still done by passing the accumulated instruments of title from one buyer to the next. However, on the continent of Europe, in all of the British Commonwealth and in the United States. systems of public registries where evidence of title could be publicly preserved were universally established. In the English-speaking world the registries maintained in the American colonies, from as early as 1640. are the oldest; registry in the English counties of Middlesex and York did not begin until the 18th century.

In the process of developing the systems of public registries, the old "prior in time, prior in right" rule was substantially modified. if not eliminated, and the modern system of priorities is based almost completely on statutes dating, in the Anglo-American world, from the 18th century. Two systems of public registry developed and are still in use. In one system a record of all documents affecting land title is kept in a public registry, and a competent examiner must himself draw the necessary legal conclusion as to the owner of a parcel of land. This system compels a buyer to investigate title and to draw, at his peril, a correct legal conclusion regarding the significance of all the recorded documents.

Under the other registry system, known as the Torrens system (see below), the legal conclusion as to the state of the title is itself shown by the public record.

The Title-History System.—Under the first system, which maintains a public record of the title history, the statutes, in order to compel use of the record, developed four different rules of priority: (1) In some parts of western Europe a conveyance attempting to create an interest in land is not effective at all until it is recorded in the public records, so that the first to be recorded is prior in right because it is the only recognized transfer. The Anglo-American legal system rejected this rule of priority and concluded that an unrecorded deed of conveyance was good as between grantor and grantee but that a grantee who failed to record might lose his priority or right to some other claimant. (2) In the original recording statute for York county, in Scotland, and in a few states of the U.S. a first grantee could lose his right as against a person who recorded first; he who wins the race to the public records has priority of title. (3) In the original Middlesex statute and in many parts of the United States, particularly in the northeast, a second grantee from the same grantor acquires priority or title only if at the time of the delivery to him of the second instrument he had no notice of a prior instrument. Since he had "record notice" of a recorded instrument whether or not he saw it, the second in time is entitled to priority only if the first instrument is unrecorded and only if the person receiving the second conveyance is without actual knowledge of the earlier instrument. (4) The third type of statute in the United States and in parts of the British Commonwealth combines the "race" type with the "notice" type described above and grants priority to a subsequent purchaser over an earlier purchaser of the same parcel of land only if the second purchaser lacks notice and records first.

Recording and Indexing.—The mechanics of recordation are relatively simple. In all jurisdictions a person is on notice by reason of record only if the instrument found in the record is one entitled to be there. If the instrument is of a type entitled to be recorded, it is accorded record notice in most U.S. states only if it is acknowledged or witnessed. The recipient of an instrument, of conveyance takes it to the office of the recording agency. usually a county, although sometimes a town office. together with the prescribed fees. The instrument is from that moment "recorded." The recorder transcribes the instrument by hand) typewriter or photography and returns the original instrument to its owner.

Because of the volume of such records, an index to the system is necessary. Two types of index are in use, many states of the U.S. having both types. By far the most common are alphabetic indexes of both grantors and grantees. In such an index system a prospective buyer would find his seller's name in the grantee index, which would also give in an appropriate column the name of his grantor and the volume and page where the instrument is recorded. By following the grantee index back as far as one wished, looking for each preceding grantor in the grantee index, one could determine the chain of title of the present owner. A search of the grantor index would indicate whether any grantor in the chain of title had made some other conveyance of the same parcel of land to another. Thus the grantee index would index that B had purchased from A. but only the grantor index would indicate that A previously had mortgaged the land to X.

The other index system is based on the parcel rather than the names of the owners) and all relevant instruments concerning each physical area in the county are listed by page and volume number of the official books of record. Thus each parcel has its own index page. This index system is called a "tract" index.

Other *Information Affecting* Title.—Unfortunately for a title examiner not all of the matters which affect title to a parcel of land are to be found in the recorder's office. Thus any real-property tax liens for unpaid taxes will be listed in the county treasurer's office; bankruptcies and federal tax liens may be in the United States courthouse in another county; if the parcel of land was transmitted by reason of the death of the owner, the records of the probate court must be searched; if one of two joint owners dies, the only evidence of the power of the survivor to convey is the death certificate of the other in the department of vital statistics. Some defects in title may not appear in the record at all. An instrument does not indicate whether a transferor at the time of transfer was married or single; it does not indicate whether the instrument is in fact a forgery; nor does it indicate that in spite of the description in the conveyance there is less land than agreed upon because a neighbour built his fence on the wrong location of a boundary or built his eaves and cornices to overhang the property being purchased.

England has alleviated some of these difficulties by providing, since 1925, a land charges registry in which tax liens. covenants, easements; annuities and certain public-building restrictions must be recorded in order to give the claimant to them priority. However, since entries in this system are made against the name of a previous owner and not against the land, title search is difficult.

Professional Aids.—The complicated nature of transactions under the title-history system has produced several kinds of professionals who are customarily employed in order to give a buyer full assurance as to title. For urban properties it is customary in many parts of the United States and England to employ a surveyor to run the lines of the description of the land in question in order to determine any discrepancies and encroachments on the property. A professional title searcher is employed to trace in the public records the history of the land title and to abstract the records. Sometimes this title searcher is the lawyer who also gives a title opinion, and more commonly in western United States he is a professional abstractor or reader of the records and not a lawyer. Finally, a lawyer is employed to read the abstract of the instruments found in the public records and to prepare a title opinion in which he states his conclusion as to the state of the title. No one of these professionals guarantees the title; each is obligated only to use the reasonable standards of competence of his profession, and in the case of the abstractor there is an absolute obligation not to misread or omit a document in the chain of title. Abstractors are usually bonded. In England, while a surveyor may be used, a solicitor performs all other functions.

Private Title Insurance.—Another expedient for overcoming the worst drawbacks of the private investigation system used in the United States is private title insurance. A title insurance company either investigates the history of a title itself or employs an abstractor to do so; then, on the basis of a legal examination of this history, it insures that the title is good except for certain reservations stated in the policy. The title insurance policy, purchased for a single premium and not an annual premium. insures not only against loss resulting from mistakes in the abstract of the public records but also insures that its legal conclusion regarding the title is correct, including loss resulting from forgery and other irregularities which may not show on the face of the records. Thus, if a married man in the chain of title states in his deed of conveyance that he is single, the public records will show no outstanding claim of marital property in the other spouse. If such a claim does exist because the man is married, contrary to his recital, this claim prevails against an innocent purchaser. Title insurance will insure against this possibility. (See TITLE INSURANCE COMPANY.)

The **Torrens** System.—Another system of title insurance guarantees that the title is as shown in a document maintained in a register of title. Where the older system maintains evidence of title in public records from which a conclusion may be drawn by an examiner, in the title registration system the ultimate conclusion itself is registered. This system prevails on the continent and in most of the British Commonwealth countries and is expanding in England. While it has been available in about 20 states of the U.S., it has failed to make headway. The system is called registration of title or Torrens title after its originator in the Anglo-American world! Sir Robert Torrens of Australia, who modeled it after the ancient ship-registry system in England.

Under the Torrens system each parcel of land is set up on a register in the public records. This page sets forth the name of the owners of the fee simple and also all other rights, interests and liens to which the property is subject. A copy of this page. called an "owner's duplicate certificate title," is delivered to the owner. The transfer of a registered title is accomplished by the owner delivering his certificate to the official registrar with a direction to issue a new certificate to the transferee. The old certificate is then canceled and a new one issued. Thus the system is analogous to the procedure for transfer of shares of stock —the old stock certificate is surrendered for cancellation and a new one issued in the name of the new owner. In the case of involuntary conveyances such as sales by order of creditors, there must be a court order directing the registrar to make the change in ownership.

On an application for first registration the Torrens system in the United States differs substantially from that in the rest of the world. In the commonwealth countries a government official, the registrar. inspects the title in the manner described above for the recording system, and his conclusions, guaranteed by the state, are then entered as the original registered title. In the United States it was thought, at the turn of the 20th century, that the state and federal constitutions required such conclusions to be made only by a court. Accordingly, an elaborate and expensive proceeding to "quiet title" is necessary, in which, after argument and hearing by all possible claimants. the court instructs the registrar as to the nature of the registered title.

The key to the Torrens system is the conclusiveness of the certificate. Everywhere in the United States, however, the statutes except certain encumbrances from being shown on the certificate. The usual matters are short-term leases, public highways, current taxes and claims of the United States. A purchaser of land under a Torrens title in the U.S. must therefore continue to search other records for these encumbrances.

The reasons for the failure of Torrens title in the United States is revealed by the reasons for its success elsewhere. The success of the Torrens title in western Canada and parts of Australia is due to the fact that the first registration commences with the initial transfer of land into private ownership from the sovereign. Thus no complicated earlier history has to be unraveled or considered. In the United States the initial registration is a costly judicial proceeding which will be undertaken by an owner only if the market value of his land promises, as a result, to increase sufficiently to cover the expense. Since this is rarely the case, the cost of registration must almost always be borne by the initiator and cannot be passed on to his successors. It is significant that even in countries where an administrative rather than judicial proceeding is available, registration has not occurred voluntarily. It was made compulsory in London in 1899 and is now compulsory in Middlesex, Surrey and in certain county boroughs. It is also compulsory in New Zealand and Australia, where it is substantially used.

Another reason for the failure of the Torrens system in parts of the United States was the bankruptcy of the assurance fund. Instead of making the guarantee an obligation of the state, each state provided that a portion of the fee paid at initial registration and at each transfer should be paid into an insurance fund which would guarantee the title of the holder of a certificate against loss. In California a judgment for more than the amount collected in the fund early in Torrens history destroyed the confidence in the assurance fund.

In the United States failure of the registered title system has caused renewed interest in methods of simplifying the old recordation system. Many states have statutes limiting or eliminating claims more than a specified number of years old; *e.g.,* 75 years, Bar associations have prepared title standards to which all lawyers are urged to adhere, and they have drafted statutes reducing some objections to the older system. Nowhere has the United States gone as far as England, which has eliminated many of the cumbersome features by changing many interests, such as legal future interests, into equitable interests, subject always to a trustee's power to convey the land free of the claim, and also by limiting the title which a purchaser may demand, in the absence of agreement otherwise, to a good title not more than 30 years old.

On the assumption that the title-history system would continue in the United States. many public and private groups were engaged in the early 1960s in technical research to determine whether all title information could be reduced to cards or microfilms that could be used with modern electronic .computer and other machines. *See* also LAWS OF REAL PROPERTY AND CONVEYANCING. (A. DM.)

TITMOUSE, a name used for certain of the small songbirds (*q.v.*) of the family Paridae, especially those of the genus *Parus*. In Europe "titmouse" used to be in general use but has been shortened to "tit" with a qualifying word to indicate the species, as blue tit, etc. In the United States, where the long form of the word is used, as tufted titmouse, some species which would be called tits in Europe are called chickadees (*q.v.*) from the voice of the birds. The second part of the word is from the old English bird name and has nothing to do with the mammal mouse. Scholars used to hold that "titmouses" was the proper plural but "titmice" is gaining ground. The short form. "tit." is also used for several other unrelated small songbirds of various families.

The name titmouse is used in the United States for the several crested species closely related to the tufted titmouse. *Parus bicolor*. It is about six inches long, with gray upperparts. white underparts and rufous flanks. This titmouse searches for insects among leaves and twigs and in the bark of tree trunks; in so doing it flits about actively and perches acrobatically in a variety of poses. It also feeds on thin shelled nuts which it breaks open by holding them in its feet and hammering with its bill. Its voice is a series of clear whistled phrases. It is not migratory. The nest is made in some natural cavity in a tree trunk and is often lined with fur The five or six eggs are white, finely speckled with broun. The young bear some down; both parents share in nest duties.

JOHN H WHIPPLE FROM NATIONAL AUDUBON SOCIETY

TUFTED TITMOUSE (PARUS BICOLOR) COMMON TO THE U.S.

The titmouse family Paridae contains about 45 species of typical tits, titmice and chickadees which occur in North America, Europe, Asia and Africa They are all small birds, four to eight inches long, often with black caps and black throat patches, and usually with subdued gray and white coloration although some are yellowish or bluish. In habits they are much like the tufted tit but some dig a nest cavity in a dead tree. (A. L. RD.)

TITO (JOSIP BROZ) (1892–), Yugoslav statesman, leader of the Yugoslav partisans in World War II and from Jan 14. 1953, president of the Federal People's Republic of Yugoslavia. He was born on May 25, 1892, at Kumrovec, near Zagreb. Croatia, then part of the Xustro-Hungarian empire. seventh son of a peasant. Franjo Broz. After a childhood of poverty, he earned his living as a metalworker. Soon after the outbreak of World War I, he was sent to the Carpathian front where he was wounded and captured by the Russians in March 1915. This proved to be a turning point ın his life. In 1917 he joined the Red army and also married a Russian girl, Pelagya Belousova, whom he divorced in 1935.

In 1920 Broz returned to his native country, which had meanwhile achieved independence, and joined the Yugoslav Communist party. In 1928 he was arrested and sentenced to five years' imprisonment for subversive activity. When released, he went to Moscow where he worked in the Comintern's Balkan secretariat. In 1936 he was sent to Zagreb and Paris to organize recruitment for the international brigades fighting in Spain. In 1937 he became secretary-general of the Yugoslav Communist party, making his headquarters in Zagreb. He visited Moscow in 1938 and 1939. In the autumn of 1940 he secretly convened in Zagreb the fifth party congress which resolved that Yugoslavia should be kept out of the "imperialist" war (World War II).

In April 1941 the Axis powers invaded and partitioned Yugoslavia, but it was only after the Germans attacked the U S S R. on June *22* that he hurried to Belgrade and decided, in response to Comintern appeals, to prepare an armed rising against the invaders with himself (under the *nom de guerre* of Tito) as commander in chief. Having organized sabotage groups and partisan detachments. Tito left Belgrade at the end of August to take operational command. By mid-September most of Serbia had been cleared of Germans. He negotiated with Dragoljub (Draza) Mihajlovic, a colonel in the Yugoslav army who had rallied some officers and members of the paramilitary chetnik organization, with a view to reaching a unified command and common action. Negotiations broke down, open clashes between partisans and chetniks followed, and by the beginning of December the Germans reoccupied virtually all Serbia. Tito led the remnant of his forces first into eastern Bosnia, then into Montenegro, and finally into western Bosnia. He appealed for unity between differing racial and religious groups in resistance to the occupying forces, and formed (Nov 1942) an embryonic political organization, the Anti-Fascist National Liberation committee, with the same program.

The Germans and their auxiliaries made numerous determined attempts to annihilate Tito's forces, and parachute troops once nearly trapped him in his headquarters at Drvar (May 25, 1944). He escaped to the island of Vis, which was held jointly by British and partisan troops. From there he was able to go to Italy to confer (Aug. 1944) with the Allied commander in chief in the Mediterranean and with Winston Churchill, the British prime minister. A few weeks before Tito had paid a secret visit to Moscow, where he met Stalin for the first time. After the liberation of Yugoslavia Tito, now a self-appointed marshal, became prime minister (March 7, 1945). He visited Moscow officially in April 1945.

Toward the end of the war relations with the west deteriorated owing to Tito's attempt to seize Trieste, the shooting down of a U.S aircraft and the establishment of an undisguised Communist dictatorship in Yugoslavia. At the same time Tito's relations with the U.S.S.R unexpectedly came under heavy strain. Though his forces co-operated with the Soviet army in clearing the Germans out of Yugoslavia, he resented the previous failure of the Soviet Union to help the partisans, the pretensions of Soviet officers and advisers in Yugoslavia. the lack of support for his Trieste claim, and Soviet attempts to exploit the Yugoslav economy. Though still a convinced Communist, he had acquired an independent, nationalist viewpoint. "The Yugoslav brand of Communism," he once said "had its origins in the hills and forests and was not imported ready-made from Moscow." The storm burst in June 1948 when Stalin and the other leaders of the U.S.S.R., followed by those of the people's democracies, openly attacked him. Tito, supported by the bulk of his party, stood firm against Soviet economic pressure and threats of violence. There followed a gradual *rapprochement* with the west, marked by Tito's acceptance of economic aid, a state visit to Great Britain in March 1953 and a compromise over Trieste in Oct. 1954.

Various moves were subsequently made, with fluctuating success, to draw him back into the orthodox Soviet bloc. But Tito continued to favour a neutralist position and cultivated close links with such statesmen as Jawaharlal Nehru of India and Abd-al-Nasser of Egypt. He played host to a meeting of neutralist leaders at Belgrade in Sept. 1961. His achievements are due to remarkable qualities: exceptional physical and moral toughness, coolness in danger, promptness in making difficult decisions; inflexibility over essentials, adaptability and openness to reason and fresh ideas; a ready sense of humour, friendliness (turning to ruthlessness if friends "deviated"); a great zest for life, with an occasional bent toward ostentation. By the 1960s he was living with his third wife, Jovanka Budisavljevic (a second marriage did not outlast the war), chiefly in Belgrade or on his favourite island resort of Brioni, enjoying the prestige of an elder statesman and the fame of a leader who had become a legend in his own lifetime.

See YUGOSLAVIA: *History; see* also references under "Tito" in the Index volume.

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TITOGRAD (PODGORICA), the capital of the People's Republic of Montenegro. Yugos., is located 298 km. (185 mi.) S.S.W. of Belgrade at the confluence of the Moraca and Ribnica rivers.

Pop. (1961) 29,100. Under the name of Podgorica it was first mentioned in 1330. From the second half of the 15th century until 1879 it mas in Turkish hands. In 1918 the union of Montenegro with Yugoslavia was proclaimed there. During World War II the town was occupied by the Italians and heavily damaged by the Allied air forces. The old Turkish-style town still exists; the new town is built on the banks of the two rivers. Titograd (as it was named after World War II in honour of Marshal Tito) has a university as well as several schools. It is an important centre of trade and tobacco growing and has cigarette manufacturing. It is also a road centre and possesses an airfield. (V. De.)

TITRATION is a process of chemical analysis in which the quantity of some constituent of a sample is determined by adding to the measured sample a series of known quantities of another substance with which the desired constituent reacts in a definite, known proportion. The process is usually carried out by adding a standard solution of titrating reagent, or titrant, from a buret, which is essentially a long graduated measuring tube with a stopcock and a delivery tube at its lower end. The concentration of the standard solution is determined by performing a similar titration with a known quantity of the substance to be determined, or a known quantity of some other substance (a primary standard) which reacts in a similar way with the titrant.

The equivalence point of a titration is that point at which an exactly chemically equivalent amount of titrant has been added to the sample. It is a theoretical quantity, which the analyst strives to determine as nearly as possible by means of some signal. This signal can be the colour change of an indicator, a substance which has been chosen to change colour as near to the equivalence point as possible. The experimental point at which the completion of the reaction is marked by the signal is called the end point. The difference between the end point and the equivalence point is the titration error, which is kept as small as possible by proper choice of end point signal and method for detecting it.

Many physical properties of the titration system (sample plus added reagent) change gradually during the course of the titration, and then change at a different rate after the equivalence point has been passed. Among these are the density, viscosity, surface tension, colour intensity and even the temperature (owing to the heat of the titration reaction and heat of mixing). Special titrations are sometimes carried out by measuring one of these properties at various points before and after the end point, and determining by graphical means the point at which an abrupt change occurs in the rate at which the measured property changes with the addition of reagent.

Most titrations, however, are carried out either by means of visual colour indicators or by electrical methods. These two classes of titrations will be considered in more detail below.

VISUAL COLOUR TITRATION

For many titration reactions it is possible to find a suitable visual colour indicator which will signal the end point at, or very close to, the equivalence point. It is convenient to classify such reactions, according to the nature of the chemical reaction occurring between the sample and titrant.

Acid-Base Titration% — For the titration of an acid with a base, or vice versa, the indicator is a substance which can exist in two forms, an acid form and a basic form, which differ in colour. For example, litmus is blue in alkaline solution and red in acid solution. Phenolphthalein, a one-colour indicator, is colourless in acid solution and red in alkaline solution. A wide choice of acid-base indicators is available, varying not only in the colours of the two forms but also in their sensitivity toward acid or base. The indicator is not necessarily chosen to change colour in a neutral solution, but rather to exhibit its intermediate colour (equal mixture of the two forms) at the acidity corresponding to the equivalence point composition. This acidity depends upon the relative strengths of the acid and base undergoing reaction. For instance, if acetic acid (a weak acid) is titrated with sodium hydroxide (a strong base) the salt, sodium acetate, which corresponds to the equivalence point composition, gives a mildly alkaline rather than neutral solution. Therefore, an indicator (such as phenolphthalein) is chosen so that in a solution of sodium acetate it exhibits its intermediate colour.

Precipitation **Titrations.**—Several types of indicator reactions will be illustrated by the example of the determination of chloride by titration with silver nitrate, with the formation of a precipitate of silver chloride. First, the appearance of the first slight excess of silver ion can be marked by the appearance of a coloured precipitate. Potassium chromate can be used as the indicator, the coloured precipitate being red silver chromate. The concentration of the indicator ion must be properly chosen, so that its silver salt precipitates at just the right silver ion concentration. If the coloured precipitate is less soluble than the precipitate formed in the titration reaction, it is necessary to resort to an external indicator titration, in which droplets of solution are tested for excess titrant by means of a spot test. Second, an adsorption indicator can be used to detect the first excess of silver ion. The indicator action is based on the formation on the surface of the precipitate, of an adsorbed layer of silver-indicator salt, which forms only when an excess of silver ion is present. Third, a soluble coloured complex can be used as an indicator. In the Volhard titration of silver ion with thiocyanate, a small concentration of ferric iron is added as an indicator. After the precipitation of silver thiocyanate is complete, the first excess of thiocyanate is indicated by the formation of a red complex ion, $FeSCN^{++}$, formed by the combination of ferric iron, Fe^{+++}, with thiocyanate ion, SCN^-.

Complex Formation **Titrations.**—The most important titrations based upon complex formation reactions are those involving the titration of metal ions with the reagent disodium ethylenediaminetetraacetate, commonly called EDTA. The indicators are dyes which have the property of forming a coloured complex with the metal ion. As the titration proceeds, the reagent reacts first with uncomplexed metal ions, and finally at the end point it reacts with the metal-indicator complex. The colour change corresponds to the conversion of the metal-dye complex into the free dye.

Oxidation-Reduction **(Redox)** Titration% — A redox indicator is analogous in action to the other types of visual colour titrations. In the immediate vicinity of the end point, the indicator undergoes oxidation or reduction depending upon whether the titrant is an oxidizing agent or a reducing agent. The oxidized and reduced forms of the indicator have distinctly different colours.

ELECTROMETRIC TITRATIONS

Electrometric titrations are those in which the end point is detected by electrical measurements. They are classified according to the electrical quantity which is measured. Potentiometric titrations involve the measurement of the potential difference between two electrodes of a cell, conductometric titrations the electrical conductance or resistance, amperometric titrations the electric current passing during the course of the titration, and coulometric titrations the total quantity of electricity passed during the titration.

Potentiometric Titration% — The usual potentiometric titration arrangement is to have two electrodes, one an indicator electrode in the solution containing the sample being titrated, the other a reference electrode, external to the sample vessel and connected to it by means of a salt bridge. The salt bridge provides electrical contact between the sample solution and the reference electrode. The reference electrode is some convenient electrode such as a calomel electrode which maintains a constant potential during the entire titration.

The indicator electrode is chosen to respond to changes in concentration of the particular substance being titrated. For instance, if silver nitrate is titrated with sodium chloride to precipitate silver chloride, silver wire serves as an indicator electrode for silver ions. As the precipitation of silver approaches completion, the potential of the silver electrode takes a sudden jump which serves as an indication of the end point. If an acid is being titrated with a base, the indicator electrode is chosen to respond to changes in hydrogen ion concentration.

In general the potential of an indicator electrode varies linearly with the logarithm of the concentration of the substance to which it responds, or $E = A + B \log C$, where E is the electrode potential, C is the concentration and A and B are constants depending on the type of electrode and the nature of the substance being titrated. During the titration, C changes in direct proportion to the volume of reagent added. Near the end point, the rate of change of C relative to the amount still remaining becomes very large, so that log C changes very rapidly and the potential takes a sudden jump. For accurate work the end point is taken as that point at which the potential is changing most rapidly with titration volume.

Conductometric **Titrations.**—A pair of electrodes, usually platinum sheets, are introduced into a titration vessel, and the electrical resistance is measured after the addition of successive portions of reagent. The reciprocal of the resistance, or conductance, is plotted against titration volume. Generally the resulting graph consists of two straight lines intersecting at the end point. In most cases, there is a region of curvature near the end point owing to incompleteness of the titration reaction. The linear portions of the graph at some distance from the end point are extended to their point of intersection, which marks the end point.

To illustrate a conductometric titration, consider a sample of hydrochloric acid, which in dilute solution is completely ionized into hydrogen ions and chloride ions. The sample is to be titrated with potassium hydroxide solution, which contains potassium ions and hydroxyl ions. The titration reaction is

$$\underbrace{H^+ + Cl^-}_{\text{sample}} + \underbrace{K^+ + OH^-}_{\text{reagent}} \rightarrow \underbrace{H_2O + K^+ + Cl^-}_{\text{product}}$$

in which the net result up to the end point is the substitution of potassium ions for hydrogen ions. Also, some dilution occurs, because water is added together with potassium hydroxide in the reagent. However, in usual practice the reagent is made about ten or twenty times more concentrated than the sample, so that dilution is negligible. If dilution is neglected, the only reason for a change of conductance before the end point is that potassium ions move more slowly than hydrogen ions in an electric field. As a result the conductivity decreases several fold before the end point. After the end point, the conductivity rises markedly because potassium ions and hydroxyl ions are being added. A V-shaped titration curve results.

Very near the end point, the slight ionization of water contributes noticeably to the conductance and causes a slight curvature at the point of the V.

To measure the electrical conductance of solutions, it is necessary to use a Wheatstone bridge with an alternating current. If a direct current is used, Ohm's law cannot be applied because chemical reactions occur at the electrodes. As a result of the reactions, a back e.m.f. is set up which must be overcome by additional voltage before appreciable current can flow. This phenomenon, called electrode polarization, is avoided by the use of an alternating current.

Amperometric **Titrations.**—Amperometric titrations are based on the measurement of electrolysis current during the course of a titration. The current is not determined by the electrolytic resistance of the solution, because the conditions are such that Ohm's law is not obeyed. Instead, the current is determined by the rate of supply of some substance to one of the electrodes. Because of this feature, the amperometric titration does not respond to the total conductance of the solution and the electrode response is therefore more specific.

To illustrate the principle, consider a solution of potassium iodide and iodine, containing two platinum electrodes. This electrolytic cell will pass a current with the smallest conceivable applied voltage, and Ohm's law will be obeyed. At the cathode, iodine is reduced to iodide $I_2 + 2e \rightarrow 2I^-$, and just the reverse reaction occurs at the anode. No polarization, and no back e.m.f. is observed for small applied voltages. Now suppose that the concentration of iodine is very low, while that of potassium iodide is relatively high. Again, a current begins to flow when a very small voltage (say 10 mv) is applied to the cell. However, if the voltage is now increased (say to 100 mv) the current does not increase in proportion to the applied voltage because the concentration of iodine is so low that the current is limited by the rate at which iodine reaches the cathode surface by diffusion and convection. By stirring the solution the current can be increased up to a value which ultimately is limited by the resistance of the solution. However, if the concentration of iodine is low enough, the current is limited by diffusion and convection even if the solution is violently stirred.

The current is then determined by the stirring rate and iodine concentration over a relatively large range of applied voltages. Suppose that a constant voltage of 100 mv is applied, and the iodine is titrated by a suitable reagent such as sodium thiosulfate or arsenite which reduces the iodine to iodide. The current is proportional to iodine concentration, and decreases toward zero at the end point. This is an example of a "dead-stop" end point or amperometric titration with two indicator electrodes. In this example it was evident that the current was limited by the current at one of the electrodes (the cathode). It is usual practice to use only one electrode as the indicator electrode, and to use a reference electrode and salt bridge as in a potentiometric titration. The indicator electrode may respond to a metal ion or an oxidizing or reducing agent in solution. In some titrations, both the substance being titrated and the reagent produce an electrolytic current, in which case a V-shaped titration curve is obtained by plotting current against titration volume. If only the sample yields a current, the titration curve is L-shaped, while if only the reagent responds, an inverted L-shaped curve results. As in a conductometric titration, the end point is detected by the intersection of two straight lines, extended from points well removed from the end point. In the immediate vicinity of the end point, curvature due to incomplete reaction is observed.

Coulometric Titration.—According to Faraday's law, the passage of 96,500 coulombs of electricity through a solution brings about one gram equivalent of chemical reaction at each electrode. In a coulometric titration the quantity of electricity required to carry out a known reaction is measured, and from Faraday's law, the quantity of material present is calculated.

Coulometric titrations may be carried out at constant potential or at constant current. In either case it is necessary to arrange conditions so that only the desired electrode reaction can occur.

In coulometric titrations at constant potential, the potential of one of the two electrodes of an electrolytic cell is maintained at a constant value with respect to a third electrode which serves as a reference electrode of constant potential. The potential is adjusted to such a value that only the desired reaction can occur, and it is maintained at this value throughout a quantitative electrolysis. For example, if silver and copper salts are in solution, the potential is adjusted to a value which permits the deposition of silver but not of copper on the cathode. The current due to silver deposition gradually decreases to a very low value as the silver is removed. The total current, as measured by means of a coulometer, is a direct measure of the silver content of the solution. By adjusting the potential to a new value corresponding to the quantitative deposition of copper, the solution can be analyzed for copper.

To be strictly analogous to ordinary titrations, coulometric titrations should be carried out at constant current. The quantity of electricity in coulombs is equal to the product of the current in amperes and the time in seconds. The time of electrolysis is analogous to reagent volume and the current is analogous to reagent concentration in an ordinary titration. In a constant current titration it is unnecessary to use a coulometer, but simply to determine the time elapsed during the quantitative electrolysis. However, some means of indicating the end point is necessary, and also special precautions are necessary to make sure that only a single electrode reaction can occur. This is usually accomplished by adding some substance which acts as a coulometric intermediate. For example, if a quantitative oxidation of ferrous iron is to be carried out at a platinum anode, it is necessary to avoid the anodic evolution of oxygen even near the end point where the concentration of ferrous iron is very low. To do this, cerous cerium is added in relatively high concentrations. It is oxidized at the anode to ceric cerium, which oxidizes the last of the ferrous iron in solution. Another procedure is to generate the titrating reagent using an electrode in an external flowing solution which is continuously being added to the titration cell.

As an example, hydroxyl ions can be generated at a platinum cathode by electrolyzing a neutral solution of sodium sulfate. The solution flowing past the cathode surface is added to the titration vessel.

The end point can be detected either by a colour indicator or by any of the electrometric methods described above.

See also ELECTROCHEMISTRY ; INDICATOR, CHEMICAL.

See I. M. Kolthoff and H. A. Laitinen, *pH and Electro Titrations* (1941); *J.* J. Lingane, *Electroanalytical Chevnistry* (1953); *H. A.* Laitinen, *Chemical Analysis* (1960). (H. A. L.)

TITUS, SAINT, like Timothy, in the New Testament, is known from allusions in the Acts of the Apostles and the Pauline epistles. He was a convert from paganism! and St. Paul refused to allow him to be circumcised (Gal. ii. 1 ff.) at Jerusalem, when the conservative party' demanded this concession to religious feeling. He then appears in connection with the Corinthian church (see I and II Corinthians) where he won the greatest praise from the apostle for his upright and loyal services. He was specially entrusted with the business of organizing the collection for the poor Christians of Judaea, in the Achaian churches (II Cor. viii, ff.), and evidently acted as a commissioner of the apostle Paul at Corinth during the dispute that followed. According to II Tim. iv. 10 he went off subsequently on a mission to Dalmatia, but the epistle addressed to him implies a tradition that he superintended the work in the island of Crete as a delegate of his chief. Later tradition made him bishop of Crete. Titus' feast day in the Greek and Syrian churches is Aug. 25, in the Roman Catholic Church Feb. 6. (J. MoF.)

TITUS, FLAVIUS SABINUS VESPASIANUS (A.D. 40 or 41–81), Roman emperor 79–81, son of the emperor Vespasian, was born on Dec. 30. A.D. 40 (or 41). As a young man he served with credit in Germany and Britain. and had command of a legion under his father in the Jewish war. In 68 he was sent by his father to congratulate the newly proclaimed emperor Galba, but hearing of Galba's death he returned to Palestine. The next year Vespasian, having been proclaimed emperor, went to Italy, leaving Titus to carry on the siege of Jerusalem! which was captured on Sept. 8, 70. On his return to Rome he and his father celebrated a triumph! recorded by the "Arch of Titus." For the rest of Vespasian's reign he was associated with him in the government with the title of Caesar. During this time he was not popular and he outraged public opinion by his connection with Berenice, sister of Herod Agrippa; both of them came and lived in the palace for a while but Titus had to send her back. He succeeded his father in 79 and put an end to prosecutions for treason, banished the informers and became pontifex maximus to avoid shedding blood. He was notably lenient to Domitian who plotted against him. The Colosseum was finished in his reign and he built new baths in Rome. He visited Pompeii when it was destroyed in 79 and contributed to its relief; during his absence there was a three-day fire in Rome and he again gave his assistance. The only fighting during his reign was in Britain, where Agricola conquered as far as the Tay. Titus died on Sept. 13, 81.

See also Index references under "Titus, Flavius Sabinus Vespasianus" in the Index volume.

TITUS, EPISTLE TO: see PASTORAL EPISTLES.

TITUS TATIUS, in Roman legend, the Sabine king of Cures, who waged war upon the Romans to avenge the rape of the Sabine women (see ROMULUS). After various indecisive conflicts the latter, who had become Roman matrons, intervened and prevailed upon the combatants to cease fighting. A formal treaty was then arranged between the Romans and Sabines, whereby Romulus and Tatius were to be joint and equal rulers of the Roman people. Rome was to retain its name and each citizen was to be called a Roman, but as a community they were to be called Quirites (*q.v.*); the Sabines were to be incorporated in the state and admitted into the tribes and curies. After this arrangement had lasted for five years it came to an end by the death of Tatius, who was killed out of revenge by the inhabitants of Lavinium. According to Mommsen, the story of his death (for which see Plutarch) looks like a historical version of the abolition of blood revenge. Tatius, who in some respects resembles Remus, is not a historical personage. but the eponymous hero of the religious college called *sodales Titii.* As to this body Tacitus expresses two different opinions, representing two different traditions: that it was introduced either by Tatius himself to preserve the Sabine cult in Rome; or by Romulus in honour of Tatius, at whose grave its members were bound to offer a yearly sacrifice.

TITUSVILLE, a city of Crawford county, Pa., U.S., on Oil creek. 40 mi. S.E. of Erie. It was founded in 1796 by Samuel and Jonathan Titus and prospered as a lumbering and agricultural centre. It was incorporated as a borough in 1847 and chartered as a city in 1866.

Oil seeping from the ground nearby aroused the interest of chemists and on Aug. 27, 1859, the first oil well in history was drilled just outside the city limits by "Col." Edwin L. Drake (1819–80). The oil industry began aith this 70-ft. well and the area boomed. The first oil refinery, blasting torpedo, casing-head gasoline plant and gasoline engine for pumping were at Titusville. The nation's first extensive natural gas industry was developed in the area about 1872. In 1934 the Drake well property became a state park of 229 ac. An exact replica of the Drake engine house and derrick and an extensive museum of early oil industry artifacts are at the site. A monument to Drake was erected in the city's Woodlawn cemetery in 1902.

There are no oil refineries in the city today, the annual production from the county's remaining producing wells being trucked to nearby Oil City (*q.v.*). Small plants use local oil to produce plastics and wax. Alloy steel, boilers and forgings are the city's major products. For comparative population figures see table in PENNSYLVANIA: Population.

See Hildegarde Dolson, *The Great Oildorado* (1959). (W. A. C.)

TIV, a Nigerian tribe living on both sides of the Benue river about 150 mi. upstream from its confluence aith the Niger. Their language is a separate subdivision of the Niger-Congo family of languages; it was reduced to writing about 1920 by missionaries and is taught to all who attend primary school. Tiv are subsistence farmers whose main crops are yams, millets and sorghums, all of which are eaten as staple porridge. made palatable by combination with sauces and stews consisting of meat, oils and vegetables. Tiv have no indigenous state organization, but form a series of territorially based lineages organized on the principle of segmental opposition. They see this system in terms of an agnatic genealogy running back about 17 generations; the descendants through males of each person in the genealogy, of whatever generation, form both a territorial group and a kinship group. The balance of power between equivalent segments in this system provides the basis for carrying out the political activities of law enforcement and military protection. In response to popular demand, the British administration established a paramount chief in 1948. Tiv who are not Christian are polygynous if they can afford to be so. Their complex system of exchange marriage was outlawed in 1927 and replaced by marriage with bride wealth. Women aluays move to the homes of their husbands. which in 83% of the cases are with the husband's lineage. Tiv religion, based on manipulation of forces entrusted to man by God, is still a powerful force. Missionaries have, however, worked among Tiv since 1911. A number of converts have been made; most Tiv have some knowledge of Christian principles. There is a minor Moslem infiltration.

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TIVERTON, a municipal borough in the Tiverton parliamentary division of Devon. Eng.. at the confluence of the Lowman and Exe. 14 mi. N. of Exeter by road. Pop. (1961) 12.296. Area 27.8 sq.mi. Twyfyrde (the double ford) is mentioned in Alfred's will (880–885). In Domesday Book Tiverton is the king's, but Henry I gave the great manor to the Redvers. William de Vernon, 5th earl of Devon, founded a borough between 1193 and 1217, and in 1615 it was incorporated by James I, who also established two members of parliament. New charters were granted by James II and George I. St. Peter's church contains a Norman doorway. John Greenway's chantry chapel (1517) has noteworthy external carvings of ships. The castle, founded by Richard de Redvers about 1105, was later a principal seat of the Courteney, earls of Devon. Enriched by the kersey trade, Peter Blundell founded (1604) the largest school in the west of England. Life at Blundells in the 1830s is vividly described by R. D. Blackmore in Lorna *Doone*. Externally the 17th-century buildings and grounds are well-preserved. The school continues in modern buildings near the town. The cloth trade failed in 1816; John Heathcoat (1783–1861), inventor of the bobbin net frame, then went to Tiverton. His firm now makes elastic net and woven nylon, as well as lace,

See M. Dunsfold, *Historical Memoirs of the Town and Parish of Tiverton* (Exeter, 1790); W. Harding, The *History of Tiverton*, 2 vol. (Tiverton, 1845–47); E. S. Chalk, *History of St. Peter's Church, Tiverton* (Tiverton, 1905); W. G. Hoskins. *Devon* (London, 1954).

TIVOLI, (ancient *Tibur*), a tonn and episcopal see, province of Rome, 18 mi. E.N E. of Rome by road and tramway, 24½ mi. by rail. 760 ft. above sea level. Pop. (1957 est.) 32.973 (commune). Tivoli lies on the west of the Sabine mts.. where the river Anio issues from them. upon a limestone rock above the river. The town on one side overlooks the Campagna di Roma and Rome itself, on the other the deep gorge of the Anio, with its lofty falls, and the environs are very beautiful.

Tivoli is in part built upon the extensive terraces of the temple of Hercules Victor, the chief deity of Tibur, of which some remains exist. A modern improvement is a channel, consisting of two parallel tunnels 290 and 330 yd. long, which was made to the N.E of the city in 1826–35, after a flood of the Anio led to a change in its course and threatened to carry away the town. On emerging from these tunnels, the river has a fall of 354 ft. Farther N.W. are smaller falls (the cascatelle) of that portion of the river which is carried through the town and serves for industrial purposes. Five miles W. are the sulphur baths of Acque Albule, with a temperature of 75.2° F. They were known to the ancients and are still frequented. Tivoli has numerous remains, many of them dating from ancient Roman times. Tibur was a favourite place of resort for such Romans as Augustus, Maecenas, Hadrian, Horace and Suetonius, all of whom had villas there; and Suetonius, as well as Catullus and Statius, made Tibur famous with their enthusiastic praise. The remains of villas in the district are numerous and important. particularly those of Hadrian's villa. which contained statues, marbles and fine mosaic pavements, some of the last being preserved in *situ*. The Villa d'Este, begun in 1549 by Pirro Ligorio for Cardinal Ippolito d'Este the younger, has the finest example of a Renaissance garden in Italy. The castle was built in 1460 by Pius II on the site of the amphitheatre and is now a prison. The town contains numerous old churches and houses. and there are some fine paintings of the later middle ages and early Renaissance in the cathedral.

Ancient Tibur. — Though on the edge of the Sabine mountains, Tibur was a member of the Latin league. It allied itself with the Gauls in 361 B.C., and in the war which followed the towns of Empulum and Saxula were destroyed and triumphs over Tibur were celebrated in 360 and 354 B.C., and again in 338 when its forces were defeated with those of Praeneste. It became, however, an ally of Rome. Its prosperity during the imperial period was mainly due to the favour in which it stood as a summer resort. During the siege of Rome by Narses, Belisarius occupied Tibur; it was afterwards treacherously surrendered to Totila, whose troops plundered it. but who rebuilt it in A.D. 547. (T. A.; X.)

TLAXCALA, smallest state of Mexico. Pop. (1960) 347,334; area, 1.555 sq.mi., gives it the highest density (183 persons per square mile) among Mexican states. It is bordered on three sides by the state of Puebla and is bounded west and northnest by the states of México and Hidalgo. Lying on the great Mesa Central, it has a mean altitude of 7,000 ft. that provides it with a cool, healthful climate. Railways and highways link it to the federal capital, Mexico City (66 mi. W.N.W.) and Puebla (14 mi. S.). Almost exclusively agricultural, Tlaxcala grows cereals and has numerous handicrafts, notably weaving of serapes and woolen cloth. It is the descendant of the Indian principality of Tlaxcala which refused to surrender to the Aztec confederation and joined Hernán Cortés as his principal Indian ally in the conquest of Mexico (1519–21). Continued loyalty to Spain brought the Tlaxcalans many subsequent privileges. Capital of the state is Tlaxcala (pop., 5,071), largest of numerous towns and villages. situated at an altitude of 7,500 ft. The Indians of this area are relatively prosperous because the Spaniards never let them be despoiled. The town itself is old and charming and has the oldest church in Mexico built in 1521. At Tizatlan across the river is a small temple whose painted altars depict the symbolism of the ancient religion. .Near the town Cortés built his brigantines which he transported to the Lake of Mexico in his final onslaught on the Aztec capital. (J. A. Cw.)

TLEMÇEN, a town of Algeria, the capital of an *arrondissement* in the *département* of Tlemqen, near the frontier of Morocco, 68 mi. by road and 102 by rail S.W. of Oran. Pop. (1960) 80,000 (metropolltan area). It stands 2,500 ft. above the sea, on the north slope of the Lella Setta hills 14,000 ft.). The railway from Oran runs from Tlemçen to Ujda and thence to Rabat via Fez. Another line links Tlemqen to the port of Beni-saf.

The various quarters are grouped around the principal mosque —the Jewish to the southwest, the Moorish to the southeast, that of the merchants to the northeast, while the new town with the civic buildings lies to the northwest. Of the 64 mosques which existed at the period of the French conquest, several have disappeared. The great mosque (Jamaa-el-Kebir) has a brick minaret 112 ft. high, adorned with marble columns. This mosque was built A.D. 1136 to replace a much older building. The mosque of Sidi Ahmed bel Hassan, usually called Abul Hassan, built A.D. 1298, now transformed into a museum of antiquities, has two series of arches, which rest on alabaster pillars. The courts are ornamented by sculptures of great beauty and richness; the delicately-carved cedar ceiling bears traces of polychromatic painting. The mosque of El-Halawi (the Sweetmeat Maker), dating from 1353, has eight magnificent columns of Algerian onyx. The ceiling of cedar is richly carved, and there is a fine colonnade on each side of the court. The military authorities occupy the Meshuar or citadel, built in 1145, which separates the Jewish and Moorish quarters and was formerly the palace of the rulers of Tlemçen. Only the minaret of the mosque, dating from the 14th century, and the battlemented wall, flanked by two towers, remain of its former magnificence. The vast basin (*sahrij*) under the old walls, now dry (720 ft. in length, 490 in width and 10 in depth), was apparently made for naval exhibitions. A covered market occupied the site of the Kissaria, the place of residence of European merchants from Pisa, Genoa, Catalonia and Provence. Besides the large trade carried on there are native manufactories of cloth, carpets and leather articles. A special manufacture is that of red shawls, used by Jewish women when in mourning. In the immediate neighbourhood of the modern Tlemçen are numerous remains of the fortifications of Agadir (vide infra), and the minaret of the mosque, a beautiful tower dating from the 13th century, the lower part of which is built of large hewn stones from the Roman Pornaria. More noteworthy, however, are the ruins of Sidi Bu Medin and of Mansura. Sidi Bu Medin (more properly El Eubbad) is a little over a mile southeast of Tlemçen. It was founded A.D. 1337 by Ali V, the first of the Beni-Marin (Marinide) sultans who ruled Tlemqen. The kubba or tomb of Sidi Bu Medin, near the palace, is held in great veneration by the Arabs. The adjacent mosque is a beautiful specimen of Moorish art.

Mansura, which is about 1½ mi. west of Tlemqen, owes its foundation to the attempts of the Beni-Marin rulers of Morocco to extend their sovereignty. The Amir Abu Yakub Yusef besieged Tlemqen in the early years of the 14th century. The siege lasted eight years, and Yusef turned his camp into a walled city. The siege being raised, El Mansura (the victorious), as the new city was called, was abandoned. It was reoccupied when (1335) Ali

V renewed the siege, which this time proved successful. On the expulsion of the Marinides in 1359 Mansura was finally deserted.

Besides the walls and towers, and the minaret of the mosque, little remains of Mansura, of which Ibn Khaldūn has left a contemporary and graphic sketch. The minaret was one of the finest mosque towers in Algeria. It was 125 ft. high, and was built of hewn stone. (X.; A. BE.)

The Sultanate **of Tlemçen.**—In 1248 Tlemçen was captured by Abu Yahia Yarmorasen (Ghamarasan) who was chief of the Zenata tribe of Berbers and claimed descent from the Caliph Ali. Yarmorasen, who died in 1282, founded the dynasty of the Abd-el-Wahid, who ruled the greater part of what now constitutes Algeria. Under their sway Tlemqen flourished exceedingly. The presence of Jews and Christians was encouraged and the Christians possessed a church. The bazaar of the Franks (kissaria) was a large walled enclosure, the gates of which were closed at sunset. As many as 5,000 Christians lived peaceably in Tlemçen, and the sultan included in his army a Christian bodyguard. In 1337 the power of the Abd-el-Wahid was temporarily extinguished by the Marinide sultans of Morocco. They left fine monuments of the period of their ascendancy, which lasted 22 years. Once more, under the Abd-el-Wahid, now known as the Beni-Zeiyan, from 1359 to 1553, Tlemqen enjoyed prosperity. The Spanish occupation of Oran (1509) struck a fatal blow at the European commerce of the town. The Beni-Zeiyan, after the capture of Algiers in 1516 by the corsair Barbarossa (*q.v.*), gradually lost their territory to the Turks, while Tlemçen itself for 40 years became tributary to the Spanish governor of Oran. In 1518 the town was held for a short time by Arouj Barbarossa, but Arouj was killed in a fight with the Spaniards. In 1553 the Turks under Salah Rais, pasha of Algiers, captured Tlemçen and the Sultanate of Tagrart, as it was still frequently called, came to an end. Under the Turks the town ceased to be of any importance. When the French entered Algeria, the sultans of Morocco were disputing the possession of Tlemqen with the Kuluglis, who fought first for themselves and afterward for France. In 1835 Abd-el-Kader, on whose appearance the Moors retired, sought to re-establish the ancient empire of Tlemqen, but he retreated before Marshal Bertrand Clauzel in 1836. The treaty of the Tafna (1837) gave Tlemçen to Abd-el-Kader, but, war being renewed in 1842, Tlemçen was definitely occupied by the French. (F. R. C.; X.)

TLINGIT, Indians of the southeastern Alaskan coast, northwest to Controller bay. A few also live inland on the extreme upper Yukon drainage in Canada. Progressively altered by Alaskan commercial development since the mid-19th century, the aboriginal culture was characterized by sea mammal hunting, fishing, woodworking, totemic art, emphasis on rank and wealth and slavery. The 16 major geographical groupings, or tribes, are crosscut by division into two moieties, which are further subdivided into matrilineal clans represented by localized lineages. The language may be related ultimately to Haida, Athapaskan and Eyak (Nadene family). Estimated population in the 18th century, 10.000; in the second half of the 20th century this had declined to about 4,000. See also INDIANS, NORTHWEST COAST; ATHAPASKAN.

See Aurel Krause, The *Tlingit Indians* (1956). (C. McC.)

TNT (TRINITROTOLUENE) was discovered by J. Wilbrand in 1863, but its explosive properties became known only later when detonators were adopted as the means of setting off high explosives. It was introduced into large-scale use during World War I and became the standard explosive in World War II, during which combined production of several warring nations ran into several thousand tons daily.

TNT, which has the molecular formula $C_7H_5O_6N_3$, is prepared by nitration of toluene $C_6H_5—CH_3$, which is obtained by distillation of coal tar or of crude petroleum, and is made synthetically from other components of petroleum. The nitration is usually carried out in three stages, the first yielding mononitrotoluene, the second, dinitrotoluene and the third, TNT. Mixed nitric-sulfuric acids are used for the nitration, the strength increasing from stage to stage. In the course of this preparation isomers of the desired product—alpha TNT, 2,4,6-trinitrotoluene—are formed in small quantities. Since these are less stable to heat and have the tendency to form low-melting mixtures and hence to cause exudation from loaded munitions, they are removed; this. purification is best accomplished by the washing of crude TNT with 5% sodium sulfite solution.

TNT is a pale-yellow crystalline powder; its melting point is 80.5° C. and its specific gravity is 1.65. TNT is only slightly soluble in water but is easily soluble in benzene, toluene and acetone. It is stable to heat and decomposes slowly only when heated above about 180° C.

Because of its low sensitivity to percussion, its low melting temperature (which permits it to be melted in steam-heated kettles) and its high explosive performance, TNT became the most favoured of preatomic military explosives. It is used singly and in mixtures with other explosives to load (by casting) all types of munitions.

See also BLASTING; EXPLOSIVES; NITROGLYCERIN.

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TOAD, a name loosely used for rough-skinned tailless amphibians of several families, Hylidae (tree toads), Pelobatidae (spadefoot toads), Pipidae (Surinam toad). The true toads, genus Bufo, family Bufonidae, number about 250 species and are world-wide in distribution with the notable exceptions of Australasia and Madagascar. Among distinctive features of the family are toothless jaws and Bidder's organ (a potential ovary with no known normal function). Besides Bufo, the familv includes five small Malaysian genera of diverse habits and three African genera, one of which (Nectophrynoides) includes the only frogs, that give birth to their young.

ISABELLE HUNT CONANT

AMERICAN TOAD (BUFO TERRESTRIS AMERICANUS) COMMON TO EASTERN NORTH AMERICA

True toads, of which the American toad (Bufo *terrestris* americanus) is a common representative, are stout-bodied with short legs that limit them to hopping or walking rather than leaping. Body size ranges from three auarters of an inch to nine inches. The thick and often warty skin on the back is generally coloured a mottled brown. The smoother underside mav not be pigmented, but males usually have a dark throat. Much of the dorsal skin and its warts contain poison-secreting glands, but these are most concentrated in two raised areas behind the eyes, the parotoid glands.

The poison, which is secreted or even ejected when the toad is molested, is very irritating to the eyes and mucous membranes. It effectively inhibits some predators (occasionally dogs have been killed), but others are not deterred at all: the North American hognose snakes (Heterodon) feed almost exclusively on toads. Among the substances that have been isolated from the milky poison are bufagin, which has properties similar to digitalis, and serotonin, a substance which causes blood vessels to constrict. For centuries the Chinese have used dried toad poison to treat various ailments, but most of the medically important substances identified in the secretion can be synthesized or obtained from better sources. Contrary to a popular belief, handling toads does not cause warts on human skin.

Toads are mainly terrestrial, their thick skins allowing them to live in many habitats closed to thin-skinned frogs. They are generally nocturnal and frequently remain in fairly small feeding areas. Food is almost any insect or other animal that can be secured with the sticky tongue. For this reason some species have been introduced to control agricultural insect pests. A particular favourite is the giant toad (Bufo *marinus*), which is native to Central and South America, but now also established in the West Indies, Hawaii, Philippines, etc.

Life histories of most toads are similar. Adults are active except in winter and periods of summer drought, at which times they retire to their burrows. Breeding usually takes place in standing or slowly moving water and may involve mile-long migrations. The small dark eggs are laid in two long jelly tubes, and number from 600 to 30,000, depending on the species. The nondescript dark tadpoles hatch in a few days and transform in one to three months. Young toads mature in two or three years. *See* also AMPHIBIA. (G. B. R.)

TOADFLAX (*Linaria*), a genus of small plants of the figwort or snapdragon family (Scrophulariaceae; *q.v.*), allied to the snapdragon (*q.v.*) but distinguished by the possession of a long spur at the base of the corolla. The common toadflax (L. *vulgaris*), called also butter-and-eggs. has yellow flowers and creeping roots and is a widespread weed in grasslands.

TOADSTOOL, the popular name for poisonous or inedible mushrooms. *See* MUSHROOM.

TOALA. Early in the 20th century this small tribe, of about 100 people, was discovered in a remote valley of southnestern Celebes. Most of them lived in caves although a few had built small huts. They were dependent on hunting and the collecting of jungle produce. By 1913 the Dutch government had moved them from their mountain homes to a spot near a Buginese village. as a result of which they underwent rapid change and may vanish as a distinct people. According to Raymond Kennedy who visited them, they are of Veddoid type.

See R. Kennedy, *Bibliography of Indonesian Peoples and Cultures* (1955) ; P. and F. Sarasin, *Reisen in Celebes, 2* vol. (1905). (F.-C. CE.)

TOASTS. Toasting, defined as drinking to the health of a person or to the success of a .cause or enterprise, is a custom of ancient origin. It is related to the earlier custom of dedicating drink offerings or libations to the gods. Offered to a deity, the libation was an act of worship and of thanks for benefits. as in Psalm cxvi, 12, 13, "What shall I render to the Lord for all his bounty to me? I will lift up the cup of salvation and call on the name of the Lord." Offered to a human being. the libation betokened wishes for his good health or welfare. Centuries before the Christian era, guests at Jewish feasts drank to one another's health. often uttering the Hebrew formula *Lekhayyim* ("to your health"; literally "to lives").

Toast, a word of Latin origin, originally referred to the "sop" or morsel of bread which was browned at the fire and put into the wine cup, the idea being that it improved the flavour of the wine. An oft-quoted anecdote connecting "toast" with healths drunk to a 17th-century beauty is fictional. It is true, however, that the word toast was applied to individuals, especially to popular ladies. in or before the 17th century; from that developed the use of the word for the act of proposing a drink to the health of a person, and for the drink itself.

Martial, the 1st-century Latin poet, wrote amusing comments on the drinking customs of his time. One of these was the "drinking of names," a cupful being quaffed for each letter in the name of the person saluted, Ida three, Lyde four. Lycas five, Laevia six, Justina seven, and so to longer names and to most interesting possibilities.

An ancient Latin poem tells how the Goths. when drinking together, frequently cried out *"Eils!"*, meaning "Hail!" or "Health," and the Saxons are said to have carried the usage to Britain. According to tradition, the 5th-century Saxon princess Rowena went to the British king Vortigern bearing a golden cup filled with wine, and said to him *"Waes Hael!"* meaning "Be of good health!" The king kissed her, then gladly drank, and bade her share the contents of the cup. In time "waes hael" uas altered into "wassail" (*q.v.*). Historians are not certain that Rowena became the king's wife (or that the charming scene described above actually took place) but she is traditionally credited with introducing a new and pleasant custom to him and to his subjects. A single loving cup, token of general friendship, was used when all about the table drank in turn. In modern times it is more usual to drink to individuals from individual cups or glasses.

In Scandinavian countries, where toasting is regulated by a sort of kindly formality, good wishes are expressed in the word *skoal*, Old Norse for bowl. Germans exclaim *Gesundheit* ("good health"), or, an echo of student Latin, *Prosit* ("much good may it do you"), New Zealanders use the Maori words *Kia ora* ("be well" or "be happy"). A similar sentiment is expressed by the Hawaiian *Aloha nui* and the Japanese *Omedetō*. In 18th-century England, a popular form of toasting was with witty speeches or songs, such as "Let the toast pass," in Richard Sheridan's *School for Scandal*. In America, at Mount Vernon, George Washington usually drank to each guest in turn, with "Your health, sir," "Your health, madam," the guests responding with "Thank you, sir." In modern times the drinking of healths tends to become less formal.

Drinking customs, in times ancient and modern, in lands far and near, show many signs of universal human kinship. In England the stirrup cup, originally quaffed on horseback, was a drink at parting. In Scotland the final drink was a *deoch an' doris*, Gaelic for "drink at the door." In Germany the parting drink is an *Abschiedstrink*. In ancient Rome it was the *poculum boni genii*, to earn the favour of guardian spirits; and in the 20th century, perhaps unmindful of traffic hazards, it is "one for the road." This last example recalls the fact that in ancient times the toastmaster's duties included some supervision over the amount of liquor consumed. Hence the Greeks called him the *symposiarch* ("ruler of the drinking party"), and the Romans spoke of him as the *arbiter bibendi* ("regulator of drinking"). Nearer to our own time, the purpose of toasting was well expressed by a poet who called the drink itself "a cup of kindness." (A. McQ.)

TOBACCO Tobacco is the name given to the plant and cured leaves of several species of *Nicotiana* which may be used immediately but, commonly, after aging and processing in various ways, for the purpose of smoking, chewing, snuffing and extraction of nicotine. Nicotine and related alkaloids of tobacco furnish the habit-forming and narcotic effects which account for the general world-wide use. This article deals with the history, botany, culture and curing of tobacco and with the tobacco industry.

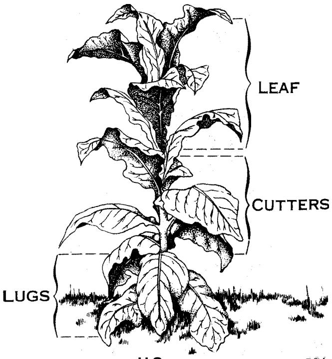
HISTORY

Tobacco was first cultivated by the Indians of North and South America. When Christopher Columbus and other early explorers arrived in America, they found the natives using tobacco much in the same manner as it is used today. The natives used tobacco in their ceremonials as, for example, in the smoking of the pipe of peace. It was generally supposed by the Indians to possess medicinal properties, and this was the chief reason for its early use following introduction into Europe. The extension of tobacco culture to practically all parts of the world began with its introduction to Europe: France, 1556; Portugal, 1558; Spain, 1559; and England, 1565. Jean Nicot, the French ambassador at Lisbon, Port., in whose honour the genus *Nicotiana* was named, is said to have sent seed of N. *tabacum* to the queen of France, Catherine de Medici.

The common name, tobacco, was derived from the word applied both to the tube used by the Indians for inhaling the smoke and to the cylinder of leaf prepared for smoking.

The early beginnings of tobacco culture by white settlers in colonial America took place in the following areas on the dates indicated: Santo Domingo, 1531; Cuba, 1580; Brazil, 1600; Jamestown, Va., 1612, by John Rolfe; Maryland, 1631. The tobacco grown soon furnished the chief product in demand in Europe as a commodity of exchange for the manufactured articles required by the colonists.

From the beginning overproduction was an economic problem. Following the American Revolution there was a tremendous expansion in culture from the colonial areas in Virginia and Maryland into Kentucky, Tennessee, North Carolina, Ohio and Missouri. The use of the fire-curing method in colonial days was modified in areas of Virginia and North Carolina about 1825 by the use of charcoal, which produced a different type of leaf, eliminating the effect of smoke on taste and aroma. This method was further modified follo ing the American Civil War by the use of the furnace with metal flues to accomplish the same purpose. White Burley variety appeared about this time (1864), when George Webb, a farmer in Brown county, O., found among his tobacco plants individuals that were somewhat deficient in green colouring. These plants when cured manifested a light yellowish-red colour. The leaf was porous and was found to have high absorptive capacity, which made it suitable for use in manufacturing chewing and smoking mixtures. This variety was improved by selection and became widely grown. It is extensively used in cigarette blends.



BY COURTESY OF U.S. DEPARTMENT OF AGRICULTURE

FIG. 1.—FLUE-CURED TOBACCO PLANT, ORINOCO VARIETY

Approximate normal division of leaves of a typical plant as grown for commercial production in most areas

BOTANY

The tobacco of commerce is derived almost entirely from *Nicotiana tabacum,* native to South America, Mexico and the West Indies. *N. rustica* (wild tobacco) was the species cultivated by the Indians of eastern North America and is cultivated in Turkey, the U.S.S.R., India and several European countries. These two species were known to Linnaeus and described by him in 1753. Certain other species, such as *N. attenuate,* N. *trigonophylla* and *N. quadrivalvis* have been utilized for smoking by the Indians of western North America. There are numerous species of *Nicotiana* besides those mentioned, two of which are commonly used as ornamentals, namely, N. *sylvestris* and *N. alata grandiflora* (flowering tobaccos). *(See* also NICOTIANA.) The best evidence available indicates that all species of *Nicotiana* are native to America with the exception of N. *suaveolens* and the related native Australian species.

Common tobacco, *N. tabacum* (fig. 1), of which there are numerous varieties, usually reaches a height of four to six feet when not topped. The flowers, borne in a panicle, normally self-fertile, are pink as a rule, although white and carmine-red forms are known. The flower is tubular in shape with the corolla tube (fig. 2[B] and 3) greatly exceeding the calyx in length. The lobes of the corolla are distinctly pointed and separated and are five in number. The leaves, varying in number with the variety, are arranged alternately, commonly sessile (that is, without petiole or stalk) and auricled or partly clasping the stem. They vary greatly in size and shape depending upon the variety and growing conditions. The leaves of some of the larger growing varieties may reach a length of two to three feet, with a width of about one-half the length, although some of the Turkish kinds, as grown commercially are sometimes less than three inches in length. A plant may produce as many as 1,000,000 seeds, but under usual conditions produces around one-half ounce of seed (150,000 to 200,000 seeds). N. *rustics* varies in height from two to four feet and commonly shows a decided development of suckers or axillary shoots. The leaves tend to be thick, broadly ovate with a distinct naked petiole. The corolla tube (fig. 2[A]) is short, with distinctly rounded lobes. and is pale yellow to greenish. The seeds are approximately three times the size of those of N. *tabacum.* Both species have a definite epidermal covering made up of hairs, some of which are glandular and secrete a viscid gummy substance. Under favourable conditions both species may produce a high content of alkaloid; however, N. *rustica* tends to show a higher content *(see* also NICOTINE).

Types of Tobacco.—The type of leaf tobacco is determined and frequently named on the basis of (1) variety; (2) methods of curing or handling; (3) the use to which the cured leaf is adapted; and (4) the section where the tobacco is grown. There are numerous types recognized by the trade which have been assigned numbers in the official U.S. department of agriculture type classification: fire-cured (21–24), dark air-cured (35–37), flue-cured (11–14); cigar wrapper (61 and 62), cigar binder (51–56), cigar filler (41–44), Burley (31), Maryland (32) and perique (72). All these types, as well as the Turkish or oriental, Sumatra cigar wrapper produced in Indonesia. and Cuban cigar leaf, are produced from *N. tabacum,* and most are important tobaccos of world commerce. The *markhorka* (sometimes *mahorka)* type is produced from N. *rustica.* Air cured, it is grown in the U.S.S.R. and Poland. The leaf is somewhat coarse in texture and high in nicotine content, and it is largely consumed locally.

The flue-cured type, sometimes designated as bright or Virginia, is by far the most popular, largely because of its adaptability to the production of blended cigarettes.

CULTURE

The methods of culture vary somewhat in different parts of the world and with the various tobacco types, but the essential features remain much the same. The plant is grown successfully under a wide range of climatic and soil conditions; however, the commercial value of the product depends largely upon the environment in which it is produced. The variety of seed used, as well as the occurrence and control of insects and diseases, is a factor of considerable importance in determining successful culture.

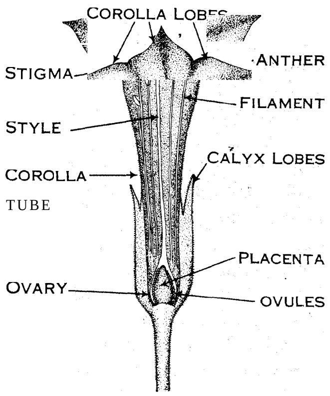
The choice of the variety of seed is contingent upon the type of leaf desired. Most strains and varieties of N. *tabacum* are local in their adaptation and are not suited to the production of widely divergent leaf. The Orinoco group with its many strains is widely used for flue-curing, while the Pryor group, which was originally selected from Orinoco, is used in the production of dark air-cured and fire-cured tobaccos. Burley differs from other tobaccos in having light colour and cream-coloured stems. The seed-leaf strains, Havana seed, Sumatra and Cuban, represent outstanding varieties used in the production of cigar leaf.

The seedlings are small and are produced in cold frames covered with thin cloth in warm regions, or in hotbeds or greenhouses covered with glass in colder regions. The rate of seeding commonly used is $\frac{1}{2}$ oz. of high-quality seed to 100 sq.yd. of seedbed area. Under favourable conditions this area can be expected to furnish 15,000 to 25,000 plants for transplanting. The soil selected for the plant bed should be fertile, possess good tilth and drainage, with the site fully exposed to the sun. Sterilization of the soil by burning, steaming, chemicals such as methyl bromide to destroy weed seeds, insects, nematodes and diseases is widely practised. It is customary to apply commercial fertilizer at the rate of one-half to two pounds per square yard, to the seedbed. The seeds are usually mixed with an inert, bulky substance, such as wood ashes, white sand or air slaked lime so that a uniform distribution may be obtained. Seeds are sown on a well-pulverized, leveled area and are pressed into the soil lightly. In from eight to ten weeks the seedlings are four to seven inches in length and are ready for

BY COURTESY OF U.S. DEPARTMENT OF AGRICULTURE

FIG. 2.—SEED PODS AND FLOWERS OF (A) NICOTIANA RUSTICA AND (B) N. TABACUM

transplanting in the field, by machine in dry weather, and by hand when the soil is wet. Watering at setting time is helpful in obtaining a stand if soil is dry. The spacing of plants in the field varies widely according to the type of tobacco grown. The rows are 3 to 4 ft. apart, with plants spaced 1 j to 48 in. in the row. Cigar and Burley tobacco are commonly spaced 3 to $3\frac{1}{2}$ ft. by 1 j to 27 in., while fire-cured and dark air-cured are planted in hills which may be as much as $3\frac{1}{2}$ ft. apart. Maryland tobacco is transplanted in hills 34 by 34 in., or closer, while flue-cured is spaced " to 24 in. by 4 ft., as a general rule. Oriental or aromatic tobacco is spaced in rows 16 to 24 in. apart with 6 to 8 in. between plants in the row. When the plant has attained the desired size, usually at or shortly after flowering, it is topped or disbudded; that is, the terminal growth is removed.



BY COURTESY OF U S DEPARTMENT OF AGRICULTURE

FIG. 3.— DIAGRAMMATIC LONGITUDINAL SECTION THROUGH TOBACCO (NICOTIANA TABACUM) FLOWER SHOWING ESSENTIAL PARTS

The number of leaves remaining varies widely. Dark air-cured and fire-cured tobaccos vary with from 10 to 16 leaves; Burley, flue-cured. Maryland and cigar types, have from 16 to 20 leaves. Following topping, the suckers, or lateral shoots, are removed at frequent intervals to increase leaf development and to provide for increased yields.

The choice of soil and its fertilization varies greatly with the kind of leaf grown. It is important that the soil is well drained and has sufficient tilth for good aeration. Much of the tobacco grown in the U.S., including flue-cured, Maryland, cigar binder and wrapper types. is produced on sandy and sandy-loam soils with a sandy or sandy-clay subsoil. Cigar filler, dark air-cured, fire-cured and Burley are produced on silt-loam and clay-loam soils with clay subsoils. Fertilization is essential in producing the desired type of leaf. The quantity of nitrogen is significantly important for the flue-cured and to a lesser extent for Maryland, and Burley types. A liberal supply of potash in the form of sulfate, carbonate or nitrate improves the over-all quality of the leaf and the fire-holding capacity of the cured tobacco. and reduces the susceptibility to leaf spot diseases. The use of chlorides in any form, such as potassium chloride or large amounts of animal manure, reduces the burning quality of cured leaf. Animal manures, when available, are used on the soil one or more years before the crop is grown. Fertilizer practices vary widely. On one acre as much as one to two tons of fertilizer containing 5% to 6% nitrogen, 5% to 8% phosphoric acid (P_2O_5) and 6% to 8% potassium oxide (K_2O) may be used for cigar tobacco, with the fertilizer applied broadcast to the soil prior to transplanting. In contrast to this, flue-cured tobacco is fertilized commonly nith 800 to 1,200 lb. per acre. of 3–9–9. or similar analysis (with the ingredients expressed in percentages in the same order as for cigar tobacco) applied in the row prior to transplanting. Burley tobacco is fertilized at the rate of 800 to 1,500 lb. of 5–10–15, 6–12–18 or similar analysis. The tobacco plant quickly develops nutritional deficiency symptoms when any of the chemical elements essential for growth is lacking in the soil. (*See* also FERTILIZERS AND MANURES.)

The preparation and cultivation of the soil consists of methods used with most cultivated crops to control weeds and maintain a well-pulverized soil-growth medium. A special method of culture employed on a limited scale in Connecticut and Florida consists of covering the field with cheesecloth or slat shade. This shading maintains a higher soil and air moisture which results in the production of a thin, elastic leaf suitable for cigar wrapper.

The culture of tobacco in Sumatra and Java suitable for cigar wrapper is limited to particular soils in regions of high rainfall, where special provisions for drainage are necessary, consisting of plantings on a mound with sufficient space for two rows of plants. These mounds are separated by definite ditches to facilitate the runoff of water to prevent water logging. It is generally recognized that in Indonesia high-quality leaf is produced for only one or two years following the clearing from the jungle. Cuban leaf, much in demand as cigar filler, is produced from special varieties grown on certain soils in the Cuban climate; this type has not been duplicated elsewhere.

The culture of oriental or aromatic tobacco in Turkey, Greece and other Mediterranean countries is unique in that the plants are not commonly topped and can be grown on soils of low productivity. The best quality oriental tobacco is grown in Mediterranean climate on upland soils during periods of little or no rainfall. There are numerous varieties which differ radically from all other known kinds.

Diseases and Pests. — The more common diseases are black root rot, fusarium wilt, mosaic, bacterial leaf spot, downy mildew or blue mold and black shank. Control may be accomplished in various ways: sanitation, crop rotation, the use of sprays and fumigants and breeding of resistant strains. Some resistant varieties of tobacco in general use have been produced by blending desired characteristics from *N. longiflora*, *N. debneyi*, *N. glutinosa* and others with some strain of N. tabacum. Resistance to bacterial leaf spot diseases, fusarium wilt, mosaic, black shank and black root rot have been accomplished in this manner.

The more common insect pests are the green June beetle larvae, cutworms and flea beetles in the plant bed; hornworms, grasshoppers, flea beetles, cutworms, budworms and aphids in the field. The cigarette, or tobacco, beetle damages stored leaf; the cigarette beetle sometimes damages the manufactured pr'oduct. The insect pests are controlled on the growing crop by the use of sprays and dusts, on the stored product by fumigation and trapping. Biological control often is effective.

Harvest. — Tobacco is harvested from 70 to 130 days after transplanting by one of two methods: (1) the entire plant is cut with the stalk split or speared and hung on a lath or tobacco stick; or (2) the leaves are removed at intervals as they mature. The leaves of cigar wrapper and Turkish tobacco are strung by means of a needle, and leaves to be flue-cured are looped. using a string tied to a lath or stick which is hung in the curing barn or shed. It is desirable for the leaf to wilt without sunburning to prevent breakage and bruising during the handling necessary in curing. To accomplish wilting, tobacco may be left in the field from a few hours to two days.

CURING

The three common methods of curing are by air, fire and flue. Sun-curing is practised with Turkish types and to a limited extent with air-cured types. Curing entails four essential steps: wilting, yellowing, colouring and drying. It consists of physical and chemical changes, and the processes are regulated to develop the desired properties of the leaf. Air-curing is accomplished primarily in buildings, equipped uith ventilators, making possible partial control of conditions. Often artificial heat provided by coke. charcoal or liquid petroleum gas is used to supplement natural conditions. The time required for air-curing varies from one to two months. Many tobaccos are cured by this process, including dark air-cured types, cigar. Maryland and Eurley.

The fire-curing process resembles air-curing except that open wood fires are kindled on the dirt floor of the barn after the tobacco has been hanging for two to six days, allowing the smoke to come in contact with the leaf, thereby imparting a characteristic creosote aroma.

The firing process may be continuous or intermittent, extending from three weeks to as long as ten weeks until curing is complete, and the leaf has the desired finish.

The barns for flue-curing are small and tightly constructed, provided with suitable ventilators and metal pipes, or flues, extending from furnaces around the floor of the barn. Fuels used are wood, coal, oil and liquid petroleum gas. Where oil or gas heaters are used, flues are not needed. Heat is applied with due attention to the chemical and physical changes in the leaf. The length of time required for flue-curing is from four to six days.

TOBACCO INDUSTRY

After curing, only during humid periods or in special moistening cellars can the leaf be handled without breakage. It is removed from the stalks or sticks and graded according to colour, size, soundness and other recognizable elements of quality. It is tied into hands, or bundles, of 15 to 30 leaves by means of a tobacco leaf wrapped securely around the stem end of the leaves. After grading, the leaf is ready for market. It may be sold directly to the purchaser who visits the farm or may be packed in bales, boxes or hogsheads and shipped to a warehouse or other centre and sold on the basis of a carefully drawn sample by private sale or auction, or it may be carried directly to the auction (loose leaf) warehouse, where it is displayed and auctioned to the highest bidder. It is a common procedure to recondition the tobacco, that is, to dry the product and then return the proper amount of moisture by "redrying" after it has been marketed and before it is packed. The purpose is to avoid damage which occurs when the leaf is packed with an excessive moisture content, and to ensure proper amount of moisture for aging. The aging period is from one to three years. This process is sometimes hastened by forced fermentation accomplished by adding moisture to the tobacco and storing it in bulk before packing and further storing.

Manufacture.—While some tobacco is consumed by the producer or sold directly for chewing and smoking, most of the leaf is aged and processed before consumption. In most cases the stems, or midribs, are first removed from the leaf. The details of certain processes of manufacture are trade secrets, but in general commonly known procedures are followed. To produce acceptable products and obtain uniformity through the years, most manufacturers blend grades of different years and from different sections and types of leaf. However, most types and grades of tobacco have rather specific uses. For example, the upper leaves on the plant are used for chewing and the lower leaves for smoking tobacco. In the U.S., cigarettes are commonly manufactured by blending flue-cured, Burley, Maryland and Turkish types. Chewing tobacco is manufactured in several different forms, such as plug, twist, fine cut and scrap. Pipe-tobacco mixtures contain considerable amounts of the Burley type. The mixture generally includes a conditioner (glycerine) and flavouring constituents. Snuff is made from fire-cured leaf and stems which are fermented before, and sometimes after, grinding, and salts and flavouring are frequently added; there are two forms—the light, containing ground stems, and the dark, made from stemmed leaf.

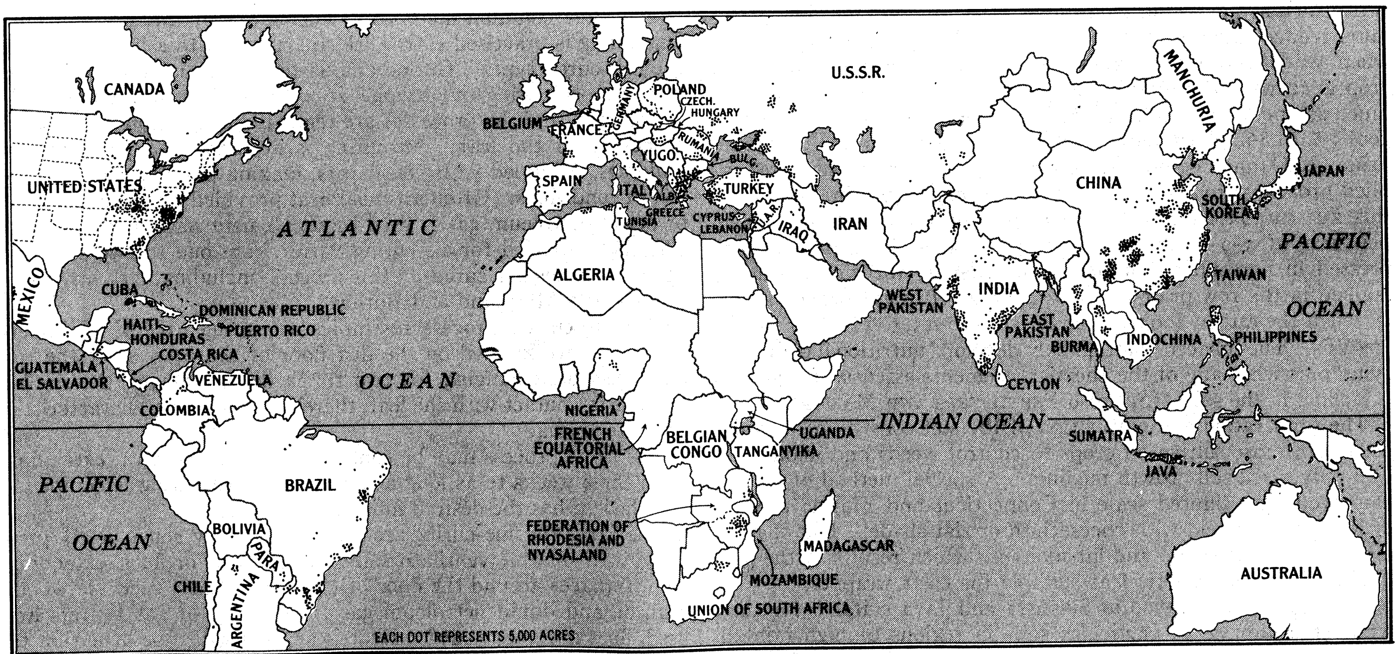
Composition.—Nicotine, the compound which definitely characterizes tobacco, occurs in various proportions combined with organic acids (malic, citric, etc.). Related alkaloids have been found in certain types, associated with the nicotine. Nicotine can be used as a raw material for preparation of the antipellagric vitamin, nicotinic acid (niacin). Factors governing the nicotine content of tobacco are: (1) the species, variety and strain; (2) the environment in which the plant is grown, primarily the conditions of soil and climate; (3) cultural, curing and handling methods employed (*e.g.*, time of transplanting and harvesting, spacing of plants, topping and suckering operations). The nicotine content of commercial types of tobacco varies considerably, but on the average the dark air-cured and fire-cured types contain 4% to 4.5%; cigar filler and Burley 3.5% to 4%; flue-cured 2.5% to 3%; Maryland 2%; and Turkish types 1% to 2% or more. *N. rustica* has been grown with as much as 10% nicotine in the leaf. Nicotine has long been used as an insecticide and as such is an important tobacco by-product.

The ash content of tobacco is high and ranges from 15% to 25% of the leaf on a water-free basis. The flue-cured type is notably rich in sugar, with the cigarette grades showing 15% to 20% or more. The Maryland cigarette leaf shows 90% of the total carbohydrates as cellulose, pectin and related compounds. Cigar tobaccos are especially high in nitrogenous compounds but are almost free of starch and sugars.

Among the changes in composition which take place during the fermentation or aging process is a loss in nicotine; with cigar tobaccos which are commonly subjected to a heavy fermentation, one-half or more of the nicotine may disappear.

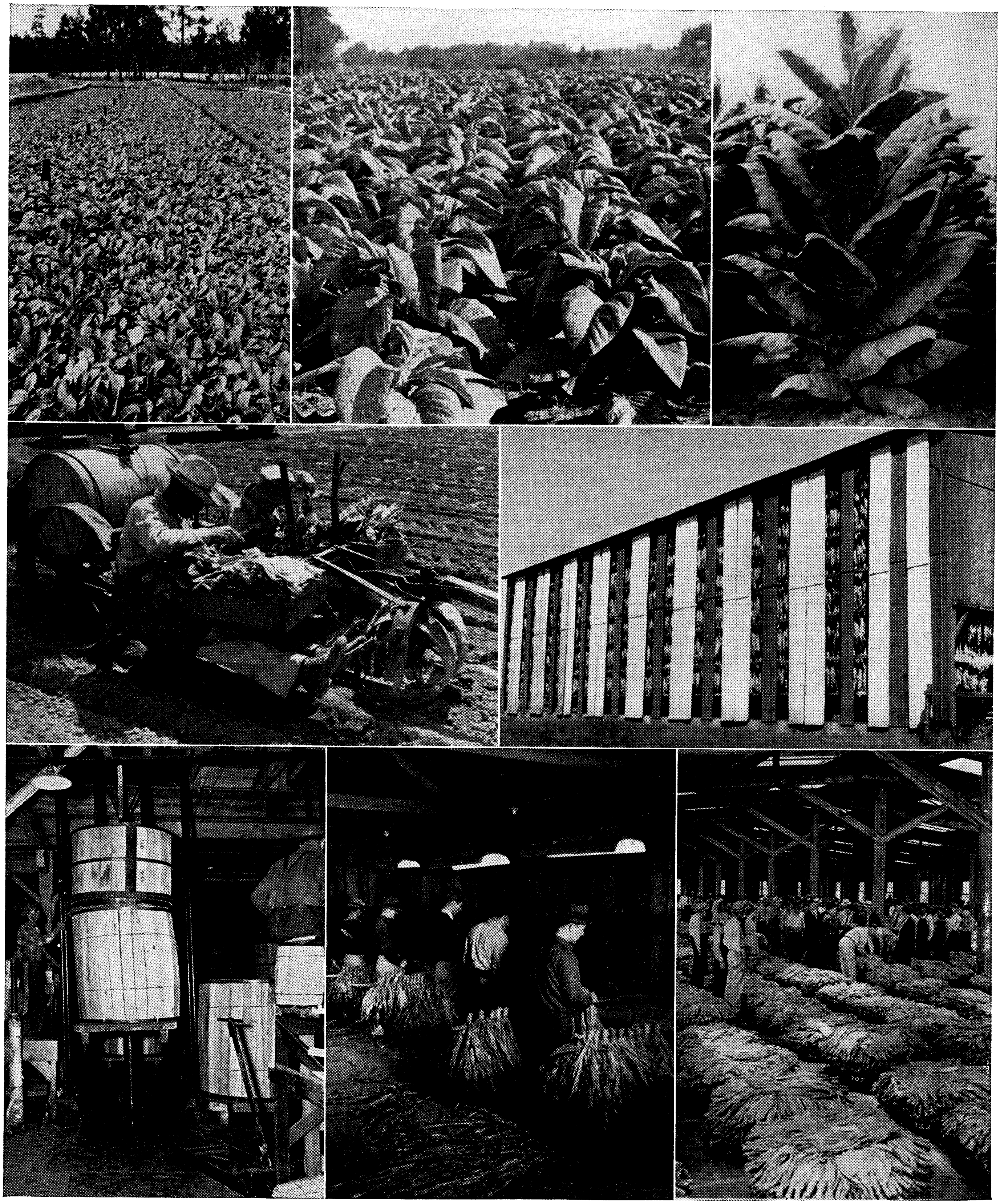
Revenue.—Tobacco has long been one of the chief sources of revenue in many countries of the world. This revenue is derived from taxes on the stored leaf and on the manufactured products as in the U.S., from duties on imports as in the U.K. or from profits from the operation of government monopolies which have been in effect in many European countries, Japan and elsewhere. The income of the U.S. government in revenue from taxes collected on manufactured tobacco products, particularly cigarettes, greatly exceeds the sale value received by farmers for the crop. Besides the revenue collected by the federal and state governments a number of cities exact a tax on tobacco products.

Production.—World production has been estimated at about 8,000,000,000 lbs. annually. The United States is the largest producer, contributing about one-fourth of this amount, and exporting slightly more than one-fourth of its production. China, India and the U.S.S.R., respectively, rank next to the U.S. in tobacco pro-



BY COURTESY OF U.S. DEPARTMENT OF AGRICULTURE

FIG. 4.—TOBACCO-PRODUCING AREAS OF THE WORLD



BY COURTESY OF (TOP LEFT) U S. DEPARTMENT OF AGRICULTURE, (BOTTOM RIGHT) THE AMERICAN TOBACCO COMPANY, (ALL OTHERS) RUSSELL A. HUNT

GROWING, PROCESSING AND SELLING OF TOBACCO

Top left: Tobacco seed bed, with plants of a suitable size for transplanting
Top centre: A field of dark air-cured tobacco topped to promote growth and development of the upper leaves
Top right: An untopped typical Burley plant showing characteristic standup growth of this type of tobacco
Centre left: A mechanical transplanter used in setting young tobacco plants
Centre right: An air-curing barn with ample ventilators for curing Maryland, dark air-cured or Burley tobacco
Bottom left: Hydraulic press in which redried tobacco is packed into hogsheads for storage and aging
Bottom centre: A stripping room, showing the use of fluorescent lights for proper sorting and grading of tobacco
Bottom right: Auction floor in a tobacco warehouse

BY COURTESY OF THE AMERICAN TOBACCO COMPANY

FURTHER STEPS IN THE PREPARATION OF TOBACCO

1. Tobacco entering a redrying machine
5. Machine which removes stems from the leaves
3. Shredding machine
4. Final mixing of blended tobaccos in a "merry-go-round." The tobacco is now ready for the manufacture of cigarettes

duction. The preferential duty extended to Commonwealth tobacco by the British government has greatly stimulated production in Canada and in the Federation of Rhodesia and Nyasaland. Oriental tobacco, grown chiefly in Turkey and Greece, is exported extensively for use in the manufacture of cigarettes. In many of the principal producing countries such as China, India, the U.S.S.R. and Japan a large part of the product is consumed locally. See also CIGAR; CIGARETTE; PIPE SMOKING; SNUFF; TOBACCO PIPE.

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TOBACCO PIPE. The smoking of tobacco in pipes is a custom which has prevailed in America for a period of unknown duration. The most ancient pipes of which remains exist have been found in mounds or tumuli called pipe mounds, principally in Ohio, Indiana. Illinois and Iowa. These mound pipes, which are carved in porphyry and other hard stones, are very uniform in type, consisting of a slightly convex platform or base, generally from three to four inches in length, and about one inch broad, with the bowl on the centre. A fine hole is pierced from one end of the platform to the bottom of the bowl, the opposite end being obviously for holding in the hand while the pipe is being smoked.

Among the North American Indian tribes the tobacco pipe occupies a position of peculiar symbolic significance in connection with their rites and usages. The calumet, peace pipe or medicine pipe: is an object of the most profound veneration. The introduction of the tobacco pipe into Europe is generally ascribed to Ralph Lane, first governor of Virginia, who in 1586 brought an Indian pipe to Sir Walter Raleigh and taught that courtier how to use it. The pipe makers of London became an incorporated body in 1619. By degrees pipes of special form and material have come to be definitely associated with particular peoples; *e.g.,* the elongated painted porcelain bowl and pendulous stem of the German peasantry; the red clay bowl and long cherry-wood stem of the Turk; and the very small metallic bowl and cane stem of the Japanese. Other kinds of pipe include the corncob, in which the bowl is made of the cob of maize or Indian corn, and the calabash with the bowl of a small gourd. The churchwarden is a clay pipe with a slender stem, about 16 to 20 in. long. The most luxurious and elaborate form of pipe is the Persian *kalyun,* hookah or water tobacco pipe. This consists of three pieces, the head or bowl, the water bottle or base and the snake or long flexible tube ending in the mouthpiece. The tobacco is placed in the head; a wooden stem passes from its bottom down into the water which fills the base; and the tube is fitted to a stem which ends in the bottle above the water. Thus the smoke is cooled and washed before it reaches the smoker.

TOBAGO, an island off the coast of Venezuela forms with Trinidad a British colony of the former West Indies federation. Tobago is 27 mi. long and 7½ mi. broad. with an area of 116 sq.mi. Pop. (1960) 32.963. Just off the northeast end of the island is Little Tobago. a 300-ac. islet used as a sanctuary for birds of paradise brought there in 1908. Tobago consists of a single 18-mi.-long mountain mass of volcanic origin which rises to a height of 1.800 ft. in the centre. Much of the island is clothed with a dense forest. The higher lands are set apart as "rain preserve," and felling of timber there is forbidden. The temperature averages 80° F.; the annual rainfall is 60 in. The rainy season lasts from June to December, with a short break in September. The valleys are adapted to horse and sheep raising. Cacao, copra, coconuts and limes are exported. Scarborough (pop. [1946] 908), formerly called Port Louis, is the capital, located on the south coast 8 mi. from the southwest point.

Tobago was discovered by Columbus, who called it Assumption (1498). It was first occupied by the Dutch (1632), who named it New Walcheren and held it precariously until 1662. Thereafter possession alternated between the French and English until 1814, when British title was confirmed by the treaty of Vienna. It formed part of the Windward Islands colony until 1889, when it was joined to Trinidad, though legal and fiscal arrangements were kept distinct.

In 1899 it became a ward of Trinidad; its revenue, expenditure and debt were then merged with those of the united colony (called Trinidad and Tobago), and Trinidad laws, with a few exceptions, became binding in Tobago. (L. W. BE.)

TOBIT, BOOK OF. This book of the Apocrypha is a religious novel which was for many centuries exceedingly popular both in Christian and Jewish circles in many lands. This is shown by the multiplicity of versions and editions which have survived. Moreover, it was not without influence upon some of the writers whose work is contained in the Old Testament (*e.g.,* Daniel and some of the Psalms), Jewish pseudepigraphists (*e.g.,* the authors of the Book of Jubilees, the Testament of Job), some New Testament writers (*e.g.,* the Synoptists. especially in the description of the Resurrection and Ascension. St. Paul, the author[s] of the Pastoral Epistles) and numerous postapostolic Christian writers, many of whom, as did in particular Clement of Alexandria, regarded it as "Scripture." But in one respect it has achieved a distinction shared by no other book of the Apocrypha. and by at most only one book (Jonah) of the Old Testament: it has made a remarkable appeal to the exponents of Christian art, and its hero and his dog and certain dramatic incidents in his history became, in the middle ages, a favourite theme of the workers in ecclesiastic glass and mural decorations.

Date of the Work.—F. Hitzig's relegation of the date of writing to a time subsequent to the catastrophe of A.D. 70, H. Gratz's conviction that it belongs to the reign of Hadrian, S. Rosenthal's that it is a product of the school of Rabbi Akiba. and even W. R. Smith's attempt to connect it uith the Maccabean revolt, are no longer favoured. Equally impossible is a date as early as 350 B.C., which was once favoured by writers influenced by H. Ewald. A date about 250 B.C. seems to present least difficulties.

The author wrote to inculcate respect for the dead, consanguineous marriages and practical virtues such as almsgiving. He found the ultimate sanction for these ideals in the Old Testament. but when he set out to inculcate them in his tale he drew on earlier, and even contemporary pagan models. The Egyptian Tractate of *Khons* supplied him with the idea of a maiden possessed by a demon whom the god expelled. It is also clear that the widely diffused "Fable of the Grateful Dead"—a dead man rewarding the burier of his corpse—was much in his mind nhen he set out to write his book; but in this case it may have been less a matter of consulting a literary model than of reproducing the general ideas of a class of fables known to him from boyhood. Similarly there is no reason to posit any literary source, as J. H. Moulton formerly did, to account for the alleged *Median* and more specifically Magian elements in the book—*e.g.,* the dog, the demon Asmodeus (Aēšma daēva), the seven angels. the saving heavenly visitor (Raphael). These are mostly not characteristics of the later Zoroastrian system, but belong equally to its earliest phases. and in great part even to pre-Zoroastrian Magianism, which, by 250 B.C., would be known wherever Persian traders and soldiers were to be found.

If, as is suggested, the author was an Egyptian Jew of 250 B.C., he may have written in Aramaic or in Greek. Numerous attempts, based on the theory of mistranslations in the extant Greek texts from an Aramaic original have been put forward. but on the whole the hypothesis that he was a Jew who "thought in" Hebrew or Aramaic. while writing in the Greek of his period, suffices to explain the "Semitisms" which are observable in his book. Apart from the poem in chapter 13 there seems to be no reason for not regarding the book as a literary unity.

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TOBOGGANING, the sport of sliding down snow-covered slopes and artificial ice-covered chutes on a runnerless sled called a toboggan. The toboggan was originally a primitive American Indian sled made of poles tied together with thongs. The 20th-century toboggan is usually built of thin, straight-grained boards of hickory, birch or oak fastened together by light crosspieces. Some toboggans are made of metal or laminated wood. The front end is bent up and back to form the "hood" and is braced by rope or leather thongs. The flat sliding surface is generally about 18 in. wide and from 4 to 9 ft. long. The toboggan is light in weight and will support a heavy load on soft snow. It is useful for hauling loads over wilderness trails or cross country as well as for sporting purposes.

Tobogganing, as a sport, probably originated on the slopes of Mt. Royal near Montreal, Can. During the late 1880s it spread to the United States where it had considerable popularity until the early 1930s when widespread enthusiasm for skiing brought about its decline. During the heyday of tobogganing many artificial chutes were constructed to make it easier for the inexperienced to enjoy the thrills of a fast ride. These chutes were about three feet wide with sides of ice or wood and frequently mere built with several parallel tracks to accommodate more than one toboggan at a time. The more elaborate chutes used trestlework to smooth out the contour of the slope. They were usually straight and varied in length up to several thousand feet. The chutes were quite steep at the top in order to accelerate the toboggan quickly. Speeds up to 60 m.p.h. were attained. From the bottom of the chute the toboggans coasted along an open track which occasionally extended for one to two miles.

The toboggan is well adapted to sliding down open slopes where its large surface rides easily on loose, fluffy snow. Several persons can ride at one time either lying prone or in a sitting position. The toboggan can be steered by lifting and twisting the front or by extending one's leg to the rear and dragging a foot in the snow. *See* also BOBSLEDDING; WINTER SPORTS. (A. W. TR.)

TOBOLSK, a city in the Tyumen *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., on the Irtysh river, below the confluence of the Tobol. Pop. 33,000. Tobolsk was founded by the Cossacks in 1587 and had an active trade in fish and furs, but Omsk rapidly superseded it. The district of Tobolsk (renamed Tyumen) became noted for *koustar* (peasant) industries, especially carpentering, the making of fishing nets, carving on ivory and the preparation of wool and skins. The Tobolsk province was the earliest to be colonized and also received the largest number of political exiles.

TOBRUK (anc. ANTIPYRGOS), a spacious and well-sheltered natural harbour in Cyrenaica, Libya, in which vessels of any size or draft may anchor, open only to the east-southeast. Pop. (1954) 4,995. It is one of the six administrative centres of the province of Cyrenaica. Water is carried to it by road from Bardia and by sea from Bengasi. It has a secondary school for boys, a primary boarding school and a hospital. For long the outlet for the oasis of Jaghbub, its export trade has become negligible. It suffered severely in World War II, changing hands five times and falling finally to the British on Nov. 13, 1942. Tobruk is the usual residence of the king of Libya. (D. G. W.)

TOCANTINS, a river rising in the Planalto Central of Brazil, in south Goiás state, a little north of Goiânia, capital of Goiás, and Brasilia, the federal capital. It flows through Goiás, and between Carolina and the junction of the Araguaia (*q.v.*) forms the boundary between Goiás and Maranhão. After meeting the Araguaia it flows through the state of Pará, finally joining the Pará river, a navigable arm of the Amazon (*q.v.*) delta, 50 mi. SW of Belém. The mouth of the Tocantins is 8 mi. wide and its total length is 1,677 mi. The river is not good for navigation, although in its mid-course above Carolina it can be navigated by small river boats. Its wide mouth is deep enough for ocean vessels which can ascend as far as Tucurui, about 200 mi. from Belém. From Tucurui a railroad, built around a succession of rapids as far as Jatobá, is being extended to São João do Araguaia at the junction with the Araguaia river. Much effort, if not much money, was expended after mid-20th century on the development of this river as an export route for the products of southern Goiás. The forests of babassu palms around Carolina could be developed to provide oil for fuel. However, the many rapids and shoals, the great length and the lack of production in the sparsely populated country through which it passes made development very costly. (P. E. J.)

TOCCATA, a musical composition — for clavichord, harpsichord or organ — of brilliant character, which originated in the 16th century. the name deriving from the Italian *toccare,* "to touch." It was thus opposed to the sonata and cantata which were works that were sounded and sung. The early examples by Andrea Gabrieli consisted of alternating sections in chords and runs. In those of Claudio Merulo fugal sections were introduced. Frescobaldi treated the form in a more elaborate manner and in later Italian examples, by Bernardo Pasquini and Alessandro Scarlatti, the toccata became a piece in rapid, unchanging tempo, resembling the *perpetuum mobile.* In Germany the toccata style of Frescobaldi was developed by J. J. Froberger, G. T. Muffat and others, while the examples of Merulo led to the large-scale toccatas for harpsichord and organ by J. S. Bach. Largely neglected during the 19th century, the toccata was revived in the 20th century, notably in piano works having the character of the *perpetuum rnobile* by Ravel, Prokofiev and others.

See E. Valentin, *Die Entwicklung der Tokkata im 17 und 18 Jarhundert* (1930).,

TOC H, an interdenominational association for Christian social service, founded as a memorial to British youth who perished in World War I. At Hooge, in the first German liquid-fire attack in July 1915, Gilbert Talbot, a lieutenant in the rifle brigade and son of the bishop of Winchester, fell. In the following December in the Flemish town of Poperinghe a soldiers' club named Talbot house was opened in his memory.

In charge of this house was a Church of England chaplain, Rev. P. B. Clayton, M.C., who created a centre of rest and recreation unique in its kind. In 1920 Clayton established in London a new Talbot house, using, since this name was already appropriated, the signalers' method of pronouncing its initials, namely, Toc H. The plan was to establish in London a house where men of all kinds would congregate, and many of them live, dedicating a reasonable proportion of their leisure time to the service of their fellowmen; membership was opened to all men of good will.

In 1922 it was incorporated by royal charter with the prince of Wales as patron. Toc H stretched with its houses, or "marks," and branches throughout the British Commonwealth. It became through the principles of service, fellowship, tolerance and honest thinking, to which its members are pledged, a great influence for good and for spiritual development and expression. Each branch was entrusted with a lamp of maintenance, lighted with simple ceremony at every meeting in remembrance of lives lived and given in service and sacrifice and in rededication to the task they left unfinished — building a "new Jerusalem." (R. C. G.; X.)

TOCHARIAN LANGUAGE. Tocharian (also called Tocharish or Tokharian) is the name commonly applied to an Indo-European language spoken in northern Chinese Turkistan (Tarim basin) during the latter half of the 1st millennium of this era. The documents date from about 500–700 A.D. There are two dialects: Tocharian A, from the area of Turfan in the east; and Tocharian B, chiefly from the region of Kucha in the west, but also from the Turfan area.

Discovery. — The first Tocharian manuscripts were discovered during the last decade of the 19th century. The bulk of the Tocharian materials, however, were brought back to Berlin by the Prussian expedition of 1903–04 and 1906–07, which explored the Turfan area; and to Paris by the French expedition of 1906–09, which investigated chiefly in the area of Kucha. Other smaller collections are those of R. Hoernle and **A.** Stein in London, M.

Berezovski in Leningrad and Otani Kozui in Japan.

Decipherment.—Tocharian is written nith a form of north Indian syllabary known as Brahmi used also in writing Sanskrit manuscripts from the same area. The first successful attempt at grammatical analysis and translation was made by the German scholars E. Sieg and W. Siegling in an article "Tocharisch, die Sprache der Indoskythen," *Sitzungsberichte,* Berlin Academy of Sciences, 1908. This article established the presence of the two dialects provisionally called A and B. The Berlin collection consisted of both, whereas all other manuscripts discovered were in B.

The name Tocharisch was proposed *(cf.* below), and the language was demonstrated to be Indo-European (IE).

Language.—Tocharian forms an independent branch of the Indo-European language family, not closely related to other neighbouring IE languages (Indic, Iranian). Rather. Tocharian shons a closer affinity with the western *(centum)* languages, *cf.* A *kant, B kante, kante* "100," Lat. *centum* v. Sans. *śatam;* A *klyos-,* B *klyaus-* "hear," Lat *clueo,* v. Sans. *śru-;* A *kus, B kuse* "who," Lat. *qui, quod,* v. Sans. *kas.* In phonology Tocharian differs greatly from the other IE languages in that all the IE stops of each series fall together, resulting in a system of three (voiceless) stops, *p, t* and *k.*

In morphology, the Tocharian verb reflects the IE verbal system both in stem formations and in personal endings. Especially note orthy is the wide development of the mediopassive in *r* (as in Italic and Celtic), *cf.* A *klyostar* "is heard." The third person preterit plural ends in *-r,* similar to Latin and Sanskrit perfects and the Hittite preterit. The noun, however, shows little trace of the original IE inflection. Instead, it has been built up by addition of postpositions to the oblique (accusative) form. This type of inflection (agglutination) has been attributed to the influence of non-IE languages (Turkish, Finno-Ugric).

The vocabulary shons a remarkable influx of loanwords, Turkish, Iranian and, later, Sanskrit. Chinese has had little influence Honever. many of the most archaic nords are retained: A *por,* B *puwar* "fire" (Gr. *πῦρ,* Hitt. *pahhur*), A B *ku* "dog" (Gr. *κύων*), A *tkaṃ,* B *keṃ* "earth" (Gr. *χθών,* Hitt. *tekan),* and especially nouns of relationship A *pdcar, mācar, pracar, ckācar,* B *pācer, mācer, procer, tkdcer* "father, mother, brother. daughter."

Literature.— Tocharian literature is Buddhistic, consisting largely of translations or free adaptations of Jatakas, avadanas and didactic, philosophical and canonical works. There exist also many commercial documents, letters, monastery records, caravan passes, medical and magical texts (translated or adapted from Sanskrit). These latter are important source materials for the social, economic and political life of central Asia.

The "Tocharian Problem."--Since the appearance of Sieg and Siegling's article "Tocharisch, die Sprache der Indoskythen," the appropriateness of the name "Tocharian" for the language has been disputed. According to the Greek and Latin historical sources, the Tochari (Gr. *τόχαροι,* Lat. *Tochari)* inhabited the basin of the upper Oxus in the 2nd century B.C. and were probably Iranians. Sieg and Siegling's identification of this language as belonging to these people was probably in error.

The proper identification of the bearers of the language among the people of central Asia is still disputed, however. Possibly the most satisfactory hypothesis identifies them with the Wo-sun, a people to the north of the Tarim basin in the first centuries B.C.

Furthermore, the name *ārśi* (*ārśiype* "Arśi-country," *ārśikāntu* "Arśi-language"), once accepted as the native name in dialect A, is probably a loanword through Iranian from Sanskrit *arya.* The question of the name is, however, of little linguistic importance. "Tocharian," even if generally accepted as a misnomer, will probably remain.

For "dialect A" and "dialect B," the substitution of Turfanian and Kuchean, or East Tocharian and West Tocharian, has been suggested.

Of greater importance is the question of the closer relationship of Tocharian to the other IE languages. Its phonology, morphology (the verb) and. to a certain extent. its vocabulary align it with the western languages. The Tochari probably once occupied a position in the IE community closely in contact with the Celtic and the Italic dialects on the one hand and the Balto-Slavonic on the other. and at the same time with some, but less significant, contacts with the Germanic and the Greek. They were, however, probably one of the earliest groups to migrate, taking a northern route to the east, as opposed to the southern route taken by the Indo-Iranians. It is possible that they were a part of that folk migration from the west which, according to archaeological evidence, appears to have invaded northeast China some time before the middle of the 1st millennium B.C. In their migration they had long contact with non-Indo-European speakers, especially Finno-Ugric and Altaic.

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TOCHARISH LANGUAGE: *see* TOCHARIAN LANGUAGE.

TOCOPILLA, leading port of Chile in nitrate shipping and in cargo tonnage embarked, and a department seat of Antofagasta province. Pop. (1952) 19,353. Initial growth occurred after the 1870 silver strike at Caracoles. The open roadstead and modest port facilities serve the Maria Elena, Pedro de Valdivia and Toco nitrate fields, which are accessible by electric railway and road Approximately 65% of Chile's nitrate production is handled there. Tocopilla has a small copper concentrator and a thermoelectric plant that generates power for the Chuquicamata (q v.) copper mine. The mine and Antofagasta may be reached by road.

(J. T.)

TOCQUEVILLE, ALEXIS CHARLES HENRI MAURICE CLÉREL DE (1805–1859), was born at Verneuil on July 29, 1805. From 1827 to 1832 a junior magistrate at Versailles, he in 1831 accepted nith Gustave de Beaumont a commission to examine the prisons and penitentiaries of the United States. This journey led to the publication of his *Du système pénitentiaire aux États-Unis et de son application en France* (Paris, 1832) and provided him with material for his penetrating study of American society and politics, *De la de'mocratie en Amérique.* This work, the first part of which appeared in 1835 and the second in 1840, won him a European reputation as well as a seat in the Académie Française. Meanwhile, encouraged by P. Royer-Collard, whom he much admired, he had entered politics. After an unsuccessful contest in 1837, he became deputy for the Manche in 1839 and sat continuously as an independent, generally critical of government policy. until the fall of the July monarchy. Then, believing that monarchy had disappeared for good in France and that it behoved moderate men to ensure the success of an orderly republic, he stood for parliament again and sat in both the constituent and legislative assemblies of the second republic. From June to Oct. 1849 he was minister for foreign affairs in Odilon Barrot's second ministry. Gifted with considerable political prescience, he early suspected Louis Napoleon's ambitions, and his protest at the *coup d'état* of Dec. 2, 1851, earned him a night's arrest. Thereafter he withdrew from public life and spent his remaining years traveling and preparing his *L'Ancien Régime et la Re'volution,* the first volume of which. generally considered his masterpiece, came out in 1856. It obtained even greater success than *De la démocratie en Amérique,* but ill-health prevented him from completing the work. He died at Cannes on April 16, 1859.

Natural diffidence, a weak voice and indifferent health prevented him from making much mark in politics; but, despite his lack of sympathy with the middle classes, his writings proved him one of the shrewdest, if more pessimistic, political observers of his century. *De* la *démocratie en Amérique* was not a detailed analysis of institutions, but a speculative investigation into the effects of popular government upon a whole society and, as such, a warning of what might happen in Europe. He saw the world moving inescapably toward democracy and social equality and discerned in property the only remaining form of privilege. A passionate believer in liberty, which he considered incompatible with equality, he disliked what he saw yet believed that men must adapt themselves to the new age. His Ancien *Régime* demonstrated his historical insight; it rejected the accepted view that the Revolution marked a complete break with the past, showed a wide understanding of the broad social forces involved in change and was a landmark in the reinterpretation of the Revolution. His *Souvenirs* are a valuable source for the history of the second republic.

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TODA, a pastoral tribe of the Nilgiri hills of south India. Few in number (879 in 1951), they are widely known for their striking appearance and specialized culture. The culture is mainly concerned with the care and cult of their buffalo. They have a distinctive Dravidian language, a complex social system (with moieties, double descent and polyandry), an oral poetry extolling buffalo and a religion which is largely the ritual of the dairies. Programs, governmental and missionary, have long attempted to change Toda ways; one was introduced in 1954. (D. G. M.)

TODD, SIR ALEXANDER (ROBERTUS) (1907–), British chemist who was awarded the Nobel prize for chemistry in 1957 for his work on coenzymes, was born in Glasgow on Oct. 2, 1907. Educated at Glasgow university, he carried out research in organic chemistry there and at Frankfurt-on-Main, Oxford and Edinburgh. He joined the staff of the Lister institute in 1936, and became reader in biochemistry at London university in the following year. In 1938 he became professor of organic chemistry at Manchester university, and there began work on the nucleosides and their phospborylation, which he continued at Cambridge, where he m-as appointed professor of organic chemistry in 1944.

Sir Alexander Todd's researches were mainlv concerned with chemical substances of important pharmacological or biochemical interest. He was associated with the prooi of structure and the synthesis of vitamin B_1 (aneurin), vitamins E (tocopherols) and the active principles of hashish (marihuana). Other achievements were the synthesis of adenosine triphosphate in 1949 and of flavinadenine dinucleotide and uritline triphosphate in 1954, and the elucidation of the structure of vitamin B_{12} in 195j, made possible by combining the methods of organic chemistry and X-ray crystallography. His studies also included certain alkaloids from the *Erythrophleum* and *Daphnandra* genera; the plant colouring matters (anthocyanins), the insect (aphis) pigments and certain mold products, including various quinones, puberulic and stipitatic acids and penicillin. His work on the structures and syntheses of nucleosides and nucleotides made an outstanding contribution to knowledge of the structure and iunction of nucleic acids.

Todd was elected a fellow of the Royal society in 1942 and knighted in 1954. In 1952 he became chairman of the British government's advisory committee on scientific policy.

TODI (anc. TUDER), a town and episcopal see of the province of Perugia. Italy. 26 mi. S. of Perugia by rail, on a steep hill above the east bank of the Tiber, 1,348 ft. above sea level, and 866 ft. above the river. Pop. (1951) 4,648. Some portions of the ancient town walls—of two enceintes. an inner and an outer, the former attributed to the original Umbrian inhabitants, the latter to the Romans—are preserved, while the medieval walls are still more extensive, and also remains of baths. amphitheatre, theatre and a substruction wall of massive masonry with four niches. There was found the bronze statue oi Mars, which was placed in the Vatican; some line bronze objects of the 5th century B.C. were iound in tombs. Beneath the cathedral square, at the highest point of the town, is a large Roman reservoir. The Romanesque cathedral has a simple façade (partly of the 11th, partly oi the 14th century) with a fine portal and rose window. In the same square are the massive Romanesque Gothic structures, Palazzo dei Priori (1213), the Palazzo del Capitano del I'opolo (c. 1290) and the Palazzo del Podesta (1293–1337). The Gothic church of S. Fortunato, with its nave and aisles of the same height, has a splendid portal. Just outside the town on the west is the church of S. Maria della Consolazione, one of the finest buildings of the Renaissance, and often wrongly attributed to Bramante. Contemporary documents prove that the interior was begun in 1508 by Cola di Matteuccio da Caprarola and the exterior completed in 1516–24 by Ambrogio da Milano and Francesco di Vito Lombardo; the slender dome was not added till 1607.

TODLEBEN (TOTLEBEN), FRANZ EDUARD IVANOVICH, COUNT (1818–1884), Russian engineer general, was born at Mittau in Courland, on May 20, 1818. He entered the school of engineers at St. Petersburg, and passed into the army in 1836. In 1848 and the two following years he was employed, as captain of engineers, in the campaigns against Schamyl in the Caucasus. On the outbreak of war between Russia and Turkey in 1853 he served in the siege of Silistria and, after the siege was raised, was transferred to the Crimea (see CRIMEAN WAR). Sevastopol, while strongly fortified toward the sea, was almost unprotected on the land side. Todleben, though still a junior field officer, became the animating genius of the defense. By his advice the fleet was sunk, in order to blockade the mouth of the harbour, and the deficiency of fortifications on the land side was made good before the allies could take advantage of it. The construction of earthworks and redoubts was carried on with extreme rapidity, and to these was transierred, in great part, the artillery that had belonged to the fleet.

It was in the improvisation of defensive works and offensive counterworks to meet changing phases of the enemy's attack that Todleben's originality showed itself. He never commanded a large army in the open field, nor was he the creator of a great permanent system of defense. But he may justly be called the originator of the idea that a iortress is to be considered not as a walled town but as an entrenched position, intimately connected with the offensive and defensive capacities oi an army and as susceptible of alteration as the formation of troops in battle or maneuver. Until June 20, 1855, he conducted the operations of defense at Sevastopol in person; he was then incapacitated by a wound. In 1860 Todleben was appointed assistant to the grand duke Nicholas, and he became subsequently chief of the department of engineers with the full rank of general. He was given no command when war with Turkey began in 1877. It mas not until after the early reverses before Plevna (*q.v.*) that he was called to the front. Todleben saw that it would be necessary to draw works around Osman Pasha and cut him off from communication with the other Turkish cpmmanders. In due time Plevna fell. Todleben then undertook the siege of the Bulgarian fortresses. After the conclusion of preliminaries of peace, he was placed in command of the whole Russian army. When the war was over, he became governor of Odessa and hereditary count. For some time aiter 1880 he held the post of governor oi Vilna. He died at Bad Soden near Frankfurt-on-Main, on July 1, 1884.

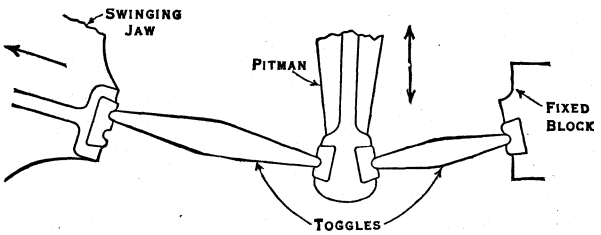
His great work on the deiense of Sevastopol appeared in Russian, French and German, 5 vol. (1864–72).

TODMORDEN, a municipal borough (1896) and market town in the Sowerby parliamentary division of the West Riding of Yorkshire. Eng., 22 mi. N.N.E. of Manchester by road. Pop. (1951) 19,074. Area 20 sq.mi. On both sides of the Calder river, at an altitude of about 500 ft., it is surrounded by high moorland. Todmorden is a railway junction for trans-Pennine routes from Manchester. Preston and Burnley to the industrial West Riding, and the Rochdale canal runs through the borough. The staple industry is the spinning and weaving of cotton, and there are also foundries and machine works. Todmorden has strong links with Lancashire, sharing its cotton industry and its county address. Until 1888 the county boundary passed through the town.

TODY, a bird (*Todus viridis*j inhabiting Jamaica, with allied species in Cuba, Haiti and Puerto Rico. A stolid bird, the tody is brightly coloured in grass green, with a crimson gorget. It feeds on insects and, like its allies the kingfishers, constructs burrows in which to lay its white eggs.

TOGGENBWRG, THE, an ancient county in the upper valley of the Thur river (Switzerland). On the death of the last count of Toggenburg (1436). Ziirich and Schwyz, in the first intercantonal war, disputed its possession. Purchased by the abbot of St. Gall in 1468. it was an area of constant strife between the abbots and the inhabitants, many among whom embraced Protestantism. The Toggenburg war between the Roman Catholic cantons and Protestant supporters of the Toggenburgers resulted in a Catholic defeat (1712) and in the restoration of the ancient liberties. Today it is a pleasant, highly prosperous part of the canton of St. Gall, inhabited by approximately equal numbers of Protestants and Catholics. Its exact limits are differently interpreted, but the entire upper valley of the Thur above the right-angled bend, near Wil, to the source near Wildhaus, is about 30 mi. long and runs mainly southeast to northwest, between steep fir-clad slopes. Near the valley head are the Churfirsten mountain (Hinterrugg, 7,566 ft.) southward and the bold peaks of the Santes (8.209 ft.) northward. The valley is well populated and has good through communications; a 20-mi. railway was built from Wil, on the Winterthur-St. Gall main line, to Nesslau. The old market centre of the valley was Lichtensteig, later surpassed in point of size and importance by several well-built towns and villages, such as Wattwil (pop., 1950, 6,336), near the entrance of the Ricken tunnel.

TOGGLE LEVER, a combination of three levers, one being at right angles to the ocher two and arranged so as to push against



A KNUCKLE FORM OF LEVER ACTION, TWO BEING STRAIGHTENED OUT BY A LATERALLY MOVING ONE

their closely set ends. One of the latter is pivoted at a fixed position, while its companion has endlong freedom. Great power is obtained by the action of the lateral lever forcing the other two into a straight line. One practical application is seen in the diagram, where the lateral lever is a rod, or pitman, given a short up and down motion from an eccentric on a shaft fitted with a heavy flywheel. As the pitman rises, it forces the toggles (which are wide pieces in this case) into line and exerts great pressure against the pivoted jaw. The latter crushes rock or stone against a fixed jaw face. Another application of toggles is in power presses for drawing hollow sheet-metal articles, such as bowls, pans, etc., from the flat sheet. This operation necessitates holding the sheet firmly around the die during the drawing. The toggle mechanism does this and transfers the great stress directly to the frame of the machine, instead of throwing it on the crankshaft.

TOGO, HEIHACHIRO, COUNT (1847–1934), Japanese admiral, was born in Kagoshima, the son of a petty retainer. He joined the navy in 1863, and his first engagement was the "Kwaiten" five years later. He studied naval science and navigation in England from 1871 to 1878 and first became a prominent figure when, in 1894, as captain of the cruiser "Naniwa," he sank the Chinese troopship "Kowshing" en route for Korea, thus precipitating war with China.

When the Russo-Japanese conflict broke out in 1904, he was appointed to the command in chief of the Japanese fleet, and under his direction various brilliant operations took place, culminating in the battle of the Sea of.Japan when the Russian fleet was annihilated. For these services he received (1907) the title of count. In 1906 he became a member of the British Order of Merit. (See RUSSO-JAPANESE WAR.)

TOGOLAND, a strip of territory in West Africa divided longitudinally into a western half, which in 1956 became united with the Gold Coast (called Ghana in 1957), and an eastern half (Togo) under French administration until it achieved full independence on April 27. 1960. To the east is Dahomey, to the north the Upper Volta and to the south the Gulf of Guinea. From north to south it extends for about 340 mi.; it is narrowest at its coast line. only 32 mi. long; its greatest width from east to west is about 140 mi. The area of the territory is approximately 35.000 sq.mi.

Physical Features. — The coastline is low and sandy: a sandbar and heavy surf impede access from the sea. A few hundred yards inland from the shore there is a line of lagoons connected by marshy creeks. Behind the lagoons lies a low plateau of lateritic clay averaging about 20 mi. in width and 200 ft. to 300 ft. in altitude. This plateau gives way to undulating plains, 1.300–1.500 ft. above sea level. The country then rises steeply to the Togo hills, which, running from south-southwest to north-northeast at an average elevation of about 2,000 ft., divide the territory into two approximately equal triangles. Mt. Agou (3.346 ft.), the highest point in the territory, is found there. To the northwest of the Togo hills is undulating savanna country drained by the River Oti, a tributary of the Volta. To the southeast of the hills the land is drained by a number of small rivers running southward, the chief of which are the Mono, which in its lower reaches forms the boundary with Dahomey, and the Haho and Sio, which terminate in the Togo lagoon, the centremost and largest of the coastal lagoons.

Climate. — Seasonal variations in climate result from the north-south oscillation of the convergence zone between the hot and dry harmattan air mass which flows from the northeast, and moist and relatively cool monsoon air from the southwest. North of the Togo hills, the harmattan is dominant except during May-October, the rainy season. Mean temperatures range from 72° F. to 92" F., while mean relative humidity lies between 45% and 67% and annual rainfall averages about 45 in. In the hills rainfall averages about 60 in. a year. South of the hills, the rainy season has two peaks, in May-June and September. and the average annual rainfall is about 30 in. Mean temperatures are low for the latitude (70° F.–85° F.), and mean relative humidity is high (around 84%). The harmattan extends to the coast for a few weeks in December–January.

Flora and Fauna. — The vegetation of Togoland has been much altered by the hand of man. True tropical forest survives only in pockets in the mountains and along the river valleys. Dense belts of reeds surround the coastal lagoons. For the rest the natural vegetation is now chiefly of the guinea-savanna type, subject to annual fires. Soils are poor and devoid of humus. Coconut palms have been planted in large numbers near the coast; oil palms, maize, cassava, yams and cotton are intensively cultivated farther inland. Cocoa and coffee are grown in the hills, while the chief crops of the northern savanna are peanuts. millet, cotton and kapok. The fauna resembles that of adjacent regions of West Africa, but, because of the relatively high density of population, the larger wild animals are now scarce, especially in the south. In the north, however, there are lions and leopards, and elephants are occasionally seen. Monkeys are common, while hippopotamuses and crocodiles live in the rivers. There are many snakes and lizards. and numerous varieties of birds and insects.

Population. — The native population is all of Negro stock, but the Togo hills divide the territory into two distinct ethnographic areas. The peoples of the north are Voltaic. subject to a degree of Hamitic influence from the Sudan e g., the Dagomba, Mamprussi and Konkomba in the west. and the Gurma, Kabre and Tem peoples in the east. South of the hills the great majority of the people are Eues, whose traditions indicate that they, or their ruling elements, migrated from southwestern Nigeria, probably about the 16th century. A number of small groups in the hill country of west central Togoland, such as the Avatime. may represent an earlier stock. In the extreme southwest are the easternmost elements of the Twi-speaking peoples. The Dagornba and Mamprussi apart, few of these peoples were organized in large or strong political units. In the north the politico-social unit was often the descent group, as among the Konkomba; in the south, the Ewes, though culturally linked with Dahomey and influenced by the Akan states to the west, were at the end of the 19th century organized into more than 100 separate tribal groups, speaking a number of different and sometimes almost mutually unintelligible dialects. The peoples of north and south alike are predominantly animists, though Christian missions have been active in the south since 1840 and the influence of Islam has been spread by immigrant Hausa and Toruba traders. The Ewes are agriculturalists and traders, the peoples of the north agriculturalists and pastoralists. Population densities are high for West Africa, the average for the territory as a whole being about 42 per square mile.

HISTORY AND ADMINISTRATION

The German Occupation. — Until 1884 what is now Togoland was merely an indeterminate zone between the predatory military states of Ashanti in the west and Dahomey in the east. (See WEST AFRICA.) Since its coastline afforded no safe landing place, the bulk of its external trade, first in slaves and then in palm oil, was conducted through the European posts in Dahomey and the Gold Coast. However. German missionaries arrived in Togoland in 1840 and 'German traders shortly followed. In July 1884, Gustav Nachtigal, sent by the German government to West Africa ostensibly to inspect German interests there, induced a number of coastal chiefs to sign treaties placing their territories under German protection. The protectorate so established was accorded international recognition at the Berlin conference of 1885, and its coastal frontiers with the adjacent colonies of Dahomey and the Gold Coast were defined by treaties with France in 1885 and with Great Britain in 1886. From 1887 to 1890 German military expeditions, penetrating into the interior and meeting with little resistance, secured a hinterland the boundaries of which were at length determined by treaties with France in 1897 and with Great Britain in 1904.

Lomé, at the western end of the coast, the only part of it which is not separated from the interior by lagoons, was selected as the political and commercial capital of the new colony. A modem town was laid out, and in 1904 a jetty was built to obviate the necessity of carrying all imports and exports through the surf. Three-metre gauge railways were constructed radiating from Lomé: one eastward through the palm-bearing coastal districts to Anécho (Little Popo), formerly the chiéf European trading centre (27 mi.) ; one north-northwest to Palimé (74 mi.) to serve the hill country; and one due north to Atakpamé (104 mi.) to open up the central area of the colony. Exploitation was practically confined to the coastal and central areas and was exclusively agricultural: no minerals were worked, and animal husbandry was hampered by the tsetse belt. Plantations were established both by the government and by private German corporations, but the greater part of agricultural development was left to the natives themselves, assisted by agriculturalists trained at a college at Nuatja. The principal products of commercial value that were developed were palm products (exports worth £239,500 in 1912), plantation and wild rubber (648,700) and cotton (625,700). Cocoa production was expanding and by 1913 exports had reached £16,600 in value. The total value of exports rose from £153,000 in 1900 to a peak of £498,000 in 1912. In the same period imports, principally cotton piece goods and hardware, increased in value from £176,000 to £572,000. In 1912 Germany took 60% of the exports and provided 42% of the imports. German administration was efficient but marred by its harsh treatment of natives and its use of forced labour. In 1912 revenue was £160,000 and expenditure £150,000.

On Aug. 7, 1914, British and French colonial troops from the Gold Coast and Dahomey respectively invaded Togoland and after a brief campaign secured the unconditional surrender of the German governor and garrison on Aug. 26. Thereafter the western part of the colony, including Lomé and the greater part of the railway system, was administered by Britain, and the eastern part by France. This division was modified by an Anglo-French agreement of July 10, 1919, by which France secured the railway system and the whole coastline. Germany having renounced her sovereignty in the treaty of Versailles, in 1922 the League of Nations issued class B mandates to Britain and France for the administration of their respective spheres.

The British Sphere.—The British sphere has an area of 13,041 sq.mi. and a population (1948) of 382,768 (51 Europeans). The northern part was administered integrally with the Northern Territories of the Gold Coast, and the southern part integrally with the Gold Coast colony. Beginning in 1951, the southern districts elected three members to the Gold Coast legislative assembly, but in the north the electoral system cannot be distinguished from that of the Northern Territories as a whole, which send 19 members to the assembly. There are no large towns in the territory, though in the north, Yendi, the Dagomba capital, has 7,694 inhabitants (1948 census), while the principal towns in the south, Ho and Hohoe, both have populations in excess of 5,000. The economy of the British sphere is exclusively agricultural. Cocoa is the principal cash crop in the south: the people of the north are mainly engaged in subsistence farming, though peanuts, yams and cattle are exported southward. Trade returns from British Togoland are not kept separately from those of the Gold Coast, but in 1953 it was estimated that the territory's exports were worth £4,345,270 (cocoa £3,646,780; maize £400,000), and its imports £4,004,200 (cotton piece goods £981,700). Although the British administration has built motor roads connecting its sphere with the road system of the Gold Coast, the bulk of its external trade passes over the railways of French Togoland. The French valuation of this transit traffic in 1951 was 66,668,000. In 1953 government revenue was £2,081,000, and expenditure £1,960,600 with an additional £585,300 on development.

The French Sphere.—The French sphere has an area of 22,008 sq.mi., and a population (1953 est.) of 1,052,318 (1,088 non-Africans). Lomé, with a population (1953 est.) of 39,200 (more than 700 Europeans), is the only town of any size. The territory is administered by a commissioner assisted by a consultative executive council of officials and by a representative assembly. The assembly has 30 members elected by more than 50,000 registered voters. Certain stipulated types of measures, including the annual budget, must receive its approval. The territory sends one representative to the French national assembly, two to the council of the republic, and one to the council of the French union. Under French administration the port facilities at Lomé have been extended and improved; the Atakpamé railway has been extended northward to Blitta, a further 68 mi.; and the mileage of roads suitable for motor traffic has been increased from 755 to 1,420. As in British Togoland, the economy is based on the peasant exploitation of cash crops, which has greatly developed. The principal exports are cocoa and coffee from the hills (worth £2,010,000 and £1,010,000 respectively in 1953), ginned cotton from the centre and north (£300.000). copra and palm kernels from the coast and centre (£510,000 and £660,000 respectively) and husked peanuts from the north. The total value of exports in 1953 was £5,580,000, and of imports £4,240,000. The principal imports were cotton piece goods) wines, spirits and beer and motor vehicles and parts. France took 64% of the exports and provided 51% of the imports in 1953. In 1953 gross revenue was £3,500,000 and gross expenditure was £3,933,000.

Modern Developments.—In 1946 the British and French governments placed their spheres of Togoland under Cnited Nations trusteeship. After 1947 Ewes in southern Togoland made a series of representations to the trusteeship council that either the territory inhabited by the Ewes or the whole of Togoland should be brought under a common administration. These proposals were difficult to implement, among other reasons, because Ewes were also inhabiting the southeast of the British colony of the Gold Coast. because of the rapid advance of the Gold Coast (including British Togoland) toward self-government, because not all the inhabitants of southern Togoland are Ewes, and because the incorporation of the northern part of the British sphere with the Sorthern Territories of the Gold Coast had satisfactorily reunited the Dagomba and Mamprussi kingdoms, both of which were cut into two by the pre-1914 boundary. However, a joint Anglo-French consultative commission for Togoland affairs was set up in 1948, frontier restrictions were relaxed, and in 1952 the Gold Coast government instituted a Trans-Volta council to deal with local problems of the Ewe areas. On Dec. 13, 1956. British Togoland was integrated with the Gold Coast (*q.v.*) which on March 6, 1957, became an independent state within the commonwealth under the name of Ghana. On April 27, 1960, Togoland under French administration became the independent Republic of Togo.

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TOJO, HIDEKI (1884–1948), Japanese army officer and political leader, was born in Tokyo Dec. 30, 1884. He attended the Imperial Military academy in Tokyo and was commissioned a sublieutenant in the army upon graduation. In 1919 he served as military attaché to the Japanese embassy in Berlin. After returning to Japan he held various posts in the war office. In 1928 he was named commander of the 1st infantry regiment, which in 1936 participated in the mutiny of the Tokyo garrison. He was named commander of the gendarmery headquarters in 1937 and shortly afterward became chief of staff of the Kwangtung army. In July 1940 he was appointed minister of war in the cabinet of Premier Prince Fumimaro Konoye. Tojo succeeded Konoye as premier Oct. 16, 1941, and pledged his government to a proaxis policy as well as a "greater east Asia" program.

After the Japanese attack on Pearl Harbor, Dec. 7, 1941, Tojo officially declared war on the U.S. After prolonged Japanese military reverses in the Pacific, Tojo assumed virtual dictatorial powers, taking over the posts of minister of war and chief of the general staff. The successful U.S. invasion of the Mariana Islands so weakened his government that he was removed as chief of staff July 16, 1944. After Japan's formal surrender in 1945, Tojo shot himself in a suicide attempt but was nursed back to health to face trial as a military criminal. He was found guilty. An appeal to the U.S. supreme court was denied, and he was hanged Dec. 23, 1948.

TOKAJ, a town in Borsod-Abauj-Zemplén megye. Hungary, at the confluence of the Bodrog and the Tisza and at the foot of the Hegyalja mountains which slope from a height of 2,700 ft. to a hilly plateau of 1.500 ft. near Tokaj.

There lies the vineyard region of nearly 150 sq.mi. on a volcanic soil. The vines are believed to have been introduced by Italian colonists in the 13th century. From their grapes is produced the famous Tokay wine, the trade in which is the principal occupation. The population is (1960) 5.031 (mun.).

TOKAT, a town in Turkey. Pop. (1960) 32,725 (town); 438.439 (*il*). It is in the Sivas-Samsun *chaussée,* altitude 2.280 ft., at the mouth of a glen opening out to the valley of the Tozanli Su. a tributary of the Yeshil Irmak. It rose to importance under the Seljuks.

Industries developed there include the manufacture of copper utensils and yellow leather and the stamping of colours on white Manchester cotton.

TOKELAU ISLANDS: see PACIFIC ISLANDS.

TOKUGAWA IEYASU (1542–1616), founder of the third and last military dynasty, or shogunate, in Japan. Son of Matsudaira, a castle lord in Mikawa fief (now in Aichi prefecture), he adopted the family name of Tokugawa in 1567. At an early age he was drawn into the gigantic feudal struggles which wracked Japan in the late 16th century.

Able and ruthless, he first fought and then allied himself with the mighty Oda Nobunaga and, after Oda's death in 1582, challenged and then supported Toyotomi Hideyoshi, who became master of the land by 1590. For his efforts Ieyasu acquired extensive lands and power. Upon Hideyoshi's death in 1598, he organized a feudal coalition to support his bid for supremacy and won the historic battle of Sekigahara in 1600. Establishing his headquarters at Edo, renamed Tokyo in 1868, he obtained the title of shogun, or generalissimo, in 1603.

The Tokugawa shogunate lasted for 265 years. As the first of 15 Tokugawa shoguns, Ieyasu was a political genius. By reorganizing the system of fiefs and devising a pattern of political and military checks and balances, the almost 300 feudal lords were brought under effective control. No serious challenge to Tokugawa authority was raised for over two centuries. To ensure the power of his house, Ieyasu acquired vast wealth and estates. Though he abdicated as shogun in 1605, he dominated the Tokugawa regime until his death in 1616. *See* also JAPAN: *History.*

See A. L. Sadler, *The Maker of Modern Japan* (1937). (HN. KN.)

TOKUGAWA YOSHINOBU, PRINCE (1837–1913), Japanese statesman, was born on Sept. 29, 1837, at Tokyo. He was the last of the Tokugawa government, succeeding as shogun the 14th shogun, Iemochi. in 1866. Realizing after a year's time that the proper government of the country was impossible on the lines of feudalism. which was a bar to all progress and a source of continual internal strife, the shogun handed his resignation to the emperor on Oct. 14, 1867.

This act of sacrifice was the prelude to the enlightened Meiji era, which dates from the beginning of 1868. Tokugawa, having renounced his shogunate rights, went into a strict retirement from which he never emerged. He even renounced the succession to his title for his direct heir in favour of a collateral branch of the family, the first to inherit the title being Prince Iyesato Tokugawa, for many years president of the house of peers. The emperor Meiji accepted the renunciation, but he conferred on him another title of prince to be bequeathed to his son. He died on Nov. 21, 1913, at Tokyo.

TOKUSHIMA, a Japanese prefecture *(ken)* in eastern Shikoku. was formed from the province of Awa after the restoration of 1868. Area 1.600 sq.mi. Pop. (1960) 847.274. concentrated mainly in the Yoshino rift valley. Expansion of hydroelectric power permitted the growth of large wood-pulp and nylon and other textile industries. The prefecture is also noted for the production of tobacco and salt.

Tokushima, a historic and industrial city on the western coast of Shikoku, is the prefectural capital. Between 1940 and 1960 the city increased in area from 74 sq.mi. to 61.3 sq.mi. and in population from 119,600 to 182,782. Its present name dates from 1678. Formerly it was called Iyama and Inotsu. The chief industry is cotton textiles, notably *Awachijimi* (cotton crepe). Ferryboats connect Tokushima city with Kōbe and Awaji while a rail line, running through the Yoshino rift valley, connects the city with the rest of Shikoku. (C. A. MR.)

TOKUTOMI SOH?) (pseudonym of TOKUTOMI IICHIRŌ) (1863–1957), usually known by his pen name, Japanese historian, critic, journalist and essayist, was born at Tsumori in Kumamoto on March 13, 1863. He received an American-style education at Doshisha university, Kyoto, and immediately entered a literary career.

He was particularly concerned with Japan's future political and moral position, and his book *Shorai no Nihon* ("The Future Japan," 1886) attracted much attention. He started a periodical, *Kokumin no Tomo* (the "Nation's Friend'!): in 1887 and a newspaper, *Kokumin Shimbun* (the "Nation"), in 1890.

Of Tokutomi's numerous publications on matters relating to Japanese history and politics the most important is his *Kinsei Nihon Kokumin-shi ("A* History of the Japanese People in Modern Times"), 77 vol. (1918–46). a journalistic rather than historical work, which, despite its ultranationalistic bias, is an invaluable compendium of events in Japan from 1534 until the late 19th century. Tokutomi died on Nov. 3, 1957.

See W. T. *de* Bary, *Sources* of *the Japanese Tradition (1958).* (DD. *K.)*

TOKYO, the capital of Japan, located at the head of Tokyo bay, is the political, economic and cultural centre of the country. Formerly called Edo or Yedo ("estuary"), it was named Tokyo, or "eastern capital," in contradistinction to Kyōto (then known as Saikyo, "western capital"), when it was proclaimed the residence of the emperor and official capital of Japan in 1868.

Greater Tokyo is claimed to be the largest city in the world. The population of the city in 1960 was 8,310,027, and the population of the urban prefecture was 9,683,802. The urban prefecture includes a number of towns around Tokyo city but not the satellite cities which extend around Tokyo bay and onto the Tokyo plain. (See *Urban Prefecture,* below.) Within 37 mi. of the centre of Tokyo there are more than 25,000,000 people. The hinterland of the city includes all of northern Japan. Tokyo is also one of the world's most modern cities, having been repeatedly rebuilt after destruction by fires, earthquakes and World War II air raids. At the beginning of the 20th century the chief means of transportation was by jinrikisha, a man-drawn carriage, but this has vanished completely except as a curiosity for tourists. The city is served by an efficient net of subways, buses, electric cars and electric or diesel trains.

The city is built on low alluvial plains, called Shitamachi, and a diluvial upland, called Tamanote. The Shitamachi lowland is less than 17 ft. above sea level and most of it has been reclaimed from the sea since 1600. This section is slowly subsiding as ground water is pumped for industrial purposes. The maximum subsidence in the mid-1950s was about $7\frac{1}{2}$ in. In general, business and industrial districts are located on the Shitamachi (downtown) and the better residential districts on the Tamanote or Yamate (uptown). Temperatures are lower on the Yamanote which has from 60 to 100 days of frost a year while in the vicinity of the delta of the Sumida river there is frost from 30 to 40 days.

The mean annual temperature for central Tokyo is about 58° F. The hottest month, August, has a mean temperature of about

79.5" while the coldest month, January, has a mean temperature of about 38°. From June through September the mean temperatures are over 68° and the relative humidity is nearly 80%. The average annual number of days of precipitation is 101.8, of which 13 are snowy. The Yamanote temperatures are often 9° cooler at night.

History **and Growth.**—While there is a questionable record of Edo as early as 1180, its real history begins in 1456 when Ōta Sukenaga (Dōkan) built the first Edo castle on the site of the present imperial palace. Toward the end of the 16th century Edo was a small fishing village with about 100 houses. The castle changed hands many times until Toyotomi Hideyoshi gave it to Tokugawa Ieyasu, along with extensive fiefs in the Kantō area in 1590. Ieyasu made Edo his principal castle because it was so located that it could control the critical land and sea communications of the Kantō plain with the west, and yet was not closely connected with the feudal family that he was displacing. When Ieyasu became shogun, he made Edo the administrative centre of the military government, *bakufu*, which in actuality made it the real capital of Japan although the emperor continued to maintain a shadowy court in Kyoto. *(See JAPAN: History.)*

The *bakufu* energetically reclaimed land from the sea and drained marshes. The Tone river: which had emptied into Edo bay, was diverted to its present course which empties directly into the Pacific ocean. The population grew rapidly. About 80,000 warriors, or samurai, who were direct retainers of the Tokugawa were soon moved to the new city. All of the *daimyō,* or feudal lords, were required to establish residences in Edo and spend part of their time there. This alternate residence in their fiefs and in the capital was called *sankinkotai*. The quarters of craftsmen, tradesmen and commoners were called the *machiya*. Numerous temples and shrines were established. The plan of the Tokugawa city resembled a spider web, a plan closely reflected in the modern Tokyo. The Tokugawa castle became the site of the imperial palace and the centre of the city plan. Parallel moats and streets encircled the castle and, with the spokelike streets which radiated out from the castle, formed the basis of the present network of streets. Some of the moats were filled to form new streets or were eventually covered with buildings. The inner circle of houses of retainers and *daimyō* was inside the outer moats; this was named the Marunouchi or "circle of houses" and is now an important business and shopping district. The tradesmen had their houses outside the moat where the Ginza, or silver shops, were located; this continues to be a main shopping district. Temples and shrines were strategically located to reinforce the defenses of the moats. Edo's population is estimated to have been 150,000 in 1613 but by 1721 it was 1,300,000. Until the end of the 18th century Edo was the largest city in the world with the exception of Peking. It probably exceeded 1,500,000 during the period 1800–50. The city became a centre of communications. Rice, fish and timber were moved to the city by sea and unloaded along the banks of the Sumida river and the net of canals. Merchants carried their goods over the five great highways that concentrated on the city. All distances on these highways were measured from a bridge in the centre of Edo, the Nihon Bashi. By the beginning of the 18th century the main features of the city were fixed and there were few changes until after the restoration of 1868. Some temples and shrines moved to the suburbs where there was more land for expansion and many *daimyd* established palaces and parks on the cooler terraces of the Yainanote section of the city. Some parks of the *daimyō* palaces later became sites of universities or public parks. Because of frequent fires some new detached *machiya* quarters were built separate from the main city. Fires were always serious in Edo and Tokyo because of the crowding of houses and the materials used in their construction. Little was left of the city after the great fires of 1657, 1668 and 1825. Smaller sections of the city were burned more frequently and it is estimated that the city was completely rebuilt on an average of every 11 years. Earthquakes, followed by fires, also took a serious toll. The most serious earthquakes have been in 1633, 1650, 1703, 1855 and 1923.

The *bakufu* was overthrown in 1868 and Edo was renamed Tokyo. Although the emperor moved to Tokyo and it continued to be the administrative centre of Japan, the restoration was accompanied by an immediate decline in the population because the dispossessed samurai and *daimyō* had owned about 60% of the city. By 1872 the population had dropped to 520,000. It was not until 1880 that the city again passed the 1,000,000 mark. The new city was an industrial, commercial and cultural centre as well as a political and administrative centre, such as it had been under the Tokugawa. The subsequent growth of the city was closely connected with the development of modern communications. A railroad built in 1872 linking Tokyo and Yokohama was the beginning of an efficient rail system which has Tokyo as its centre. A circular electrified line called the Yamate loop was completed within the city in 1910. This was the beginning of a system of electric lines, subways and buses which permit large numbers to be moved about the city quickly.

The main shopping street with its great department stores developed in the Ginza district while business concentrated in the Marunouchi district. Wherever the Yamate loop was joined by a rail line leading away from the city. a secondary shopping district developed, such as Shibuya, Shinjuku and Ikebukuro. The eastern lowland between the Sumida river and the Arakawa developed as the first industrial area. Later the entire coast line between Tokyo and Yokohama became an industrial area knoan as the Keihin.

On Sept. 1. 1923, a disastrous earthquake struck the city. The fire which followed it was fanned by strong winds and did most of the damage. The loss of life was estimated at 74,000 and 64% of the surviving population was left homeless. This disaster accelerated the move of the residential areas to the Uamanote upland which had not suffered as much damage as the Shitamachi lowland. The heavy damage in the eastern industrial area was followed by the building of new factories on reclaimed lands near the mouth of the Sumida river. in the Keihin area and to the west along the Chūō railroad. The area of the city began to expand in 1932 when neighbouring communities mere absorbed to increase the area from about 33 to 214 sq.mi. Continued expansion gave the city about 222 sq.mi. by 1958.

During the 1930s the military adventures in China were accompanied by an increase in the factories. industries and populaticn of Tokyo. In 1942 the population reached 6,916,000. During World War II, 51% of the population of the ward areas lost their homes and other people migrated, so that by Sept 1945 the population nas reduced to 2,777,000. Little was left standing in the heart of the city except some of the foreign-style buildings in the Marunouchi district. Recovery was rapid after the war with the return of refugees, rebuilding of old factories and establishment of new industries. By the mid-1950s the population was greater than before the war. The continued expansion gave rise to many problems of housing and congestion. After 1951 the government subsidized low-cost housing units. Large modern apartment houses became a feature of the city after the war.

Yokohama developed in the last half of the 19th century as Tokyo's outer port because the upper part of Tokyo bay is shallow. How-ever, in the late 1930s a channel was dredged to Tokyo which enables large ocean-going vessels to dock in the extensive Tokyo harbour area. After World War II industry expanded along the northern end of Tokyo bay. This new industrial zone, which includes the iron and steel industry of Chiba, is called Keiyō The Tokyo International airport at Haneda is the focal point of the domestic airlines and the chief Japanese airport for the international airlines

The grounds of the imperial palace form the core of the city. The palace itself mas destroyed by fire in the past and almost completely destroyed in World War II Most of the important government buildings are close to the core. The diet building nhere the Japanese legislature meets is a magnificent building nhich survived the war. Nearby are the supreme court building. the prime minister's official residence and offices and the offices of the various government ministries. The Tokyo city government and police also have their offices in the vicinity of the palace.

The greatest concentration of the government buildings is in the Kasumigaseki area to the southwest of the palace.

Culture. — A concentration of universities. libraries and museums makes Tokyo the cultural leader of Japan. The city contains 146 of the 465 universities and colleges of the country. In the early 1960s there were about 250,000 full-time college students besides those attending night school. Many of the older universities were established on the grounds of *daimyō* palaces after the restoration of 1868. The constant increase in students coupled with high land values in the vicinity of the existing campuses forced the establishment of branch or new campuses on the periphery of the city. Bookstore districts are found near the chief universities.

Tokyo contains major museums of Japanese and world art, such as the Tokyo National museum (formerly the Imperial Household museum), the National Museum of Modern Art, the Metropolitan Fine Art gallery, the Bridgestone gallery, the Okura Museum of Antiques and the Folkcraft museum. Science is represented by the Communications museum, the Electric Science museum, the National Science museum and the Transportation museum. In addition, the big department stores are famous for their special exhibits of contemporary and ancient art.

Tokyo has four types of theatres: the classical nō, the Kabuki, modern drama and moving pictures (Japanese and foreign). While the nō plays were for the upper classes of old Japan, the Kabuki were for the common people. Tokyo has continued to be the centre of Kabuki as it was in the Edo period. *(See* Nō Drama; Kabuki Theatre.)

The Tokyo dialect of Japanese was made the standard for the schools of all Japan.

Parks and Shrines. — There are more than 250 parks used for recreation. Some of these are famous gardens which were attached to *daimyō* palaces in the Tokugawa period, such as the Kiyosumi and Kōrakuen gardens. Ueno and Shiba parks, which contain the tombs of most Tokugawa shoguns, were opened to the public as parks after the restoration. The shrines and temples of Shiba park represented some of the finest Tokugawa architecture but were completely destroyed during World War II. Nearby, the third highest man-made structure in the world, a TV tower erected in 1958 and modeled on the Eiffel toner, dominates all Tokyo. Ueno park contains the Academy of Science, the Science council, the Ueno library, the Tokyo National museum, the Science museum, the Art gallery and the Ueno zoo. The Meiji park contains extensive gardens, the shrine to the memory of the Meiji emperor and athletic fields. After World War II some gardens and parks owned by the imperial family were opened to the public: Shinjuku Gyoen, Hamma Rikyii and Shiba Rikyii.

Urban Prefecture. — Tokyo-to, the prefecture, was formed after the restoration of 1868 from eight counties of Musashi province, the seven Izu Islands and the Ogasawara Islands. The prefecture covered an area of about 828 sq.mi. in 1940 but this was reduced to 780 sq.mi. with the loss of the Ogasawara Islands after World War II. In addition to the city of Tokyo, the prefecture contains other industrial and residential cities of importance which are closely tied to Tokyo. Hachiōji and Ome are textile centres. Tachikawa is a military and air base. Musashino, Fuchu and Chofu are tourist and recreational centres. Musashino is also noted for its artists' colony.

Administration. — The city is divided into 23 wards (ku), four of which (Bunkyō, Chiyoda, Shinjuka and Minato) are in the Yamanote district, and four (Chūō, Taitō, Sumida and Koto) in the Shitamachi district. Fifteen other wards were incorporated into the city in 1932, namely Katsushika, Edogawa, Arakawa, Adachi. Itabashi, Nerima, Kita, Meguro, Shinagawa, Nakano, Shibuya, Setagaya, Ota, Toshima and Suginami. Tokyo-to is administered by a governor and a metropolitan council of 120 members, who are elected to office. See also references under "Tokyo" in the Index volume. (C. A. Mr.)

TOLAND, JOHN (christened Janus Junius) (1670–1722), English deist, was born on Nov. 30, 1670, near Londonderry, Ire. Brought up a Roman Catholic, in his 16th year he became a zealous Protestant. He studied at Glasgow and then at Leiden under the famous scholar Friedrich Spanheim. He went in 1691 to Oxford, where he began the book which made him famous — his *Christianity not Mysterious* (1696. anonymous; 2nd ed. in the same year, with his name; 3rd ed.. 1702, including an *Apology for Mr. Toland*). It gave great offense, and several replies were immediately published. The author was prosecuted by the grand jury of Middlesex, and when he attempted to settle in Dublin at the beginning of 1697, he was denounced from the pulpit and elsewhere. His book having been condemned by the Irish parliament (Sept. 9, 1697) and an order issued for his arrest. Toland fled to England. The resemblance, both in title and in principles, of his book to Locke's *Reasonableness of Christianity* led to a prompt disavowal by Locke of the supposed identity of opinions and subsequently to the famous controversy between Stillingfleet and Locke. Toland's next work of importance was his *Life of Milton* (1698), in which a reference to "the numerous suppositious pieces under the name of Christ and His apostles and other great persons" provoked the charge that he had called in question the genuineness of the New Testament writings. Toland, replying in his *Amyntor, or a Defence of Milton's Life* (1699), opened up the question of the history of the scriptural canon. In 1702 he published *Vindicius Liberius*, in which he described *Christianity not Mysterious* as a youthful indiscretion.

The next year he visited Hanover and Berlin and on his return to England published (1704) his *Letters*. In two of these (*A Letter to a Gentleman in Holland* and *Motion Essential to Matter*). ostensibly an attack on Spinoza, he anticipated some of the speculations of modern materialism. The *Account of the Courts of Prussia and Hanover* (1705) was used by Carlyle in his *Life of Frederick the Great*. From 1707 to 1710 Toland lived in varying circumstances on the continent. In 1709 he published (at The Hague) *Adeisidnenzon* and *Origines Judaicae*. The last of his theological works were *Nazarenus, or Jewish, Gentile and Mahometan Christianity* (1718), in which he maintained that the early Christians were Jewish Christians observing the Mosaic law and that their successors were the Nazarenes or Ebionites. He died on March 11, 1722, in London. as he had lived, in great poverty. with his pen in his hand. The term "freethinker" was first applied to Toland, who indeed uses it himself.

See Mosheim's *Vindiciae antiquae christianorum disciplinae* (1722), containing the most exhaustive account of Toland's life and writings; a *Life of Toland* (1722), by "one of his most intimate friends"; "Memoirs of the Life and Writings of Mr. John Toland," by Des Maizeaux, prefixed to *The Miscellaneous Works of Mr. John Toland* (1747) ; also G. Berthold, *John Toland und der Monismus der Gegenwart (1876)*.

TOLBUKHIN (formerly Dobrich), a town and regional centre of northeastern Bulgaria, lies in the great fertile plain of the Dobruja. Pop. (1956) 42.661. It was part of Rumania from 1913 to 1940. when it mas known as Bazargic. The town is connected by rail to the port of Varna (Stalin) and to Medgidia, Rumania: and it is on the main road from Varna to Constanta.

Tolbukhin has many vocational and general schools. Its industries are largely connected with the agriculture of the fertile neighbouring regions and include ensilage. flour milling, baking and vegetable oil extraction. There are also factories for cotton and woolen fabrics, furniture. bricks and tiles. The city was renamed in 1949 for the Soviet marshal Fyodor Ivanovich Tolbukhin, who took it from the Germans in World War II.

(An. Be.)

TOLEDO, a province of Spain. formed in 1833 from part of New Castile. Pop. (1950) 533.654. Area 5,925 sq.mi. The surface is mountainous. Toward the centre there are extensive tablelands, but the south and east are occupied by the Montes de Toledo and the hills which separate the waters of the Tagus on the north from those of the Guadiana on the south.

Toledo is well watered by the Tagus (*q.v.*) and its affluents. Gold, silver, lead, iron, quicksilver. copper. tin and other minerals are mined; manufactures include textiles, earthenware, soap. oil. chocolates. wine, rough spirit (*aguardiente*), guitar strings and arms. There is also trade in charcoal and timber.

TOLEDO, the capital of the Spanish province of Toledo and formerly of the whole country. 47 mi. S.S.W. of Madrid, on the river Tagus, 2,400 ft. above sea level. Population (1950) 38.136 (mun.). Toledo is of immemorial antiquity; it mas a stronghold of the Carpetani and may have been a Carthaginian trading station. Captured by the Romans in 193 B.C, it became a *colonia* and the capital of Carpetania. Its ecclesiastical importance is coeval with the introduction of Christianity into Spain; there mere numerous church councils held there. notably in 396. 400 and 589. and it also was the chief battleground in the long political and religious struggle which ended (589) in the triumph of Spanish Catholicism over Arianism. From the reign of Athanagild (534–547) until the Moorish conquest in 712, Toletum was generally regarded as the capital of Visigothic Spain Tolaitola, as the city was then called, prospered under the Moors. first as a provincial capital in the caliphate of Cordova, governed by an emir (712–103.5). afterward as an independent state (1035–85). Its rulers protected the large Jenish colony, founded extensive silk and woolen industries and made their city an important centre of Arab and Hebrew culture, one of the great names associated with it being that of Rabbi ben Ezra (1119–74). Toledo was captured by Alphonso of León and Castile, aided by the Cid, in 1085, and two years later he made it his capital. It declined after Philip II moved the capital to Madrid (1560). In one of the most famous sieges of the Civil War of 1936–39, nationalists in the Toledo Alcázar held out for 70 days and were relieved on Sept. 27, 1936.

Toledo occupies a rugged promontory of granite, washed on all sides except the north by the Tagus, nhich there flows swiftly through a deep and precipitpus gorge From a distance it has the aspect of a vast fortress. The principal plaza is the arcaded Zocodover, described by Cervantes in the *Novelas ejemplares.*

The Tagus is spanned by tno fortified Moorish bridges, the Puente da Alcántara, on the northeast, which was rebuilt in the 13th and 17th centuries, and the Puente de San Martin, on the northwest, founded in 1212 and rebuilt in 1390. The Mudéjar Puerta del Sol is the finest of several ancient gateways, among nhich the Puerta Visagra (1550, restored 1575) and the Puerta del Cambron (1102, restored 1576) are also interesting The Puerta Visagra Antigua, a Moorish gateway of the 9th century, has been walled up, but its original form is preserved. The Alcázar, a huge square building with a tower at each corner and a fine arcaded patio, stands on the highest ground in Toledo, originally the site of a Roman fort and now a military academy. Its fine façade designed by Juan de Herrera, a gateway by Alonso de Covarrubias and a staircase by Herrera and Francisco de Villalpando have been preserved. The Apuntamiento, or city hall, is a 15th-century building with 17th-century alterations by Domenico Theotocopuli (El Greco).

The cathedral occupies the site of a Visigothic church. St. Ferdinand founded the present cathedral in Aug. 1227 The completion of the main fabric was delayed until 1493, while many of the chapels and other subordinate buildings mere added even later; thus Renaissance and baroque features have been introduced into a design which was originally Gothic of the 13th century. Most of the chapels date from the 15th and 16th centuries and are very magnificent in detail. The superb stained-glass windows. chiefly of Flemish work, belong to the same period and number 750. In the Mozarabic chapel, mass is still performed daily according to the Mozarabic liturgy. (See MOZARAB)

Several other churches. notably Santo Tom6 and San Vicente. contain masterpieces of El Greco. The Franciscan convent and church of San Juan de los Reyes (florid Gothic) were founded in 1476 by Ferdinand and Isabella. El Cristo de la Luz mas originally a mosque, built in 922 and incorporating some pillars from an older Visigothic church. El Cristo de la Vega, formerly known as the Basilica de Santa Leocadia, occupies the site of a Visigothic church built in the 4th century to mark the burial place of the saint. The Mudéjar Santa Maria la Blanca became successively a synagogue (in the 13th and 14th centuries), a church (1405), an asylum for women (1550), barracks (1791–98) and again a church.

Toledo's characteristic industry is the manufacture of swords Toledan blades have been famous for 2,000 years, being mentioned in the Cynegetica of Grattius (Faliscus), during the 1st century B.C. The industry throve under the Moors, especially during the 16th century; it is now practised on a smaller scale.

TOLEDO, a city of northwestern Ohio. U.S.. a port of entry and the seat of Lucas county. is on Maumee bay (the southwestern tip of Lake Erie) at the mouth of the Maumee river, 60 mi. S W. of Detroit, Mich. Toledo is at the head of modern navigation on the Maumee; bridges connect the two parts of the city but most of the land area lies on the west side of the river. The population of the city in 1960 was 318,003, an increase of 4 7% in the decade; that of the standard metropolitan statistical area (Lucas county) was 456,931. an increase of 15.5%. (For comparative population figures see table in OHIO: Population.) Suburban communities in the metropolitan area are Ottawa Hills, Maumee, Oregon, Sylvania. Perrysburg and Rossford.

History. — The Indian title to land in the Toledo area was transferred to the United States in a series of treaties negotiated from 1795 to 1817. From 1803 to 1805 there was an occasionally occupied government supply post for the Indians (Ft. Industry) at the mouth of Swan creek in what is now downtown Toledo. Settlement began about 1807, although a few French families were living in the area among the Indians prior to that time After the War of 1812 a permanent settlement was made on the northwest side of the Maumee river near the mouth of Swan creek, at a point where the river channel was close to shore. As the size of lake ships increased, the river traffic became confined to the Toledo area because of low water a few miles above Swan creek. In 1825 the opening of New York's Erie canal and the beginning of work on the Ohio canal system gave rise to expectations that the harbour would be a commercial centre. Toledo came into formal existence in 1833 with the union of two villages, Port Lawrence (founded in 1817) and Vistula (founded in 1832). It was chartered as a city in 1837. Through canal traffic was opened in 1843 to Indiana and in 1845 to Cincinnati.

Ohio's decision to include the Toledo area in the state's canal system led to the so-called Toledo war of 1835. Residents of Toledo in 1835 organized to transfer the political jurisdiction of the lower Maumee from Michigan territory to Ohio. Michigan, led by Gov. Stevens T, Mason, opposed this and sent troops. Ohio Gov. Robert Lucas called out the militia and the legislature organized most of the disputed area into Lucas county, with Toledo as the county seat and the present Ohio line as the northern boundary. The dispute was settled when the Democratic state administration sent delegates to Washington to persuade Pres. Andrew Jackson to favour Ohio, whose influence as a state was greater than Michigan's as a territory. In 1836 congress compensated Michigan for the loss by awarding it the upper peninsula and admission to statehood. Toledo's subsequent political history has been characterized by a flare for independence: in 1848 it elected a Free-Soil congressman; in 1879 a Greenback mayor; in 1899–1913 Independent Mayors Samuel M. ("Golden Rule") Jones and Brand Whitlock; and in 1950 and 1952 an Independent congressman.

Population Characteristics. — Migrants from New England and New York predominated in Toledo at first. A large German and Irish element settled prior to the American Civil War and had much influence in political. economic and cultural life. So, likewise, did the later coming of Polish, Hungarian, Balkan and near eastern elements. In 1950 the population was 87.4% native-born white, 5.9% foreign-born white and 6.7% Negro.

Government. — Toledo has a council-manager form of government, in effect since 1936. The Toledo-Lucas County Port authority was established in 1955, in anticipation of the opening of the Great Lakes-St. Lawrence seaway in 1959, with power to own, operate, develop. promote, levy taxes on and acquire property and issue revenue bonds. It is engaged in developing grain and general cargo facilities.

Commerce, Industry and Transportation. — Toledo is a major fresh-water port and is one of the largest bituminous coal shipping ports in the world. The harbour has 35 mi. of shore nith a 17-mi. long, 400–500-it. wide, 125-ft. deep straight channel leading to Lake Erie. Foreign commerce receipts consist mostly of grain. wood pulp, paper, pig iron, iron ore, stone, sand and gravel. aluminum ingots and structural steel. Exports are mostly coal, petroleum products, iron ore. scales and automobiles. Domestic receipts are largely iron ore, coal and petroleum products; domestic shipments consist mainly of coal from Ohio, Kentucky and West Virginia.

Glass, automobiles and parts, weighing machines, industrial furnaces. machinery, machine tools and shipbuilding are among the important products of Toledo's diversified manufacturing industries. Transportation facilities, in addition to the port (which has benefited from the St. Lawrence seaway), include good rail connections and service by several airlines. Toledo is on several federal highways as well as the Detroit-Toledo expressway and the Ohio turnpike. two of whose interchanges (the Maumee-Toledo and Stony-Ridge-Toledo) are within the metropolitan area.

Education and Cultural Activities.—In addition to an extensive public school system, Toledo has Roman Catholic. Lutheran and Seventh Day Adventist parochial schools. The University of Toledo is a municipal institution chartered in 1872; Mary Manse college is a Roman Catholic college for women. chartered in 1873. The city has a public library with numerous branches, a well endowed museum of art, an orchestra and a zoological park with an open-air amphitheatre. There are more than 2,000 ac. in the city park system. (R. C. Do.)

TOLEDO, COUNCILS OF. Councils of great importance for the Spanish kingdom gathered in Toledo 18 times from the 5th to the 8th century. At least 11 of these councils were considered national or plenary, the rest being provincial. The acts of each of these councils except the 18th have been preserved. The conciliar procedure is found in the acts of the fourth council. The bishops always constituted a majority of those present at the councils: however, some abbots, priests, deacons and members of the lay nobility also attended. Though ecclesiastical in nature. these councils were of considerable importance in civil and political affairs. Nearly all were convoked by kings. sometimes with the primary purpose of gaining political support.

The third council of Toledo, summoned by King Reccared in 589, is considered the most important. It was the occasion of the conversion of the king and the nobility from the Arian heresy to the Catholic faith. There followed the unification of Visigothic Spain. the establishment of Catholicism as the state religion and a strong union between the Catholic Church and the Visigothic state. The greatest theological significance is found in the 11th council. held in 675. Its Trinitarian symbol (creed) and its Christological doctrine have interested later theologians.

From the 11th to the 16th century at least ten other councils, some national, some provincial: were held in Toledo. Their importance was great for the canonical history of Spain. The last council of Toledo mas that of 1582–83.

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(J. R. GA.)

TOLIMA, an interior department of the republic of Colombia within the drainage basin of the Magdalena river. Area 8,646 sq.mi. Pop. (1951) 712.490. Stock raising predominates on the dry lower Magdalena plains except where water is available for irrigation. On the precipitous Andean slopes, especially in the volcanic Central cordillera, coffee is the principal crop. The coffee area, which supports the largest part of the rural population, was settled by Antioqueño colonists in the 1850s. Ibagué (*q.v.*), the departmental capital, is strategically located at the foot of the Quindio pass (elevation 10,800 ft.) between the Magdalena and Cauca valleys. (J s J. P.)

TOLL, JOHAN KRISTOFFER, COUNT (1743–1817), Swedish statesman and soldier. was born at Mölleröd in Scania. He served in the Seven Years' War. In the coup *d'état* of 1772 he ranged himself on the side of Sprengtporten and mas told to capture the southern fortress of Kristianstad. By sheer bluff he won over the whole garrison. Gustavus III's *coup* d'ktat at Stockholm completed the revolution. Toll was liberally rewarded. In 1783 he was placed at the head of the secret "commission of national defense," which ruled Sweden during the king's absence abroad. In 1786 he had risen to the rank of major general and was Gustavus' principal adjutant.

After the death of Gustavus III, Toll was for a short time war minister and commander in chief in Scania. and mas sent later as ambassador to Warsaw. Unjustly involved in the "Armfelt conspiracy," he was condemned to two years' imprisonment but was reinstated in 1796 when Gustavus IV attained his majority. At the riksdag of Norrköping, 1800, he was elected marshal of the diet and was an able leader of the royalist party. He carried on the negotiations with the powers concerning Sweden's participation in the war against Napoleon. In the Pomeranian campaign of 1807 he helped to defend Stralsund, and on its surrender to Marshal Brune on Aug. 20, he persuaded the latter (Sept. 7) to make a convention by which the Swedish army was allowed to return unmolested to Sweden. and was rewarded by his marshal's baton. In 1814 Bernadotte created Toll a count. (R. N. B.)

TOLLER, ERNST (1893–1939), German dramatist, one of the exponents of the left-wing revolutionary movement after World War I, was born at Szamocin on Dec. 1, 1893. In 1914 he volunteered. but the war turned him into a pacifist. He became a radical socialist, joining the Independent Socialist party, and was imprisoned for five years for his part in the Munich rising of 1919. In prison he won fame with revolutionary plays in the expressionist style, with rousing mass scenes (Die *Wandlung*, 1919; *Masse* Mensch, 1921; Die *Maschinenstürmer*, 1929; etc.), and with two books of lyrics, *Gedichte* der *Gefangenen* (1921) and *Das Schwalbenbuch* (1923; The Swallow-Book, 1924). Toller left the Independent Socialist party in 1923 though he kept the idealism and pity that drew him into the movement. His later plays (Hoppla! wir leben, 1927; *Feuer aus* den *Kesseln*, 1930; etc.) were more realistic than the earlier work. In 1933 he emigrated to New York where he committed suicide on May 22, 1939.

Most of his plays have been translated into English. For a selection see *Seven Plays* (1935). He also wrote an autobiography, *Ein Jugend* in *Deutschland* (1933; *I Was* a German, 1934).

See P. Singer, *Ernst Toller* (1924); W. A. Willibrand, *Ernst Toller and His Ideology* (1945).

TOLMAN, EDWARD CHACE (1886–1959), U.S. psychologist identified with a form of behaviouristic psychology known as purposive behaviourism, or molar behaviourism, was born in West Newton, Mass., April 14, 1886. He studied at the Massachusetts Institute of Technology, Cambridge, and received the Ph.D. degree from Harvard in 191j, afterward teaching at Northwestern university, Evanston, Ill., until 1918 and then at the University of California, Berkeley, until his retirement in 1954.

Tolman believed that the "molecular" behaviourism of John B. Watson (*q.v.*) was too limited because it selected the conditioned reflex as the unit of habit. For him the unit of behaviour is "molar," a total goal-directed act, using varied muscular movements, organized about the purposes served and guided by cognitive (*i.e.*, perceptionlike or ideational) processes. His system remained a behaviourism (*q.v.*) by retaining an anchorage throughout on objective observations. It has acknowledged relationships with the philosophical positions of C. D. Broad and Ralph Barton Perry, and with the psychological systems of William McDougall, Wolfgang Köhler, Kurt Lewin and Egon Brunswik. Tolman's major work is *Purposive Behaviour in Animals and Men* (1932). He died Nov. 19, 1959, in Berkeley, Calif.

See *Collected Papers in Psychology* (1951), with bibliography of writings. A later biography and bibliography appear in the *American Psychologist*, 13:155–158 (1958). (*E*. R. H.)

TOLMAN, RICHARD CHACE (1881–1948), U.S. physical chemist and physicist, was one of the principal scientific figures in the first half of the 20th century. His scientific interests were broad and varied, but they centred on chemical kinetics, statistical mechanics, relativity and relativistic cosmology. Born March 4, 1881, in West Newton, Mass., he received his Ph.D. from the Massachusetts Institute of Technology, Cambridge, in 1910. He taught at the universities of Michigan, Cincinnati and California. From 1922 until his death he served as professor at the California Institute of Technology, Pasadena, and for many years was also dean of graduate studies there.

With T. D. Stewart, he was the first to measure the mass of the electric carrier in common conductors. The great part of his work was theoretical; he published two authoritative treatises on statistical mechanics in 1927 and 1938, and two on the theory of relativity in 1927 and 1934.

During World War I he was chief of the dispersoid section of the chemical warfare service. During World War II he was vice-chairman of the National Defense Research committee, chairman of its armour and ordnance division, and scientific adviser to Gen. L. R. Groves. head of the Manhattan project which developed the atomic bomb. For these services he was awarded the medal for merit and the Order of the British Empire. After the war he was principal scientific adviser to Bernard M. Baruch, United States representativeon the United Nations Atomic Energy commission, concerned with the prbblems of the international control of atomic energy.

Tolman died Sept. 5, 1948, in Pasadena, Calif. (J. R. O.)

TOLSTOY, ALEKSEY KONSTANTINOVICH, COUNT (1817–1875), Russian novelist, dramatist and poet, was a distant relation of Leo Tolstoy. Born at St. Petersburg on Sept, j. 1817, and brought up on his uncle's estate at Tchernigoff. which he inherited in 1836, he was a playmate of the emperor Alexander II. He studied at the university of Moscow, and was afterward attached to the Russian legation at Frankfurt and served in the Crimean War. He held various court appointments, and spent much time in western Europe. He died at his Tchernigoff estate, Krasni Rog, on Oct. 10, 1875. With his two cousins Zhemchuzhnikov, Tolstoy wrote between 1853 and 1863 much satirical nonsense-verse under the joint pseudonym of a fictitious civil servant, Kosma Prutkov. He also wrote some magnificent lyric poetry; one of his most famous pieces. a paraphrase of the lament for the dead in the Russian church service, is translated by Maurice Baring in the *Oxjord Book of Russian Verse.* Outside Russia, however, Aleksey Tolstoy is best known by his historical romance, *Prince Serebruny* (1863; Eng. trans. by C. A. Manning, 1927), and his dramatic trilogy: *Death of Ivan the Terrible* (1866; Eng. trans. by A. Hayes. 1926). *Tsar Feodor Ioannovich* (1868; verse trans. A. Hayes. 1924) and *Tsar Boris* (1870). Some of his poems were translated in C. T. Wilson's *Russian Lyrics* in *English Verse* (1887); Anglo-Russian Literary Society, Nos. 21, 23, 25; and J. Pollen's Rhymes *From the Russian* (1891).

TOLSTOY, LEO (LYEV) NIKOLAYEVICH, COUNT (1828–1910), Russian novelist and moral philosopher. was born on Aug. 28 (Sept. 9), 1828, at his parents' country place of Yasnaya Polyana, in the province of Tula. The Tolstoys are a family of Russian gentry dating back to the 16th century (*not* of German origin as is often affirmed. and as Tolstoy himself believed). Petr Andreyevich Tolstoy (*q.v.*) was created a count by Peter the Great. His descendant, Count Nicholas Ilyich, the novelist's father, married Princess Marie Volkonsky, who brought him a substantial fortune. They had five sons of whom Leo was the youngest but one. The surroundings in which he grew up were those of a family of the upper middle gentry of the last of the period of serfdom. This environment produced in him the "peer-and-peasant" view of life.

Early Years.—Tolstoy's mother and father died in 1831 and 1837, and he was brought up by elderly female relatives. His education was in the hands of French tutors, a state of things that was already an anachronism. So his intellectual and cultural groundwork was mainly 18th century French, and his contact with contemporary Russian culture was late and unsympathetic. In 1844 Tolstoy matriculated as a student of Kazan university, which was then probably the greatest seat of learning east of Berlin. But he worked little, and early developed an attitude of contempt for academic learning. He spent most of his time in society, Kazan being a social centre for the Russian gentry second only to St. Petersburg and Moscow. In his old age he remembered with gratitude these years of unreflecting happiness. But his questioning mind was already asserting itself, and it is to his Kazan years that he assigns the "tremendous" influence on him of the works of Rousseau. In 1847 he gave up the university and settled at Yasnaya Polyana with the intention of farming and looking after his serfs. But he found himself unprepared for the work he had undertaken, and the attempt ended in failure.

The next years were mainly passed in Moscow, where he gave himself over to the dissipated and irregular life so frequently led by the young men of his class and time. But the work of self-study and self-criticism, of which his diary, started in 1847, is such a remarkable record, went on, and the idle life could not satisfy him. In 1851 he turned a new page: he went to the Caucasus and there enlisted as a *junker* (gentleman volunteer) in an artillery unit. His time was spent in quiet garrison life in Cossack villages, diversified by hunting and occasional expeditions against the mountaineers. In 1852 he completed his first story, *Childhood*, and sent it to Nekrasov, the editor of the leading literary review, who accepted it enthusiastically and had it published at once. In 1854 Tolstoy received his commission, and was transferred (on his application) to the army that was operating against the Turks on the Danube, and a few months later to Sevastopol, where he remained till the end of the siege. After the fall of the fortress he was sent with dispatches to St. Petersburg, where he remained, frequenting society and literary circles, and much preferring the former to the latter. With the *littérateurs* he failed to get on. Their plebeian arrogance shocked him, and he had no respect for their ideal of European progress. His resounding quarrel with Turgeniev may be taken as typical of these relations. In 1857 he retired from the army.

In the same year (and again in 1860) he travelled abroad, and (like Dostoyevsky a few years later) brought back nothing but disgust with the materialistic and plutocratic civilization of the west. After his second journey abroad he settled at Yasnaya Polyana, and accepted an appointment to a magistracy introduced by the Emancipation act of 1861 for the settling of land disputes between the squires and their former serfs. He also started a school for peasant children on new and original lines, based on his belief in the superior value of their natural lights to the artificial standards of civilization, and published a journal (*Yasnaya Polyana*) devoted to the advancement of his pedagogical ideas. But before long he gave up both magistracy and school. He was on the brink of an inner crisis.

The crisis, however, did not mature till 15 years later: it was postponed by his marriage. He had been contemplating marrying for some time. His romance with Valeria Arseniev had ended in nothing. He was obsessed by grave misgivings and doubts before he proposed to Sophie Behrs, a young girl 16 years his junior, with whom he fell in love in 1861. He overcame them, however, and they were married in the following year.

Literary **Works (1852–76).** Tolstoy's literary work grew out of his diary. It was primarily an attempt to lay bare the *mechanism* of the inner life, and to give clear and verbal definition to the semi-articulate processes of the consciousness. His first literary attempt, *The Story of Yesterday* (1851, first published 1926) sets out to give an exhaustive account of his feelings and reactions during a given space of twenty-four hours. His first completed and published work, *Childhood* (1852), less exuberantly analytical and more conventional in form, reveals a greater command over the more intimate and elusive movements of the consciousness than had ever before been displayed in literature. In the stories that followed he further perfected his instruments of analysis, often to the detriment of the imaginative unity of the work. At the same time a conflict which was to remain dominant throughout his life comes to the forefront—the conflict between spontaneous, unreflecting, natural Life and the claims of reason and moral law. In *The Cossacks* (written 1854, published in what the author regarded as an unsatisfactory form in 1862) the victory rests with life: natural man, unconscious of good and evil, and consequently beyond the reach of ethical reason is glorified in the Cossacks who put to shame the reflecting and impotent hero, Olenin. The futility, meanness and vulgarity of civilized man is exposed again and again in *Two Hussars* (1856), *Lucerne* (1857), *Three Deaths*

(1859) and in *Kholstomer* (1861), a very characteristic satire on the life of the upper classes, in which the rôle of the intelligent savage of 18th-century literature is played by a racehorse. All his early work is subjective, and the reflecting and introspective character, whether his name is Olenin or Nekhlyudov (as in *Boyhood,* 1854, and *Youth,* 1857) is always Tolstoy himself. The other men whose feelings are analyzed, are merely types of "man in general"—psychological mechanisms of cause and effect, devoid of personality. Such for instance are the officers of the *Sevastopol* stories (1855) in whom Tolstoy dissects the components of fear and courage.

After his marriage Tolstoy lived at Yasnaya Polyana, passing some part of the year at Moscow and on his estate beyond the Volga. His married life was happy and prosperous. His income was increased by successful farming and the sale of his books. His wife was entirely devoted to him and to her children of which she bore him nine. His inner conflict was lulled for many years by the triumph of spontaneous life over questioning reason. His philosophy in those years was "that one should live so as to have the best for oneself and one's family;' and not try to be wiser than Life and Nature.

This philosophy found its full expression in the first of his few great novels, *War and Peace.* It was commenced in 1864 and completed in 1869. After that he turned again for a time to pedagogical writings, and made several attempts at other historical novels, including one on Peter the Great, that remained unfinished, because of the invincible repulsion aroused in him by the proposed hero. In 1873 he began *Anna Karenina*, which appeared in instalments from 1875 to 1877. Towards the end of his work on this second of his great novels he entered on the prolonged and fateful crisis that resulted in his conversion. Indications of its approach are clearly visible in the latter part of the novel.

War and Peace and *Anna Kareninu* are Tolstoy's masterpieces. They mark, in a certain sense, the highest point reached in its development by the modern realistic novel. Literary realism attains in them its goal: an adequacy of the verbal pattern to the living reality which ultimately produces the feeling, familiar to readers of Tolstoy, that his characters are to be classified with people in flesh and blood, not with other characters in fiction. This supreme achievement was largely prepared for by his previous apprenticeship, but *War and Peace* marks an enormous advance over all that had preceded it. The countless characters that fill the stage are seen not from outside only, but from the inside. The women in this respect are particularly remarkable, and among them most of all Natasha who is the centre of the novel, the embodiment of its philosophy, the quintessence of spontaneous, nature-wise mankind. Nor does the author introduce himself so crudely as he docs in his earlier work, but is transformed into the two distinct and objective characters of Prince André and of Pierre. With its world of characters, and against its vast background of Russian and European history the novel is a real piece of life, transformed by art. The novel is markedly optimistic, and has not without propriety been described as an idyll of the Russian landed gentry Not that the horrors of life are entirely absent but they are overcome by the beneficent influence of a benevolent Life-god presiding over the action. The idyllic atmosphere is preserved in the greater part of *Anna Knrenina,* which as a whole marks no advance on *War and Peace,* though each of the individual characters (and again especially the women) come up to the same level, and even, perhaps, present a greater variety of persons entirely different from the author and seen from inside.

His Conversion.—About 1876 Tolstoy began to feel uneasy about the unreflecting and prosperous life he was leading; the thought of approaching death grew into an invincible obsession; and the passionate craving for a religious justification of his life became the dominating force in him. At first he turned to the orthodox faith of the people, hoping that a religion that made sa many millions happy in the midst of their misery would save him, but the proud rationalism of his mind could not accept its rites and fasts, he renounced the Church, and out of his own reading of the Gospels gradually evolved a 'new Christianity, from which all the metaphysical and non-ethical elements were eliminated. The decisive stage in this conversion, he tells us, was the moment when he realized that the whole message of Christ was contained in the words (Matt 5, 39) "that ye resist not evil." This doctrine of non-resistance became the foundation of the creed which soon became known as Tolstoyism (tolstovstvo.)

It is necessary to distinguish two stages in this conversion: the initial pang of despair, and disgust with unjust and fleshly life, and the subsequent efforts to reduce this essentially mystical and incommunicable experience to a logical and consecutive doctrine. Tolstoy gave a complete account of his conversion in *A Confession* (written 1879, revised 1882, published 1884). It is a work of great imaginative sincerity and tremendous rhetorical power worthy to rank by the side of the *Confessions* of St. Augustine. But the initial and more essential stage of despair is recorded with even greater power in a fragment, posthumously published, The *Memoirs of a Madman* (1884). The same experience is at the base of the two greatest imaginative works of his old age—The *Death of Ivan Ilyich* (1884) and *Master and Man* (1895).

At first Tolstoy took no steps to propagate his new faith. It was not till after the revelation of social misery he had in a visit to the Moscow slums that his religion assumed a definitely social coloring, and not till his intimacy with V. G. Chertkov that "Tolstoyism" became an organized sect, and began to acquire proselytes. This happened in 1884.

Tolstoy's **Teaching.**—Tolstoy's religion expounded in *What I believe in,* and in *A Short Exposition of the Gospels,* is based on the natural light immanent in the human conscience which reveals to us the God that is the supreme Good and Reason. God is not personal, and there is no personal immortality. Jesus was a great man, whose teaching is true not because he was the Son of God, but because it coincides with the light of the human conscience. The Buddha and other men were as great, and Jesus holds no monopoly of the truth. Tolstoy advanced no metaphysics and no image of the world order. His religion is purely anthropocentric. God and the Kingdom of God are "inside us." The aim of man is to achieve happiness, which can be done only by doing right, by loving all men, and by freeing oneself from the appetites of greed, lust and anger. All forms of violence are equally wicked. Not only war but all forms of compulsion inherent in the State are criminal. The true Christian must abstain from participating in them; he must refuse conscription; he must not accept any work under the State; he must not sit on a jury. Opposing the State with violence is also wicked and cannot lead to any better forms of life. Revolutionary activity, though it may be based on the good feeling of love for the oppressed, is evil because it breeds hatred and violence. The social order can become better only when all men have learned to love each other. Still there is a great difference in Tolstoy's attitude to the State and to the Revolutionaries; he disapproves of the latter, but all the force and bitterness of his invective is kept for the former. Property, as the gratification of greed and lust and the assertion of a single man's monopoly over things that belong to all, is wicked. It is the chief source of violence and so on. The rich have built up a corrupt and artificial civilization, and created for themselves fictitious values, which must be got rid of. The poor, however demoralized by servitude, have preserved their good nature in greater purity because they have not been corrupted by the artificial culture of the rich. Love and compassion must be extended to all living things, and abstention from the flesh of slaughtered animals is a characteristic tenet of Tolstoyism. So are abstinence from intoxicants and drugs (particularly tobacco), the artificial demand for which was created by a corrupt civilization, and which dim the natural conscience of man.

Tolstoy can hardly be called a social reformer for he advanced no practical proposal for the improvement of social conditions. He did not believe in the possibility of reform in the accepted sense of the word. The first duty of the true Christian being is to abstain from living by the work of others, and from taking part in the organized violence of the State. The only practical measure he advocated was the solution of the land question by means of the land tax of Henry George. His disapproval extended to the organized violence of Western capitalistic democracy as well as of Russian autocracy.

On the whole, the direct influence of Tolstoy's teaching in Russia was not great. His disciples were never numerous (and seldom of a very high quality). He established relations with many dissenting Russian sects, but most of these (*e.g.,* the *Dukhobors, q.v.*) were essentially alien to him in spirit. His larger influence, however, was immense, and very soon crossed the frontier. In the last 15 or 20 years of his life he was probably the most venerated man in the world. His fame reached into China and India as well as Europe and America. Visitors from all ends of the world made Yasnaya Polyana a new Mecca.

From the first, the Russian Government viewed Tolstoy's new activity with hostility. But it never attempted to do anything against him. Some of his more anti-Orthodox writings, as well as some of his bitterest attacks on the Romanoff dynasty had to appear abroad. But what appeared in Russia was quite sufficient for a complete acquaintance with his teaching. In 1901 the Synod of the Russian Church excommunicated him,—an act which has been much misinterpreted and which merely registered a fact he had himself proclaimed many years earlier, viz., that he had ceased to belong to the Church. On the other hand many of Tolstoy's followers suffered imprisonment and banishment to Siberia chiefly for refusal of military service.

Tolstoy's conversion changed his attitude to his literary creation. He did not abandon it, nor did it deteriorate in quality, but it became different, so did his views of its social and moral function. They are contained in *What is Art* (1896), one of the most remarkable books ever written on the subject. Art, according to Tolstoy, is a means of emotional communion, a means by which the artist "infects" other people with feelings he has himself experienced. If this "infection" does not take place there is no art. If it is limited to a small number of persons of the same class, time or nationality as the author, it is negligible and inferior art; if the appeal extends to mankind in general, but the feelings thus communicated are evil feelings it is genuine but evil art; if the feelings are good, it is good art and if they are the highest feelings possible, the religious feelings of love and compassion, it is the highest form of all, religious art. The application of these standards led Tolstoy to reject or to minimize by far the greater part of modern art and literature, including his own early work, which had exalted the life of the rich and idle. This change of attitude went hand in hand with a change in his literary taste. He rejected the "superfluous detail" of realism not only because it limited the appeal of literature to those familiar with the society described, but because it ceased to satisfy him aesthetically. Already in 1873 he had written some stories for the people, in which everything that was not essential for the narrative development had been rigorously eliminated. From 1884 onwards he wrote a number of new stories of the same kind, masterpieces of chaste and classical narrative technique at the service of one unifying and crystallizing idea, the idea of ethical Christianity.

The same method, on a larger scale, is applied in *Father Sergius,* in *The False Coupon,* and in *Hadji-Murād* (1896–1904) which was the favourite work of his old age and which he intended as an example of good art appealing to the sense of human brotherhood, though not to the highest religious feelings.

Apart from these works stands *Resurrection* (published in 1899–1900) in which he returned to his old "superfluous-detail" and which consequently failed to satisfy him. It contains beautiful passages in the idyllic style of *War and Peace,* and pages of powerful satire on the evil social order, but it falls short of being a masterpiece.

The most important imaginative work of his last period are the stories based on his inner experience—those connected with his conversion (*The Death of Ivan Ilyich, Master and Man, The Memoirs of a Madman),* and those in which he embodied his experience of sex, the *Kreutzer Sonata* (1889) and *The Devil* (1889, pub. 1911). The former group in particular stands in importance by the side of *War and Peace.* The atmosphere pervading them is totally different: they are as grimly tragical as the earlier novel is idyllic. They are on a level with the greatest religious writings of the world.

Tolstoy's plays (with the exception of a comedy written in 1863 and published in 1926) all belong to the period after his conversion. They include *The Power of Darkness* (1889), a powerful drama of peasant life; *The Fruits of Enlightenment* (1st ed., 1891; 2nd ed., 1911), a light comedy satirizing the fads of "society," and *The Living Corpse* (pub. 1911), one of his last writings in which there is a mellowness of old age, and in which the character creator of *War and Peace* makes his last appearance.

Last Years.—Tolstoy's conversion led to his adopting a new mode of life—he dressed like a peasant, did much manual work, learned bootmaking and adopted a vegetarian diet. His wife and children (except his youngest daughter, Alexandra) remained hostile to his teaching and the Countess Tolstoy would not hear of his renouncing his worldly belongings which, she maintained, be held in trust for his children. So he made over all his property (including the copyright of his works written before 1880) to her. The paradoxical situation arose of the preacher of poverty and abstention continuing to live in affluence surrounded by a family who disapproved of his views, but adored him. The first tension between him and his wife was followed by a rapprochement, cemented by the birth in 1886 of a sixth son. But the death of the little boy at the age of seven was followed by an increasing estrangement between husband and wife. She grew increasingly hysterical, embittered and tactless, and life at Yasnaya became a hell, a constant state of war between the family and followers of Tolstoy, between Countess Tolstoy and Chertkov. Tolstoy suffered deeply from the incongruity of his position at home. At last on Oct. 28, 1910, he left home secretly at night with his daughter Alexandra.

He had no particular aim in view. His health broke down at Astapovo (gov. of Ryazan). He was laid up there in the station-master's room, and he died on Nov. 8 (21), 1910.

Tolstoy was interred at Yasnaya, without a Christian burial.

(D. S. M.)

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TOLSTOY, PETR ANDREYEVICH, Count (1645–1729). Russian statesman, was the son of Andrei Vasilevich Tolstoy, an okolnichy or courtier attached to the person of the tsar. He served in 1682 as chamberlain at the court of Theodore III. Miscalculating the strength of the tsarevna Sophia, he became one of her most energetic supporters, but contrived to join the other, and winning, side just before the final catastrophe. For a long time Peter kept his latest recruit at arm's length, but nhen, in 1697, Tolstoy volunteered to go to Venice to learn Italian and shipbuilding, Peter could not resist the subtle flattery implied in such a proposal from a middle-aged Muscovite noble. In Nov. 1701 Tolstoy was appointed the first regularly accredited Russian ambassador to the Porte, and more than justified the confidence of the most exacting of masters. though his peculiar expedients (such as the procuring of the strangulation of a grand vizier and the removal by poison of an inconvenient private secretary) savoured more of the Italian than of the Russian Renaissance.

Even before Poltava, Tolstoy had the greatest difficulty in preventing the Turks from aiding the Swedes, and when Charles XII took refuge on Turkish soil he instantly demanded his extradition. This was a diplomatic blunder, as it only irritated the already alarmed Turks; and on Oct. 10 1710, Tolstoy was thrown into the Seven Towers, a proceeding tantamount to a declaration of war against Russia. On his release from "this Turkish hell," in 1714, he returned to Russia, was created a senator, and closely associated himself with the omnipotent favourite. Menshikov. In 1717 his position during Peter's reign was secured once for all by his successful mission to Naples to bring back the unfortunate tsarevitch Alexius. uhom he may be said to have literally hunted to death. For this he earned the undying hatred of the majority of the Russian people. but Peter naturally regarded it as an inestimable service and loaded Tolstoy with honours and riches, appointing him, moreover, the head of the secret chancellery, or official torture chamber.

Tolstoy materially assisted Menshikov to raise the empress consort to the throne on the decease of Peter (1725), and the new sovereign made him a count and one of the six members of the nenly instituted supreme privy council. Tolstoy was well aware that the elevation of the grand duke Peter, son of the tsarevitch Alexius, would put an end to his onn career and endanger his whole family. Thus, when Menshikov, during the last days of Catherine I declared in favour of Peter II, Tolstoy endeavoured to form a party of his own whose object it was to promote the accession of Catherine's second daughter. the tsarevna Elizabeth. But Menshikov was too strong and too quick for his ancient colleague. On the very day of the empress' death (May 11, 1727), Tolstoy, now in his 82nd year, mas banished to the Solovetsk monastery in the White sea. where he died two years later. He nas the author of a sketch of the impressions made upon him by western Europe during his tour in the years 1697–98 and also of a detailed description of the Black sea.

See R N. Bain, *Pupils of Peter the Great* (1897), *The First Romanovs* (1905). (R. N B)

TOLTEC. The Toltecs ("reed people") were a Nahua-speaking tribe of Chichimec stock who dominated the centre of Mexico betneen the 10th and 12th century A.D. The name is derived from their capital. Tollbn, which means "place of rushes or reeds." situated near the modern town of Tula, 80 km from Mexico City. They have been identified by some investigators with the Teotihuacanos and Teotihuacán itself nas considered to be the city of Tollán. Others have refused to acknowledge their actual existence, maintaining that they were an Aztec invention for the purpose of claiming a distinguished heritage. Both of these conceptions are erroneous.

The first Toltecs, arriving under the leadership of Mixcoatl, "Cloud Serpent," were responsible for the collapse and end of Teotihuacán. Mixcoatl left a posthumous son. Ce Acatl Topiltzin, who built Tollán and founded the Toltec empire, a federation of several small kingdoms of diverse ethnic and linguistic origins. Topiltzin is without doubt the most famous hero-god in Meso-American history. He is better known as Quetzalcbatl, "Feathered Serpent," the name of the god which he introduced and whose high priest he was. He is credited with being a remarkable leader and educator. and was responsible for some of the most impressive temples in Middle America. In A.D. 999 he mas compelled to leave Tollán during a religious upheaval and emigrated with some of his followers to Yucatán. There he was known as Kukulcán, which means "feathered serpent" in Maya, and exercised an important influence over the cities of Chichén Itzá and Mayapán.

The Toltecs have been credited with the invention of agriculture and the calendar system which, of course, is erroneous because these cultural traits are much earlier. But they did introduce several important innovations such as monumental porticoes, serpent columns, gigantic atlantean statues, human and animal standard bearers and the peculiar reclining Chac-Mool figures. Because of their high reputation as builders and craftsmen the term Toltec became synonymous with "artificer."

The Toltec empire came to an end in A.D. 1168, during the reign of Huemac, and Tollán was destroyed by waves of barbarous invaders known as Aztecs (*q.v.*) or Mexicas. (J. R. Ac.)

TOLUCA (Toluca de Lerdo), capital of the state of México and municipality seat; is located 45 mi. W.S.W. of Mexico City by highway on the road to Morelia and Guadalajara. Founded in 1530, renamed Toluca de Lerdo in 1861 in honour of Sebastián Lerdo de Tejada. Mexican statesman. the city (pop. [1960] 71.026) is a commercial and communications centre in the valley of Toluca. The basin. highest of the great valleys in the plateau region of central Mexico. has an elevation of about 8.500 it.: it is ringed by impressive mountains. among them the snow-capped Nevado de Toluca or Xinantecatl (15,433 ft.). Agriculture and livestock raising are of major significance. Industries include textile manufactures. brewing and distilling and food processing; commercialized household crafts include weaving and the making of baskets and pottery. The Friday market is one of Mexico's largest and most interesting. An airfield and railway facilities serve Toluca. Its oldest church was founded soon after the conquest and rebuilt in 1585; governmental buildings are post-1870. (J. T.)

TOLUENE, or Methylbenzene. is an aromatic hydrocarbon (see Chemistry: Organic *Chemistry: Reaction* to Organic *Compounds*). It is a water-white liquid which has a boiling point of 110.56" C. at 760 mm. mercury pressure, a specific gravity of 0.3665 at 20° C. compared with water at 4° C., and an index of refraction of 1.4962 at 20° C. for the D-line of sodium. It is insoluble in water hut is soluble in all common organic solvents. Two commercial grades are produced: a nitration grade: the purer grade. and an industrial grade.

Toluene is one of the important constituents of coal-tar light oil (see Coal Tar). comprising 12%–20% by volume of the light oil; it is also present in petroleum. the toluene content usually being less than 0.5%. Prior to 1917 toluene was produced almost exclusively from coal-tar light oils. During World War I toluene mas in such great demand for the manufacture of the high explosive trinitrotoluene. TNT (*q.v.*), that the production from cod-tar light oil was supplemented to a small extent by toluene isolated from petroleum. Between World Wars I and II the processes for recovering toluene from petroleum were so improved that the petroleum industry became a major source of toluene. In the United States during World War II about 30 000.000 gal. of toluene were produced from coal-tar light oils and about 60.000.000 gal. were obtained from petroleum sources.

Toluene is an important chemical raw material. It is used in the manufacture of henzoic acid (*q.v.*), saccharin (*q.v.*), dyes (see Dyes) photographic chemicals. pharmaceuticals, etc. Its principal peacetime use is as a solvent. Because TNT has remained an important ingredient of explosives, and because toluene was an important constituent of high-octane aviation gasoline, toluene was one of the strategic materials of World War II.

Toluene should be used only in well-ventilated rooms since its vapours are poisonous. (F. E. Cl.)

TOMAHAWK, the war hatchet of the North American Indians (Algonkian otomahuk, "to knock down"). The earliest tomahawks were of chipped stone, sharpened to a point at each end, something like a pickaxe, and passed through a hole bored in a stout wooden cudgel. In the more primitive types the stone head was simply tied to the handle by animal sinews, or a withe was doubled over the head and fastened below to form a handgrip. Sometimes deer antlers were used instead of stones. After the arrival of the white man, the heads were usually of iron. Where the stone head was sharpened only at one end, the blunt end was sometimes cut out into a pipe bowl, the handle, hollowed, serving as the stem.

The weapon was at once symbolical of war and peace and was ceremoniously buried at the termination of hostilities, to be as formally exhumed when the feuds revived. Hence the colloquialism "to bury the hatchet."

TOMAR, a city of Portugal on the Nabão river: a tributary of the Zezere. 4 mi. from Paialvo railway station, which is 80 mi. N.E. of Lisbon by the main line to Oporto. Population (1950) 8,063.

Tomar contains examples of the best Portuguese architecture from the 12th century to the 17th. The ruined castle of the Knights Templar, given to that order in 1159, is said to occupy the site of the ancient Nabantia. On the suppression of the Templars, King Dinis of Portugal founded the Order of Christ in 1311. The convent palace of the Knights of Christ includes a church and cloister dating from the 12th century, two cloisters and a chapter house added in the 15th century by Prince Henry the Navigator and a very fine 16th-century church built in the Manueline style by João de Castilho.

Other interesting buildings include the churches of Santa Maria do Olival, rebuilt in the Gothic style in 1450 on the site of an older Templar foundation; São João Baptista, also Gothic, built in 1490, but with Manueline additions; and Nossa Senhora da Conceição, Renaissance of 1579. The ruined palace of Prince Henry the Navigator was restored in the 16th century by Queen Catherine, the widow of John III. The city was formerly known as Thomar.

TOMASZOW, an industrial town of Poland, in the *wojewodztwo* (province) of Lodz. Pop. (1960) 49,000.

It has woolen mills, ironworks and steam flour mills and is the centre of the silk industry. Germany occupied it during World War II.

TOMATO (*Lycopersicon esculentum*), a plant and its succulent, acid fruit, of the family Solanaceae. All cultivated forms of tomato belong to this species except the tiny currant tomato (L. *pimpinellifolium*). The tomato plant is a frost-tender perennial that is cultivated as an annual. The plants are generally much branched, spreading two to six feet, and recumbent when fruiting, but a few forms are compact and upright. The leaves are more or less hairy, strongly odorous, pinnately compound, up to $1\frac{1}{2}$ ft. long. The flowers are yellow, three-quarters of an inch across, pendant and clustered. Fruits vary in diameter from one half to three inches or more, are scarlet, scarlet-red or yellow; they vary in shape from oblate through globular to oval. elongate: or pear shaped. The fruit is a soft, succulent berry containing two to many cells of small yellow seeds surrounded by jellylike pulp. Silvery hairs thickly covering the seeds become evident when they are dry and free of pulp.

Botanically the tomato is a fruit but in the U.S. it is considered a vegetable for purposes of trade. It was so classified in a decision of the U.S. supreme court in 1893 because of its common use in the main part of a meal, prepared either alone or mixed with other vegetables. Although it is extensively used in America in the form of juice as an appetizer, and in salads, as some fruits are used, it is not used as a dessert. Use in soups and in sauces and catchup for meats contribute to its classification as a vegetable. It is an excellent source of vitamins A and C.

The wild species originated in the Peru-Ecuador-Bolivia area of South America. Cultivated forms were developed before Columbus in Mexico and possibly in Central and South America. Definite records are lacking but evidence indicates that the tomato reached Europe from Mexico. The first definite description, in Italy in 1554, carried the common name *pomi* d'oro, or apple of gold. Thus the first form known to Europeans was yellow. Before the end of the 16th century it was known in the gardens of England. Spain, Italy, France and mid-Europe chiefly as a curiosity.

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TOMATO (LYCOPERSICON **ESCULENTUM**)

By the mid-1700s it was used for food in several European countries. but there is no record of its culture in the U.S. until Thomas Jefferson grew it in 1781 It was used for food in Louisiana as early as 1812 but not in the northeastern states until about 1835. Until nearly 1900 many believed it to be poisonous, possibly because some members of the family Solanaceae are poisonous.

Disease control is a major problem in producing tomatoes. The plant is susceptible to many serious disorders variously caused by fungi, bacteria, viruses. nematodes and unfavourable environment. Breeders have developed many varieties that are resistant to fusarium wilt and a few resistant to verticillium wilt. two soil-borne diseases not controllable in the field by artificial means. By the late 1950s little success had been attained in breeding varieties resistant to fungus diseases of the foliage, to viruses, bacteria and nematodes. Extensive production is not feasible in certain parts of the western U.S. because of curly top, a virus disease that is carried from infected desert plants to tomatoes by the beet leafhopper.

The tomato is a major crop in the U.S. where it is grown commercially in every state (except Alaska) for use fresh, also for canning whole or as juice or making a variety of sauces. In the winter tomatoes are grown in Florida and Texas and shipped all over the country; they are also imported from Mexico and Cuba for use fresh. They are grown under glass but in small quantities compared with field and garden cultivation. Since the plant requires relatively warm weather (and much sunlight) it is grown chiefly in hothouses in Alaska, Great Britain and northern Europe, although a few varieties are cultivated out of doors. Tomatoes are grown extensively in southern Europe', particularly in Italy, where they are used for paste and other canned products.

In most of the United States and in Europe tomato seed is sown under glass or cloth protection about six weeks before the frost-free date, when the plants can be set in the open. The seedlings are grown singly in pots and other containers or so spaced in boxes or beds of soil—from 2×2 to 4×4 in.—that sturdy plants about 8 in. tall may be produced for setting in the field. For winter crops in the south, seed is sown in open beds in the fall. Frequently in gardens, and in large fields in some areas, the tomato plants are pruned to a single stem and each tied to a stake to keep the fruits off the soil. In this system plants are set 2 to $2\frac{1}{2}$ ft. apart in rows 3 to 4 ft. apart. Most of the crop in America is grown by allowing the plants to grow naturally upon the ground, spaced 3 to 5 it. apart in rows 5 to 6 ft. apart. The fruits are highly perishable when ripe and should be harvested every three or four days. For long-distance shipment, the fruits are harvested when fully grown but still green in colour. They will ripen later only if mature. Green-harvested tomatoes never develop the high quality and high vitamin content characteristic of well-grown, vine-ripened fruit.

Most of the tomato fields of the central and northern part of the United States are set with plants grown in large "plant fields" in the southern states and shipped northward by fast motor truck or rail express at planting time. About 5,000 to 6,000 ac. in the state of Georgia are devoted to growing tomato plants for this purpose. Seed is sown in March at four pounds per acre in rows 14 to 16 in. apart, about 1j to 20 seeds per foot of row. All growing operations are done by motorized equipment; but pulling the plants from the soil. counting. wrapping in wet moss and packaging for shipment must be done by hand. About 70,000 to 100.000 plants are usually obtained per acre. In many districts having long growing seasons, tomatoes for midseason or late harvest are planted by sowing seed directly where the plants are to mature. Seed is sown at one-quarter to one-half pound per acre and the plants thinned to the desired spacing.

In the U.S. about 225,000 ac. of tomatoes are grown annually for fresh market and 300.000 to 400,000 ac. for processing. Annual production is about 1,000,000 tons for fresh market and 3,000,000 to 4,000,000 tons for processing. In a year of high production the total of processed tomatoes is as much as 30,000,000 cases of canned tomatoes. 36,000,000 of juice and 48,000,000 cases of catchup. pulp. paste and sauces.

See also HORTICULTURE; VEGETABLE; VIRUSES: Plant Viruses. (V. R. B.)

TOMB in the strict sense implies some idea of a home or house for the dead. although the term is applied loosely to all kinds of graves, funerary monuments and memorials. In many primitive cultures the dead were buried in their own houses. and the tomb form may have developed originally out of this practice, as a reproduction in permanent materials of primeval house types. Thus, prehistoric tomb barrows were usually built around an actual round hut, in which the body was placed. along with tools and other personal effects for use in the next life. With the more advanced technology of early civilizations, brick and stone tombs appeared, often of great size, but still preserving primitive house forms. They were sometimes domical and sometimes rectangular, depending on which form had come into commonest domestic use by the time tombs began to be built. Being thought of as houses. such tombs were often lavishly provided with clothes. utensils and furniture. so that they are major sources of archaeological knowledge about the cultures that built them.

In very early times, royal dead were apparently provided not only with all manner of necessary objects. but also with actual servants. who were put to death at the time of the burial. so that they might continue to serve their master in his tomb house. Typical is the tomb of Queen Shub-Ad of Ur (Early Dynastic period in Mesopotamia, *c.* 3000 B.C.), which contained the bodies of more than 60 of the queen's attendants. It became more common, however, to substitute statues or painted images for human beings; this was the practice in most Egyptian tombs, and from such painted pictures and statuettes, particularly in old and middle kingdom tombs, a vivid idea of every phase of ancient Egyptian life can be gained. Lavish furnishings continued to be placed in tombs throughout ancient Egyptian history. the most famous example being the tomb of Tutenkhamon of the 18th dynasty, discovered intact in the 1920s. (See PYRAMID.)

The use of the tomb as a house for the dead persisted into early classical times (*e.g.*, the Treasury of Atreus at Mycenae; the Etruscan tombs at Volterra and elsewhere). By the jth century B.C., however, the Greeks superseded it with monuments or memorials to the dead; the actual bodies were burned and the ashes put in funerary urns. The Romans, however. revived the use of the tomb; later emperors particularly set the example of building great tumuli of domical shape (*e.g.*, the tombs of Augustus and Hadrianj. as symbols of the divine ruler's heavenly home.

In medieval Christian thought, the tomb was considered an earthly prototype and symbol of a heavenly home. This concept appeared in the Roman catacombs. the walls of which were decorated with scenes'of the resurrected dead in paradise. The church building itself sometimes functioned as a tomb (*e.g.*, the Hagia Sophia in Istanbul was the tomb of Justinian). Throughout the middle ages it was common to inter bodies in churches, monasteries and chapels, with depictions of them on carved or painted plaques. or as life-size *gîsants* (figures lying on their backs) placed above them. The deceased were represented not as corpses. but as souls living in paradise, with their hands pressed together in adoration and the symbols of their salvation beside them.

During the 1jth century, however, it became common to represent such figures as dead (usually on biers); typical examples are the funeral cortège of Philippe Pot in the Louvre. and Donatello's tomb of the antipope John XXIII in the Florence baptistery. This foreshadowed a general revival of the Greek practice of erecting iunerary monuments, rather than tombs proper. during the 16th century. Since the Renaissance. the idea of the tomb as a home has died out, except as a faint reminiscence in the mausoleums sometimes erected above graves or serving as burial vaults in modern cemeteries.

See BARROW; CEMETERY; FUNERARY RITES AND CUSTOMS; SARCOPHAGUS; SCULPTURE, SEPULCHRAL; MONUMENTS AND MEMORIALS: SCULPTURE. See also references under "Tomb" in the Index volume. (As. G.)

TOMBIGBEE, a river formed in northeast Mississippi by the junction of Old Town creek and the East fork which arises in eastern Prentiss county. The river flows south and southeast for nearly 450 mi. to a junction with the Alabama river. to form the Mobile river, about 45 mi. N. of Mobile, hla. The chief tributary of the Tombigbee is the Black Warrior. which flows southwest through Alabama. joining it at Demopolis. Ala. The Tombigbee has a drainage basin of about 19.500 sq.mi.

During the 19th century the Tombigbee was important for navigation to and above Aberdeen, Miss.; only the 185 mi. below Demopolis were important after 1900. In 1915 the last of a series of 17 locks and dams was opened on the lower Tombigbee and Black Warrior, providing a 426-mi. nine-foot channel from Mobile to Port Birmingham, 18 mi. from Birmingham. By the second half of the 20th century, most of the original locks and dams had been, or were being, replaced by the Jackson, Demopolis, Warrior, Oliver and Bankhead locks and dams.

In 1947 congressional approval was given a Tennessee-Tombigbee waterway, though no money was appropriated. In 1958 Alabama and Mississippi signed a compact to promote the building of that waterway, which was planned to link the East fork of the Tombigbee with Yellow creek of the Tennessee by a 45-mi. canal. Tuscaloosa, Ala., is the chief city on the Black Warrior; Aberdeen and Columbus, Miss., and Demopolis are the chief cities on the Tombigbee. (M. W. M.)

TOMBSTONE, a town of Cochise county in southeastern Arizona. U.S., on a mesa between the Huachuca and Dragoon mountains: is about 30 mi. from the Mexican border. Noted for its colourful history, the town was named, as an ironic gesture. by a prospector, Ed Schiefflin, shortly after his discovery of silver deposits near the site in 1877. Schiefflin. who did not profit greatly from the discovery, reported that an acquaintance told him that all he would find in the area would be his tombstone. The strike was rich, some of the assays running as high as $5,000 a ton. By 1881 a silver rush had set in and 7,000 persons were estimated to be living in the region. Innumerable claims were staked out within a radius of eight miles of Tombstone; mining companies such as the Contention Consolidated and the Grand Central were soon making fabulous profits. In 1880 an enterprising businessman, John P. Clum, founded the Tombstone *Epitaph*, a weekly and daily journal. Along with prospectors, miners and businessmen came adventurers and outlaws, among whom were "Doc" Holliday and Johnny Ringo. Feuds were common; the most notable of them culminated in the gun battle at the O.K. corral in 1881 between the Earp and Clanton families. In 1881 Tombstone became the seat of the newly created county of Cochise.

Floodwaters in the mines, labour strikes and low prices for silver spelled the end of the boom days. In 1902 and 1916 there were short periods of renewed hope for the mines. but nhen the seat of Cochise county was removed from Tombstone to Bisbee in 1931. the colourful epic of the town was ended. With a population of about 1.000 in the second half of the 20th century, the tonn was of interest for its preserved and restored historic sites and monuments, such as Boot Hill cemetery, the Bird Cage theatre, the *Epitaph* office and the original city hall. An annual festival is held in the town in October. (R. C. E.)

TOMLINE, SIR GEORGE PRETYMAN (1750–1827). bishop of Winchester, tutor and secretary to William Pitt the younger. was born at Bury St. Edmund's, Oct. 9, 1750, the son of George Pretyman. He took the name Tomline in 1803, in accordance with the terms of a will of which he was the beneficiary. He was graduated from Pembroke hall, Cambridge, in 1772. and was made fellow and tutor of the college the following year. In 1774, when Pitt came to Pembroke, Tomline was appointed his tutor, an incident which marked the beginning of a lifelong friendship between the two men. Tomline remained at Cambridge until 1782, serving as moderator of the university in 1781. He was made rector of Corwen, Merionethshire. in 1782 and in 1783, when Pitt became first lord of the treasury, he asked Tomline to become his secretary. a position the latter held until 1787 Concurrently, Tomline was for a short time rector of Sudbourn-cum-Offord. Suffolk (1785). In 1787, probably through the intercession of Pitt, he was appointed dean of St. Paul's and bishop of Lincoln. and in 1820 he became bishop of Winchester. where he remained until his death. Pitt attempted at one time to have Tomline made archbishop of Canterbury, but without success.

Tomline was much consulted by Pitt and had, perhaps, more influence on him than any other of his friends and advisers. He was with the prime minister only a few hours before his death and was made his literary executor. He was the author of a number of works, the most important of which were *Elements of Christian Theology* (1799) and *A Refutation of Calvinism* (1811), nhich was the subject of considerable ecclesiastical controversy. He also wrote a moderately valuable biography of Pitt (1821). He died Nov. 14, 1827, at Wimborne, Dorsetshire.

TOMMASINI, VINCENZO (1880–1950), Italian composer, was born in Rome on Sept. 17, 1880. He studied at the Liceo in Rome and later became assistant director of the Accademia di S. Cecilia. His first work of importance was the string quartet of 1910; this was followed by the "Erotic Poem" for orchestra and the comic opera *Uguale fortuna* in 1911. The symphonic poem *Chiari di luna* was produced in 1916, and in 1917 he achieved his great triumph with *The Good-Humoured Ladies,* a ballet founded on Carlo Goldoni's comedy. The original performance was in Rome and it was later played in the principal music centres by Sergei Diaghilev's company with great success. Later works were: *Il beato regno* (1922); *Paesaggi Toscani* (1923); *Preludio, fanfara e fuga* (1928); *11 Carnevale di Venezia* (1929): and *Il Diavolo si Diverte* (*The Devil Has a Good Time,* New York city. 1939). He died in Rome on Dec. 24, 1950.

TOMMASEO, NICCOLÒ (1802–1874), Italian statesman and writer. was born in Sebenico. Dalmatia, Oct. 9, 1802. He studied law at Padua and then removed to Florence. where he joined the staff of the *Antologia,* a liberal periodical. One of his articles led to the suppression of the magazine in 1833 and to his own exile to Paris the following year. He returned to Italy in 1839. an amnesty having been granted, and settled in Venice. In Jan. 1848 he and Daniele Manin were arrested and imprisoned for making anti-Austrian speeches but they were set free by revolutionists in the uprising of March 17, 1848. Toinmasseo was made minister of public instruction in Manin's provisional government. When Venice fell to the Austrians in Xug. 1849, Manin's terins of surrender included exile for the leaders of the revolutionary movement in order that all the other revolutionists might be spared. Tommasseo therefore spent the years until 1554 on the island of Corfu, when he went to Turin, returning to Florence in 1861. During the last years of his life he lost his sight but continued with his writing. He died May 1, 1874, in Florence.

Of Tommasseo's numerous norks perhaps the best. and certainly the best known, are his several dictionaries of the Italian language—the *Dizionario dei sinonimi italiani* (1835), the *Dizionario estetico* (1840) and the *Dizionario universale della lingua italiana,* nhich he compiled in collaboration with B. Bellini and some of which was published after his death (1861–79). His *Supplizio d'un Italiano,* the story of his exile on Corfu, is also well thought of, and his *Canti Popolari Corsi, Toscani, Greci, e Illirici* is a valuable study. His other writings include treatises on moral and political philosophy, works of literary criticism, several volumes of poetry, a biography of Pasquale de' Paoli, a history of 16th-century France and a historical novel.

TOMPA, MIHALY (MICHAEL) (1817–1868), Hungarian lyric poet, was born in 1817 at Rima-Szombat, in the county of Gomor, his father being village bootmaker. He studied law and theology in Sáros-Patak and subsequently at Budapest. At the age of 30, after many vicissitudes, he accepted the post of Protestant minister in Beje, a small village in his native county, whence, in two years: he removed to Kelemér, and four years later to Ha-ma, in the county of Borsod, where he remained until his death in 1868. At the age of 24 Tompa published his first poems in the *Athenaeum,* which soon procured for him a high reputation. His first volume, *Népregék és Népmondák (Folk-Legends and Folk-Tales),* in 1846, met with great success, and the same may be said of the first volume of his *Poems* in 1847. In 1848 he took part in the War of Independence, acting as field chaplain to the volunteers of his county and seeing several battles, but the unfortunate close of that struggle silenced him as a poet for a considerable time and when in 1852 and 1853 he gave vent to his patriotic grief in some masterly allegories on the state of oppressed Hungary. he was twice arrested by the Austrian authorities. After being released he published his *Virágregék (Legends of Flowers);* a collection of poems showing great imagination and love of nature. Soon after this he became oppressed with melancholy and abandoned this branch of poetry. He published three volumes of sermons in addition to his poetry. His collected poetical works were first published at Budapest in 1870.

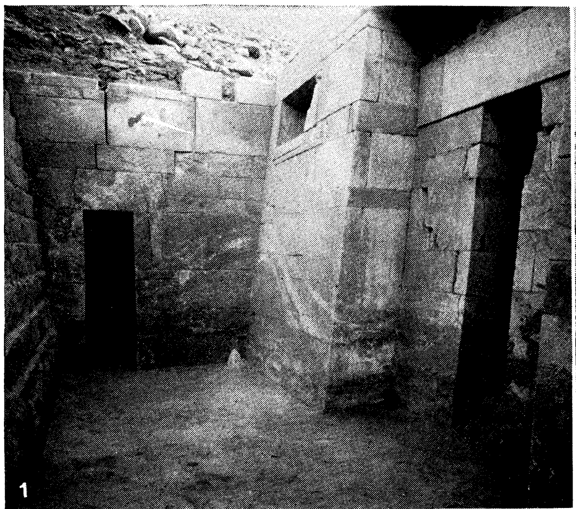
TOMPION, THOMAS (1639?–1713), English clockmaker, known as the "father of English watchmaking," was baptized at Northill, Bedfordshire, on July 25. 1639. It is thought that he first worked as a blacksmith and that in 1664 he was apprenticed to a London clockmaker. In 1671 he was admitted to the Clockmakers' company! of which he became master in 1704. In 1676 he was chosen clockmaker for the newly established royal observatory. He was responsible for a number of improvements in the construction of watches. notably for his collaboration in the invention of the cylinder escapeinent with horizontal wheel, which first made possible the construction of flat watches. He also made. with the aid of its inventor. Robert Hooke, one of the first English watches with a balance spring. Many of his clocks still exist, including several constructed to run for a year without being rewound. There is a barometer which Tompion made for William III at Hampton Court. and other examples at Windsor castle and Buckingham palace. Tompion died in London on Nov. 20, 1713.

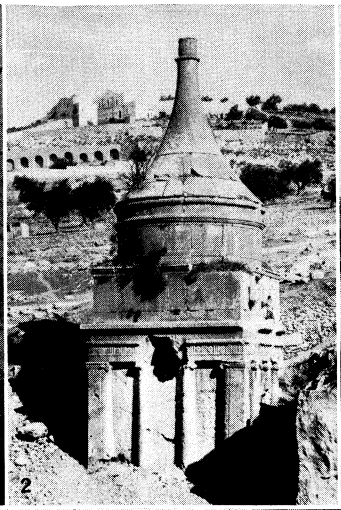
See R. W. Symonds, *Thomas Tompion* (1951).

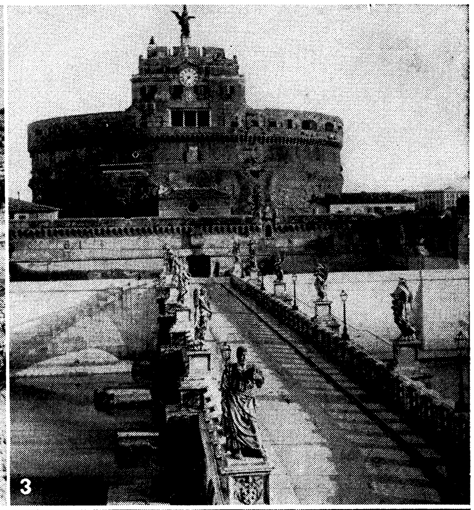
TOMPMINS, DANIEL D. (1774–1825). U.S. politician, was born at Scarsdale, Westchester county, N.T., on June 21, 1774. He graduated at Columbia college in 1795 and was admitted to the bar in 1797.

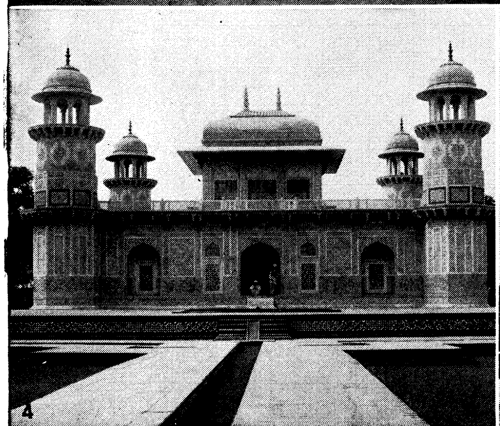
In 1803 he was a member of the state assembly, and in 1804 he was elected to the national house of representatives: but became a judge of the state supreme court and served as such until 1807. He was governor of New York in 1807–17; and in 1817–25, during both terms of Pres. James Monroe, was vice-president of the United States. In March 1812, under the authority of the New Tork constitution of 1777, he prorogued the legislature—the only instance of the exercise of this power.

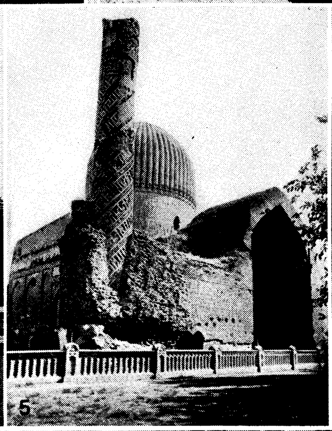
During the War of 1812 he was active in equipping and arming the New York militia. For this purpose he borrowed much money on his personal security, and sometimes neglected to secure

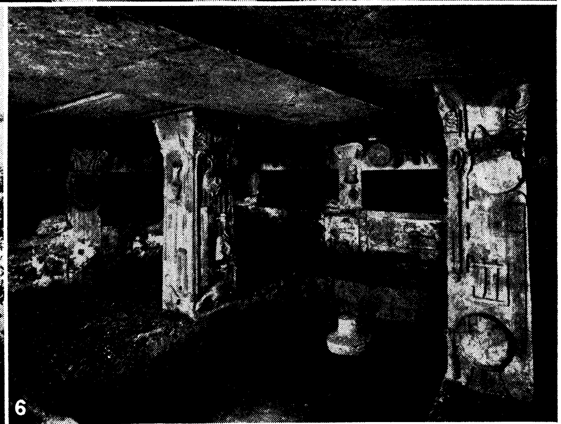


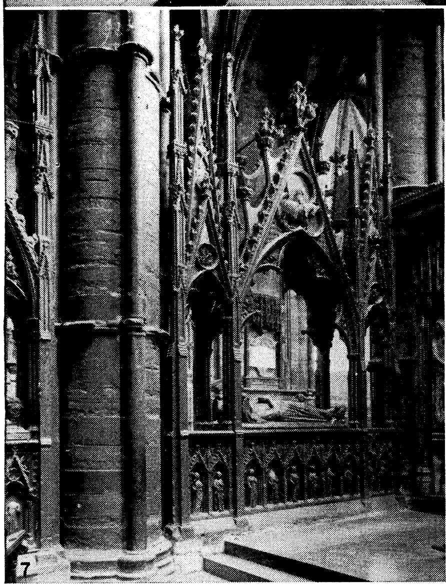


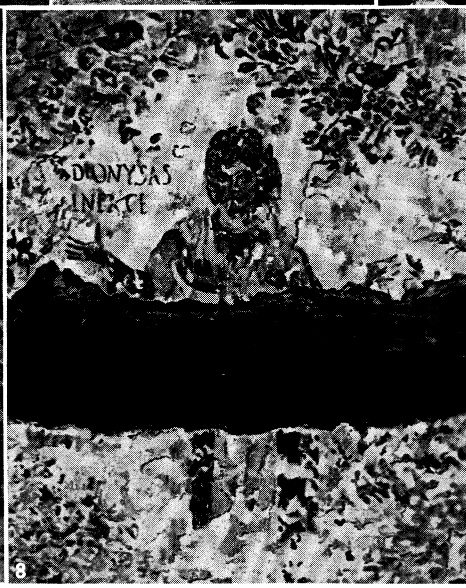


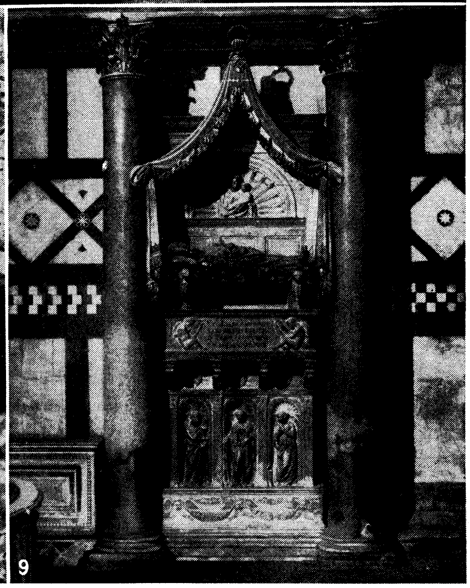












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DECORATIVE TOMBS

1. Exterior of the tomb of **Perneb,** Egyptian 5th dynasty, as **it** appeared at the time of its excavation
2. Tomb of Absalom at Jerusalem, a rock-cut tomb of typically Syrian Graeco-Roman style. Probably 2nd century A.D.
3. Hadrian's tomb, Rome, 2nd century A.D. Originally capped with a great dome, its present appearance results from its transformation into a fortress **(Castel** S. **Angelo)** during the Middle Ages
4. Tomb of **Itimad-ud-daula** at Agra, India. Built in 1628, **it** shows the characteristic Mogul use of pierced and inlaid marble
5. Tomb of the Mongol conaueror Timur **(Tamerlane)** at Samarkand, 1405, typical of the Persian use of polychrome tile and decorative dome form
6. Tomb of the Stuccoes, or Grotta **Bella,** Cerveteri (Caere), 5th to 7th centuries, B.C.
7. Tomb of Edmund Crouchback, earl of Lancaster (d. 1296) **;** Westminster abbey
8. Decoration in the catacomb of Calixtus, Rome, c. A.D. 300
9. Tomb of John **XXIII** (Baldassare **Cossa)** by Donatello and **Michelozzo,** 15th century. In the Baptistry, Florence

proper vouchers. Later the state comptroller announced a shortage of $120,000 in the military accounts, but Tompkins claimed that the state owed him $130,000. Later investigations disclosed that the state actually owed him more than $90,000. He died on Staten Island, N.Y., on June 11, 1825.

The *Military Papers of Daniel D. Tompkins, 1807–1817* (1898–1902) were published by the state.

TOMPKINS, SALLY LOUISA (1833–1916), U.S. hospital head and Confederate army captain, was born at Poplar Grove in Mathews, Va., Nov. 9, 1833. Before the Civil War she used her rather considerable fortune to assist worthy causes. In 1861, after the first battle of Bull Run, Jefferson Davis asked that private homes be converted into hospitals. Miss Tompkins was able to obtain Judge John Robertson's Richmond home for the purpose, and with her own funds equipped and maintained it as a hospital until 1865.

Davis shortly ordered that all nonmilitary hospitals be discontinued, but Miss Tompkins was loath to abandon her project and since Davis was anxious to retain her as head of the hospital, he commissioned her a cavalry captain (Sept. 9, 1861), a rank she retained until her death, although she would not accept pay. During the nearly four years her hospital existed, Miss Tompkins, who became known as "Captain Sally," cared for more than 1,300 patients. The Robertson hospital was maintained until April 2, 1865. Miss Tompkins died in Richmond, July 25, 1916, and was buried with military honours. She was the only woman to hold a commission in the Confederate army.

TOMSK, a town of the Tomsk *oblast* of the Russian Soviet Federated Socialist Republic. U.S.S.R., in latitude 56° 30' N., longitude 85° 12' E., on the right bank of the Tom river and on both sides of its tributary the Ushaika, at an altitude of 485 ft. above sea level. Pop. (1959) 249.000. The river is frozen from Nov. 17 to May 13. A branch line links Tomsk with Taiga on the Trans-Siberian railway.

The town was founded in 1604, but did not become important until 1824, when gold was found in the district and a gold smelting laboratory was later established in the town; the gold industry later declined rapidly. The town is an educational centre, with a university, library and museum.

TOM-TOM or TAN-TAM, a native Indian and Asiatic word, reduplicated and onomatopoeic in form, for a drum, hence often loosely applied to the various types of primitive drum used for purposes of religious excitement. war, signaling and the like by savage tribes throughout the world. The term is applied strictly to the metal gongs of the far east, which are flat disks with a shallow rim.

TONALITE, in petrology, a name originally applied by German mineralogist Gerhard vom Rath (1830–88) to a rock consisting largely of quartz, andesine, biotite and hornblende, with a little interstitial orthoclase. The name is from Mt. Tonale, in the Italian Tirol. In the type area the rock is apparently streaky and inhomogeneous, with clots and patches of intergrown green hornblende and brown biotite. The plagioclase feldspar is conspicuously zoned, the cores being sometimes spongy and irregular in outline, and usually more calcic than the mantles or rims. Pyroxene is sometimes present in the centres of hornblende crystals. Apatite, sphene and magnetite are abundant. As originally described, tonalites are ordinarily far richer in dark silicates and often far poorer in quartz than granite. The type is of worldwide occurrence, excellent examples being known from Norway, the southwest upland and Grampian Highlands of Scotland. the British Columbia and southern California batholiths and numerous other localities.

Originally defined without satisfactory quantitative limits, the name tonalite has been so differently used in different classifications as to obscure any meaning it may originally have possessed. In various rock classifications it appears as a synonym for quartz diorite, granodiorite and plagioclase granite *(see* DIORITE; GRANITE). Despite its popularity among taxonomists it has never attained wide usage in petrography; of 53 rocks listed as tonalites by the author of one well-known classification, for instance, only three are actually called tonalite in the original descriptions.

Probably the term is best reserved for rocks richer in dark silicates and poorer in quartz than granite, and in which orthoclase is low or lacking. This is suitably close to the original definition. Rocks satisfying it rarely form independent masses of batholithic dimensions. They sometimes occur in separate small plutons, but more commonly they are marginal facies of gabbro, or norite, or members of an intrusive cycle of gabbroic parentage. (F. Cs.)

TONAWANDA, a city of Erie county in western New York, U.S., on the south bank of the State Barge canal near its juncture nith the Niagara river about 8 mi. N. of Buffalo. Settlement began about 1809 on both sides of Tonawanda creek, which in 1823 was integrated into the Erie canal. The community was organized in 1836 and in 1855 mas separated from North Tonananda (*q.v.*) on the north bank of the canal and incorporated as a village. It nas chartered as a city in 1903. Manufactures include chemicals, paper and metal products, office furniture and amusement equipment. For comparative population figures *see* table in NEW YORK: *Population.* (R. T. R.)

TONBRIDGE, a market town and urban district in the Tonbridge parliamentary division of Kent, Eng., 14 mi. S.W. of Maidstone by road. Pop. (1951) 19,237. Area 7.2 sq.mi. Tonbridge stands at the navigable head of the Medway. Its castle (now town property) was built by Richard de Clare in the 11th century to guard the bridge over the river there. Tonbridge school was founded in 1553 by Sir Andrew Judd and was rebuilt in 1865. The town is an educational, residential and agricultural centre and a railway junction; its industries include printing, sawmills and the making of cricket balls, bricks and plastic goods.

TONE, THEOBALD WOLFE (1763–1798), Irish rebel, the son of Peter Tone, a Dublin coachmaker, was born in Dublin on June 20, 1763. He entered Trinity college, at 22 he married Matilda Witherington, a girl of 16, took his degree in 1786 and went to London. He was entered at the Middle Temple, and afterward read law in Dublin, being called to the Irish bar in 1789. Tone wrote two pamphlets in 1790, one of which, *A Review of the Conduct of Administration,* attracted some notice from the Whigs.

Tone made the acquaintance of Thomas Russell (1767–1803), Napper Tandy (*q.v.*) and others, and the society of the United Irishmen was formed (1791). The original purpose of this society was simply the formation of a political union between Roman Catholics and Protestants, to secure parliamentary reform; it was only when that object appeared to be unattainable by constitutional methods that the majority of the members adopted the more uncompromising opinions which Wolfe Tone held from the first, and conspired to establish an Irish republic by armed rebellion. Tone desired to root out the popular respect for Charlemont and Grattan, and to transfer to more violent leaders the conduct of the national movement. Grattan was a reformer and a patriot without a tincture of democratic ideas; Wolfe Tone was a revolutionary whose principles were drawn from the French Convention. Grattan's political philosophy was allied to that of Edmund Burke; Tone was a disciple of Danton and Thomas Paine.

In 1794 the United Irishmen, persuaded that their scheme of universal suffrage and equal electoral districts was not likely to be accepted by any party in the Irish parliament, began to found their hopes on a French invasion. An English clergyman named William Jackson, who had imbibed revolutionary opinions in France, came to Ireland to negotiate between the French committee of public safety and the United Irishmen. For this emissary Tone drew up a memorandum on the state of Ireland, which he described as ripe for revolution; the paper was betrayed to the government, and'in April 1794 Jackson was arrested on a charge of treason. Several of the leading United Irishmen, including Reynolds and Hamilton Rowan, immediately fled the country; the papers of the United Irishmen were seized; and for a time the organization was broken up. Tone, who had not attended meetings of the society since May 1793, remained in Ireland till after the trial and suicide of Jackson in April 1795. He was enabled to make terms with the government, stipulating only that he should not be called on to give evidence against Rowan and the others, and was permitted to emigrate to America, where he arrived in May 1795.

He went to Philadelphia where he met fellow exiles, and the French minister, Adet, who gave him letters of introduction to the committee of public safety in Paris. In Feb. 1796 he arrived in Paris and had interviews with De la Croix and L. N. M. Carnot, who were greatly impressed by his energy, sincerity and ability. A commission was given him as adjutant general in the French army, which he hoped might protect him from the penalty of treason in the event of capture by the English. He drew up two memorials representing that the landing of a considerable French force in Ireland would be followed by a general rising of the people, and giving a detailed account of the condition of the country. The French Directory, which possessed information from Lord Edward Fitzgerald (*q.v.*) and Arthur O'Connor confirming Tone, prepared to dispatch an expedition under Hoche. On Dec. 15, 1796, the expedition, consisting of 43 sail and carrying about 15,000 men, sailed from Brest. Tone, who accompanied it as "Adjutant General Smith," had the greatest contempt for the seamanship of the French sailors, which was amply justified by the disastrous result of the invasion. The ships were dispersed by a storm off the coast of Kerry.

But the Dutch fleet was delayed by bad weather, and before it put to sea in October! only to be crushed by Duncan in the battle of Camperdown, Tone had returned to Paris; and Hoche, the chief hope of the United Irishmen, was dead. Bonaparte, with whom Tone had several interviews about this time, was much less disposed than Hoche had been to undertake in earnest an Irish expedition; and when the rebellion broke out in Ireland in 1798 he had started for Egypt. When, therefore, Tone urged the Directory to send effective assistance to the Irish rebels, all that could be promised was a number of small raids to descend simultaneously on different points of the Irish coast. One of these under Humbert succeeded in landing a force in Killala bay, and gained some success in Connaught before it was subdued by Lake and Cornwallis, Wolfe Tone's brother Matthew being captured, tried by court-martial and hanged; a second, accompanied by Napper Tandy, came to disaster on the coast of Donegal; while Wolfe Tone took part in a third, under Admiral Bompard, with General Hardy in command of about 3,000 men, which encountered an English squadron near Lough Swilly on Oct. 12, 1798.

Tone, who was on board the "Hoche," refused Bompard's offer of escape in a frigate before the action, and was taken prisoner when the "Hoche" was forced to surrender. At his trial by court-martial in Dublin, Tone made a manly straightforward speech, avowing his determined hostility to England and his design "by fair and open war to procure the separation of the two countries," and pleading in virtue of his status as a French officer to die by the musket instead of the rope. He was, however, sentenced to be hanged on Nov. 12; but on the 11th he cut his throat with a penknife, and on Nov. 19, 1798, he died of the wound.

TONE POEM: see SYMPHONIC POEM.

TONGA, a Polynesian kingdom and archipelago in the South Pacific, lying east of Fiji and south of Samoa. It became a self-governing state under the protection of Great Britain by a treaty of friendship in 1900. Area 270 sq.mi. Pop. (1956) 56,838.

The first European contact with Tonga was made by the Dutch navigators Willem Cornelis Schouten and Jacob Lemaire who anchored off the Niuas, outlying islands of the group, in 1616. Abel Tasman landed in Tongatabu in 1643. Capt. James Cook made three visits and gave the name Friendly Island to Lifuka, an island first discovered by him during his famous voyage in 1777. This name was later applied by Europeans to the whole group. Both Tasman and Cook were struck by the peaceful conditions which prevailed during their visits, but within a few years of Cook's departure the country was embroiled in savage civil war which was finally quelled by a great chief, Taufaahau, who became king in 1845, assuming the name George Tubou I. When a young man he came under the influence of the Methodist mission which commenced its work in Tonga in 1822. His baptism in 1831 was of considerable assistance to the early missionaries and within a few years of their arrival the Tongans renounced their heathen gods and accepted Christianity.

Tonga has an interesting history. At one time it was ruled by a sacred king whose power was absolute. A list of these kings has been preserved and dates back to the 10th century. In the 15th century one of them divested himself of executive powers and set himself up as a temporal king. This delegation was repeated in the 17th century by the temporal king transferring part of his authority to a second temporal king. In the course of time the dignities and powers of the sacred and first temporal kings declined and were finally conferred upon King George Tubou I.

This king was one of the great figures of Pacific history. During his long reign (1845–93) he made treaties with France, Germany, the United States and Great Britain, all of whom recognized his sovereignty and independence. He granted parliamentary government to his people and introduced the land system, unique in the Pacific, under which every male Tongan taxpayer is entitled by law to $8\frac{1}{4}$ ac. of planting land. The king died in his 97th year. Salote Tubou (1900–), his great-great-granddaughter, succeeded as queen in 1918.

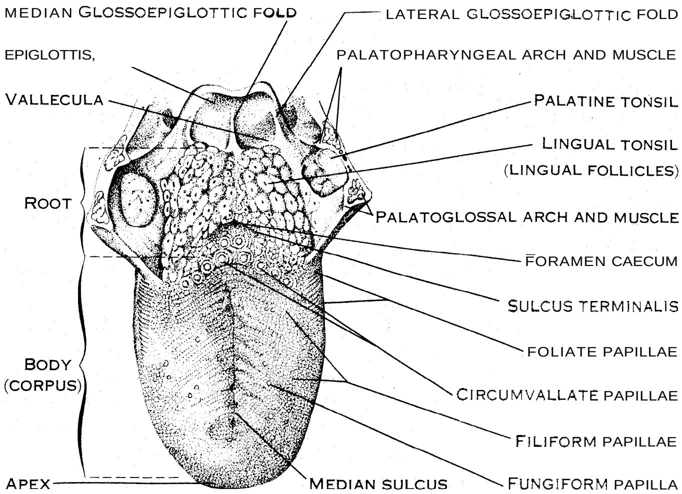
Tonga is an agricultural country. Its economy depends on copra, its main export. Tongans receive free medical and dental treatment. Primary education is free and compulsory between the ages of 6 and 14 years. Secondary education is well developed. The country has its own currency notes and its own stamp issue. British weights and measures are standard. No newspapers are published in Tonga; the government issues a news sheet daily which is distributed without charge. The climate from May to November is subtropical. From December to April the temperature rarely exceeds 90° F. but humidity is high. Rainfall in Nukualofa, the capital, averages 60 in. Though the Tongan group lies in the western hemisphere, between long. 172.5° and 177° west, it keeps eastern time, 12 hr., 20 min. ahead of Greenwich. See also PACIFIC ISLANDS. (J. S. N.)

TONGKING: see INDOCHINA; VIETNAM.

TONGUE, a movable, muscular organ, found in most vertebrates. located on the floor of the mouth. The tongue in man is a very mobile structure and is an important accessory organ in such motor functions as speech, chewing and swallowing. In conjunction with the cheeks it is able to guide and maintain food between the upper and lower teeth until mastication is completed. In persons whose tongue has been excised, speech is defective. In a mammal, such as the whale, that does not chew its food, the tongue is greatly reduced in size. Its mobility aids mammals in creating a negative pressure within the oral cavity, enabling them to suckle. In the horse this negative pressure is great enough to lift a column of water three feet, so that he can easily drink from a stream without raising his head to swallow.

The mucous membrane which covers the tongue is likewise concerned with seizing, holding and grinding food and with the reception of liquids. Its relief varies greatly. In man it is not so highly differentiated as in other mammals because he has learned to use artificial means in procuring and preparing his food. The mucous membrane is especially important as a peripheral sense organ. It contains groups of specialized epithelial cells, known as taste buds, which are the special sense organs of taste, and many nerve fibres which carry stimuli from the oral cavity to the central nervous system. The tongue informs individuals of changes which occur within the oral cavity and at times aids in locating particles of food lodged between the teeth. The central nervous system is kept informed by this membrane as to the consistency and state of salivation of the food. Furthermore, the tongue's glands produce some of the saliva necessary for swallowing (deglutition). The general appearance of the mucous membrane has interested physicians for centuries, and the custom of having the patient protrude his tongue during an examination is not without meaning since certain changes in its appearance reflect disturbances in other organs and systems. A paralysis of one-half of the tongue would also show on examination, for the tongue would deviate toward the affected side when protruded.

The mammalian tongue consists of a mass of interwoven, striated muscles covered with mucous membrane and interspaced with some glands and a variable amount of fat. By its extrinsic muscles, the tongue is attached to the mandible, the hyoid bone, the skull, the soft palate and the pharynx. It is bound to the floor



BASED ON AN ILLUSTRATION BY FRANK H. NETTER, M.D., IN "THE CIBA COLLECTION OF MEDICAL ILLUSTRATIONS"

FIG. 1.—DORSUM OF THE TONGUE

of the mouth and to the epiglottis by reflections of its mucous membrane.

The tongue presents on its upper surface a median groove, which traced posteriorly ends in a small pit, the foramen caecum linguae, which is the point of origin of the thyroid gland and forms the apex of a V-shaped groove, the sulcus terminalis linguae. The median groove and the terminal sulcus form an arrow, the tip of which is directed toward the oral pharynx. The terminal sulcus indicates the division of the tongue into two parts. The larger anterior part, or body, belongs to the floor of the mouth, while the smaller posterior, or root, forms the anterior wall of the oral pharynx.

The superior surface of the body is called the dorsum. It is separated from the inferior surface by the lateral margins, which meet anteriorly at the tip. The dorsum exhibits a rough appearance because of numerous small projections, the lingual papillae, of which five kinds are recognized. Filiform and conical papillae are slender, threadlike. cornified epithelial projections arranged in V-shaped rows, parallel with the terminal sulcus. They are numerous over the whole of the dorsum and contain an axial core of vascular fibrous tissue. Fungiform papillae are similar in structure but less numerous than the last and are easily distinguished by their larger size and reddish colour. Taste buds occur on most of the fungiform papillae. Circumvallate papillae, usually 7 to 11 in number, are found immediately in front of, and parallel to, the sulcus terminalis linguae. Each papilla consists of a flat central mound surrounded by a moat. On the sides of the moat are taste buds. and into the bottom of the fossa open ducts of the serous glands of Ebner.

Foliate papillae, rudimentary in man, are represented by a few (three to eight) vertical folds on the lateral margin of the dorsum at its hinder part. Taste buds occur on the opposite sides of these papillae.

The inferior or under surface of the body is covered in its free portion by a thin, smooth mucous membrane. It presents a prominent median fold, the fraenulum linguae, which connects rhe tongue with the mandible and the floor of the mouth; on each side of this structure is an irregular, fringed fold, the plica fimbriata, extending from near the apex, backward approximately parallel with the lateral margin of the tongue. Between the fraenulum and the plicae fimbriatae, the lingual vein on each side shines through the mucosa.

The root of the tongue differs topographically, developmentally, structurally and functionally, in innervation and in appearance, from the body.

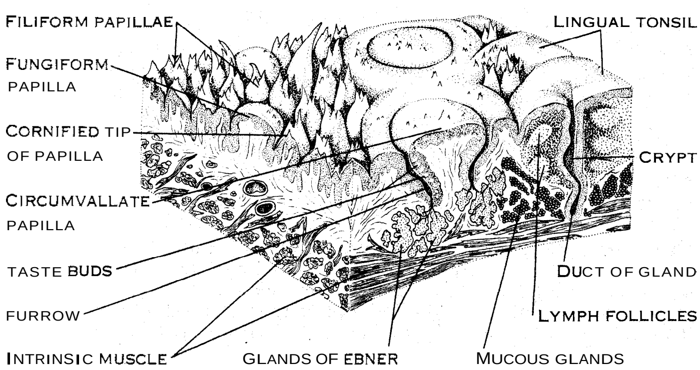
Topographically, the root belongs to the oral pharynx, and developmentally its mucous membrane arises primarily from the second branchial arches but receives additions from the third and fourth as well, while that of the body develops from the first and second (perhaps) branchial arches. Ultimately, the sensory portions of the trigeminal and facial cranial nerves (the nerves of the first and second branchial arches) innervate the epithelium of the body of the tongue, while the glossopharyngeal and vagus nerves (the nerves of the third and fourth arches) supply chiefly the root.

In appearance the mucous membrane of the root is warty because of the underlying nodules of lymphoid tissue, the lingual follicles, which collectively are designated as the lingual tonsil. The mucosa is not firmly adherent to the underlying structures. and a loose median fold of mucous membrane passes from the root to the epiglottis and separates the valleculae, or little valleys. where foreign bodies often become lodged. The lateral boundaries of the valleculae are two folds of mucous membrane, the pharyngoepiglottic or lateral glossoepiglottic folds.

The substance of the tongue is composed chiefly of interlacing striated muscle fibres arranged symmetrically on each side of a median fibrous septum. They are derived from cervical myotomes and innervated by the hypoglossal nerve. The muscles which lie entirely within the tongue are the intrinsic muscles, four on each side—the superior and inferior longitudinal, the vertical and transverse muscles. On contracting they change the length, width and breadth of the tongue and protrude it. Moreover, when contracted on one side only, they effect a contralateral deviation of the tongue's tip. A special branch of the hypoglossal nerve, known as the end branch, innervates the intrinsic muscles. Other muscles, the hyoglossus, chondroglossus, styloglossus and genioglossus, come from skeletal parts and insert into the substance of the tongue. They are the extrinsic muscles, and there are four on each side. With the exception of the genioglossus muscle, they are retractors of the tongue. The genioglossus muscle can protrude the tongue a small amount, but its main function is to build a fulcrum around which the intrinsic muscles function. The arteries of the tongue are derived mainly from the lingual branches of the external carotid arteries (see ARTERIES). The lingual veins return the blood from the tongue to the internal jugular veins (see VEINS).

Comparative Anatomy.—The tongue in fishes is rudimentary and practically immobile since it is composed mostly of thickened epithelium. In some fishes teeth are developed on the tongue. In the tailed forms of the Amphibia the tongue resembles that of the fishes, but in frogs, toads and other tailless amphibians it contains muscles and is quite movable. In reptiles the tongue is generally very movable, though this is not true in crocodiles, alligators and turtles. Many variations of tongue form are encountered in reptiles, and the forked tongues of snakes are familiar. In birds, the tongue possesses no intrinsic muscles, and its mobility varies. When it is very protrusible. as in the woodpecker, the movement is due to the hyoid bone's moving forward.

In Mammalia the tongue, except in whales, is always movable and protrusible. In the lemurs an undertongue is found, which probably is represented by the plica fimbriata under the human tongue.



BASED ON AN ILLUSTRATION BY FRANK H. NETTER, M.D., IN "THE CIBA COLLECTION OF MEDICAL ILLUSTRATIONS"

FIG. 2.—SCHEMATIC STEREOGRAM OF SECTION OF THE TONGUE

See also DIGESTION, MOUTH.

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TONGUE, DISEASES OF. Diseases arising primarily in the tongue are. in order of their severity: cancer. leukoplakia. syphilis and actinomycosis. Cancer of the tongue typically begins as a firmly walled-in ulcer. Cancer. however. is so variable in appearance that inspection and observation alone do not permit a responsible distinction between serious and harmless states. Presence or absence of pain bears no relationship to the nature of a lesion of the tongue. Cancer of the tongue must be suspected whenever a lesion develops gradually and persists. Any such lesion requires medical investigation; microscopic examination of a small piece of tissue is the quickest and most reliable means for early detection or safe exclusion of cancer. In its early stage. cancer of the tongue can safely be removed by surgical treatment, possibly combined with radiation. The cause of cancer of the tongue is as unknown as that of cancer in other parts of the body; defective teeth have been suspected as one of the contributory causes, the use of tobacco seemed to account for the prevalence of tongue cancer in men until statistics proved its incidence among nonsmokers also to be twice as great in men as in women.

Leukoplakia consists in a thickening of the mucous membrane which covers the tongue and it appears as a sharply outlined uniformly whitish patch. Although it may be produced by any number of irritants (tobacco. faulty teeth. ill-fitting dentures). syphilis should be suspected as the cause and cancer anticipated as its possible outcome. It therefore requires treatment even if it should remain painless or fail to spread. Syphilitic leukoplakia often involves the entire surface of the tongue. Leukoplakia is also observed in persons without any of the above-named causes.

Syphilis of the tongue appears either as a primary lesion (chancre) or as a tumour (gumma) associated with the tertiary stage; the latter can be extensive and greatly impair the function of the tongue. Treatment is antisyphilitic or if necessary surgical.

Actinomycosis can produce a small nodule within the substance or an inflammation of part of the tongue; if preceded by complicated tooth extraction, the diagnosis is often missed because of the infrequency of this disease. Treatment with antibiotics is usually very successful.

Secondary Changes.——The tongue as part of the digestive system often reflects gastrointestinal disturbances through changes in colour, evenness of surface or degree of moisture. The well-known coating, however, provides no diagnostic clues since it also depends on diet habits and factors like breathing through the mouth or smoking. One of the earliest symptoms of systemic disease: may concern the tongue; *e.g.*, the fiery redness of pellagra, or the smoothness and burning in pernicious anaemia.

The appearance of the tongue is usually affected in febrile diseases. The various infections of the mouth often involve the tongue which may become predominantly painful because of 'the muscular efforts required for speaking, chewing and swallowing. The tongue may be abnormally small or large congenitally; largeness may result from a tumour spread diffusely through the substance of the tongue (lymphangioma) or from acromegaly. The tongue may deviate from its normal position; the tip of the outstretched tongue may point asymmetrically to either side instead of remaining in the midline. This deviation is found most often in persons who have suffered a stroke (apoplexy) but occurs occasionally in healthy persons as a result of uneven development or nerve supply of the musculature of the tongue.

The normal tongue has an evenly coloured finely granular surface. Two variations of this normal appearance may cause needless alarm: (1) the evenness of colour is disturbed by irregular grayish markings best described by the designation "geographic tongue"; (2) the surface shows deep irregular indentations and furrows (scrotal or beei tongue). The tongue can be the distressing site of allergic reactions; in some persons who are sensitive to certain drugs, the tongue can react with pain or burning or changes of appearance.

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TONGUES, GIFT OF, a faculty of abnormal and inarticulate vocal utterance, under stress of religious excitement. which was widely developed in the early Christian circles, and has its parallels in other religions. It is also called Glossolalia (Gr. γλῶσσα, tongue. λαλεῖν. speak). In the New Testament such experiences are recorded in Caesarea (Acts x. 46). at Corinth (Acts xix. 6: 1 Cor. xii., xiv.), Thessalonica (1 Thess. v. 19), Ephesus (Eph. v. 18), and universally (Mark xvi. 17). From the epistles of Paul, who thanked God that he spake with tongues more than all or any of his Corinthian converts. we can gather a just idea of how he regarded this gift and what it really was.

Paul discriminates between the Spirit which during these paroxysms both talks and prays to God and the *nous* or understanding which informs a believer's psalm, teaching, revelation or prophesy, and renders them intelligible, edifying and profitable to the assembly. Accordingly Paul lays down rules which he regarded as embodying the Lord's commandment. A man "that speaketh in a tongue speaketh not unto men, but unto God; for no man understandeth"; and therefore it is expedient that he keep this gift for his private chamber and there pour out the mysteries. In church it is best that he should confine himself to prophesying, for that brings to others "edification and comfort and consolation." If, however. tongues must be heard in the public assembly, then let not more than three of the saints exhibit the gift, and they only in succession. Nor let them exhibit it at all. unless there is some one present who can interpret the tongues and tell the meeting what it all means. If the whole congregation be talking with tongues all at once, and an unbeliever or one with no experience of pneumatic gifts come in, what will he think, asks Paul. Surely that "you are mad." So at Pentecost on the occasion of the first outpouring of the Spirit the saints were by the bystanders accused of being drunk (Acts ii. 13). In the church meeting. says Paul, "I had rather speak five words with my understanding, that I might instruct others also, than ten thousand words in a tongue."

Paul on the whole discouraged glossolaly. "Desire earnestly the greater gifts," he wrote to the Corinthians. The gift of tongues was suitable rather to children in the faith than to the mature. Tongues were, he felt, to cease whenever the perfect should come; and the believer who spoke with the tongues of men and of angels, if he had not love. was no better than the sounding brass and clanging cymbal of the noisy heathen mysteries. It was clearly a gift productive of much disturbance in the Church (1 Cor. xiv. 23). He would not, however. entirely forbid and quench it (1 Thess. v. 19), so long as decency was preserved.

It is not then surprising that we hear little of it after the apostolic age. It faded away in the great Church, and probably Celsus was describing Montanist circles (though Origen assumed that they were ordinary believers) when he wrote (Origen, Contra *Celsum*, vii. 9) of the many Christians of no repute who at the least provocation. whether within or without their temples, threw themselves about like inspired persons; while others did the same in cities or among armies in order to collect alms.

Tertullian in the 3rd century testifies that glossolaly still went on in the Montanist Church which he had joined; for we must so interpret the following passage in his De *anima*, cap. ix.: "There is among us at the present time a sister who is endowed with the charismatic gift of revelations, which she suffers through ecstasy in the spirit during the Sunday service in church. She converses with angels, sometimes even with the Lord, and both hears and sees mysteries." The magical papyri teem with strings of senseless and barbaric words which probably answer to what certain of the Fathers called the language of demons. It has been suggested that we here have recorded the utterances of glossolalists.

The attitude of Paul toward glossolaly among his converts strikingly resembles Plato's opinion as expressed in the *Timaeus*, p. 72, of the enthusiastic ecstasies of the ancient *μάντις* (soothsayer). The gift of tongues and of their interpretation was not peculiar to the Christian Church, but was a repetition in it of a phase common in ancient religions. The very phrase *γλώσσαις λαλεῖν*, "to speak with tongues," was not invented by the New Testament writers, but borrowed from ordinary speech.

Virgil (*Aen.* vi. 46, 98) draws a life-like picture of the ancient prophetess "speaking with tongues." He depicts her quick changes of colour, her dishevelled hair, her panting breast, her apparent increase of stature as the god draws nigh and fills her with his divine afflatus. Then her voice loses its mortal's ring: "nec mortale sonans." The same morbid and abnormal trance utterances recur in Christian revivals in every age, *e.g.*, among the mendicant friars of the 13th century, among the Jansenists, the early Quakers, the converts of Wesley and Whitefield, the persecuted Protestants of the Cevennes, the Irvingites, and the revivalists of Wales and America.

Oracular possession of the kind above described is also common among savages and people of lower culture; and Dr. Tylor, in his Primitive Culture, ii. 14, gives examples of ecstatic utterance interpreted by the sane. Thus in the Sandwich Islands the god Oro gave his oracles through a priest who "ceased to act or speak as a voluntary agent, but with his limbs convulsed, his features distorted and terrific, his eyes wild and strained, he would roll on the ground foaming at the mouth, and reveal the will of the god in shrill cries and sounds violent and indistinct, which the attending priests duly interpreted to the people."

See E. B. Tylor, *Primitive Culture;* H. Weinel, *Die Wirkungen des Geistes und der Geister* (Freiburg, 1899); Shaftesbury's *Letter on Enthusiasm;* Mrs. Oliphant, *Life of Irving,* vol. ii; G. B. Cutten, *Speaking with Tongues, Historically and Psychologically Considered* (1927) (the most complete existing survey of the subject). *See* also Thouless, *Introduction to the Psychology of Religion,* chap. xi.

TONIC SOL-FA. Tonic Sol-fa has as its leading principle the relationship of sounds. The system is based on "mental effect," *i.e.* the effect on the mind of any note, chord or progression in relation to a central Tonic or key-note. The prefix "tonic" was first used by John Curwen (1816–1880). He developed his method from that of Miss Sarah Ann Glover (1785–1867) of Norwich, to whom he always acknowledged his indebtedness, but, since her system could not become popular (it was out of print), he announced a number of modifications (twenty-one are tabulated in his Teacher's *Manual*), which established the "Tonic Sol-fa Method and notation" as a national movement.

What, then, is Tonic Sol-fa? It is a letter-notation, as distinguished from a staff-notation. The initials of seven old syllables are used. They formed what was later called a "movable do" system, and Tonic Sol-fa follows this old practice. Guido d'Arezzo (995–1050) noticed that each line of a hymn to St. John began stepwise, forming his hexachord instead of the former Greek tetrachords, and he took the first syllable of each line of the hymn as a sound-name, thus ut, re, mi, fa, sol, la. The last line of the hymn was Sancte Iohannes. The initial letters; *si,* were added in the 16th century to represent the seventh of the modern major scale. In the 17th century *do* (probably from Dominus) was substitued in most countries for *ut.* In the 19th century in England *si* was changed to te to avoid confusion with the initial of *sol,* and the spelling of all the syllables was adapted to the English language, with the advantage of having an open vowel sound for every note. The higher octave was shown by a small figure on the right above the note (d^1), and the lower octave syllables had a figure below the note (s_1s_2) at the right side as shown.

Besides the signs for tune already given, a notation of time was adopted, and varied spacing represented duration pictorially. A vertical line (|) precedes the accent at the beginning of the bar (measure). A short perpendicular line (|) shows the middle or medium accent of common time (four-pulse measure). An accent mark if followed by an unfilled (un-syllabled) space indicates a rest. When a note follows the accent mark it occupies the time from that accent to the next. A long dash (—) after a note requires the sound to be continued through the next pulse or beat. A dot (full point) between two notes divides the pulse into equal parts (d.r). A dot before a continuation mark (short dash) indicates that the previous note is to be continued through half of that pulse. A comma is the sign for a quarter-pulse (d,r). A dot and comma placed together show that the preceding note is of $-pulse length, and the following note ¼-pulse length (d.,r). An inverted comma is placed after a note of one-third pulse length (d'r). A line placed below two or more notes signifies that the notes are to be sung to the single syllable or word underneath the notes (d.r). A brace binds each line of the score, and a double bar shows the end of the music. A tune may be quoted which gives within one bar five signs for rhythm:

A.	m	:m	., r	|d ,l_1	.— : l_1	.d	‖
	Oft	in	the	stilly	night,	Ere	‖

The question of key arises. At the beginning of the tune the pitch of it is indicated by the standard pitch-names (Key A, etc.). Here comes the "enlightening fact" to a beginner. A tune in Tonic Sol-fa notation has the same appearance (apart from octave marks) whether pitched high or low; it is recognized as the same tune. In the song of Moore above, for example, the same syllables would be used whether sung at a pitch suitable to tenor or bass. The Tonic Sol-faist, having a movable doh method, has not to use a fresh set of syllables with every change of pitch, in the "fixed doh" way.

In modulation (called transition) to a new key in the course of a tune, the Tonic Sol-faist finds a new signature at the point of change, and is thus prepared. If a sharp key (passing from key F to key C is a remove sharp-wards) is imminent, the new tone (the sharp) is printed over the music (for example, A.t.) on the right of the key-name. If the tune passes flat-wards, the "distinguishing tone" is placed on the left of the key-name (fah in key F, for example, f.F.). If the transition involved four removes to the right (sharp-ward progressions) the distinguishing tones would be t.m.l.r. Four flat-ward removes would have as distinguishing tones at each remove, r.s.d.f., read backwards. The latest practice is to name the number of new tones above three by a figure, as B 4, for example. In the minor key (mode) the key-note is *lah,* thus in A minor "Lah is A."

Besides having changes of key defined by fresh signature (a practice which is growing in staff notation printing), the Tonic Sol-faist is given a new syllable, forming a bridge-tone or double-name, of which, with practice, he thinks the first and sings the second, or as a beginner he will glide from one to the other, as m'lah, or as a barrister addresses m'lor. In print, this is shown thus *ml.* Explanation of the treatment of minor keys cannot be pursued here, but the "minor mode" gives the Tonic Sol-faist no trouble.

A further detail is with regard to the inflected names adopted for "accidentals" (chromatics). Doh becomes, a semitone higher, de, and the long e sound also represents re, fe, se, *le.* Depress *te* and it is named *taw,* printed *te.* Similarly down "the modulator" may be found *la, ma,* rn. Characteristic of the minor mode are *ba* (pronounced bay) and se.

First lessons in Tonic Sol-fa are begun with the aid of a chart of tune: the modulator just named. Its ladder-like appearance is a great aid to the beginner; it is the counterpart of the up-and-down picture of the staft notation. The mental image of the modulator remains; it is the answer to the objection that Tonic Sol-fa is a dead-level picture. Even before it is used. the learner hears "the sound before the sign." He learns the scale by "steps of the method." first d, *s* and *m,* second r and *t,* third *f* and 1, fourth the whole scale and transition. Such simple tools enable the ordinary teacher of an elementary school to get from small children amazing results in sight-singing. Each scale tone when sung slowly is also found to have its own character or mental effect, and this is noticed in illustrating by familiar phrases of music, which. however. must not be pressed too far; d is firm. *s* martial, *m* mild, *r* prayerful (at high, pitch, rousing). t leading upward: f leaning downward, *l* the mournful tone. The method applies other devices for teaching effect: French time-names for rhythm; hand-signs which. dispensing with printed notes. enable the teacher to give exercises rapidly. The ear is trained from the first lesson.

The value of it all is greatest in the higher stages: harmony is clarified by the tonic principle; transposition of music is easy; rhythm is analyzed and simplified by the time names; and, in addition, Tonic Sol-fa is the best introduction to the staff notation. More and more, publishers find it worth while to print the Tonic Sol-fa notation along with the staff. The facility and certainty of the Tonic Sol-faists have been admitted and praised by every conductor who has had experience of them. The story of the successful struggle to give this method a footing need not be told here. The danger now is when people in authority, or capable musicians who learned music easily, say that the notation is unnecessary, while passing compliments upon the method of teaching; and at the same time ignoring the need of giving children a good foundation in reading this notation. (J. GRA.)

TÕNISSON, JAAN (1868– ?), Estonian statesman, was the son of a farmer in the Viljandi district of Livonia. After graduating in law at the University of Dorpat (Tartu) he was for some years in the judicial service of the Russian imperial government, but left that position in 1896 to become editor of *Postimees* (The Postilion), the oldest Estonian daily newspaper, in Tartu. Tonisson's initiative and influence ranged from agricultural shows to the founding of co-operative banks and from the temperance movement to schools and literary societies. In the revolution of 1905 he was at the head of the Estonian moderate constitutional movement, which he likewise represented in the Russian duma. With the other signatories to the Viborg Appeal, he was sentenced to a term of imprisonment. From 1917 onward Tonisson, as leader of the Estonian People's party, was a member of all the parliaments and other representative assemblies. He was expelled by the Bolsheviks in Nov. 1917, but in Stockholm and in Copenhagen he carried out with the representatives of the Allied Powers the preliminaries of a de facto recognition of Estonia. From 1919 to 1920 he was prime minister, and during his period of office peace was concluded with Russia. In the second *riigikogu* (parliament) he formed a new centre party by the amalgamation of his own party, the Christian People's party, and the National Liberals and became president of the chamber. He was *Rügivanem* (president) in 1927–28, and 1933. During the suspension of parliamentary activity (1934–37), Tonisson became professor of social sciences at Tartu; but later he was elected into the constituent assembly and into the parliament, where he was a prominent member of the opposition. In 1940 he was arrested and deported by the Soviet occupation forces, after which his fate was unknown.

TONK, a town and district of Rajasthan state, India. The town (pop., 1951. 42,833), headquarters of the district, is 55 mi. S. of Jaipur, near the right bank of the Banas river.

The former princely state of TONK (pop.. 1941, 353,687) was in the Rajputana agency (Haraoti and Tonk subagency till 1936, then Jaipur residency) prior to its accession to Rajasthan on March 25, 1948. It was divided into six isolated tracts around the following cities: Tonk; Aligarh, 25 mi. S.E. of Tonk; Nimbahera, Pirawa and Chhabra (towns c. 120–130 mi. from Tonk in enclaves along the northwest fringe of Central India); and Sironj (180 mi. S.E. of Tonk and entirely within Central India); total area 2,543 sq.mi. The district of Tonk has an area of 2,754 sq.mi.; pop. (1951) 400,947. The former *nawab* was of Afghan or Pathan descent. The founder of the family was the notorious Pindari leader Amir Khan, who submitted to the British in 1817.

TONKA BEAN. The tonka, tonqua or tonquin bean, also called the coumara nut, is the seed of *Dipteryx* odorata and D. *oppositifolia,* two leguminous trees native to tropical South America. The drupelike pod contains a single almondlike black seed possessed of a fine sweet odour of new-mown hay or vanilla, due to the presence of coumarin (*q.v.*). Besides its use in perfumery, an alcoholic extract is being used more and more as a substitute for vanilla in confections.

TONKAWA, a tribe of south central Texas, usually considered as a distinct linguistic stock, belonged to the plains group of nomadic buffalo-hunting Indians. They lived in tepees and bore a reputation for cannibalism.

The Tonkawa fought, at one time or another, most of their neighbours, from the Apache to the Caddo. The original population of perhaps 1,500 decreased to a few dozen.

TONNAGE AND POUNDAGE. In England, customs duties anciently imposed upon exports and imports, the former being a duty upon all wines imported in addition to prisage and butlerage, the latter a duty imposed ad valorem at the rate of 1*s.* on the £ on all merchandise imported or exported. The duties were levied at first by agreement with merchants (poundage in 1302, tonnage in 1347), then granted by parliament in 1373, at first for a limited period only. They were considered to be imposed for the defense of the realm.

From the reign of Henry VI until that of James I they were usually granted for life. They uere not granted to Charles I, and in 1628 that king took the unconstitutional course of levying them on his own authority, a course denounced a few years later by 16 Car. I c. 18 (1640), when the Long parliament granted them for two months. After the Restoration they were granted to Charles II and his two successors for life. By acts of Anne and George I, the duties were made perpetual and mortgaged for the public debt. In 1787 they were finally abolished, and other modes of obtaining revenue substituted, by 27 Geo. III c. 13 (1787).

Poundage also signified a fee paid to an officer of a court for his services; *e.g.,* to a sheriff's officer, nho is entitled by 29 Eliz. c. 4 (1586–87) to a poundage of 1*s.* in the £ on an execution up to £100, and sixpence in the £ above that sum.

TONSBERG, a seaport of Norway, Vestfold fylke ("county"), situated on the south coast. near the entrance to Oslo fjord. 72 mi. S.W. of Oslo Pop. (1950), 12,211. It is one of the most ancient towns in Norway, declined after the middle ages, but before World War II was a growing industrial town and headquarters of a sealing and whaling fleet.

TONSILLITIS is an inflammation of the tonsils; it may be acute or chronic.

Acute Tonsillitis. — This is an acute infection of the tonsils and throat caused by invasion of the mucous membrane by microorganisms, usually hemolytic streptococci. Because the tonsils contain deep folds of mucous membrane, the inflammation is greatest in these structures. On examination, the throat appears red. and the tonsils are swollen and often covered with small white patches.

The symptoms of acute tonsillitis are sore throat with difficulty in swallowing, fever, malaise and frequently enlarged lymph glands on both sides of the neck. The infection is self-limited and lasts about five days The treatment includes bed rest until the fever has subsided, isolation to protect others from the infection, and warm throat irrigations or gargles with a mild antiseptic solution. Antibiotics (penicillin) or sulfonamides or both are prescribed in severe infections to prevent complications. Throat cultures and investigations of the white blood count aid in determining the treatment.

Scarlet fever. diphtheria (*qq.v.*) and trench mouth (*see* PERIODONTAL DISEASES) may also produce acute tonsillitis. In diphtheria, the tonsils are covered with a thick whitish adherent membrane, in trench mouth with a grayish membrane that wipes off readily.

The complications of acute tonsillitis are proportional to the severity of the infection. The infection may extend upward into the nose, sinuses and ears or downward into the larynx, trachea and bronchi. Locally. virulent bacteria may spread from the infected tonsil to the adjoining tissues, resulting in a peritonsillar abscess (quinsy). More serious are two distant complications—acute nephritis and acute rheumatic fever, with or without heart involvement.

A peritonsillar abscess or quinsy may follow an acute tonsillitis; it is usually confined to one side. The massive swelling displaces the involved tonsil toward the median line. Extreme pain interferes with swallowing and talking. High fever and general prostration accompany the infection. Early administration of antibiotics may obviate the necessity of surgical incision and drainage.

Chronic Tonsillitis. — This is a chronic inflammation of the tonsils caused by repeated acute infections. Enlargement of the tonsils is accompanied by the accumulation of purulent secretions in the tonsillar crypts. In children, chronic tonsillitis may be evidenced by frequent or persistent sore throats and large lymph glands in the neck. The treatment is surgical removal (tonsillectomy).

Turnours. — Benign neoplasms of the tonsils are rare. A gradual swelling of one tonsil with or without ulceration may indicate cancer. Early diagnosis by biopsy must be followed by immediate irradiation or surgery. (H. V. v. L.)

TONSURE, a religious observance in the Roman Catholic and Orthodox Eastern Churches, consisting of the shaving or cutting of part of the hair of the head as a sign of dedication to special service. The reception of the tonsure in these churches is the initial ceremony which marks admission to orders and to clerical rights and privileges. It is administered by the bishop with an appropriate ritual. Candidates for the rite must have been confirmed, be adequately instructed in the elements of the Christian faith, and be able to read and write. Those who have received it are bound (unless in exceptional circumstances) to renew the mark, consisting of a bare circle on the crown of the head, at least once a month, otherwise they forfeit the privileges it carries. The practice is not a primitive one, Tertullian simply advises Christians to avoid vanity in dressing their hair, and Jerome deprecates both long and closely cropped hair. According to Prudentius (Περισ. xiii. 30) it was customary for the hair to be cut short at ordination. Paulinus of Nola (*c.* 490) alludes to the tonsure as in use among the (Western) monks; from them the practice quickly spread to the clergy. For Gaul about the year 500 we have the testimony of Sidonius Apollinaris (iv. 13), who says that Germanicus the bishop had his hair cut "in rotae speciem."

The earliest instance of an ecclesiastical precept on the subject occurs in can. 41 of the Council of Toledo (A.D. 633): "omnes clerici, detonso superius capite toto, inferius solam circuli coronam relinquant." Can. 33 of the Quinisext council (692) requires even singers and readers to be tonsured. Since the 8th century three tonsures have been more or less in use, known respectively as the Roman. the Greek and the Celtic. The first two are sometimes distinguished as the tonsure of Peter and the tonsure of Paul. The Roman or St. Peter's tonsure prevailed in France, Spain and Italy. It consisted in shaving the whole head, leaving only a fringe of hair supposed to symbolize the crown of thorns. Late in the middle ages this tonsure was lessened for the clergy, but retained for monks and friars. In the Eastern or St. Paul's tonsure the whole head was shaven, but when now practised in the Eastern Church this tonsure is held to be adequately shown when the hair is shorn close. In the Celtic tonsure (tonsure of St. John, or, in contempt, tonsure of Simon Magus) all the hair in front of a line drawn over the top of the head from ear to ear was shaven (a fashion common among the Hindus). The question of the Roman or Celtic tonsure was one of the points in dispute in the early British Church, settled in favour of the Roman fashion at the Council of Whitby (664). The tonsure at first was never given separately, and even children when so dedicated were appointed readers, as no one could belong to the clerical state without at least a minor order. From the 7th century, however, children were tonsured without ordination, and later on adults anxious to escape secular jurisdiction were often tonsured without ordination. Till the 10th century the tonsure could be given by priests or even by laymen, but its bestowal was gradually restricted to bishops and abbots.

TOOKE, JOHN HORNE (1736–1812), English politician and philologist, third son of John Horne, a poulterer in Newport Market, London, was born on June 2j, 1736. He was educated at Westminster school, Eton, and St. John's college, Cambridge. He had been entered at the Inner Temple, but his father wished him to take orders and he was ordained to a curacy at New Brentford in 1760. He travelled in France in 1765–67, where he met John Wilkes (*q.v.*). In 1767 he returned and became Wilkes' most energetic and ingenious supporter. In 1771, however, he quarrelled violently with his leader, to the damage of their cause. Horne's supporters took the name of the Constitutional Society.

In 1773 he was placed beyond the reach of want by the gratitude of William Tooke, of Croydon, whose rights in an enclosure case he had protected by turning attention to his case.

But Horne was now involved in serious trouble. For signing the advertisement soliciting subscriplions for the relief of the relatives of the Americans "murdered by the king's troops at Lexington and Concord," he was tried at the Guildhall on July 4, 1777, before Lord Mansfield, found guilty, and committed to the King's Bench prison in St. George's Fields, from which he only emerged after a year's durance, and after a loss in fines and costs amounting to £1,200. Soon after his deliverance he applied to be called to the bar, but his application was negatived on the ground that his orders in the Church were indelible. Horne thereupon tried his fortune, but without success, on farming some land in Huntingdonshire. He also published two influential reforming pamphlets: *Facts Addressed to Landholders,* etc. (1780), and *A Letter* on *Parliamentary Reform* (1782).

On his return from Huntingdonshire he became once more a frequent guest at Mr. Tooke's house at Purley, and in 1782 assumed the name of Horne Tooke. In 1786 Horne Tooke gave his philological treatise of Ἔπεα πτερόεντα (2 pts. 1786–1805), the sub-title of The *Diversions* of *Purley,* as *a* tribute to his friend.

Between 1782 and 1790 Tooke supported Pitt, and in the election for Westminster, in 1784, threw all his energies into opposition to Fox. After the Westminster election of 1788 Tooke depicted the rival statesmen (Lord Chatham and Lord Holland, William Pitt and C. J. Fox) in his pamphlet of *Two Pair* of *Portraits.* At the general election of 1790 he was a candidate for Westminster, in opposition to Fox and Lord Hood, but was defeated; and, at a second trial in 1796, he was again at the bottom of the poll. Meantime the excesses of the French revolution had provoked reaction in England, and the Tory ministry adopted a policy of repression. Horne Tooke was arrested early on the morning of May 16, 1794, and conveyed to the Tower. His trial for high treason lasted for six days (Nov. 17–22) and ended in his acquittal, the jury only taking eight minutes to settle their verdict. Through the influence of the second Lord Camelford, he was returned to parliament in 1801 for the pocket borough of Old Sarum. Efforts to secure his exclusion on the ground of his clerical orders failed, but an act was passed rendering all persons in holy orders ineligible, and he sat for that parliament only.

The last years of Tooke's life were spent in retirement in a house on the west side of Wimbledon Common, where he gave the Sunday parties, attended by Thurlow, Bentham, Coleridge, Paine and others, which became a legend. He died on March 18, 1812.

The *Life of Horne Tooke,* by Alexander Stephens, is written in an unattractive style and was the work of an admirer only admitted to his acquaintance at the close of his days. The notice in the *Quarterly Review,* June 1812, of W. Hamilton Reid's compilation, is by J. W. Ward, Lord Dudley. The main facts of his life are set out by Mr. J. E. Thorold Rogers, in his *Historical Gleanings,* 2nd series. Many of Horne Tooke's wittiest sayings are preserved in the *Table Talk* of Samuel Rogers and S. T. Coleridge.

TOOKE, THOMAS (1774–1858), English economist, was born at St. Petersburg in February, 1774. Entering a large Russian house in London at an early age, he acquired sound practical experience of commercial matters and became a recognized authority on finance and banking. He was one of the earliest advocates of free trade and drew up the *Merchants' Petition* presented to the House of Commons by Alexander Baring. afterwards Lord Ashburton. He gave evidence before several parliamentary committees, notably the committee of 1821, on foreign trade, and those of 1832, 1840 and 1848 on the Bank Acts. He was elected F.R.S. in 1821. He died in London on Feb. 26, 1858.

Tooke is known for his *History of Prices and of the State of the Circulation during the Years 1793–1856* (6 vols., 1838–1857). In the first four volumes he treats *(a)* of the prices of corn, and the circumstances affecting prices; (b) the prices of produce other than corn; and *(c)* the state oi the circulation. The tn-o final volumes, written in conjunction with W. Newmarch, deal with railways, free trade, banking in Europe and the effects of new discoveries of gold.

TOOL: *see* MACHINE TOOLS and articles on specific tools; for the tools of prehistoric man *see* ARCHAEOLOGY; FLINTS.

TOOLE, JOHN LAWRENCE (1832–1906), English actor, was born in London on March 12, 1832. He was educated at the

City of London school. He definitely took to the stage in 1852, appearing in Dublin as Simmons in *The Spitalfields Weaver.* In 1854 he made his first professional appearance in London at the St. James's theatre, acting Samuel Pepys in *The King's Rival* and Weazel in My *Friend the Major.* In 1857 he met Henry Irving in Edinburgh and recommended him to go to London. and their friendship remained thenceforth of the closest kind. In 1858 Toole joined Webster at the Xdelphi, and established his popularity as a comedian.

In 1868 he was engaged at the Gaiety, appearing among other pieces in *Thespis,* the first Gilbert and Sullivan collaboration.

In 1879 he took the "Folly" theatre in London, which he renamed "Toole's" in 1882. He died July 30, 1906.

TOOL STEEL. This term designates steels used for machine tools, hand tools and cutlery and. loosely, includes alloys other than of iron, and even ceramic combinations. Prior to 1870 these a-ere exclusively high-carbon steels made by crucible or cementation process; since then alloy steels have been introduced for cutting metals. Plain carbon steels of high quality are still pre-eminent for woodworking, stonecutting and cutlery. The amount of carbon ranges from 0.6% to 1.3%, the lower carbon content giving a moderate hardness but great toughness. Sledges, chisels. picks, rock drills. axes, woodworking tools, files. cutlery and razors —each item needs greater and greater hardness and more ability to maintain a cutting edge, with toughness progressively less important as the carbon content increases.

If carbon steels are worked at high rates of speed, the friction between chip and tool nose generates enough heat to draw the temper of the tool, *i.e.,* to soften it to a lesser hardness than the material being cut. This is avoided by using special alloys that temper very slowly, retain their hardness at high heats; or are intrinsically hard and thus require no heat treatment. Mushet steel (introduced by R. F. Mushet in 1871) is of the first category of low-alloy tool steels. It was a high-carbon steel containing 5% tungsten and 1% chromium. *(See* STEELS, ALLOY.) High-speed steel *(q.v.)*, which has the property of hardness at a red heat and contains much more tungsten and chromium, is widely used in machine shops for mass production of iron and steel parts. Stellite (although really not a steel) is an example of a third class of hard tool materials. Discovered by Elwood Haynes. it is one of a family of intrinsically hard alloys of tungsten, chromium and cobalt. It enjoyed wide popularity in the 1920s and 1930s for machining hard cast iron (semisteel) and for rough turning medium steels. Another material of great hardness, introduced in 1928, is a mixture of powdered tungsten (and tantalum) carbide with about 12% of metallic cobalt for binder, pressed together and sintered by processes of powder metallurgy *(q.v.)*. This idea was commercialized in Germany in 1936 and the material marketed as Widia; in the United States a well-known brand is called Carboloy. Tips of this sort are brazed to steel tool shanks. Starting with an ability to cut tough or abrasive substances like Hadfield's manganese steel and nonmetallic electrical insulation, they rapidly have expanded in their utility to almost all machine shop operations on mass-produced articles. Other hard carbides, such as boron carbide, consolidated by powder metallurgy methods, have also been introduced as cutters for special services.

This trend toward the use of nonmetallics as cutting tools has its latest example in the use of bonded. and sintered hard oxides. Artificial corundum or emery (crystallized alumina) is an example of material long used in grinding wheels or polishing cloths and it is formed into cutting tools for those uses suggested above for hard carbides.

Steel is essentially a crystalline alloy of iron and iron carbide. Iron is naturally a soft and malleable metal, primarily because the iron atoms in the microscopic crystallites are arranged in a very simple geometric space pattern. Carbide, on the other hand. is hard and brittle because of its exceedingly complex crystalline architecture. Hardening of steel consists of (1) heating the metal to a point where the carbide particles dissolve and the carbon atoms diffuse uniformly in the solid iron, then (2) quenching so rapidly that the reverse action is inhibited. What results is a highly strained (hard) iron matrix shot through with an infinite number of submicroscopic iron carbide particles. The maximum possible hardness is related to the carbon content. *See* IRON AND STEEL: *Metallography and Heat Treatment.*

A little heat relaxes the internal strain and permits carbide particles to grow by joining together, softening the hard steel. Hence properly hardened plain carbon tool steels cannot be run at high speeds because they are quickly softened by the heat generated. Mushet found that the metals tungsten and chromium combined with high-carbon steel slowed down the softening reactions, so that such alloy steel tools could be run at much higher speeds (and frictional temperatures). Research after 1900 also proved that another prime function of alloys in steel is to slow down the reversionary actions during quenching; *i.e.,* to retard the transformation from the hot solution which is soft and ductile into a hard mixture of strained iron and carbide crystals. If the optimum combination of carbon and alloying metals such as nickel, chromium and molybdenum is used, the transformation is caught midway)and the hardening effects are fairly permanent. The resulting metal resists tempering and retains its hardness even after being subjected to the heat of a tempering furnace, of friction in cutting or from contact with hot metal as in a forging die.

A great variety of tool steels have been marketed containing various combinations of alloying elements, either for economics or for the sake of special properties. For example, shortage of tungsten in World War I turned attention to the use of molybdenum (a close cousin) as a substitute, with the subsequent development of high-speed steel in which 6% to 8% of molybdenum replaces nearly all of the tungsten. Some tools—especially gauges with hard surfaces to resist normal wear—must be hardened with a minimum of size change; high manganese (1.5% to 1.75%) gives "nondeforming" tool steels. Dies for contact with hot metal, either molds in die-casting machines or forging dies, need to retain hardness at high temperatures to resist scour. The former may contain up to 7.5% chromium and an equal amount of tungsten. Tungsten in the latter formerly ran as high as 10%, but economics have forced the metallurgists to economize in alloy content. Very successful hot die steels contain 0.40% carbon, 5% chromium. 1.25% molybdenum and 0.5% vanadium.

Since there is a nearly constant relationship between hardness and strength, it may be appreciated that a steel which is hard, even when hot, will simultaneously be strong at high temperature. Hence it is that sheets rolled of hot die steel are most useful for high-speed aircraft and missile parts where working temperatures do not exceed 950° F. Its tensile strength at 800° F.. for example, is 220.000 lb. per square inch. By comparison, the best of the higher alloy stainless steels has a tensile strength of 150,000 p.s.i. at 800° F.

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TOOMBS, ROBERT (1810–1885), U.S. political leader, was born near Washington, Ga., on July 2, 1510. He was educated at Franklin college (University of Georgia), at Union college, Schenectady, N.Y., from which he graduated in 1828, and at the lam school of the University of Virginia. He was admitted to the bar in 1830, served in the Georgia house of representatives (1838, 1840–41 and 1843–44), in the U.S. house of representatives (1845–53) and in the United States senate (1853–61). He supported the Compromise Measures of 1850. denounced the Nashville convention. opposed the secessionists in Georgia and helped frame the Georgia platform (1850). He and the southern unionists thought secession not wrong but inexpedient. When the Whig party dissolved, Toombs went over to the Democrats. He favoured the Kansas-Nebraska bill, the admission of Kansas under the Lecompton constitution and the English bill (1858) and on June 24, 1856, introduced in the senate the Toombs bill, which proposed a constitutional convention in Kansas under conditions acknowledged by antislavery leaders as fair and marking the greatest concessions by the proslavery senators during the Kansas struggle. The failure of the bill to provide for the submission of the constitution to popular vote was the crux of the Lecompton struggle *(see* KANSAS). On Dec. 22, after the election of Lincoln, he sent a telegram to Georgia which urged "secession by the 4th of March next." With Gov. Joseph E. Brown he led the fight for secession. His influence induced the "old-line Whigs" to support immediate secession. He was secretary of state in President Davis' cabinet and then entered the army (July 21, 1861), serving as a brigadier general in the army of northern Virginia and, after 1863, as adjutant and inspector general of Gen. G. W. Smith's division of Georgia militia. After two years in Cuba. France and England, he returned to Georgia in 1867. He died on Dec. 15. 1885.

TOOTHACHE TREE: *see* PRICKLY ASH.

TOOTHWORT, the popular name for a small British plant of curious form and growth, known botanically as *Lathraea squamaria* (family Orobanchaceae). It grows parasitically on roots, chiefly of hazel, in shady places such as hedge sides. It consists of a branched whitish underground stem closely covered with thick fleshy colourless leaves, which are bent over so as to hide the under surface; irregular cavities communicating with the exterior are formed in the thickness of the leaf. On the inner wall of these chambers are stalked hairs. The only portions that appear above ground are the short flower-bearing shoots, which bear a spike of two-lipped dull purple flowers. The scales which represent the leaves secrete water. *Lathrnea* is closely allied to broomrapes *(Orobanclze),* of which seven species occur in Great Britain; they also are parasitic. In the United States various species of *Dentaria,* family Cruciferae, are called toothwort.

TOOWOOMBA, a city in the southeast of Queensland, Austr., at an altitude of nearly 2,000 ft. on the Darling Downs, 101 mi. by rail and 84 mi. by road west of Brisbane. It is an industrial centre, pop. (1954) 43,149. It is a summer resort ("The Garden City of Queensland"), on the main Southern and Western Railway lines which connect it with Brisbane and Sydney, and a centre for much of the agricultural and pastoral produce of the Darling Downs, besides the wheat, fruit and pastoral products of the Roma and Charleville areas.

There are butter and cheese factories, one of the largest bacon factories in the southern hemisphere, engineering works and coal mines in the Toowoomba region. Milk production is on a large scale.

TOP, a toy having a body of conical. circular or oval shape. often hollow. with a point or peg. usually metal, on which it turns or is made to whirl. If given a knock. a spinning top will go round in a circle at a slant; if spun with a slant at the start. it will quickly stand upright till halted by friction. Some tops, as the common peg top, are spun by means of a cord. Whipping tops are kept spinning by whips with a lash. Other tops are spun by a twist of the hand or the action of a spring or a plunger. Some hollow tops, such as the thunder tops of Japan, have holes cut in them to produce a hum or roar.

Tops were known to the ancients. The Greek *bemble* mentioned in Aristophanes' *Eirds* was evidently a whipping top. Plato, in the *Republic,* mentions *stoblos,* a humming top spun by a string. In Homer the word *stombos* seems to point to a humming top. The Latin word *turbo* and the Greek *rhombos* are sometimes translated by "top" when they refer to the instrument used in the Dionysiac mysteries, something like a bullroarer (*q.v.*), which was whirled in the air by a string to make a booming noise. The Romans made tops out of boxwood or terra cotta. Virgil, in the *Aeneid,* compares Queen Amnta, poisoned by a Fury, to a "whip-top whirling under the twisted lash."

Tops have also long been known in the east where they were made out of such natural materials as conch shells. gourds, nuts, bamboo and stone. In Japan, top spinning or *koma asobi* has for centuries been a pastime of adults as well as children. There are street top players who earn money by making tops run along strings, etc.

Potaka, or top playing is a favourite pastime of Maori men and boys. These tops, often beautifully inlaid with shell. are sometimes pointed at both ends and made to reverse by means of a whip. *Potaku tukiri* or humming tops were made from small gourds and because of their loud wailing sound, were used in ceremonial mourning of the dead or to avenge a defeated clan. In Borneo very large wood tops often have a spindle seven inches long. In the Solomons, they are made of large hard nuts.

The top was known in Europe as early as the 14th century and in Shakespeare's day a large village top was often kept for use in cold weather as a warming-up exercise. During Napoleon's time a Chinese game known for centuries as *Koen-gen* was introduced as diabolo and became the rage. The spool or devil was whipped up by a cord, tossed up by the player and caught again on the cord. During the 18th century the hexagon *teetotum* (known to the ancient Greeks and Romans) was used in place of forbidden dice. Tops are still popular and a top of plastic and metal often plays choral reeds and changes colours while spinning.

For scientific properties of the top, *see* GYROSCOPE.

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TOPAZ is a mineral used as a gem stone, and is of some industrial value as a raw material for refractories, sharing with kyanite and similar minerals the property, when heated to the proper temperature, of conversion to mullite (*q.v.*). Chemically it is a fluosilicate of aluminum in which part of the fluorine may be replaced by hydroxyl, the formula being $Al_2SiO_4(F,OH)_2$. With this range in chemical composition there is a slight variation in the specific gravity (3.5–3.6) and in the optical properties. Topaz is the standard for hardness of 8 on the Mohs' scale (*q.v.*). It is infusible and is insoluble in acids. It is formed through the agency of fluorine-bearing vapours given off during the last stages in the crystallization of igneous rocks, and typically occurs in cavities in rhyolites and granite, in pegmatite dikes and in high-temperature veins. It is often associated with the tin-bearing mineral cassiterite, and thus can be useful as an indication of the presence of tin ore.

Topaz is orthorhombic, and the crystals are usually prismatic in habit, with several dome and pyramid faces. The prism faces are striated vertically, in contradistinction to quartz in which the prism faces are striated horizontally. Usually the crystals are attached at one end in the rock cavities in which they were formed, and when detached from the matrix they often break along a flat surface parallel to the basal plane. This perfect cleavage is an important character, and enables topaz to be distinguished at sight from other minerals of similar appearance. The ,cleavage flakes when examined in convergent polarized light show a good biaxial interference figure.

The crystals are often perfectly colourless and water clear, but owing to the presence of traces of various colouring matters they may show a wide range of colours—red, yellow, brown, green, blue. Further, some of these colours are not stable. The fine brown crystals from pegmatite veins in Transbaikalia, Siberia, and the smaller wine-yellow crystals occurring in rhyolite in Colorado and Utah, fade on exposure to light; and the sherry-yellow crystals from Brazil assume a fine pink colour when they are heated.

The sherry-yellow crystals of topaz, which in the past have been cut and extensively used in jewelry, are all from the neighbourhood of Ouro Preto, in Brazil; ,and it is this material that has supplied the pink ("burnt") topaz.' Brazil also supplies colourless and pale-blue topaz. Good crystals of pale-blue and green colours have come from the Ural mountains and from Nerchinsk in Siberia. Colourless waterworn crystals and clear pebbles resembling rock crystal are abundant in the alluvial deposits of tin ore in northern Nigeria, and small colourless crystals are well known from the Cornish tin mines. Some crystals are large; one, of transparent material, weighing almost 600 Ib., from a pegmatite in Brazil. is on exhibition in the American Museum of Natural History, New York. *See* also GEM. (L. J. S.; B. H. M.; X.)

TOPE, name given to various tumuluslike structures in India, almost aluays connected with Buddhist shrines or sites and forming, undoubtedly, the most primitive type of Buddhist temple. They are usually built over, enclose one or more relics of Buddha, and consist of a low, vertical, cylindrical wall or drum surmounted by a solid conical mass of carefully built masonry. The most famous of the Indian topes is the largest of a group at Sanchi, which is generally attributed to the time of Asoka (3rd century

B.C.). In this the tope proper is surrounded by a circular walk, around which is a richly decorated stone fence, pierced by four lavishly sculptured gateways, the whole designed in forms manifestly reminiscent of wooden construction. (See INDIAN ARCHITECTURE.) The Sanskrit word for a tope, stupa (*q.v.*), is used generally of various types of sacred Buddhist structures in China, Japan, Java, etc., which all have the common characteristic of being high circular masses of solid masonry. Those of Tibet and China are often remarkable for their fantastic profiles.

TOPEKA, capital city of Kansas, and the counfy seat of Shawnee county, is in the east central part of the state 70 mi. W. of Kansas City. The name Topeka is of American Indian origin; one version meant "Smoky Hill." The present site was chosen in 1854 by a group of antislavery colonists from Lawrence, Kans., under the direction of Charles Robinson, a resident agent of the New Englancl Emigrant Aid company. Cyrus K. Holliday helped to found the city uhich later became headquarters for the building of the Atchison, Topeka and Santa Fe railway system. of nhich he was first president. Prior to the Civil War Topeka was the scene of several conflicts between the free soil and slave interests in Kansas territory, of which it was the temporary capital. The city became the permanent capital of Kansas in 1861 and was designated a first class city in 1881.

Topeka covers a land area of 12.5 sq.mi. and is known for its wide streets and avenues which are well shaded in the residential areas. The population has three main sources of income: a rich agricultural area, manufacturing and governmental services. Of the 48.000 wage and salaried personnel, over 12,000 are employed by some governmental agency. Approximately 8.000 persons are employed in over 200 manufacturing plants. Goodyear Tire and Rubber, the Dupont company and Forbes air base are leading employers and several insurance companies have home and regional offices there. The area is served by the Topeka Capital and the State Journal.

The Menninger foundation has made Topeka a national centre for the treatment of mental illness The foundation has become an important psychiatric training school for the medical profession. There are six major hospitals in the city. Washburn Municipal university, founded in 1865 and made municipal in 1941, is known for its well established law school. The Mulvane art museum is located on the Washburn campus. The state capitol, modeled after the national capitol (1866–1903) is in the centre of the business district. The J. Stewart Curry and the David Overmeyer murals are in the capitol. The Kansas State Historical society's memorial building, located east of the capitol, has an extensive historical collection for research and a modern museum. The city has many churches and is the seat of an Episcopal diocese.

Topeka maintains a year-round supervised recreational program. There are many spacious parks. Lake Shawnee is a boating and picnic area. Gage park has the Reinsch collection of over 20.000 roses. The city is the home of the Topeka Hawks. of the western baseball league, and the Kansas free fair. The municipal auditorium is used for the civic theatre and symphony concerts.

Pop. (1960) city, 119,484; standard metropolitan statistical area (Shawnee county) 141,286. For comparative city population figures see table in KANSAS: Population. (A. B SR.)

TOPETE, JUAN BAUTISTA (1821–1885), Spanish naval commander and politician, was born in Mexico on May 24, 1821. His father and grandfather were also Spanish admirals. He entered the navy at the age of 17, cut out a Carlist vessel in 1839, became a midshipman at 22, obtained the cross of naval merit for saving the life of a sailor in 1841 and became a lieutenant in 1845. He served on the West Indian station for three years, and was engaged in repressing the slave trade before he was promoted frigate captain in 1857. He was chief of staff to the fleet during the Morocco War, 1859, after which he got the crosses of San Fernando and San Hermenegildo. Having been appointed chief of the Carrara arsenal at Cádiz, he was elected deputy and joined the Union Liberal of O'Donnell and Serrano. He was sent out to the Pacific in command of the frigate "Blanca," and was present at the bombardment of Valparaiso and Callao, where he was badly wounded, and in other engagements of the war against Chile and Peru. On his return to Spain, Topete was made port captain at Cádiz, which enabled him to assume the leadership of the conspiracy in the fleet against the Bourbon monarchy. He sent the steamer "Buenaventura" to the Canary isle for Serrano and the other exiles; and when Prim and Sagasta arrived from Gibraltar, the whole fleet under the influence of Topete took such an attitude that the people, garrison and authorities of Cádiz followed suit. Topete took part in all the acts of the revolutionary government, accepted the post of marine minister, was elected a member of the *cortes* of 1869, supported the pretensions of Montpensier, opposed the election of Amadeus, sat in several cabinets of that king's reign, was prosecuted by the Federal republic of 1873 and again took charge of the marine under Serrano in 1874. After the Restoration Topete for some years held aloof, but finally accepted the presidency of a naval board in 1877, and sat in the Senate as a life peer until his death on Oct. 29, 1885 at Madrid.

TOPFFER, RODOLPHE (1799–1846), Swiss writer and artist, son of the painter Adam Topffer, was born at Geneva on Jan. 31,1799. Abandoning his art studies on account of weak eyesight, he became a teacher, eventually establishing a school of his own (1824), which attracted boys from England and America as well as from other European countries. He was the first to introduce schoolboy tramps in the Alps, and he described these in his Voyages *en* Zigzag, illustrated by clever drawings by himself. From 1832 till his death, on June 8, 1846, he was professor of belles-lettres at the university of Geneva. He wrote various novels and short stories, including the exquisite little masterpiece, La *Bibliothèque* de mon *Oncle* (1833). His tales were collected under the title Nouvelles *Génevoises* (1841), and several have been translated into English. His series of humorous drawings with explanatory text (Doctor *Festus,* Monsieur Vieux-Bois, etc.), collected under the title of Histoires en *Estampes* (1846–47), were very popular and earned the cordial approbation of Goethe.

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TOPOLOGY, ALGEBRAIC. This branch of topology, also described as "combinatorial," is characterized by the extensive use of algebraic techniques for the solution of topological problems. Although isolated examples of its methods may be found in the work of various mathematicians of the 19th century, the first person to attempt to develop the subject systematically was the French mathematician Henri Poincaré in a series of papers written from 1895 to 1905. Since then the subject has grown at an increasing rate and has had important influence on the other principal branches of mathematics.

The aim of this article is to consider some typical problems in the field and then apply homology theory, the core of algebraic topology, to the solution of these problems. For a general background in the subject and an explanation of technical terms see TOPOLOGY, GENERAL.

Typical Problems. — The following examples were chosen as representative yet not too technical.

Example 1.—By a "plane domain" is meant an open, connected subset of the plane of ordinary Euclidean geometry. Given any two plane domains, one can ask whether or not they are homeomorphic, or topologically equivalent (see TOPOLOGY, GENERAL: *Homeomorphism*). Examples of plane domains are shown in fig. 1. It seems reasonable to conjecture that the domains represented in 1(A) and 1(B) are homeomorphic, as are those in 1(C) and 1(D), but that no other pair of these domains is homeomorphic. The use of homology theory to prove the last part of this statement is indicated below.

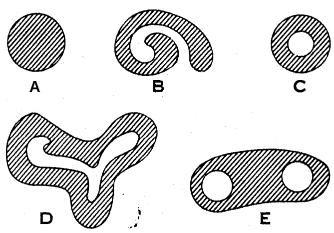

FIG I — EXAMPLES OF PLANE DOMAINS (see TEXT)

Example 2.—In a similar manner, given two closed surfaces in ordinary Euclidean three-dimensional space (3-space), we can ask whether or not they are homeomorphic. Examples of closed surfaces in 3-space are those of a sphere an egg, a cube. a torus (a doughnut-shaped surface, see fig. 2(A)) and the surfaces pictured in fig. 2(B) and 2(C). Later it will be proved that no two of the closed surfaces shown in fig. 2 are homeomorphic and that none of them is homeomorphic to the suriace of a sphere.

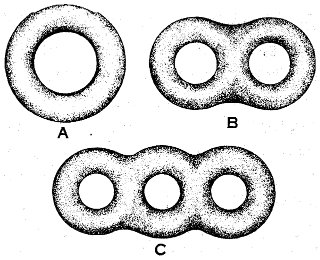

FIG. 2.— EXAMPLES OF CLOSED SURFACES (*see* TEXT)

Examples 1 and 2 both have higher-dimensional analogues. Instead of considering domains in the plane, one could consider' domains in Euclidean 3-space, or more generally, in Euclidean n-space for any integer n. Instead of closed surfaces. once could consider their three-dimensional analogues: which are called "closed three-dimensional manifolds." or even their n-dimensional analogues, called "closed n-dimensional manifolds" (see MANIFOLDS).

In order to describe the next example it is convenient to introduce some conventions of notation and terminology. Recall that a circle of unit radius with centre at the origin of a given co-ordinate system in the plane is the set of all points (x_1, x_2) which satisfy the equation $x_1^2 + x_2^2 = 1$. Similarly the unit sphere with centre at the origin of a given co-ordinate system in 3-space is the set of all points (x_1, x_2, x_3) which satisfy the equation $x_1^2 + x_2^2 + x_3^2 = 1$. In an analogous manner we define the unit n-sphere, S^n, to be the set of all points $(x_1, x_2, \ldots, x_{n+1})$ in Euclidean $(n+1)$-space which satisfy the equation $x_1^2 + x_2^2 + \ldots + x_{n+1}^2 = 1$. Thus S^1 is a unit circle and ST is the unit sphere in 3-space. The set of points in $(n+1)$-space which lie inside or on the unit n-sphere will be called the $(n+1)$-dimensional ball, E^{n+1}. To be precise, E^{n+1} is the set of all points $(x_1, x_2, \ldots, x_{n+1})$ in $(n+1)$-dimensional space which satisfy the inequality $x_1^2 + x_2^2 + \ldots + x_{n+1}^2 \leqq 1$. Thus E^2 is the disk in the plane which is bounded by the unit circle, and E^3 is the solid ball in 3-space bounded by the unit sphere. Note that according to the definitions stated above. S^n is a subset of E^{n+1}.

Example 3.—Consider the following question: Does there exist a continuous map f of the $(n+1)$-dimensional ball E^{n+1} onto the n-sphere S^n such that for any point p of S^n, $f(p) = p$? If one tries to visualize geometrically what the existence of such a continuous map would mean for $n = 1$ and $n = 2$, geometrical intuition strongly suggests that such a map cannot exist in these two cases. In fact it is a theorem of algebraic topology that such a map cannot exist for any value of n. Indications of the proof are given below.

Why should there be any interest in such a theorem of a negative nature? One reason is that it is representative of one of the most important problems of algebraic topology (see *Homotopy Theory,* below); another is that it implies one of the classical theorems of algebraic topology. the fixed-point theorem of L. E. J. Brouwer. This theorem asserts that any continuous map g of the n-dimensional ball E^n into itself has at least one fixed point. *i.e.,* a point x such that $g(x) = x$. To prove this assume the contrary: that there exists a continuous map g of E^n into itself which has no fixed points, *i.e.,* the points x and $g(x)$ are always distinct. Then define a continuous map f of E^n into the boundary sphere S^{n-1} as follows: for any point x of E^n, $f(x)$ is to be the point of intersection of the straight line through x and $g(x)$ with the sphere S^{n-1}. Moreover, $f(x)$ is to be chosen so that either x lies between $f(x)$ and g (~)or $f(x)$ and x coincide. (The situation for $n = 2$ is illustrated in fig. 3.) It can be shown that the map f is continuous and it is clear that for any point x of S^{n-1}, $f(x) = x$. But the existence of such a map f of E^n into S^{n-1} contradicts the theorem above. Thus the assumption that g has no fixed points is false and Brouwer's theorem is established. Although Brouwer's theorem is very plausible for the cases $n = 1$, 2 or 3, the advantage of the methods of algebraic topology is that it is proved for all integers n at once.

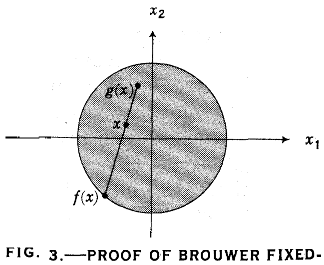

FIG. 3.—PROOF OF BROUWER FIXED-POINT THEOREM (see TEXT)

There is great mathematical interest in fixed-point theorems such as Brouwer's because they have been used in various other branches of mathematics (*e.g.,* differential equations, the theory of games) to establish fundamental existence theorems.

The Homology Groups.—In homology theory one studies closed curves, closed surfaces and similar geometric configurations in a given topological space. Simple examples show that such a study is likely to reveal important topological information about the space in question. For example. the spherical surface S^2 has the property that any simple closed curve separates it into two domains. On the other hand, on the torus there are simple closed curves which do not separate it into two domains. These are basic topological properties of the sphere and torus and show that they are not homeomorphic.

Orientation.—The curves, surfaces, etc.. which one considers in homology theory are usually "oriented." To orient a curve or line segment, place an arrow on it indicating the positive direction. To orient a surface or domain on a surface one must choose which direction of rotation (around small circles in the surface) is to be considered positive. There are two possible ways of orienting a curve or surface and the choice is purely arbitrary. The two orientations possible for a certain plane domain are indicated in fig. 4. (Nonorientable surfaces exist but are not considered here; see MANIFOLDS.) If we assign an orientation to a piece of a surface bounded by one or more curves. then the orientation of the surface in turn induces an orientation of the bounding curves in an obvious way. In fig. 3 the induced orientations of the boundary curves of the region are indicated in the two possible cases.

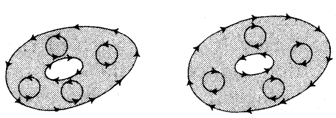
FIG. 4.— THE TWO POSSIBLE ORIENTATIONS OF A PLANE DOMAIN AND THE INDUCED ORIENTATIONS OF THE BOUNDARY CURVES

Considerations of orientation can be extended to regions in 3-space, or more generally, to three-dimensional manifolds and regions in three-dimensional manifolds. There are various ways of doing this. One way is by consideration of screw threads or spirals (like a spiral staircase) in the given region. Spirals may be right-handed or left-handed. In orienting the region one of the tno types of spirals is designated as the positive type; again the choice is entirely arbitrary.

It is easy to devise rules for specifying the induced orientation of the bounding surfaces of an oriented three-dimensional domain; we assume that this has been done. The situation is similar to that of the induced orientation of the boundary curves of an oriented tno-dimensional domain on a surface.

Questions of orientation occur in branches of mathematics other than topology—as, for example, in the discussion of line integrals, surface integrals and volume integrals in calculus. The correct staternenti of the well-known theorems of Carl Friedrich Gauss, George Green and Sir George Gabriel Stokes about these integrals require certain assumptions regarding orientation.

These definitions of orientation can be extended to n-dimensional manifolds or regions in such manifolds Naturally for values of $n > 3$ the ordinary geometric intuition is useless. The definitions are of necessity of a more formal nature. based on analogy nith the one-, tno- or three-dimensional case. It is not possible to go into this matter in the present article.

Definition of *Homology Groups:* Cycles.—The first step in the definition of the homology groups of a topological space X is the definition of a cycle in X. A one-dimensional cycle (1-cycle) in X is an expression of the form

$$z = \alpha_1 C_1 + \alpha_2 C_2 + \ldots + \alpha_k C_k$$

where $\alpha_1, \alpha_2, \ldots, \alpha_k$ are integers (positive, negative or zero) and $C_1, C_2, \ldots, C_k$ are oriented closed curves in X. A two-dimensional cycle (2-cycle) in X is an expression of the form

$$z = \alpha_1 S_1 + \alpha_2 S_2 + \ldots + \alpha_k S_k$$

where the α_1's ere integers and $S_1, S_2, \ldots, S_k$ are oriented closed surfaces in X. A three-dimensional cycle (3-cycle) in X is an expression of the form

$$z = \alpha_1 M_1 + \alpha_2 M_2 + \ldots + \alpha_k M_k$$

where once again the a's are integers and $M_1, M_2, \ldots, M_k$ are oriented closed 3-manifolds in X. One could define in an analogous manner n-dimensional cycles in X for every positive integer n.

These definitions call for tno observations. First, the curves, surfaces and 3-manifolds in the above definitions must be allowed to have self-intersections and various other singularities. Secondly, a reversal of the orientation of a curve, surface or 3-manifold occurring in the expression for a cycle is assumed to have the same effect as changing the sign of that particular term in the cycle. For example, if C_1 and C_1' denote the same curve but with opposite orientations, then

$$\alpha_1 C_1 + \alpha_2 C_2 = -\alpha_1 C_1' + \alpha_2 C_2$$

Cycles are added and subtracted in an obvious way. For example, if $z = \alpha_1 S_1 + \alpha_2 S_2 + \ldots + \alpha_k S_k$ and $z' = \alpha_1' S_1 + \alpha_2' S_2 + \ldots + \alpha_k' S_k$ are 2-cycles in X, then

$$z + z' = (\alpha_1 + \alpha_1')S_1 + (\alpha_2 + \alpha_2')S_2 + \ldots + (\alpha_k + \alpha_k')S_k$$

and

$$z - z' = (\alpha_1 - \alpha_1')S_1 + (\alpha_2 - \alpha_2')S_2 + \ldots + (\alpha_k - \alpha_k')S_k$$

With these definitions it is clear that the set of all 1-cycles in X is a commutative group (*see* GROUPS) under the operation of addition. Similarly the set of all 2-cycles in X and the set of all 3-cycles in X are commutative groups.

Note that the set of boundary curves of an oriented domain on a surface in X may be considered as a 1-cycle in X if each of the boundary curves is given the orientation induced by the orientation of the domain and assigned the coefficient $+1$. Such a cycle will be called a bounding 1-cycle in X. More generally, a cycle which is a sum of cycles of this type will also be called a bounding 1-cycle in X. Not every 1-cycle need be a bounding cycle; consider, for instance. the case in which X is a torus.

Similarly. starting with the set of bounding surfaces of an oriented three-dimensional domain in X one can define the concept of a bounding 2-cycle. One could imagine the definition of a bounding 3-cycle, although there are complications when extending this concept to higher dimensions. The remarks about bounding 1-cycles in the preceding paragraph also hold for bounding cycles of dimension 2 or 3. Note that by the very definition the set of all bounding cycles in any dimension is a subgroup of the group of all cycles in that dimension.

Homology Classes.—Two cycles z_1 and z_2 are said to be homologous (notation: $z_1 \sim z_2$) if their difference $z_1 - z_2$ is a bounding cycle. This is an equivalence relation and may be used to separate all the cycles of any given dimension into homology classes: two cycles belong to the same homology class if, and only if, they are homologous. The homology relation has the important property of being compatible with the addition of cycles. By this is meant that if $z_1 \sim z_2$ and $y_1 \sim y_2$, then $y_1 + z_1 \sim y_2 + z_2$. Because of this the addition of cycles may be used to define the addition of homology classes. To be precise, if u and v are homology classes in X, to define their sum $u + v$ one chooses representative cycles y and z from the homology classes u and v respectively and defines $u + v$ to be the homology class of $y + z$. This definition is independent of the choice of the representative cycles. It is seen that the addition between homology classes thus defined satisfies all the axioms of a group. Thus the following groups have been defined: the one-dimensional homology group of X, denoted by $H_1(X)$; the two-dimensional homology group of X, $H_2(X)$; etc. These groups are basic to all iurther developments in algebraic topology; it is hard to overestimate their importance. Actually there is not much interest in the cycles as such; it is rather the homology classes of cycles that are important.

Let us consider the homology groups of the spaces mentioned in Examples 1 and 2. In the plane domains considered in Example 1, the two-dimensional and all higher-dimensional homology groups are trivial groups (consisting of the zero element alone) because there are no bona fide two-dimensional (or higher-dimensional) cycles. Thus the main interest is in the one-dimensional homology group. In the domains illustrated in fig. 1(A) and 1(B) every 1-cycle is a bounding cycle; hence the one-dimensional homology group is trivial. This is not true of the domains illustrated in fig. 1(C) and 1(D). however. In these cases the one-dimensional homology group is infinite cyclic (*i.e.,* isomorphic to the group of integers under addition'). This situation may be described more precisely as follows: Choose an oriented closed curve C that goes around the hole in the domain exactly once; then every one-dimensional homology class contains a unique cycle a.C for some integer a.

The one-dimensional homology group of the domain shown in fig. 1(E) has a slightly more complicated structure. If one chooses oriented closed curves C_1 and C_2 in this domain such that C_1 goes around one of the holes exactly once and C_2 goes around the other hole once, then every one-dimensional homology class contains a unique 1-cycle of the form $\alpha_1 C_1 + \alpha_2 C_2$, where α_1 and α_2 ark integers.

Since spaces which are homeomorphic must obviously have isomorphic homology groups. these considerations show that the domains in fig, 1(A) and 1(C) cannot be homeomorphic. nor can the domains in fig. 1(C) and 1(E), for example.

For closed surfaces in 3-space, such as those considered in Example 2 above, the two-dimensional homology group is infinite cyclic. In each case the entire surface, when given an orientation and assigned a coefficient. is a 2-cycle which is not bounding. The three-dimensional homology group is trivial in each case because there cannot be nonzero 3-cycles in a 2-space. The one-dimensional homology groups are different in the diiferent cases, however. For the case of a spherical surface the group is trivial; every 1-cycle is a bounding cycle. In the case of a torus it is a group with two generators, isomorphic to the one-dimensional homology group of the domain shown in fig. 1(E). One may choose as generating cycles oriented circles C_1 and C_2 which lie in planes perpendicular to each other. each of which goes around the torus exactly once and which intersect in a single point. Then any 1-cycle is homologous to a unique cycle of the form $\alpha_1 C_1 + \alpha_2 C_2$.

The one-dimensional homology group of the surface in fig. 1(B) has four independent generators. and that in fig. 1(C) has six.

Note that these considerations show that no two of these surfaces are homeomorphic since their one-dimensional homology groups are nonisomorphic.

The Homomorphism Induced by a Continuous Map.— Suppose that X and Y are topological spaces and f is a continuous mapping of X into Y (notation: $f: X \to Y$). If C is a closed curve in X, then the image of C under f (denoted by $f(C)$) is a closed curve in Y. Moreover if C is oriented, this orientation is carried over to $f(C)$ by the map f in an obvious way, so we may consider $f(C)$ as an oriented closed curve. This suggests the iollowing definition: If $z = \alpha_1 C_1 + \alpha_2 C_2 + \ldots + \alpha_k C_k$ is any 1-cycle in X, then let

$$f_{\#}(z) = \alpha_1 f(C_1) + \alpha_2 f(C_2) + \ldots + \alpha_k f(C_k)$$

It is clear that $f_{\#}(z + z') = f_{\#}(z) + f_{\#}(z')$ for any 1-cycles z and z' in X. Thus $f_{\#}$ is a homomorphism of the group of 1-cycles of X into the group of 1-cycles of Y. Furthermore this homomorphism sends bounding cycles into bounding cycles. This follows from the fact that the image of an oriented piece of surface in X bounded by several curves is carried by f into an oriented piece of surface in Y bounded by the image curves. As a consequence homologous cycles are carried into homologous cycles by $f_{\#}$ and all the cycles in any homology class are mapped into a single homology class. Thus $f_{\#}$ induces a homomorphism of the homology group $H_1(X)$ into the homology group $H_1(Y)$, denoted by f_*: $H_1(X) \to H_1(Y)$.

In a similar manner the function f induces homomorphisms f_*: $H_2(X) \to H_2(Y)$, $H_3(X) \to H_3(Y)$, etc. The details are exactly the same as in the one-dimensional case.

The homomorphisms of homology groups induced by continuous maps are as important as the homology groups themselves. Applications of this concept to one of the examples given above are shown below. First, it is necessary to note that these induced homomorphisms satisfy the following two rather obvious but important conditions:

1. Let $i:X \to X$ be the identity map of the space X, *i.e.*, $i(x) = x$ for any point x in X. Then the induced homomorphism $i_*:H_n(X) \to H_n(X)$ is also the identity, *i.e.*, $i_*(u) = u$ for any homology class u.

2. Let X, Y and Z be topological spaces and $f:X \to Y$, $g: Y \to Z$ be continuous maps. Define a continuous map $h:X \to Z$ by $h(x) = g[f(x)]$ for any point x of X; for brevity one often writes $h = gf$. The map h is called the composition of f and g. Then the induced homomorphism $h_*:H_n(X) \to H_n(Z)$ is the composition of the homomorphisms $f_*:H_n(X) \to H_n(Y)$ and $g_*: H_n(Y) \to H_n(Z)$, *i.e.*, $h_*(u) = g_*f_*(u)$ for any homology class u in X, or more briefly; $h_* = g_*f_*$. The proof of these conditions can be left to the reader.

As an application of these ideas the theorem mentioned in connection with Example 3, above, can be proved. Assume that there exists a continuous map $f:E^{n+1} \to S^n$ such that $f(x) = x$ for any point x in S^n. It will be demonstrated that this assumption leads to a contradiction. thus establishing the theorem. In the course of the proof. the following facts about the homology groups of the spaces E^{n+1} and S^n are needed: (a) all the homology groups of E^{n+1} are trivial groups (*i.e.*, they contain only the zero element); (b) the homology group $H_n(S^n)$ is infinite cyclic. These two facts are certainly plausible in case $n = 1$ or $n = 2$; methods of proving facts like this are discussed below.

Now let $g:S^n \to E^{n+1}$ be the continuous map defined by $g(x) = x$ for any point x of S^n. Let $h = fg$ denote the composition of g and f. The hypothesis that $f(x) = x$ for any point x of S^n implies that $h:S^n \to S^n$ is the identity map of S^n. Then apply the two fundamental properties of induced homomorphisms mentioned above. By property (1), $h_*:H_n(S^n) \to H_n(S^n)$ is the identity homomorphisnl. By property (2), h_* is the composition of the homomorphisms $g_*:H_n(S^n) \to H_n(E^{n+1})$ and $f_*:H_n(E^{n+1}) \to H_n(S^n)$. But this is impossible since $H_n(S^n)$ has an infinite number of distinct elements, while $H_n(E^{n+1})$ consists of the zero element alone. Thus the theorem is established.

In the description of homology theory in the preceding paragraphs it may be observed that the definitions lack mathematical precision at certain points. This is especially noticeable when one tries to define n-dimensional homology groups for $n > 2$ by these methods. Although details cannot be given in the present article. there are methods of avoiding these difficulties. Completely rigourous definitions of the terms "n-dimensional cycle in X," "bounding cycle" and "n-dimensional homology group" are given in textbooks.

Determination of the Homology Groups of a Space.—In each of the preceding examples of the application of homology theory to a topological problem it was necessary to know the structure of certain homology groups. The purpose of the present section is to give brief descriptions of methods of obtaining such information.

In certain cases a topological space can be cut into small pieces of very simple type. For example, a closed surface such as that shon-n in fig. 2 could be cut into small triangular pieces. Analogously, a closed 3-manifold could be dissected into small tetrahedra. Whenever it is possible to chop a topological space into sections (line segments, triangles: tetrahedra and their higher-dimensional analogues) that fit together nicely, it is possible to determine the structure of the homology groups from the dissection by following a routine procedure. The method is of great theoretical but little practical importance because of the lengthy computations involved.

If A is a closed subset of a topological space X, and $X - A$ is the complement of A ($X - A$ is an open subset of X), then certain relations must hold between the homology groups of $A, X - A$ and X. These relations are expressed by means of something called an "exact sequence of groups and homomorphisms." which is a concept of great importance in the further development of algebraic topology.

If A and B are closed subsets of a space X such that the union of A and B is the whole space X, then certain relations must hold between the homology groups of the four spaces X, A, B and $A \cap B$ (here $A \cap B$ denotes the intersection of A and B). Once again this relation is expressed by means of an exact sequence of groups and homomorphisms, which is called the "Mayer-Vietoris sequence" in this case.

If X is the product of two spaces A and B (*i.e.*, $X = A \times B$), then the homology groups of X can be computed explicitly if the homology groups of A and B are known. The relations involved are called the "Künneth formulas."

There is a generalization of the notion of product space called a "fibre space" which is of great importance in algebraic topology, differential geometry and algebraic geometry because of its frequent occurrence and many "nice" properties. Roughly speaking, a fibre space is a twisted or a local product space. For example, the product of a circle and a segment is a cylindrical surface, like a belt. By introducing a twist one obtains the one-sided surface known as a Mobius strip (*see* MANIFOLDS: *Möbius Strip;* GEOMETRY: *Topology*).

Locally. 'a Mobius strip is the product of a segment with a piece of a circle but it is not a product space in the large because of the twist. Given two spaces A and B, there is only one way to form the product space $A \times B$, but there are usually many ways to build a fibre space from A and B. Certain relations hold between the homology groups of A and B and those of the various fibre spaces which can be constructed from A and B. These relations are much more complicated than the Kunneth formulas for product spaces.

In the preceding paragraphs we have mentioned various ways of building topological spaces out of simpler spaces and have asserted in each case that certain useful relations hold between the homology groups of the various spaces involved. This is not the only type of information available for determining homology groups, however. For example, one of the most famous theorems of algebraic topology is the Poincaré duality theorem. which asserts that for any closed, orientable, n-dimensional manifold X the homology group $H_q(X)$ is completely determined by the groups $H_{n-q}(X)$ and $H_{n-q-1}(X)$.

Homotopy Theory.—If X and Y are topological spaces, two maps f and g of X into Y are *homotopic* if there exists for each real number t such that $0 \leqq t \leqq 1$ a map $h_t:X \to Y$ such that $h_0 = f$, $h_1 = g$ and the position of the image point $h_t(x)$ depends continuously on both x and t. It is helpful to think of the variable t as representing time. At time $t = 0$, $h_t = f$; at time $t = 1$, $h_t = g$; and during the time interval $0 \leqq t \leqq 1$ the map f is continuously deformed into the map g. The relation of being homotopic is an equivalence relation between maps and it enables one to separate the set of all continuous maps from X into Y into classes, called *homotopy classes;* two maps belong to the same homotopy class if and only if they are homotopic.

Homotopic maps have many properties in common. For example, if f and g are homotopic. then the induced homomorphisms f_* and g_* of $H_n(X)$ into $H_n(Y)$ are the same. This may be seen in case $n = 1$ as follows: Let C be any oriented closed curve in X and let $h_t:X \to Y$ be defined for $0 \leqq t \leqq 1$ and have the properties listed in the preceding paragraph. Consider the various image curves $h_t(C)$. As t varies from 0 to 1, these image curves sweep out a cylindrical surface in Y bounded by the curves $h_0(C) = f(C)$ and $h_1(C) = g(C)$. Taking account of orientations. it is seen that the cycles $f(C)$ and $g(C)$ are homologous. It follows easily that if $z = \alpha_1 C_1 + \alpha_2 C_2 + \ldots + \alpha_k C_k$ is any 1-cycle in X, then $f_\#(z)$ and $g_\#(z)$ are homologous; hence if u is the homology class of z, $f_*(u) = g_*(u)$.

As an example of homotopy classification of maps, consider the case in which $X = S^1$, a circle! and Y is the plane domain shown in fig. 1(C). A continuous map $f:S^1 \to Y$ defines a closed curve in Y. Two such maps (or curves) are homotopic if, and only if, they wind around the hole in the domain the same number of times.

In general, the homotopy classification of maps of a given space X into another given space Y is one of the most difficult yet important problems of algebraic topology. Any solution of particular cases of this problem is likely to have significant implications. In some cases it has been found possible to define an "addition" or "multiplication" of homotopy classes of maps $X \to Y$ so as to obtain a group. If this can be done, the problem of describing the set of all homotopy classes of maps $X \to Y$ becomes the problem of determining the structure of the group of all homotopy classes, which is usually a more precise problem. If $X = S^n$, an n-sphere, then it is always possible to define an addition between homotopy classes of maps $X \to Y$ so as to obtain a group, denoted by $\pi_n(Y)$, and called the nth homotopy group of Y. In case $n =$ I this group is called the fundamental group, or PoincarC group, of Y. The homotopy groups for $n > 1$ were introduced by the Polish mathematician W. Hurewicz in 1935 and have played an increasingly important role in algebraic topology. Although the homotopy groups have many properties which are analogues of properties of homology groups, it is usually much more difficult to determine the homotopy groups than the homology groups.

Alongside the classification of continuous maps into homotopy classes there is a corresponding classification of topological spaces according to homotopy type. Two topological spaces X and Y are of the same homotopy type if and only if there exist continuous maps $f: X \to Y$ and $g: Y \to X$ such that the composed map gf is homotopic to the identity map of X onto itself, and the map fg is homotopic to the identity map of Y onto itself. If X and Y are homeomorphic, then they are of the same homotopy type. However. spaces may be of the same homotopy type without being homeomorphic. A simple example is the circle S^1 and the ring-shaped region in the plane shown in fig. 1(c).

Spaces which are of the same homotopy type have many similar properties. For example, if X and Y are of the same homotopy type, then their homology groups are isomorphic. In fact if $f: X \to Y$ and $g: Y \to X$ are continuous maps such that the composed maps gf and fg are homotopic to identity maps, then the induced homomorphisms $f_*: H_n(X) \to H_n(Y)$ and $g_*: H_n(Y) \to H_n(X)$ are isomorphisms. This may readily be proved on the basis of the properties already listed for the homomorphisms induced by continuous maps.

As the subject of algebraic topology developed and matured, ideas involving the homotopy classification of mappings and the classification of spaces according to homotopy type became more prominent. The re-examination of many of the more significant theorems of algebraic topology showed that they actually concerned entire homotopy classes of maps or all spaces of a certain homotopy type, and so belonged to the domain of homotopy theory. Also the classical problem of trying to find sufficient conditions for two spaces to be homeomorphic seemed impossibly difficult except in a few favourable cases. On the other hand it seemed like a much more reasonable problem to try to obtain sufficient conditions for two spaces to be of the same homotopy type: many results of this kind are known.

The *Extension Problem.*—This is another leading problem of homotopy theory, and it may be stated as follows: Suppose X and Y are topological spaces; A is a closed subset of X; and $h: A \to Y$ is a continuous map. Does there exist a continuous map $g: X \to Y$ such that g is an extension of h, *i.e.,* so that $g(x) = h(x)$ for any point x of A? Example 3, considered above, is really an extension problem. In this example $X = E^{n+1}$, $Y = S^n$, $A = S^n$, and $h: A \to Y$ is the identity map. The use of homology theory to prove the nonexistence of an extension in this example is a typical method of attacking an extension problem. By this method one can obtain necessary conditions for the existence of an extension, which in certain cases are also sufficient.

The homotopy classification problem and the extension problem are inextricably linked together. Any progress on either implies corresponding progress on the other. They are the object of much research in algebraic topology.

Other Topics.—A brief article such as this must of necessity omit many important features. One such topic is homology with coefficientsother than integers. A cycle, as defined above, is an expression of the form $\alpha_1 C_1 + \alpha_2 C_2 + \ldots + \alpha_k C_k$, where the coefficients $\alpha_1, \alpha_2, \ldots, \alpha_k$ are integers. One could equally well allow these coefficients to be rational fractions, real numbers or complex numbers and an analogous homology theory could be developed. More generally, one could choose coefficients from any ring or even from any commutative group. In certain investigations it is quite natural to do this.

Cohomology Theory.—This represents another important modification of homology theory. Although cohomology groups have properties similar to homology groups, they have several important advantages. It is possible, for instance, to define a "product" of cohomology classes (sometimes called the "cup product"). With this product and the usual addition of cohomology classes the direct sum of the cohomology groups of all dimensions becomes a ring, called the cohomology ring. This is definitely a richer algebraic structure than the homology groups and enables one to obtain finer results in many cases.

One can go still further and define various other algebraic operations on cohomology classes which have an invariant topological significance and lead to results not otherwise provable. The most important of these cohomology operations are the Steenrod squares and reduced powers (named after the U.S. mathematician Norman Steenrod) and the Pontrjagin powers (named after the Russian mathematician Leon Pontrjagin). The theory of these operations is extremely complicated. Finally, in certain situations cohomology groups definitely seem more natural than homology groups. For example, the Poincaré duality theorem mentioned earlier is easier to state precisely if cohomology groups are used.

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TOPOLOGY, GENERAL. This branch of mathematics is so fundamental in nature that its influence is apparent in practically every other branch. Topology has also found uses among fields that are not integral parts of the domain of mathematics proper. Thus an intimate relation exists between some aspects of topology and symbolic logic. For applications of fixed-point theorems in mechanics *see* below. An approach to certain problems of psychology has been based on the concept of topological space. Because of its foundation in general-set theory. topology is not limited in its applications to problems of a quantitative character and it may therefore contribute to research in fields, such as the social sciences, that have not been considered susceptible to mathematical treatment.

Despite its basic character topology lacked full development until the advent of the 20th century, although its roots lie in the 19th-century researches of Georg Friedrich Bernhard Riemann, Georg Cantor and Henri PoincarC. Principally because of the geometric aspects of the topological work of Riemann and PoincarC, topology became known as a type of geometry—formerly called analysis situs, or "position analysis"—in which the shape and size of configurations are unimportant, the object of study being rather the "connectivity" of a figure. For example, that a circle is round. a triangle has corners or an ellipse is oval are not of interest from a topological point of view; what matters is that each of these figures is so constituted that (1) the omission of a single point leaves each of them connected (in a sense to be made precise below); and that (2) the omission of two points will in each case disconnect the figure. In topology all such figures—circles, triangles, ellipses, polygons, etc.—are designated by the same term, "simple closed curve."

If one imagines a circular figure made of some pliable material being subjected to stretching and bending of any sort without being torn in the process, then the figure may be said to be unaltered topologically, remaining a simple closed curve throughout the process. Similarly the surface of a sphere and the surface of a cube are topologically equivalent ("homeomorphic") but difier from the surface of the anchor ring or doughnut (torus) in the following manner: if S is the surface of a sphere or cube. then the omission of a simple closed curve in S disconnects S (this is part of the classical Jordan curve theorem); but a simple closed curve on a torus may or may not disconnect it, depending upon the particular simple closed curve chosen. Such properties of curves and surfaces as those exemplified here are topological properties.

The great advances in mathematical research made during the first few decades of the 20th century were to a rapidly increasing extent made possible by concepts which, while not geometrical in the older sense of the term. are evidently topological in nature. In topology itself a change took place which is evidenced in the dropping of the term ,'geometrical configuration" and its synonyms in favour of "point set" and ultimately "topological space." The notion of a configuration made up of a finite set of "pieces" such as straight-line intervals, triangles, etc., emphasized in the geometric combinatorial topology (see TOPOLOGY, ALGEBRAIC) of Riemann and Poincaré. gave way to the Cantorian concept of an organization of individual points, the number of points usually being infinite. It gradually became recognized that any collection of things, be it a set of numbers, algebraic entities? functions or even nonmathematical objects, can constitute a topological space in some sense or other, the degree of utility in such an interpretation being dependent upon the number of topological properties exhibited by the collection. From this realization stem the fundamental importance of topology and its use as a tool even in such investigations as those of the foundations of logic. This is not to imply that the older. geometric aspects lost their importance; it is rather the case that along with the rest of the subject their importance was enhanced by the newer concepts.

For a collection to be assigned a topological character it is sufficient that for each set M of its points the limit points of M 'be specified; then the collection may be called a topological space. The intuitive meaning of this becomes clearer: perhaps, if one returns to the well-known spaces of geometry for an illustration. Consider, for instance, the space in which the figures of ordinary plane geometry are imbedded—the Euclidean plane. denoted by E^2. Considering E^2 as a collection of points. a point p of E^2 may be called a "limit point" of a collection M of points of E^2 if it is true that every circle with centre p encloses points of M (that are different from p if p happens to belong to the collection M). For example. if M is the set of all points enclosed by a triangle T, then every point of T is a limit point of M; also every point of M is a limit point of M. On the other hand, no point exterior to T is a limit point of M, since each such point can bc enclosed in a circle whose interior contains no points of M. In three-dimensional Euclidean space. limit points may be defined similarly, but using spheres instead of circles. The intuitive concept underlying the notion of limit point then is that of nearness. or proximity, a point p being a limit point of a collection of points M if there are points of M arbitrarily near to p. However, the latter would not be an adequate definition since in some topological spaces no such notion as distance exists. In this manner. however, all the well-known spaces of the classical types of geometry become topological spaces. And an important part of topology is devoted to the study of Euclidean spaces and their subsets, as well as their counterparts in more general topological spaces.

Point Sets.—Since the configurations of topology are ultimately considered as being types of organizations of their individual points, and consequently called point sets (*q.v.*), a few of the terms and some of the symbols of set theory (see LOGIC) used in topology are given here.

The fact that a point p belongs to a point set A may be expressed by the relation $p \in A$, which is read "p is an element (or point) of A." A set which has at least two elements is called "nondegenerate": but if it has no elements it is called "empty.!' If the cardinal number of the elements of a set is not greater than that of the infinite set of positive integers. then the set is called "countable." (*See* NUMBER.) If A and B are two sets. their "sum" or "union" (in set-theoretic symbols $A + B$) is the set which consists of all elements x such that $x \in A$, $x \in B$, or both. The "product" or "intersection" of A and B ($A \cdot B$) is the set which consists of all elements x such that $x \in A$ and $x \in B$. (Thus if A and B are two nonparallel straight lines in the plane, their product is a set consisting of a single point.) By the "difference" $A - B$ is meant the set of all elements of A that are not in B; in case B is itself part of A, then B is called a "subset" of A and $A - B$ is called the "complement" of B in A. If A and B have no point in common. they are called "disjoint." See also SET THEORY (THEORY OF AGGREGATES).

Homeomorphism.—A basic notion of topology is that of topological equivalence or homeomorphism and it is this notion that makes precise the sense in which all circles, triangles, etc., in the Euclidean plane E^2 are considered topologically to be the same. Suppose that S and T are two collections in which limit points have been specified (hence topological spaces) and that between the points of S and the points of T there exists a one-to-one correspondence such that (1) if in S a point p is a limit point of a point set A, then in T the point q corresponding to p is a limit point of the point set B which corresponds to A; and conversely (2) if in T a point q is a limit point of a point set B, then in S the point p corresponding to q is a limit point of the point set A which corresponds to B; then S and T are called "topologically equivalent." or "homeomorphic," and the one-to-one correspondence just described is called a "homeomorphism" (between S and T).

The "congruences" of elementary plane geometry are particular cases of homeomorphisms; likewise. similar figures are homeomorphic. But a homeomorphism is a much larger class of correspondences than these represent. Indeed, a simple closed curve may be defined as any topological space that is homeomorphic with a circle, and since in assigning limit points for all subsets of Euclidean space every subset is itself turned into a topological space, this definition permits identification of those configurations in Euclidean space that are simple closed curves; in particular it is easy to see that every polygon is homeomorphic with a circle, and hence a simple closed curve. And similarly. to take a case in three-dimensional Euclidean space, the surface of a sphere is homeomorphic with the surface of a cube.

Topological Properties.—Any property which is definable in terms of the notion of limit point may be called topological. For example. suppose that A and B are disjoint, nonempty point sets (in a topological space) neither of which contains a limit point of the other; then A and B are called "separated." And if a space is not the sum of separated sets, it is called "connected." The property of being connected is topological and is one of the most fundamental properties in topology. All the ordinary configurations of Euclidean geometry are connected. In the second paragraph of this article, property (1) means precisely that the point set which remains when a point is removed from a circle is connected in the sense here defined: and property (2) means that when any two points are removed the resulting point set is not connected; that is. it is the union of separated sets.

One of the most important statements of topological properties of E^2 is the Jordan curve theorem: if J is a simple closed curve in E^2, then $E^2 - J$ is the sum of two separated connected sets A and B such that each point of J is a limit point of both A and B. In this theorem E^2 may be replaced by S^2 n-here S^2 denotes any homeomorph of the ordinary spherical surface (*see* items [1], [2], [10, pp. 154–155], [8], [9], [6] and [7] in bibliography).

Properties nhich relate a subset of a space to the space are often termed relative, or positional. For example. a point set M in a space S is called "closed" (relative to S) if it contains all its limit points in S. The set M of all points enclosed by a circle C in the plane E^2 is not closed (relative to E^2) but the union of M and C is closed. And a subset of a space S is "open" (relative to S) if its complement in S is closed. Such properties are affected by changes in S; a point set M which is closed in S may fail to be closed if new points are added to S, for example.

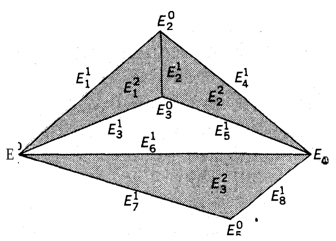
Topological properties of spaces form the basic tools and objects of study in topology. Their significance is made clearer by the concept of topological invariant. Suppose R is a class of topological spaces (see Topological Spaces, below) and consider properties that have significance for the spaces of R. Any such property which, if it holds for one space S of R, holds for every space of R that is homeomorphic with S, may be called a "topological invariant of S in R." The properties defined above, and indeed all topological properties, are topological invariants no matter what the class R of topological spaces may be. However, properties that are invariant in certain classes of spaces may cease to be invariant in larger classes and sometimes properties are investigated in topology about which it is not known for just how large a class of spaces they are invariant.

An important type of problem in topology is the recognition, by means of topological invariants, of the class of configurations to which a given point set belongs. Thus in E^2 the simple closed curve may be characterized by topological invariants as follows: every nondegenerate point set in E^2 which is (a) connected, (b) closed and (c) has properties (1) and (2) of the second paragraph of this article, is homeomorphic with a circle. Similarly, if in addition to (a) and (b) it is known of a point set in S^2 that the removal of any one of its points, with the possible exception of two, disconnects it. then it must be homeomorphic with a finite closed interval of a straight line (such a point set is called an "arc," the two special points which do not disconnect it being called its "end points").

Some invariants are of a numerical nature. Let M be a point set in a topological space and $p \in M$. Then a point x of M may be said to be connected to p in M if some connected subset of M contains both p and x. The set of all points x that are connected to p in M is called a "component" of M; any point of such a component will serve instead of the point p to determine the component. For example. if M consists of two circles having no common point, then M has two components, each of the circles constituting a component. The number of components of a point set is an excellent example of a numerical topological invariant. Numerical invariants occur frequently in algebraic topology.

Some of the aspects of topology that have proved of most importance or excited the greatest interest are described below. Because of its geometric nature and early development historically, the first topic to be considered is that of the topology of polyhedral or combinatorial topology, the beginnings of which are found in the work of Riemann. Enrico Betti and Poincaré.

Combinatorial Topology.—Let **K** denote a configuration in E^2 consisting of a finite collection of triangular-shaped pieces that meet only along entire edges or at vertices. By a "cell" of K is meant either a vertex, an edge or a triangular piece; to differentiate, the term 0-cell is used for vertex, 1-cell for edge and 2-cell for a triangular piece. An r-cell ($r = 0$, 1 or 2) is denoted by E_i^r, where i is an enumerative index. Such a figure, made up of cells. is called a "complex."



EXAMPLE OF A COMPLEX K

For each 2-cell E_k^2 there may be written a "bounding relation" of the form $\partial E_k^2 = E_1^1 + E_2^1 + E_3^1$, where E_1^1, E_2^1 and E_3^1 are the edges of E_k^2. Similar bounding relations may be written for the edges. This leads to a consideration of polynomials whose terms are 1-cells, such as $E_4^1 + E_5^1 + E_7^1 + E_8^1$ (where the coefficients are all understood to be unity as in ordinary algebra).

Such polynomials are called "r-chains" of K, where r is the dimension of the cells involved. In particular the monomial E_1^2 is a 2-chain.

The notion of "boundary chain" may be extended to arbitrary chains. Thus, if C^{r+1} denotes an $(r+1)$-chain. then the boundary chain ∂C^{r+1}, of C^{r+1} is obtained by selecting those r-cells that are present in the boundary chains of an odd number of the $(r+1)$-cells of C^{r+1}; or more concisely, by "adding modulo 2" the boundary chains of these 1-cells. For example. the boundary chain of the chain $E_1^2 + E_2^2$ of the figure is obtained thus: $\partial(E_1^2 + E_2^2) = (E_1^1 + E_2^1 + E_3^1) + (E_2^1 + E_4^1 + E_5^1) = E_1^1 + E_3^1 + E_4^1 + E_5^1$. Similarly, if $E_1^1 + E_3^1 + E_4^1 + E_5^1$ is denoted by L^1, then $\partial L^1 = (E_1^0 + E_2^0) + (E_1^0 + E_3^0) + (E_2^0 + E_4^0) + (E_3^0 + E_4^0) = 0$. If the boundary chain of a chain C^{r+1} is 0, then C^{r+1} is called a "cycle," or an $(r+1)$-cycle; thus L^1 was just shown to be a 1-cycle and it may be shown that every such boundary chain is a 1-cycle. However, usually not every cycle is a boundary chain; for example, the chains $Z_1^1 = E_3^1 + E_5^1 + E_6^1$ and $Z_2^1 = E_1^1 + E_4^1 + E_6^1$ are cycles but are not boundary chains for the complex K of the figure.

The fact that a cycle Z bounds is expressed by a relation $Z \sim 0$ on K, called a "homology relation," and read "Z is homologous to zero on K." Above, for instance, $L^1 \sim 0$ on K. Since if cycles bound, their sum must bound. homologies may be added like equations, modulo 2. And a relation $Z_1 + Z_2 \sim 0$ is also written $Z_1 \sim Z_2$; such a relation holds for the cycles Z_1^1 and Z_2^1 defined above for K. The one-dimensional "Betti number modulo 2 of K," denoted by $p^1(K,2)$ (or simply p^1 when the modulo 2 algebraic operations are understood to be used without explicit mention). is the greatest number of 1-cycles $Z_1^1, Z_2^1, \ldots, Z_{p1}^1$ of K that satisfy no homology of the form $a_1^1Z_1^1 + \ldots + a_i^1Z_i^1 + \ldots + a_{p1}^1Z_{p1}^1 \sim 0$ modulo 2, where the coefficients a_i^1 are all 0 or 1 but not all 0 (making the convention that $0 \sim 0$). It can be shown that p^1 is not dependent upon the manner in which K is fashioned from triangles so long as the two figures are homeomorphic; the value of p^1 will be the same for both, and may be considered a numerical measure of the "one-dimensional connectivity" of the figure.

The combinatorial method just exemplified may be generalized to figures of any dimension that are made up of a finite number of cells (a 3-cell is a tetrahedron, for instance) and Betti numbers of any dimension r, denoted by p^r, defined. The restriction to modulo 2 addition of chains is unnecessary if orientation is introduced: suppose $v_0, \ldots, v_i, \ldots, v_r$ are the vertices of an r-cell. To a certain order of these vertices: as for instance that just named, a symbol σ^r may be assigned, allowing σ^r to denote any order obtained from this by an even number of transpositions of the vertices (thus. if $\sigma^3 = v_0v_1v_2v_3$, then also $v_1v_2v_0v_3 = \sigma^3$); to the other orderings we assign the symbol $-\sigma^r$. By definition, $\partial\sigma^r = \Sigma_{i=0}^r\ (-1)^i v_0 \ldots v_{i-1}v_{i+1} \ldots v_r$; thus, $\partial\sigma^r$ takes the form $\Sigma_{i=0}^r (-1)^i\eta^i\sigma_i^{r-1}$, where the η^i's are -1 or 1.

Now let G be any Abelian group (for example, the additive set of integers used by Poincaré or that of the rational numbers). (See GROUPS.) Then for an "r-chain over G" of a complex K we may take a polynomial of the form $\Sigma g^i\sigma_i^r$, where the g^i's are elements of G. Chains are added by adding corresponding coefficients in G, and thereby form a group $C^r(K,G)$ called the "r-dimensional chain group of K over G." For such chains the boundary $\partial(\Sigma g^i\sigma_i^r)$ is defined to be $\Sigma g^i\partial\sigma_i^r$, where by convention $g.(-1) = -g$, $g.0 = 0$ (the identity of G), etc. It follows that for every chain c^r, $r > 1$, $\partial(\partial c^r) = 0$, and the boundary of a chain is therefore a cycle. Thus the boundary chains form a subgroup of the group of cycles and if we denote the group of cycles of dimension r by $Z^r(K,G)$ and the group of chains that bound by $B^r(K,G)$, then the factor group $Z^r(K,G)/B^r(K,G)$ is called the rth "homology group (or rth Betti group) of K over G," and is denoted by $H^r(K,G)$; it is a topological invariant of K in the class R of all complexes. If G is the group of integers I, then the rank of $H^r(K,G)$ is the rth Betti number $p^r(K,I)$. The orders of finite cyclic subgroups of $H^r(K,I)$ are the so-called "torsion numbers."

In the special case $r = 0$ the convention may be made that $\partial\sigma^0 = 0$ for all 0-cells σ^0; in this case p^0 is the number of components of K, thus forming what could be called a measure of the "0-dimensional connectivity" of K. However, frequently the convention is made that $\partial\sigma^0 = \sigma^{-1}$, where σ^{-1} is a unique "ideal" cell which is added to the complex, thereby obtaining the "augmented complex"; in this case $p^0 + 1$ is the number of components of K.

One of the most striking relations obtained by the combinatorial method. and which illustrates the power of the method in that it embodies a generalization of the classical Euler formula for polyhedral~which states that for any (nonaugmented) complex K,

$$\Sigma(-1)^r\alpha_r = \Sigma(-1)^r p^r \qquad (1)$$

where a,. denotes the number of r-cells. When K is an ordinary polyhedral, topologically equivalent to the two-dimensional sphere $p^0 = p^2 = 1$, $p^1 = 0$ and relation (1) gives the Euler polyhedral formula: a, $- \alpha_1 + \alpha_2 = 2$.

Applications.—The simplest complex of significance is the "linear graph!'; this is the one-dimensional complex obtained by piecing together straight-line segments. The 0- and 1-cells of the figure form a linear graph, for instance. The linear graph has been applied to the theory of electrical circuits, chemistry (the structure of a molecule may be represented by a linear graph in which the 0-cells denote the respective atoms and the 1-cells denote the bonds joining them), games, many topological problems such as the "four-colour map problem" (see items [1], [2] of bibliography'] and to many other parts of mathematics. For a linear graph the Euler-Poincaré formula gives $p^1 = \alpha_0 - \alpha_1 - p^0$; in the case of the linear graph representing a paraffin molecule C_nH_{2n+2}, for example, this formula gives $p^1 = 0$, so that the configuration contains no simple closed curve.

In the consideration of solutions of irreducible algebraic equations of the form $f(x,y) = 0$ and in certain integration problems a two-dimensional complex called "manifold" plays a prominent part. Its characteristic feature is that each point is contained in an open set that is homeomorphic with the Euclidean plane. Manifolds of more than two dimensions were studied by Poincaré, who showed that the Betti numbers of an orientable n-dimensional manifold (nonaugmented) satisfy the relations

$$p^r(K,I) = p^{n-r}(K,I), \qquad r = 0, 1, \ldots, n \qquad (2)$$

Relation (2) is the so-called "Poincaré duality," and allows of generalization to a certain type of duality between homology groups. In 1923 James W. Alexander stated and proved another type of duality theorem: if S^n is the Euclidean n-sphere (= ordinary n-space nith the addition of an ideal "point at infinity") and K is a point set in S^n nhich is homeomorphic with some (augmented) complex, then numbers $p^r(S^n - K,2)$ may be defined in a natural fashion for the complement of K in S^n and the following relation holds:

$$p^r(K,2) = p^{n-r-1}(S^n - K,2),\ r = 0, 1, \ldots, n-1 \qquad (3)$$

Relation (3) tells, for instance, that the complement of every topological image of an $(n-1)$-sphere in S^n has just two components. In the case $n = 2$ it readily yields the Jordan curve theorem. Relation (3) may also be extended to a duality between homology groups. and both relations (2) and (3) may be brought within the scope of the same group-theoretic considerations.

Topological Spaces.—It was stated in the introductory remarks above that all that is needed to introduce a topology into a space is that the limit points of point sets be determined and it was shown how this may be done for ordinary Euclidean spaces and their subsets. But topological spaces are not limited to a Euclidean framework since, as stated above, any collection of objects whatsoever may be converted into a topological space by assigning to each subcollection M the set of its limit points. These assignments are usually made with a definite object in view, such as an application to some particular problem either within or exterior to mathematics, and this ordinarily requires more than the mere assignment of limit points for the various point sets. Consequently in practice the term "topological space" is usually applied to a concept slightly more restricted than that indicated above, the particular concept to be employed being set forth in axiomatic form as a rule. (*See* items [4], [5], [8] and [9] of bibliography.) Some of the more important types of topological spaces are described below.

Hausdorff Spaces.—One of the favourite methods of giving the topological character of a space is by specification of its open sets. From this point of view if E is any collection of things whatsoever and one specifies quite arbitrarily that certain subsets of E are to be "open"—in such a manner! however, that (1) E itself is open and the empty set is open; (2) if A and B are open sets. then A . B is open; and (3) the sum of any number of open sets is open—then in E one has one of the most commonly employed types of topological space. A point p of E is a limit point of a subset M of E if every open set which contains p also contains at least one point of d l distinct from p (compare the definition given for limit point in E^2 in the fifth paragraph of this article). If to the axioms just given one adds (3) if p and q are distinct points of E, then there exist disjoint open sets P and Q containing p and q respectively; then the combined set (1)–(4) characterizes the so-called Hausdorff topological spaces. For example, if one calls the interior of each circle in E^2 an open set, and also calls open every set obtained by taking sums (finite and infinite) of these. then the plane becomes a Hausdorff space.

Metric Spaces.—The Euclidean spaces are also special cases of the metric spaces: a metric space is a set S together with a "distance function" $d(x,y)$ which is defined as a unique real number for each pair of points x, y ϵ S having the property that (1) $d(x,y) = 0$ if and only if x and y are the same points, and (2) for every three points x, y, z of S, distinct or not, $d(x,y) \leqq d(x,z) + d(y,z)$. These requirements imply that $d(x,y) = d(y,x)$ and that $d(x,y)$ is never negative. Condition (2) will be recognized as the "triangle inequality" of plane geometry, where $d(x,y)$ is the usual distance between the points x and y. In a metric space a "spherical neighbourhood" $U(x,r)$, where x ϵ S and r is a positive real number, is the set of all points y such that $d(x,y) < r$. Thus in E^2 the interiors of circles are spherical neighbourhoods. And if. in a metric space, each spherical neighbourhood is called open and all sums of spherical neighbourhoods are called open, then the space becomes a Hausdorfi space.

Metrizable Spaces.—A Hausdorff space is called metrizable if there exists a distance function $d(x,y)$ such that the open sets obtained as in the preceding paragraph are identical with the original open sets of the space. An interesting problem, the "metrization problem." is to determine what topological properties of a Hausdorff space, if any. render it metrizable. Not all Hausdorff spaces are metrizable; for example, if in E^2 we allow to be open any circle interior from which has been deleted a countable set of points, as well as arbitrary sums of such open sets, then the resulting space is a Hausdorff space but is not metrizable. For if it were, then any set having a limit point p would contain a countable subset having p as a limit point (this is true of all metric spaces) but this is impossible in the space just defined. (Note that the same set—that consisting of all points in the Euclidean plane—has been called a topological space in two different senses; first as the usual Euclidean plane, in nhich sense it is a metric space. and secondly as a nonmetric Hausdorff space. Thus, the same collection may be converted into many different topological spaces.)

A variety of solutions may be given of the metrization problem. One such is obtained as follows: if a space S has the property that for arbitrary disjoint closed sets A and B there exist disjoint open sets containing A and B, respectively, then S is called "normal." Using the properties of the distance function, it is not difficult to show that every metric space is normal. If. in the definition of normal, the set A consists of a single point. then the resulting (weaker) property is called "regular." Each of the properties regular. normal, is a strengthening of the axiom (4) used in defining a Hausdorff space. Now if a space contains a countable set G of open sets such that every open set in the space is the sum of elements of G, then the space is called ' perfectly separable,· or said to have a "countable base." A necessary and sufficient condition that a perfectly separable Hausdorff space be metrizable is that ıt be regular As a corollary it follons that among the perfectly separable Hausdorff spaces, metrizability is a topological invariant since regularity is a topological invariant. Thus aithough distance itself is not invariant, capability of having a distance function is invariant among such spaces. A property closely related to that of perfect separability is that of separability. a space S being separable if it contains a countable set M such that every point of S is either a point of M or a limit point of M. Every perfectly separable space is separable and every separable metric space is perfectly separable.

Complete Spaces.—An important class of metric spaces is that of complete spaces. In analogy with the Cauchy sequences of algebra and function theory, a sequence $p_1, p_2, \ldots, p_n, \ldots$ of points of a metric space is said to form a Cauchy sequence if for arbitrary positive number ϵ there exists a number $N(\epsilon)$ such that if m and n are both greater than $N(\epsilon)$, then $d(p_m,p_n) < \epsilon$. A sequence is said to "converge" if there is a point p such that $d(p_n,p)$ approaches zero as n increases, and a metric space in which every Cauchy sequence converges is called "complete." The Euclidean spaces are complete. The set of all single-valued real functions defined over the interval $[0 \leqq x \leqq 1]$ forms a complete space in which each function is a point and the distance between two functions f and g is taken to be the least upper bound of the absolute values $|f(x) - g(x)|$. Every metric space is homeomorphic with a subset of some complete space.

Compact Spaces.—If G is a collection of open sets in a space S and S is the sum of the elements of G, then G is said to "cover," or to be a "covering" of S. A "compact" (sometimes called "bicompact") space is a space which has the property that every covering of it by open sets has a finite subset forming a covering. The Euclidean spaces are not compact but every closed subset lying in a finite portion of such a space is compact. Not all compact spaces are metric; among the compact Hausdorff spaces metrizability is equivalent to perfect separability (every compact Hausdorff space is normal). A nondegenerate space which is both compact and connected is frequently called a "continuum" and the term "compactum" is used to denote a space which is both compact and metric.

Product Spaces.—If A and B are any two sets, then the "product set" $A \times B$ is the set of all pairs (a,b) where a and b are elements of A and B, respectively. Let S and T be any two topological spaces. Then by the "product space" of S and T is meant the space obtained from $S \times T$ by letting all products $U \times V$ be open, where U and V are open subsets of S and T, respectively; it is also denoted by the symbol $S \times T$. For example. the product space of two Euclidean straight lines is topologically equivalent to the plane (a fact used in Cartesian geometry); if S and T are circles, then $S \times T$ is topologically equivalent to the surface of the anchor ring. Products may also be defined for any number of spaces. They furnish an excellent source of topological configurations.

Peano Spaces.—If S and T are topological spaces, then by a "continuous mapping of S into T" is meant a function f which assigns to each point x of S a point f(x) of T, in such a manner that if A is a subset of S with limit point p, then $f(p)$ is in $f(A)$ or is a limit point of $f(A)$ in T. It may be symbolized by the expression $f:S \rightarrow T$. (If for every $y \epsilon T$ there is at least one $x \epsilon S$ such that $f(x) = y$, then f is called a mapping of S onto T.)

The concept of a mapping of one space into another has proved one of the most important tools in topology, leading to numerous important invariants, such as the homotopy classes, as well as to many interesting problems (see bibliography items [8], [11] and [12]). One of the most widely investigated types of topological spaces is obtained by mappings of the real number interval R; more precisely. if P is a Hausdorfi space and there exists a mapping $f:R \rightarrow P$ which is onto. then P is called a "continuous curve" or "Peano space." Such spaces form a much larger class than one might at first suspect; for instance, a circle together with its interior in E^2 is a Peano space (the latter name has its origin in the fact that the Italian mathematician and logician Giuseppe Peano was the first to prove [1890] the statement just made). The Euclidean 2-sphere. S^2, is completely characterized among the Peano spaces by the Jordan curve theorem: a necessary and sufficient condition that a space S be homeomorphic with S^2 is that it be a Peano space which contains at least one simple closed curve, and in which the Jordan curve theorem holds.

The investigation of the topological properties of Peano spaces forms an aesthetically satisfying and fruitful department of topology (see bibliography items [6], [8], [9] and [10]). The first successful characterization of them in terms of intrinsic topological invariants utilized the property of local connectedness: a space S is called "locally connected" if, given $x \epsilon S$ and an open set U containing x, there exists a connected open set V containing x and lying in U. A Peano space is characterized by the fact that it is a metric continuum which is locally connected.

The structure of the higher-dimensional Peano spaces, while exhibiting a large number of interesting properties, may be rendered more attractive from a geometrical point of view by the imposition of local connectedness properties of higher dimensions. The local connectedness described above is then the 0-dimensional case of an n-dimensional type of local connectedness in which the homology theory (see TOPOLOGY, ALGEBRAIC) plays a part; specifically, given $x \epsilon S$ and an open set U containing x, there exists an open set V containing x and lying in U such that every n-cycle on a compact subset of V bounds on a compact subset of U. Peano spaces that are locally connected in this sense for all dimensions up to and including a given positive integer exhibit properties of which the corresponding properties of Peano spaces are the 0-dimensional cases, and in structure they begin to approximate the n-dimensional manifolds.

(See item [9] in bibliography.)

Fixed Points.—Consider a mapping of type $f:S \rightarrow S$. If x is a point of S such that $f(x) = x$, then x is called a "fixed point" of the mapping f. For example, using the homology theory it is not difficult to show that if D is a circular disk, then every mapping $f:D \rightarrow D$ has a fixed point; and more generally, if E^n is a solid cube, then every mapping $f:E^n \rightarrow E^n$ has a fixed point. Theorems on the existence of fixed points have many applications in mathematics and mechanics. (For further details see bibliography items [1] and [15].)

Dimension Theory.—One of the most important contributions made by topology is embodied in solutions of the ancient problem concerning the nature of dimension. One may expect of such a concept that it will: (1) assign to each space a unique integer, its "dimension number"; that, in particular, it will (2) assign to Euclidean n-space the dimension number n; and that (3) if S is a subspace of a larger space T, then the dimension of S will not exceed that of T. For a wide class of spaces, including all of the ordinary spaces of mathematics and physics (indeed. all separable metric spaces) such a dimension concept has been provided. This has been done in a variety of ways, some from the standpoint of pure point-set concepts of topology and some from the standpoint of algebraic topology.

Such a "dimension function," as it might be called, may be exemplified briefly by use of the coverings mentioned above. Suppose S is a separable metric space and C is a covering of S by a finite number of open sets. **A** similar covering C' of S is called a "refinement" of C if each element of C' is contained in an element of C. Then the dimension of S is called "at most n" if every finite covering of S by its open sets has a refinement C' such that not more than $n+1$ elements of C' have common points. The dimension of S is "equal to n" if n is the smallest integer for which the dimension of S is at most n. Such a dimension function is a topological invariant and has the required properties (1) (2) and (3). listed above. The following may be cited as examples of some of the interesting theorems of dimension theory: every separable metric space is homeomorphic with a subset of a compactum of the same dimension, and every such space which is of finite dimension n is homeomorphic with a subset of the $(2n+1)$-dimensional Euclidean space.

Applications.— In addition to such applications as have been cited above, mention could be made of a wide variety of special applications to other fields of mathematics, as for instance the proof of the fundamental theorem of algebra (see EQUATIONS. THEORY OF: The *Fundamental Theorem*), which may be deduced from any of a number of theorems of plane topology; special properties of functions (*e.g.*, existence of real continuous functions having no derivative); analytic functions; algebraic geometry; calculus of variations; harmonic integrals; etc. The theory of topological groups and their applications has been extensively developed.

(See bibliography items [13] and [14].)

See also CALCULUS OF VARIATIONS; ANALYSIS, COMPLEX.

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TORADJA (TORAJA), a group of tribes of central Celebes who, together with the closely related Sadang, are survivors of the invading Proto-Malayan people that overran the island and absorbed or exterminated the aboriginal Negrito. In later centuries they in turn have been driven back from the coasts by the more typical Malayans such as the Bugis. Their warfare and headhunting made it necessary to locate their villages on easily defended hilltops.

There the houses surrounded a square in which stone memorial slabs were erected in honour of the nobility. Painted houses with saddle roofs resembled those of the Toba Batak while the use of golden ornaments by the nobles, coffin burials in caves and strong class distinctions suggest the situation found among the Proto-Malays of Nias and Sumatra.

Under Dutch control warfare was stopped and missionary efforts led to the conversion of most of the population to Christianity. These changes led, in turn, to the abandonment of many of the hilltop strongholds and to the establishment of villages in the valleys.

Early accounts tell of the elaborate tapa garments of the women. Today their poncholike blouses of cloth are decorated with scroll designs made with shell disks. A sarong is worn but below this the woman wears short trousers. It was a custom, now going out of style, for members of both sexes to have their front teeth broken off at the gums. Face painting in dots and lines is common. Descent is reckoned bilaterally.

See also CELEBES.

See R. Kennedy, *Field Notes on Indonesia* (1953); W. Keer, *Anthropological Survey of the Eastern Little Sunda Islands: the Proto Malays* (1948). (F.-C. CE.)

TORBERNITE, one of the principal uranium minerals, is a hydrous uranium and copper phosphate of secondary origin (*see* URANIUM: Occurrence). The crystals are tetragonal, thin to thick tabular; also in scaly or foliated aggregates. There is a perfect micaceous cleavage parallel to the base, and on this face the lustre is pearly; otherwise it is vitreous to subadamantine. The bright grass- to emerald-green colour is characteristic. The hardness is 2 to 2.5 and the specific gravity 3.22. The formula is $Cu(UO_2)_2(PO_4)_2.12H_2O$. The water content varies with the temperature and humidity, and is normally less than the formula indicates. When torbernite loses four molecules of water it passes over to metatorbernite, with a change in optical properties. Torbernite is found in Bohemia and Saxony and is abundant in the Katanga district of the Belgian Congo; the best specimens are from Cornwall. The name torbernite is after Torbern Bergman (1735–84), a Swedish chemist. (L. S. RL.)

TORCELLO, an island of Venetia, Italy, in the lagoons, 6 mi. N.W. of Venice. It was a flourishing city in the early middle ages, but now is thinly settled. It has two interesting churches. The former cathedral of S. Maria was founded in 641. The present building, a basilica with columns, dates from 864; the nave was restored in 1008, in which year the now ruined octagonal baptistery was built. It contains large mosaics of the 11th century, strongly under Byzantine influence; those on the west wall represent the Resurrection and Last Judgment. The seats for the priests are arranged around the semicircular apse, rising in steps with the bishop's throne in the centre—an arrangement unique in Italy. Close by is S. Fosca (c. 1011), octagonal outside, with colonnades on five sides and a rectangular interior intended for a dome which was never executed, beyond which is a three-apsed choir.

See B. Schulz, *Kirchenbauten auf der Insel Torcello* (1927).

TORCH LILY, RED-HOT POKER PLANT and FLAME FLOWER are common names for about 70 species of plants belonging to the genus *Kniphofia* of the lily family. About 40 species occur in South Africa, the remainder being native to tropical Africa and Madagascar. The plants possess a fleshy rootstock from which basal, persistent, lanceolate leaves arise, and usually a tall scape of red and yellow drooping flowers in a dense, terminal, spikelike raceme. The common names are highly appropriate because of the brilliantly coloured pokerlike spikes. Some of the species, and particularly some of the numerous hybrids available, make excellent hardy border plants that bloom from midsummer until late autumn and with a wide range of colour. (J. M. BL.)

TORDENSKJOLD, PEDER (1691–1720), Danish naval hero, son of Jan Wessel of Bergen, in Norway, was born at Trondhjem on Oct. 28, 1691. Wessel ran away from home as a stowaway in a ship bound for Copenhagen, made a voyage to the West Indies, and finally gained a cadetship. In 1712 he was promoted to a 20-gun frigate. Wessel was renowned for his audacity and his unique seamanship. The Great Northern War had now entered upon its later stage, when Sweden, beset on every side, employed its fleet principally to transport troops and stores to its distressed German provinces. The audacity of Wessel impeded it at every point. He was continually snapping up transports, dashing into the fiords where its vessels lay concealed.

When in 1715 the return of Charles XII from Turkey to Stralsund put a new life into the jaded Swedish forces, Wessel fought numerous engagements off the Pomeranian coast, and did the enemy infinite damage by cutting out their frigates and destroying their transports. On returning to Denmark in the beginning of 1716 he was ennobled under the title of Tordenskjold ("Thundershield"). When Charles XII invaded Norway and besieged Fredrikshald (1716) Tordenskjold compelled him to raise the siege and retire to Sweden by pouncing upon the Swedish transport fleet laden with ammunition and other military stores which rode at anchor in the narrow and dangerous strait of Dynekil, utterly destroying the Swedish fleet with little damage to himself. For this, his greatest exploit, he was promoted to the rank of commander.

Tordenskjold's last feat of arms (he was then rear admiral) was his capture of the Swedish fortress of Marstrand, when he partially destroyed and partially captured the Gothenburg squadron which had so long eluded him. He was rewarded with the rank of vice-admiral. Tordenskjold did not long survive the termination of the war. On Nov. 20, 1720, he was killed in a duel with a Livonian colonel, Jakob Axel Stael von Holstein. Although, Dynekil excepted, Tordenskjold's victories were of far less importance than Hannibal Sehested's at Stralsund and Ulrik Gyldenlöve's at Rügen, he is certainly, after Charles XII, the most heroic figure of the Great Northern War.

See Carstensen and Lütken, *Tordenskjold* (1887). (R. N. B.; X.)

TORDESILLAS, TREATY OF, between Spain and Portugal, was signed on June 7, 1494, to settle conflicts arising from Columbus' first voyage. In 1493 Pope Alexander VI had set up a line of demarcation from pole to pole 100 leagues west of the Cape Verde Islands. Spain was given exclusive rights to the region west of the line; Portuguese expeditions were to keep to the east. King John II of Portugal was dissatisfied because Portugal's rights were not specifically affirmed and the Portuguese would not have sufficient sea room for their African voyages. Meeting at Tordesillas in northwestern Spain, Spanish and Portuguese ambassadors reaffirmed the papal division, but the line itself was moved to 370 leagues west of the Cape Verde Islands. Papal sanction of this change was finally given on Jan. 24, 1506. Since the line now intersected the bulge of South America from the mouth of the Amazon to Santos, Portugal successfully laid claim to Brazil after its discovery by Pedro Alvares Cabral in 1500.

(M. D. Be.)

TORGAU, a town in the district of Leipzig, Ger.. on the left bank of the Elbe river, 30 mi. E.N.E. of the city of Leipzig and 26 mi. S.E. of Wittenberg by rail. Pop. (1950) 19.633. Torgau is said to have existed as the capital of a distinct principality in the time of the German king Henry I, but early in the 14th century it was in the possession of the margraves of Meissen and later of the electors of Saxony: In 1526 John, elector of Saxony, Philip, landgrave of Hesse, and other Protestant princes formed a league against the Roman Catholics, and the Torgau articles. drawn up there by Martin Luther and his friends in 1530, were the basis of the Confession of Augsburg. Torgau was formally ceded to Prussia in 1815. The Schloss Hartenfels, on an island in the Elbe, was built by John Frederick the Magnanimous, of Saxony.

Battle of Torgau, 1760.—This, the last great battle of Frederick the Great, and the last of his victories, was so truly Pyrrhic that it paralyzed his offensive power and left him in a gravely weakened condition to meet his gathering foes. The battle and the events which rescued him from his critical position are dealt with under Seven Years' War.

TORNADO, the violently revolving funnel cloud of small diameter that is well known in the United States east of the Rockies, in southern and middle U.S.S.R. and in southern Australia. Rotation is either clockwise or counterclockwise. In west Africa, tornado is the local name for the violent squall that blows out of the front of thunderstorms and dust storms (equivalent to the haboob of Sudan). Less commonly and in less violent form than in the U.S., tornadoes occur in nearly all other parts of Europe and America and locally in Africa and Asia. In the United States they are also popularly known as twisters or cyclones. North American tornadoes average 300–400 yd. in width, although some extend a mile or more. They often form in families of two or more in the same region at the same time. Paths are usually short, from several to 50 mi., but occasionally up to 300 mi. long; in the U.S. they generally run from southwest to northeast at 10–50 m.p.h.

The funnel cloud results from the condensation of moisture through cooling by expansion and lifting of air in the vortex. However. the air for some distance outside the funnel cloud is also part of the vortex, and near the ground this outer ring becomes visibly laden with dust and debris. The wind speed in the vortex has never been measured; but judging from the effects and from theoretical considerations, it is of the order of 100–500 m.p.h. E. M. Brooks found that some tornadoes are centred in a larger, much weaker cyclone of about a five-mile radius. which he called "the tornado cyclone." Because of centrifugal effects, very low barometric pressure occurs in the core of the vortex, creating a small "eye" that is clear and nearly calm. When observed on radar, some tornadoes are located near a distinctive hooked echo. The echo seems to revolve with the storm and may be associated with the tornado cyclone. (See Radar Meteorology.)

The whirling funnel cloud appears to grow vertically or slantingly down from a dark heavy cloud of the cumulo-nimbus or thunderstorm type and to reach the ground while twisting and bending slowly, the base of the funnel dragging because of friction. It soon dies out in reverse order.

Many tornadoes have bases elevated 50–100 ft. above the ground. in which case winds at the ground have speeds of less than 1jo m.p.h. The funnels may extend down from as high as 25,000 ft. (as reported in one instance). Rain and hail usually occur just before or after the tornado. There is considerable variation in details of appearance of individual tornadoes.

The minute or so that it takes for the storm to pass results in fantastic destruction: buildings totally flattened, exploded to bits or moved bodily for hundreds of yards; straws driven through posts; some objects left unharmed amid complete wreckage. A safe refuge during a tornado passage is a "cyclone cellar" with a stout door, such as provided on many farms in the midwestern U.S. The roar of the tornado can be heard as far as 25 mi. away.

The continental plains of North America and the U.S.S.R., reaching from polar regions to the tropics. are specially favourable for tornadoes, and no season is free from them. In spring and summer, however. tornadoes are five times as numerous as in winter and fall. They are more likely to occur during the day than at night. In the U.S., the greatest number occur in a belt along the eastern edge of the Great Plains area! extending from Iowa to northeastern Texas. The centre of maximum frequency moves north and south, in winter near the Gulf coast, in summer over Iowa.

The high speed of the revolving winds in a tornado is a result of convergence of slowly rotating air; the same principle is involved when an ice skater increases his speed of rotation by drawing in his arms. Usually tornadoes form in association with thunderstorms that are in the vicinity of either a squall line or a front which is invading a region where a layer of warm dry air overlies moist air. This sort of stratification is often rendered unstable by the lifting and convergent effects of a front, but apparently a very special combination of additional circumstances is required to produce a tornado. *See* also Squall and Squall Line; Thunderstorm.

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(R. G. Se.; J. C. F.)

TORNEBOHM, ALFRED ELIS (1838–1911), Swedish geologist and pioneer in mountain tectonics, was born in Stockholm on Oct. 16. 1538. Graduating from the Technological institute in 1858, he joined the geological survey of Sweden in 1859 but resigned in 1873. After travel in central Europe and a visit to Ferdinand Zirkel in Leipzig. he returned to Stockholm as professor of mineralogy and geology at the Royal Institute of Technology.

He then became director of the geological survey from 1897 to 1906. Tornebohm's researches give him high rank in the annals of mountain tectonics. He spent many years traversing the ground of his original surveys in the Scandinavian mountains and he presented in 1888 the first outlines of his theory of the overthrust of the Caledonian chain onto a foreland to the southeast. Later (1896) he demonstrated that the overthrusting applied to the entire extent of the mountain range and exceeded 80 mi. He illustrated his completed description. in which he had the assistance of A. G. Högbom, with a map covering 36,000 sq.mi. Tornebohm was an accomplished mineralogist and petrographer. He gave special attention to the iron ores of Sweden and early presented an exhaustive account of the crystalline phases of portland cement clinkers (1897).

Tornebohm died at Strangnas, near Stockholm, on April 21, 1911. (C. E. T.)

TORO, a town of Spain: in the province of Zamora. on the right bank of the Duero (Douro) river, and on the Zamora-Medina del Campo railway. Pop. (1950) 9.799 (mun.).

Toro is an ancient fortified town, with picturesque narrow streets. A fine bridge spans the river. The cathedral church is Komanesque; it dates from the 12th century but has been partially restored.

The palace of the marquesses of Santa Cruz was the meeting place of the *Cortes* of 1371, 1442 and 1505, which made Toro and its code of laws celebrated.

PHOTOGRAPH, WIDE WORLD

VIEW OF AN APPROACHING TORNADO

Tornado approaching Vulcan, Alberta, Canada. The destructive power is not in the straight wind, but in the counterclockwise rotating mass which always moves in an easterly, and generally in a north-easterly direction. Barometric pressure in the tornado falls very rapidly, causing houses to blow apart from the outward pressure of the air inside them

BY COURTESY OF (BOTTOM ROW) ILLINOIS STATE WATER SURVEY; PHOTOGRAPH, (TOP) LUCILLE HANDBERG

TORNADOES SEEN FROM THE GROUND AND BY RADARSCOPE

Top: Side view of a funnel-shaped tornado cloud sweeping in a path 50 yd. wide near Jasper, Minn. The tornado traveled only three miles

Bottom: Three radarscope photographs showing echoes from a tornado in Illinois. At 5:13 P.M. (left) the tornado developed a "hooking appendage," the projection below and at the left side of the larger cloud. At this point the tornado reached the ground and caused surface damage. The photographs taken at 5:25 and 5:36 (centre and right) show the further development and break-up of the tornado cloud as it moved eastward

TORONTO, capital of the province of Ontario and the second largest city in Canada, is situated on the northern shore of Lake Ontario. It lies on a level lake plain, bounded to the north by the 40-ft. cliff of the glacial "Lake Iroquois" shore line. The plain is traversed by the Don and Humber rivers. The city covers approximately 40 sq.mi., including Toronto bay (2 sq.mi.) and the islands stretching to the south of the city. Pop. (1961) 672,407; metropolitan Toronto 1,618,787.

History. — Toronto is the old name the Hurons gave to their country and probably means "land of plenty." In 1750–51 the French established a fortified trading post called Ft. Rouillé on the site of Toronto, but they burned it nine years later to prevent its use by the British. In 1787 the British purchased the site from the Missisauga Indians and in 1793 settlement began with its establishment as the capital for the newly formed province of Upper Canada. The site was well away from the U.S. border and possessed an easily defended natural harbour at the beginning of an overland route to the Upper Lakes. In 1797 the legislature met for the first time in the new capital, which was called York. During the War of 1812 York was captured by U.S. forces and the parliament buildings and archives were burned (1813). At first the settlement remained a small administrative and garrison town. In 1820 it numbered about 1,250 people. In the 1830s the population grew rapidly as a result of large-scale immigration, and commerce became more important than the administrative function. In 1834 York resumed its original naine and was incorporated as the city of Toronto. with a population of over 9.000. The centre of the city shifted from near the Don outlet to Yonge street. In the second half of the 19th century Toronto became the leading financial, commercial and industrial centre of the province and gradually became the focal point for the reorientated railway network. In 1885 the city included about 120,000 people and spread over most of the lake plain.

The Municipality of Metropolitan **Toronto.**—Between 1881 and 1914 the city expanded considerably by means of a number of important annexations. After that the built-up area gradually spiiied over into various municipalities, creating numerous problems in urban development. Accordingly. the provincial legislature in 1953 enacted legislation to provide for the federation of Toronto and its 12 suburban municipalities into a new municipality called metropolitan Toronto. The federated suburban municipalities have greatly contrasting economic structures. The towns of Leaside (pop. [1961] 18.579). New Toronto (13.384) and Weston (9.715) have heavy concentrations of manufacturing industries. Much larger industrial and commercial complexes are found in the townships of North York (267.705). Etobicoke (155.358), Scarborough (215.641) and York i128.521) but their industrial assessment is not so high in relation to their residential assessment as in the first three municipalities. The town of Mimico (18.212) and the village of Long Branch (11,039) also have some important industries. Of a more residential nature are the townships of East Uork (71.626). the village of Swansea (9.628) and especially the village of Forest Hill (20.489), which is almost entirely an upper-class. high-income residential district.

The formation of the new municipality attracted world-wide attention. Each of the federated municipalities retains its autonomy in local matters and is represenred in the metropolitan council. which has 25 members: a chairman. city of Toronto representatives (the mayor. two controllers. nine aldermen) and the suburban representatives (the heads of council of the 12 suburban municipalities). The chairman is elected annually by the council. which is empowered to elect him from among its membership or to elect any other person. The metropolitan corporation is responsible for assessment. water supply, sewage disposal. air pollution control, certain roads and public transportation. education, health and welfare, administration of justice. housing, licensing. police, planning, parks. civil defense and finances. The metropolitan corporation collects the revenue for its budget from the 13 municipalities by a metropolitan tax rate on the assessment of each member municipality. The corporation also issues debentures required for permanent financing in the municipalities The municipalities may appeal to the provincial government in cases of dispute.

The new municipality functioned quite successfully, an achievement which was due in large part to the energetic leadership of its first chairman. Frederick G. Gardiner. Among its accomplishments were cheaper financing for the entire area. large scale improvements in water supply and sewage disposal, equalization of the financial burden for education, the establishment of a centralized police force, improvements in parks and recreational facilities. the building of expressways and the inauguration of better welfare services.

The metropolitan Toronto planning area comprises, in addition to metropolitan Toronto, 13 other municipalities. The local planning boards retain the right to formulate or amend their local official plans, provided they receive the approval of the metropolitan planning board and the provincial minister of planning and development.

Economic Development. — Toronto is the second largest manufacturing centre of Canada; many U.S. and British branch plants are located there. In the early 1960s its 4,700 factories produced about 160 different types of products; fewer than 175 plants employed more than 200 workers and the average number of workers was 43. The resulting diversification helped to stabilize the economy. Some of the more important industries are slaughtering and meat packing. printing and publishing. agricultural implements. aircraft, heavy electrical machinery and a wide variety of iron and steel products. The city is also a leading trade and financial centre; it accounts for 19% of the wholesale trade in Canada. The Toronto stock exchange is in dollar value one of the largest on the continent. handling annually over 900.000.000 shares. Three of the nine Canadian chartered banks and about 45 life insurance companies have their head offices in Toronto.

The city has excellent transportation connections. and hence is an ideal distribution point. Within a radius of 100 mi. lies one-third of the buying power in Canada. The St. Lawrence seaway gives Toronto the additional advantage of being an ocean port. The leading commodities are coal. petroleum. grain. general cargo and cement. The Toronto Island airport accommodates non-scheduled flights; Malton airport. 13 mi. N.W. of the city, is one of the most important air terminals in Canada. A 4½-mi. subway under and near Yonge street was opened in 1954 and in the 1960s was being expanded with lines under and along University avenue and Bloor street. Road transportation was greatly improved in the 1950s and 1960s with the building of the Toronto bypass. its counterpart along the lake shore and a north-south connection via the Don valley.

The City and Its Institutions. — The central business district of Toronto is located around the intersection of Uonge and Queen streets. There are the large. department stores and farther south are Cnion station and a centre for the performing arts. Lower Bay street is the financial district and also the site of the city hall. completed in 1899 and well known for its great stained-glass window. In the 1950s a site was cleared to the —est of the old city hall for a civic square and new city hall. A fashionable shopping area extends along Bloor street between University avenue and Yonge street. Immediately east of it stands a concentration of modern buildings housing insurance offices. The seat of the provincial government is in Queen's park. It is an imposing structure of red sandstone: immediately opposite stands a large addition in blue dolomite, called the Whitney block.

Queen's park is bounded to the west by the campus of the University of Toronto, founded in 1827. It is a blend of the English college system and the faculty system. The constituent and federated colleges are University (nondenominational), Victoria (United Church). Trinity (Anglican) and St. Michael's (Roman Catholic). Also federated with the university are three theological colleges: Knox (Presbyterian). Wycliffe (Anglican) and Emmanuel (United Church). In the 1950s the university entered a period of considerable expansion, acquiring 26 ac. of land adjacent to the campus and beginning a $51.000.000 building program scheduled to he completed by 1970. The university has promoted research in many field?.and is particularly well known for the medical research conducted in the Banting and Best institutes and Connaught medical research laboratories. Near the university is the meteorological service of Canada. North of the city is the David Dunlap observatory with a 74-in. reflector, one of the largest in the world. Just to the south of Queen's park, along University avenue with its impressive array of modern office buildings. is a huge concentration of medical facilities: Toronto General hospital. Hospital for Sick Children and Mount Sinai hospital. In addition to the university, Toronto has numerous other educational institutions. Upper Canada college, a boys' school founded in 1829, in many respects resembles an English public school. Osgoode hall houses the higher courts of law and appeal and also a law school. The Royal Ontario museum is famous for its far eastern collection. Toronto has a large number of parks, totaling over 1.800 ac. Exhibition park. comprising 350 ac. with a lake frontage of $1\frac{1}{2}$ mi., is the site of the Canadian National exhibition. Fashionable residential districts are found along the ravines to the north of Bloor street in Rosedale, in the northern part of the city. and in High park and Kingsway district in the west end. Don Mills is an attractively laid out and carefully planned community about 8 mi. N.E. of downtown Toronto.

Population and Religion.— Until World War II the population of Toronto was predominantly British in origin; after the war there was a steady influx of immigrants from Europe and the city acquired a more cosmopolitan atmosphere. In the early 1960s the Anglican Church and the United Church had the largest memberships. followed by Roman Catholics. Presbyterians. Jewish congregations and Baptists. Toronto is an archiepiscopal see of the Anglican and Roman Catholic churches and the headquarters of the United Church of Canada.

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TORPEDOES. The modern torpedo is a cigar-shaped. self-propelled. underwater missile designed for attacking surface vessels and submarines. It may be launched from a submarine, surface vessel or airplane. Sicknamed "tin fish," the torpedo is an underrvater guided missile with intricate devices that control its travel in depth and direction according to a preset plan or in response to signals received from an outside source. A torpedo is fitted with an exploder that detonates the explosive-filled warhead when it strikes its target or comes close to it. Against surface vessels the great value of the torpedo lies in its ahility to attack the target in the most vulnerable area—below the water line. Against submarines the torpedo possesses an uncanny ability to seek and destroy its target regardless of the evasive action the target may take.

Originally the word torpedo referred to any explosive charge, including the type of weapon known in modern times as a land or naval mine. When the modern self-propelled torpedo appeared it was called the automobile or Gsh torpedo to indicate that it contained its own source of power. Some modern underwater mines. called mobile mines, resemble torpedoes in appearance and are self-propelled but they differ in function. Aiter launching, they run for a certain distance. sink and then operate the same as any other type of naval mine. *See* MINE, NAVAL.

History.— Credit for the development of the torpedo belongs to Robert Whitehead (*q.v.*), a British engineer who was manager of a firm of engine builders in Fiume, Yugos. In 1864 an officer in the Austrian navy, Giovanni Luppis, presented Whitehead with an idea for an explosive-currying. self-propelled boat that could be steered from its launching site by means of long yoke lines. After building a model of the device Whitehead rejected the scheme as impracticable and began work on an idea of his own. By 1866 he had a successful torpedo: two years and some modifications later Whitehead was able to offer his invention for sale.

One rnodel of the Whitehead weapon measured approximately 14 ft. in length and 14 in. in diameter and weighed about 300 Ib., including an 18-lb. charge of dynamite in its nose. It was powered by a compressed-air engine driving a single propeller. Its depth was controlled by a hydrostatic valve that operated rudders on the horizontal tail surfaces; there was no provision for lateral steering. Most authorities credit this torpedo with a speed of 6 knots: its range is given variously as between 200 and 700 yd.

Modifications and adaptations of the Whitehead design mere made by various nations. The most significant of these changes were the use of heat engines and gyroscopic control. British firms achieved the most notable success with propulsion units! introducing both heat engines and contrarotating propellers. From models using the Armstrong-\\'hitworth dry-heater system of 1905, British torpedoes advanced to the high-performance, steam-driven Royal Saval Torpedo factory Mark IV weapon of 1917. Concurrently with these developments the American firm E. W. Bliss company (Brooklyn) successfully used a turbine to drive their modihcation of the Whitehead design. This torpedo, called the Bliss-Leavitt. was used extensively in the U.S. navy before World War II; the destroyers transferred to Great Britain early in that war were equipped with Bliss-Leavitts.

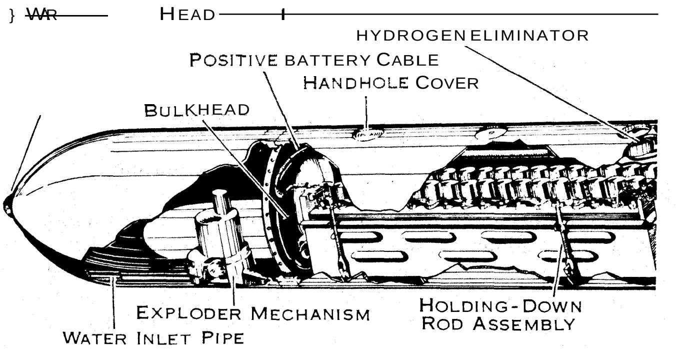
The Austrian, Ludwig Obry, is generally credited with adapting the gyroscope to use in torpedoes for directional control (1895). Any deviation from the set course caused the gyroscope to react and apply corrective movement to the vertical rudders. Further modifications to the gyroscope permitted the introduction of a set angle (up to 90°) into the torpedo's course before the steering rudders took full control. This feature allowed a ship to launch torpedoes at any point within a wide angle of heading and greatly opened up the field of torpedo tactics.

To utilize the striking power of the torpedo small, fast boats were designed to carry and launch these weapons. These torpedo boats were highly maneuverable and presented difficult targets for larger, slower cruisers and battleships. To counter them, torpedo-boat destroyers were introduced; these ships mere larger than the torpedo boats but possessed equal or greater speed. They were armed with both guns and torpedoes. From this type of ship evolved the large, heavily armed destroyer of today. See DESTROYER.

Description and Operation.— The modern torpedo differs from its predecessors in substantially increased power and reliability, and in methods of control of its underwater travel. Torpedoes may be grouped according to four general characteristics: (1) the source of propulsive power; (2) the method of control during water travel; (3) the type of target against which the torpedo will he used; and (4) the type of craft from which the torpedo is launched.

Torpedoes are driven by steam turbines or by battery-powered electric motors. Underwater travel is controlled in several ways. "Active-acoustic" torpedoes generate sound signals similar to sonar, and home on the echo received from the target. "Passive-acoustic" torpedoes home on noise generated by the target. Gyroscopic-controlled torpedoes are, as the name implies, kept on course by means of gyroscopes; this course may be straight or it may be a definite preset pattern. The pattern begins at a predetermined clistance from the launching vessel and is usually a spiral or a zigzag.

Torpedoes are intended for use against either surface vessels or submarines, or occasionally both types. Torpedoes may be launched by submarines, surface vessels, aircraft and as a com-



BY COURTESY OF U.S. BUREAU OF ORDNANCE

CUTAWAY DRAWING OF THE ELECTRIC TORPEDO MARK 18, WITH WARHEAD ATTACHED. SHOWN FROM PORT SIDE ponent of a guided missile. Frequently torpedoes are described by terms which combine the names of the launching craft and the target, *i.e.,* submarine-launched antisubmarine, or destroyer-launched antisurface vessel.

A typical n·eapon designed for above-water launching from torpedo tubes is 24 ft. long and 21 in. in diameter. The U.S. navy's Mark 15 torpedo is of these dimensions; it weighs over 3.500 lb. and carries a charge of more than 600 Ib. of the explosive torpex, which is particularly effective for underwater detonation. The Mark 15 is a three-speed, steam-driven weapon capable of traveling 15,000 yd. at a speed of 28 knots, 10,000 yd. at 33 knots or 6,000 yd. at 46 knots.

The Mark 18 torpedo (see figure) is a single-speed torpedo driven by an electric motor and designed to be launched from a submarine. It has the same diameter as the Mark 15 but is somewhat shorter. It can travel 4.000 yd. at a speed of 29 knots. Two major advantages possessed by the Mark 18 and other electric torpedoes are the absence of wake (caused by exhaust gases in the steam-driven type) and the freedom from change of weight throughout the run (steam torpedoes lose weight as their fuel is burned).

The modern torpedo is divided into four major sections: the warhead; the air flask section or, for electric torpedoes, the battery compartment; the afterbody; and the tail. The warhead carries the explosive charge and the exploder mechanism. In homing torpedoes, the homing mechanism is located in a detachable nose section, forward of the explosive-filled part of the warhead. Torpedo exploders operate either on impact with a target or on passing within a certain range of the target. Since a ship is almost never armoured on the bottom of the hull, an exploder that detonates a torpedo directly beneath the bottom is especially efiective.

An exercise head is substituted for the warhead in test and practice firings. The exercise head is a hollow shell with the same dimensions as the warhead. Liquid ballast replaces the explosive; at the end of the torpedo's run compressed gas blows the ballast out of the exercise head and the torpedo rises to the surface. A light and a smoke pot in the exercise head assist in locating the torpedo so that it may be recovered and used again.

The air-flask section of a steam torpedo is the main body of the torpedo and carries highly compressed air, water and fuel. The fuel is an alcohol-and-water mixture in some torpedoes, alcohol and Navol (a hydrogen-peroxide mixture) in others.

The afterbody is the "engine room" of the torpedo; it contains the gyroscope. the depth-regulating mechanism, the combustion flask and the turbine. The combustion flask converts the fuel-air-water mixture into steam, which drives the turbine at high speed. Reduction gears connect the turbine to the coaxial propeller shafts. The shafts pass through the tail section to the propellers. Other parts of the tail section are the tail blades and rudders.

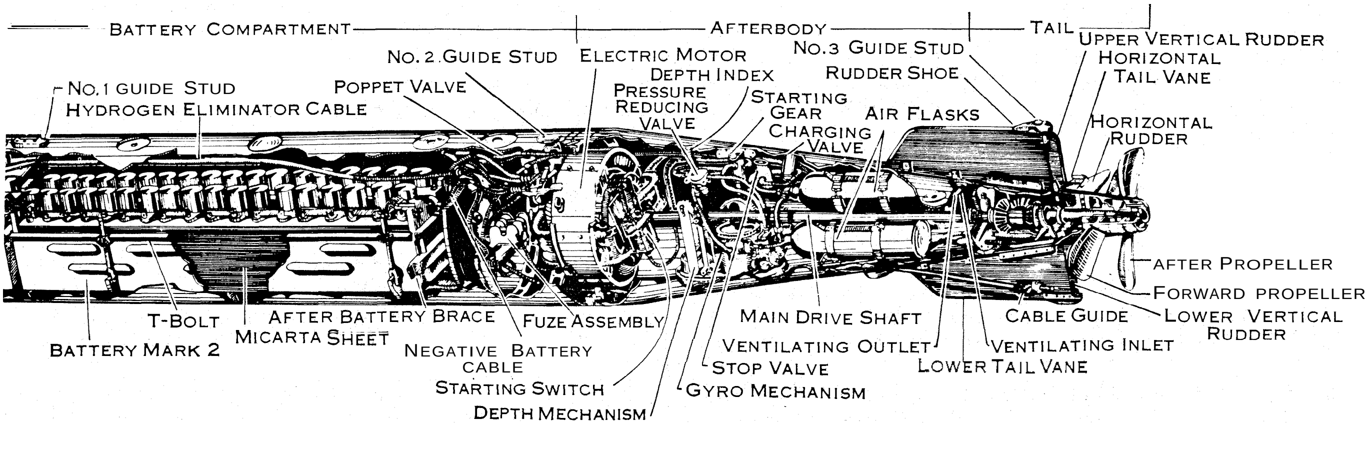
In electric torpedoes the battery compartment replaces the air-flask section. Current from the batteries drives electric motors. which in turn drive the propellers. Compressed air to power the gyroscope is stored in small air flasks in the afterbody. To minimize noise homing torpedoes are electrically powered throughout; the gyroscope is brought up to speed by an electric motor, and both vertical and horizontal rudders are electrically operated. As a further noise-reduction measure homing torpedoes are usually equipped with but a single propeller.

Most surface ships and submarines launch their torpedoes from tubes. In submarines and the most advanced surface vessels, these tubes are built into the vessel's structure. In older surface vessels. the torpedo tubes are mounted so that they can be trained to either side of the ship. Many above-water torpedo tubes are fired by means of a charge of black powder. Compounds to suppress flame and smoke are frequently added to the powder charges. and above-water tubes are often equipped with flash-hiders. Most submerged tubes and fixed, above-water tubes are discharged by means oi high-pressure air. Submarines are often equipped with devices to eliminate the air bubble caused by firing. Some submerged tubes are designed to be flooded after the torpedo is loaded: upon firing, the torpedo "swims" out of the tube. This method reduces noise and other indications of firing to a minimum. After launching, torpedoes must run for a short distance before they become "armed," or ready to explode. This provides a degree of safety for the launching vessel, particularly in the use of homing torpedoes.

Aircraft torpedoes are virtually identical to submarine and surface-ship torpedoes except in size. A typical aircraft torpedo. the C.S. navy's Mark 13, has a diameter of $22\frac{1}{2}$ in. and a length of $13\frac{1}{2}$ it. It is designed to be launched from aircraft flying at low or medium altitudes and moderate to high air speeds. .Aircraft-launched homing torpedoes are usually equipped with small parachutes designed to reduce the shock of impact with the water and thus protect the sensitive homing mechanism.

Torpedoes must be built to overcome essentially the same problems of underwater propulsion as those faced by submarines. The principal problem is to provide an adequate self-contained power supply within a vehicle of small size. This power supply must be great enough to overcome the resistance of skin friction and the drag of n·ake and propeller cavitation (*see* NAVAL ARCHITECTURE). In addition, it must drive internal mechanisms such as devices for homing. depth control and steering. Ideally torpedoes should have high speed and great endurance and should function silently but no torpedo possesses all these characteristics. Steam torpedoes with high speeds (40 knots) and long range (10.000 yd.) have been built by using a hydrogen-peroxide solution called Navol to provide the oxygen for combustion but these advantages are partially offset by the noise of the turbine and the contrarotating propellers and the telltale n·ake left on the surface. Electric torpedoes are silent but their batteries restrict either their speed or their range. New developments in marine engineering. such as the supercavitating propeller, and in electrical engineering may eventually prove adaptable to torpedo propulsion and bring about an ideal underwater weapon.

Improved performance in U.S. naval torpedoes during World War II n·as the result of intensive wartime research and development. At the outset of hostilities the U.S. navy's torpedoes were generally unsatisfactory in combat. Limited prewar funds and



excessive secrecy masked serious defects in torpedo and exploder performance. Severe criticism from the operating forces. based on dud hits, premature explosions and unaccountable misses, brought action. Efforts of the operating forces, the National Defense Research committee and the bureau of ordnance finally bore fruit but it was not until *1944* that G.S. naval forces received consistently good torpedoes.

Employment and Tactical Use.—The earliest recorded use of torpedoes in combat was in an engagement between H.M.S. "Shah," an unarmoured British frigate: and the Peruvian ironclad turret ship "Huascar." The "Huascar" had been seized by a rebellious faction and was operating in a piratical manner. In an engagement on May *29, 1377.* H.M.S. "Shah" fired a single torpedo at "Huascar." The target ship maneuvered clear with no difficulty. Authorities disagree on the earliest successful use of the automobile torpedo; it probably occurred in the war between Russis and Turkey (1877–78). It was in World War I, however. that the torpedo came of age.

During the years of the weapon's development: experiments in its tactical use were being tried. Small. fast torpedo boats, especially intended for firing torpedoes, were designed and built. As a countermeasure larger, equally fast torpedo-boat destroyers were constructed and armed with the very weapon they were intended to defeat. Large ships! up to and including battleships, were equipped with torpedo tubes. some above water and others submerged. To protect against torpedoes, armour belts were extended below the water line on major combatant vessels and anti-torpedo nets were designed for under-way use.

Maneuvering to avoid the weapon's course and to present the smallest possible target became the best means of torpedo defense. To counteract this tactic and to compensate for possible firing errors. ships usually launched several torpedoes set to run on slightly divergent courses. These "spreads!' were intended to increase chances of a hit regardless of evasive maneuvers.

The submarine was the naval vessel that used the torpedo most successfully. In the four years of World War I. German C-boats sank more than *11.000.000* tons of merchant shipping. The unrestricted submarine campaign came close to success in its attempt to deieat the Allies. (See WORLD WAR I: *Naval.*)

Between World Wars I and II, the torpedoplane (*q.v.*) was developed. An airplane carrying a torpedo extended a fleet's striking range far beyond that of its big guns. For inshore operations small. high-speed motor torpedo boats (U.S. PT's, British MTB's, German E-boats, Italian MAS-boats) were built. Submerged torpedo tubes in surface vessels fell into disuse. Cruisers and destroyers were commonly equipped with above-water tubes. Torpedo nets for under-way use disappeared. Extensive watertight compartmentation and the use of double and triple bottoms on large warships were adopted as protective measures against torpedo damage.

As in World War I, the submarine in World War II achieved its greatest success with the torpedo. In the Atlantic submarines sank more than *14.000.000* tons of Allied merchant shipping and nearly 200 naval vessels. United States submarines in the Pacific destroyed more than 5.000,000 tons of Japanese naval and merchant shipping. *(See* WORLD WAR II: *The War at Sea.)*

Torpedoplanes scored notable victories for each side in World War II. British naval aircraft sank or heavily damaged several major units of the Italian fleet in a torpedoplane attack on Taranto, It. Japanese torpedo bombers sank H.M.S. "Prince of Wales" and '.Repulse" and contributed heavily to the damage done at Pearl Harbor. U.S. torpedoplanes played a major part in sinking the world's largest battleships, "Yamato" and "Musashi."

The homing torpedo was introduced in World War II. This weapon was guided by the sound of the target ship's propellers. The German acoustic torpedo, called "Gnat" by the British and "Wren" by the Germans. was designed to home on the high-pitched sound of an escort vessel's propellers. With the escorts sunk or crippled by "Wrens," U-boats could attack a convoy with conventional torpedoes at leisure. The Allies, however, anticipated the "Wren," and were prompt in introducing a countermeasure. This was an expendable noiseniaker. called "Foxer," that was towed astern of a ship and provided a better attraction for "Wren" than the vessel's propellers.

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(H. P. Dy.)

TORPEDOPLANE. In the torpedoplane. naval science combined one of the most dangerous underwater weapons, the torpedo. with one of the most feared aerial developments, the bomber. to produce the torpedo bomber. A great tactical advantage is enjoyed by a naval force employing torpedoplanes, as the commander can launch a torpedo attack hundreds of miles from the originating ship. instead of the hundreds of yards common in destroyer or submarine attacks.

Naval experiments in aerial launching of torpedoes commenced almost as soon as experiments in the use of the plane itself. The early United States navy advocate of aerial torpedoes was Adm. Bradley Fiske, who described the advantages of such use in *1912* and finally persuaded navy technical offices to undertake the design of aircraft torpedo launching mechanisms, as well as the types of torpedoes suitable for aerial use.

By *1917* an experimental model (Bliss) torpedo of eight-inch diameter had been completed, and a successful drop was made at Huntington. L.I.. in August of that year. In May *1919* an R-6 type navy plane made the first successful drop of a live torpedo (one carrying actual explosive charge) at Hampton Roads, Va. The first navy torpedo squadron of planes was established at Yorktown. Va., in *1920* and the first carrier-based torpedoplane landed on the U.S.S. "Langley" in *1924.* In the same year, torpedoplanes helped sink the battleship "Washington" in target tests. Two years later, the new carriers "Lexington" and "Saratoga" carried torpedoplane squadrons and thereafter this type of plane played an effective part in development of naval air power. The British "Swordfish" gave yeoman service as a torpedoplane for many years, including the early phase of World War II.

In *1911* the United States entered World War II with large numbers of carrier-based Douglas Devastators. which were gradually replaced, after the battle of Midway in *1942,* with Grumman Avengers; with heavier armament and much higher speeds. Torpedoes carried by these planes were particularly designed for high-speed launchings from heights up to *100* ft. A postwar development of this type of plane was the Martin Mauler. a single-engine craft weighing more than ten tons and carrying three torpedoes. For tactical employment *see* TORPEDOES. (A. S. L.)

TORQUAY, a seaport. holiday resort and municipal borough in the Torquay parliamentary division of Devon, Eng., on Torbay, *22* mi. S. of Exeter by road. Pop. (1961) *53.915.* The beauty of its setting and the equability of its climate have gained for it a high repute as an all-year-round resort where palms and other Mediterranean plants grow. It is also a well-known conference centre.

A village existed at Torre before the foundation of the abbey for Premonstratensians by William. Lord Briwer. in *1196;* the abbey remains now house an art gallery. South of the gateway is a 13th-century building known as the Spanish harn. After the defeat of the Armada. Don Pedro's galley was brought into Torbny. and William of Orange landed there on Nov. 5. 1688. The cliff railway at Bahbacombe, to the southeast. was reconstructed. Cockington court. which is Elizabethan and later. and its fine estate. are part of the *1,330* ac. of parks and open spaces owned by the corporation.

TORQUE, the twist or torsion which a shaft undergoes n-hen transmitting power. The degree of tn-ist is very slight. but it can be measured and the horsepower that is transmitted can thus be ascertained. the method being applied particularly to steam turbines. There are several types of torsion meters for measuring horsepower, electrical, mechanical and flashlight. One of the last-named types is here described; its principle depends primarily on the straightness and very high velocity of a ray of light. Two disks are fastened to the shaft a measured distance apart. Each disk has a small slit in it, about $\frac{3}{4}$ in. by $\frac{1}{8}$ in..

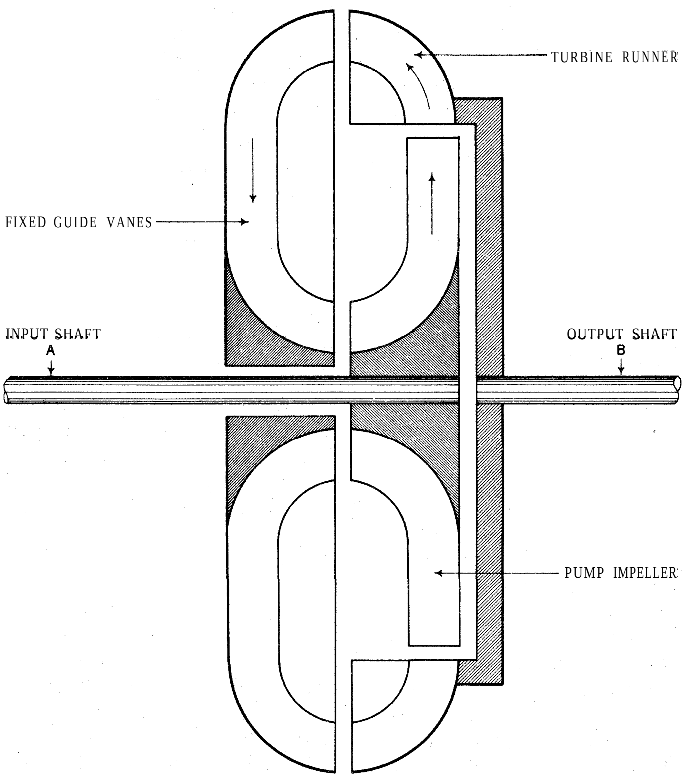
and a lamp is attached near one disk by a rigid support; the torque finder is also rigidly secured. The light from the lamp is limited by a slit of similar size to those in the disks, and the torque finder comprises a casting with a small telescopic eyepiece screwed to a brass plate which also has a slit of the same size as .the others. The plate and eyepiece can be moved circumferentially by means of a micrometer apparatus, reading to .01 of a degree. If the lamp, disks and torque finder are set so that the four slits are in line, the observer looking through the eyepiece parallel to the axis of the shaft will see the light shining in the lamp. If the shaft starts to revolve, at each rotation as the two slits in the disks pass the sight line between lamp and finder the light will be seen momentarily. The persistence of this flash with the rapidly revolving shaft makes it appear as a continuous light. When however the shaft commences to transmit power the torque throws the disk slits out of line and the light is obscured. The observer now adjusts the micrometer and the eyepiece until a sight is again taken through the disk slits. By noting the amount of the displacement thus made the degree of twist is measured, and therefrom the horsepower transmitted. See DYNAMOMETER. (F. H.)

TORQUE AMPLIFIER : see SERVOMECHANISM.

TORQUE CONVERTER. a fluid device for connecting two shafts with a change in torque (*q.v.*).

Sometimes the fluid torque converter is called a hydraulic, hydrodynamic. hydrokinetic or fluid transmission. inasmuch as power is transmitted from one shaft to another by fluid. One of the commonest applications of the fluid torque converter is in automotive transmissions as a replacement for the gearbox. The fluid torque converter pro\-ides an'automatic torque variation at different car movements and speeds and eliminates the gearshift and clutch. The converter is essentially a combination of a pump, turbine and fixed guide vanes. Oil is usually used in commercial units for the circulating fluid because of its lubricating properties, availability and stability.

Various methods can be used for joining or connecting two ro-



TCRQUE CONVERTER. SHOWING INTERNAL FLOW OF FLUID

tating shafts. such as for connecting an engine or motor to some load In many cases purely mechanical. rigid or flexible connections are most suitable: gears, chain drives and other devices can be used. In various applications, however, service requirements are best met with some form of fluid conriector.

As indicated in the figure, the input shaft A (driven, for example, by an internal-combustion engine) drives the pump impeller, which is usually a centrifugal pump runner with curved blades. Energy is transferred from the impeller to the fluid as the pump builds up speed; fluid flows from the inlet radius to the outlet radius. Leaving the impeller, the fluid enters the turbine runner. which usually has curved blades. After sufficient energy has been developed by the pump, the fluid rotates the turbine runner and turns the output shait B, which is connected to some load. Fluid leaving the turbine runner then passes through the fixed guide vanes before returning to the pump impeller. The fluid moves through a closed circuit shaped like a vortex ring. There is no rigid or mechanical connection between the input and output shafts; the connection between these shafts is solely by means of a fluid.

The fixed or stationary vanes (which are curved) change the flow direction of the fluid; thus there is a torque and speed transformation. The fixed guide vanes take some reaction; carrying it. to the fixed casing or foundation; thus the turbine torque does nor. equal the pump torque. This explains the term "torque converter." Different blade arrangements are possible. For example. the pump impeller action may be in separate stages. Similarly the turbine action or the fixed guide vane action may be in two or more stages.

The torque converter provides smooth starting of the load and absorbs torsional shocks and vibrations. If extreme loads on the output shaft of the converter stall the output shaft during operation, the input shaft will not stall but will continue running. In some converters the speed of the input shaft is almost conitant, regardless of the speed of the output shaft.

In some torque converters the starting output torque is about five times the input torque. The efficiency of a converter is defined as the ratio of the power at the output shait divided by the power at the input shaft. Converters have been built with maximum efficiencies ranging from 85% to 87%. In general. the efficiency of a torque converter is maximum at intermediate speeds. with zero efficiency at zero output shaft speed and when the input and output shafts rotate at the same speed.

Two rotating shafts could be coupled by an arrangement which includes a separate pump and a separate'turbine connected by intermediate piping. The fluid torque converter. however, provides a real saving in weight and space because of the concentric arrangement of pump impeller and turbine runner. Also, the concentric arrangement eliminates the friction loss in the intermediate piping.

A distinction should be made between a fluid coupling and a fluid torque converter. Sometimes the fluid coupling is called a fluid flywheel. If there were no fixed guide vanes in the flow circuit, then the unit would be a fluid coupling. Thus a fluid coupling is simply a combination of a centrifugal pump and a turbine. The action of the fluid coupling can be illustrated by means of two common electric fans which are set facing each other. One fan, connected to a supply of electricity, is put into motion by turning on the electric current. As the fan blades rotate, the air current turns the blades of the other fan, which is not receiving any electric current. Since there are no torque reacting elements in the fluid coupling besides the pump impeller and the turbine runner! under steady operating conditions the output torque always equals the input torque; this explains the term "fluid coupling." 'The efficiency of a fluid coupling increases from zero at zero output shaft speed to a maximum when the output and input shafts rotate at the same speed.

A torque converter can be arranged to operate as a fluid coupling if the fixed guide vanes are arranged n·ith a free wheeling device so that the vanes do not give any reaction to the fluid at certain speeds. Thus, in an automotive unit, the fluid transmission can act as a torque converter with the guide vanes fixed at low speeds; at high speeds the guide vanes can freewheel with no torque reaction, allowing the unit to operate as a fluid coupling. Thus the unit utilizes the principles of both the torque converter and the fluid coupling in their most efficient speed ranges.

See AUTOMOBILE: *Transmission System;* POWER TRANSMISSION.

See P. M. Heldt, *Torque Converters or Transmissions,* 5th ed. (1955); R. C. Binder, *Advanced Fluid Mechanics,* vol. i (1958).
(R. C. BR.)

TORQUEMADA, THOMAS (1420–1498), inquisitor-general of Spain, was born in 1420 at Valladolid. There he joined the Friars Preachers (Dominicans), took his vows, studied philosophy and received the baccalaureate in theology. About 1452 he became prior of the monastery of Santa Cruz of Segovia, a post which he held for 22 years. He retained the title, "Prior of Santa Cruz" until his death.

Torquemada was a man of strong character. His ardent love for the Catholic faith and his Spanish homeland developed in him a hatred for anything that endangered them. He was convinced that the Moors, and many of the Jews, the *Marranos* (Jewish converts to Christianity, also called *conversos* and "New Christians"), and the *Moriscos* (converts from Mohammedanism) were undermining the religious and social life of Spain. He was well thought of by contemporaries. Sebastian of Olmeda called him: "a scourge of heresy, a light of Spain, the saviour of his country and an honour to his Order." Hernando del Pulgar, secretary of Queen Isabella, referred to him as a man "of honest life, who had great zeal for the faith." Popes Sixtus IV and Alexander VI praised his zeal and wisdom, and Ferdinand and Isabella entertained a high opinion of him. Isabella may have consulted him during her frequent residences at Segovia before she became queen. She chose him as confessor on her accession to the throne. Later he was appointed confessor to Ferdinand as well.

In spite of his high station at the Spanish court, Torquemada had no desire for honours and steadfastly refused ecclesiastical preferments. He was possessed of considerable administrative ability as is witnessed by his long tenure as prior, his reorganization and direction of the inquisition and his appointment to special posts, such as visitor to the congregation of reformed Dominican priories of Aragon (1487–88). His interest in the arts is shown by his various architectural ventures, notably the construction of the monastery of St. Thomas at Avila.

The Inquisition.— In 1478 Ferdinand and Isabella decided to establish the inquisition in Castile. The motivation for this step was the problem of the *conversos* and *moriscos,* many of whom had embraced Christianity insincerely and were using the immunity and privileges thus gained to work against the Catholic faith and the unity of the Spanish nation. It is the opinion of some that the very existence of Christian Spain was at stake. A number of ecclesiastics urged the foundation of the inquisition as the only cure for these problems, and possibly Torquemada, as royal confessor, was consulted and added his voice to these representations. He and Cardinal Mendoza drafted the petition to Sixtus IV asking for authority to establish the inquisition. The pope acceded to the request in a bull of Nov. 1, 1478. Two years later, Sept. 26, 1480, the first inquisitors, Miguel Morillo and Juan de San Martin, were appointed. Mendoza and Torquemada appear to have acted as consultors. Morillo and San Martin proceeded to Seville where they established the first tribunal. The complaints of severity and injustice lodged at Rome during these early years of the inquisition were directed against the activities of these two men. On Feb, 11, 1482 Sixtus IV appointed Torquemada and seven other Dominicans as assistant inquisitors. The following year Isabella petitioned for a reorganization of the inquisition under unified control. At the suggestion of Mendoza, she recommended Torquemada as inquisitor-general and early in October he was appointed for Castile. On Oct. 17 his jurisdiction was extended to Aragon, and in Feb. 1486 to Barcelona. He was recommissioned by Pope Innocent VIII in 1485 and 1486. By virtue of his office he was appointed a member of the royal council.

As inquisitor-general Torquemada was the highest official of the Spanish inquisition. He had wide powers of appointment and dismissal of subordinate inquisitors and appellate power in cases brought before episcopal courts (1496). His jurisdiction did not extend to prelates, and Jews were tried only in cases of proselytism, sorcery, or other spiritual offenses. Torquemada reorganized the inquisition completely and promulgated standard rules of procedure. He constituted local tribunals at Seville, Jaén, Cordova, Ciudad Real (later transferred to Toledo) and at Saragossa. A supreme council of five members, including himself, was organized for the hearing of appeals.

On Nov. 29, 1484, he convoked a general assembly of all Spanish inquisitors at Seville and presented 28 articles for their guidance. New statutes were added in Dec. 1484, in 1485, 1488 and 1498. It is noteworthy that crimes other than heresy and apostasy, such as witchcraft, necromancy, bigamy, blasphemy and usury were brought under the inquisition's jurisdiction. As in the royal tribunals, torture was authorized as a means of gaining evidence. The use of irons was not allowed. Under Isabella about 2,000 persons were executed by the inquisition. Torquemada was probably responsible for one-half to two-thirds of this number. It is estimated that approximately 100,000 cases were tried during his tenure as inquisitor-general. On three occasions Torquemada sent Alphonse Badaja to Rome to represent him before the pope. In June 1494, owing to Torquemada's age and infirmity, Alexander VI appointed four assistant inquisitors. Their power was equal to Torquemada's, though he retained control until his death.

Expulsion of the Jews.—Ferdinand and Isabella had long contemplated the expulsion of the Jews, whom they considered a source of disunity for the kingdom and of contamination for the *conversos.* Thus on March 31, 1492, they signed an edict ordering the expulsion of all Jews who had not embraced Christianity. Torquemada may have been consulted before the order was issued and perhaps presented the evidence of the La Guardia trial (1490–91) as a further inducement to the sovereigns. Undoubtedly he was in thorough sympathy with the move. It is estimated that from 160,000 to 200.000 Jews left Spain. There is no adequate proof for the tale that when a ransom of 30,000 ducats was offered by the Jews, Torquemada indignantly threw his crucifix on the table and asked the king and queen if, like Judas, they would betray their Lord for money. This story seems to have become current toward the end of the 16th century.

Some critics have said that Torquemada never travelled unless accompanied by 250 armed retainers and 50 horsemen. Undoubtedly he was sufficiently protected, but there is no contemporary evidence for this statement, nor for the charge that he never ate unless the horn of a unicorn or the tongue of a scorpion lay at the side of his plate. These accusations first appeared almost a century after his death. Torquemada died at Avila, Sept. 16, 1498.

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(W. A. HH.)

TORRANCE, an industrial and residential city on the southwestern coastal plain of Los Angeles county in southern California. U.S., 15 mi. from downtown Los Angeles (*q.v.*). It was founded in 1911 by Jared Sidney Torrance and associates, who purchased 3.500 ac. of the Rancho San Pedro for slightly more than $1,000,000. Torrance was planned as an industrial community; a tool company began operations late in 1912, with 280 employees, and was soon joined by an ironworks. By the second part of the 20th century there were more than 200 manufacturing plants in the city

Torrance was incorporated in 1921; it has a council-manager form of government, in effect since 1948. After discovery of oil in the nearby area, the city expanded rapidly. The population in 1960 was 100.991; for comparative population figures *see* table in CALIFORNIA: *Population.* Through a series of annexations after 1950, a large residential district, with modern housing, was added to the city. This stimulated construction of marketing centres, modernization of municipal facilities, including recreational areas, and the completion of a new civic centre. (R. C. GM.)

TORRE ANNUNZIATA, a seaport of Campania. Italy, in the province of Napoli, on the east of the Bay of Naples, and at the south foot of Mt. Vesuvius, 14 mi. S.E. of Naples by rail. Pop. (1951) 52,175. It is on the main line to Battipaglia, at the point of junction of a branch line from Cancello round the east of Vesuvius, and of the branch to Castellammare di Stabia and Gragnano. It has an arms factory and other ironworks, manufacture of macaroni and breeding of silkworms. There are numerous mineral springs.

TORRE DEL GRECO, a seaport of Campania, Italy, in the province of Napoli, $7\frac{1}{2}$ mi. S.E. of that city by rail. Pop. (1951) 50,099. It lies at the southwest foot of Vesuvius, on the shore of the Bay of Naples. It is built chiefly of lava, and stands on the lava stream of 1631, which destroyed two-thirds of the older town. Great damage was done by the eruption of 1737 and 1794; the earthquake of 1857 and the eruption of Dec. 8, 1861, were even more destructive.

TORRENS, SIR ROBERT RICHARD (1814–1884), British colonial statesman, was born at Cork, Ireland, in 1814, and educated at Trinity college, Dublin. He went to South Australia in 1840, and was appointed collector of customs. He was an official member of the first legislative council and in 1852 was treasurer and registrar general. When responsible government was established he was elected as a representative for Adelaide and became a member of the first ministry. In 1857 he introduced his famous Real Property act, the principle of which consists of conveyance by registration and certificate instead of deeds. The system was rapidly adopted in the other colonies and elsewhere, and was expounded by the author during a visit to the United Kingdom in 1862–64. After leaving South Australia, Torrens represented Cambridge in the house of commons from 1868–74; in 1872 he was knighted. He was the author of works on the effect of gold discoveries on currency, and other subjects. He died Aug. 31, 1884.

TORRENS, WILLIAM TORRENS McCULLAGH (1813–1894), English politician and social reformer, son of James McCullagh, was born near Dublin Oct. 13, 1813. He was called to the bar, and in 1835 became assistant commissioner on the special commission on Irish poor-relief, which resulted in the extension of the workhouse system in Ireland in 1838. In the '40s he joined the Anti-Corn Law league, and in 1846 published his *Industrial History of Free Nations*. From 1847–52 he represented Dundalk in parliament, in 1857 he was returned for Yarmouth, and from 1865–85 he represented Finsbury. Torrens devoted himself mainly to social questions in parliament. His amendment to the Education bill of 1870 established the London School board, and his Artisans' Dwellings bill in 1868 facilitated the clearing away of slums by local authorities. He wrote *Twenty Years in Parliament* (1893) and *History of Cabinets* (1894). He died in London April 26, 1894.

TORRENS, LAKE: *see* SOUTH AUSTRALIA.

TORREÓN, a modern city of Mexico in the state of Coahuila, is located on the Rio Nazas about 788 mi. N.W. of the federal capital. Pop. (1950) 128.976; (1958 est.) 142,100. Opposite is the picturesque colonial city of Gómez Palacio in the state of Durango. Torreón is an important railway juncture served by the El Paso to Mexico City line of the National Railroad of Mexico, and by branch lines to Durango and Monterrey. It is also served regularly by bus and air lines. Torreón's industries, such as cotton and flour mills, and iron and steel works, make it one of the most important manufacturing centres in northern Mexico. It is also the commercial centre for the cotton- and wheat-growing region known as La Laguna, one of the largest state-operated agricultural co-operatives in Mexico, begun in 1936 under Pres. Lázaro Cárdenas. , (R. B. McCK.)

TORRES NAHARRO, BARTOLOMÉ DE (1480–1530), Spanish dramatist. was born toward the end of the 15th century at Torres, near Badajoz. After some years of soldiering and of captivity in Algiers. Torres Naharro took orders, settled in Rome about 1511, and there devoted himself chiefly to writing plays. Although he alludes to the future pope, Clement VII, as his protector, he left Rome to enter the household of Fabrizio Colonna at Naples where his works were printed under the title of *Propaladia* 1) . He is conjectured to have returned to his native place, and to have died there shortly after 1529. His *Diálogo del nacimiento* is written in unavowed, though obvious, imitation of Encina, but in his subsequent plays he shows a much larger conception of dramatic possibilities. He classifies his pieces as *comedias á noticia* and *comedias á fantasia;* the former, of which the *Soldatesca* and *Tinellaria* are examples, present in dramatic form incidents within his personal experience; the latter, which include such plays as *Serafina, Wimenea, Calamita* and *Aquilana,* present imaginary episodes with adroitness and persuasiveness. Torres Naharro is much less dexterous in stagecraft than many inferior successors, his humour is rude and boisterous and his diction is unequal; but to a varied knowledge of human nature he adds knowledge of dramatic effect, and his rapid dialogue, his fearless realism and vivacious fancy prepared the way for the romantic drama in Spain.

TORRES VEDRAS, 43 mi. N.W. of Lisbon, Portugal, on the Lisbon-Figueira da Foz railway. Pop. (1950) 5,178. Roman inscriptions were found there, but the Latin name of the town, *Turres Veteres,* is probably mediaeval. There were "lines of Tôrres Vedras," constructed by Wellington in 1810 *(see* PENINSULAR WAR). There also in 1846 the troops of General Saldanha defeated those of the Count de Bomfim.

TORRES Y VILLAROEL, DIEGO DE (1696–1759?), Spanish writer, was born in 1696 at Salamanca, where his father was bookseller to the university. In his teens Torres escaped to Portugal where he enlisted under a false name; he next moved to Madrid, living from hand to mouth as a hawker; in 1717 he was ordained subdeacon, resumed his studies at Salamanca, and in 1726 became professor of mathematics at the university. Torres was suspected of complicity in the stabbing of a priest and fled to Portugal, where he remained until his innocence was proved. He then returned to his chair, which he resigned in 1751 to act as steward to two noblemen. Torres had so slight a knowledge of mathematics that his appointment as professor was thought scandalous even in his own scandalous age, yet he quickly acquired a store of knowledge which he displayed with serene assurance. His almanacs, his farces, his devotional and pseudoscientific writings show that he possessed the alert adaptiveness of the born adventurer; but all that remains of his 14 volumes (1745–52) is his autobiography, an amusing record of cynical effrontery and successful imposture. He was known to be alive in 1758, but the date of his death is uncertain.

TORREY, JOHN (1796–1873), U.S. botanist and chemist, originator of the monumental *Flora of North America,* was born in New York city, Aug. 15, 1796. He graduated (M.D.) in 1818 from the College of Physicians and Surgeons in New York. After holding various professorships (chemistry. geology, mineralogy and natural history), in 1836 he became New York state botanist. Torrey's *Flora of the State of New York* was produced in 1843, and from 1838 to 1843 he carried on the publication of the earlier portions of *Flora of North America,* with the assistance of his pupil Asa Gray (*q.v.*). From 1853 he was chief assayer to the U.S. assay office when it was located in New York city. In or about 1860 he gave his valuable herbarium and botanical library to Columbia college. Torrey continued to take an interest in botanical teaching until his death at New York on March 10, 1873.

See A. D. Rodgers, John *Torrey* (1942).

TORREY, REUBEN ARCHER (1856–1928), U.S. evangelist, was born in Hoboken, N.J., Jan. 28, 1856. He graduated from Yale university in 1875 and from the Yale divinity school in 1878. He became a Congregational minister in 1878, studied theology at Leipzig and Erlanger in 1882–83, joined D. L. Moody in his evangelistic work in Chicago in 1889, and became pastor of the Chicago Avenue church in 1894 and afterward superintendent of the Moody Bible institute of Chicago.

In 1902–03 he made an evangelistic tour, preaching in many parts of the world, and with Charles McCallon Alexander conducted revival services in Great Britain in 1903–05; Torrey conducted a similar campaign in U.S. and Canadian cities in 1906–07, returned to England, Scotland and Ireland in 1911 and visited

Japan and China in 1919. He was dean of the Bible institute, Los Angeles, 1912–24, and pastor of the Church of the Open Door, Los Angeles, 1915–24. Included among his many religious works are: *The Fundamental Doctrines of the Christian Faith* (1919), *The Christ of the Bible* (1923) and *Lectures on First Epistle of John* (1928). His books were translated into many languages. He died Oct. 26, 1928.

TORRICELLI, EVANGELISTA (1608–1647), Italian physicist and mathematician who discovered the principle of the barometer, was born at Faenza on Oct. 15, 1608. In 1627 he went to Rome to study science under the Benedictine Benedetto Castelli, professor of mathematics at the Collegio di Sapienza. The perusal of Galileo's third dialogue of the *Discorsi . . . a due nuove scienze* (1638) inspired him with many developments of the mechanical principles there set forth, which he embodied in the treatise *De motu* (printed among his *Opera geometrica,* 1644). In 1641 he went to Florence, where he met Galileo and acted as his amanuensis during the three remaining months of Galileo's life. After Galileo's death Torricelli was nominated grand-ducal mathematician and professor of mathematics in the Florentine academy. The discovery of the principle of the barometer (*q.v.*) which has perpetuated his fame ("Torricellian tube," "Torricellian vacuum") was made in 1643. Torricelli was brought into controversy with G. P. de Roberval as to the priority of the solution of a problem on the properties of a cycloid. Torricelli wrote on fluid motion, on the theory of projectiles and on the motion of two bodies connected by a string passing over a fixed pulley. He used and developed B. Cavalieri's method of indivisibles. He died at Florence, Oct. 25, 1647.

TORRIGIANO, PIETRO (1472–1528), Italian sculptor whose greatest achievements were the tombs he executed in England, was born and educated in Florence. For a brief period he was a professional soldier. A wanderer by nature, he carved stucco decorations (1493) in the Borgia apartments of the Vatican; later he worked in Bologna and in Siena cathedral on the Piccolomini altar (*c.* 1501). Subsequently he traveled to Antwerp, where he engaged in unspecified work for Marguerite of Austria (1509–10), and thereafter went to England. In the chapel of Henry VII in Westminster abbey, London, are his masterpieces: the double tomb of Henry VII and Elizabeth of York (1512–18), whose gilded bronze effigies lie upon a black-marble base decorated with bronze reliefs; and the tomb of the king's mother, Margaret of Richmond, in similar Renaissance style. The high altar (1517–22) of the same chapel, also commissioned of Torrigiano, was destroyed in 1643. The tomb of Henry VIII, ordered in 1518, was never begun. During 1519 and 1520 Torrigiano returned to Florence to engage other sculptors as his assistants in London. Sometime after 1522 he went from England to Spain, probably with the hope of finding important commissions there. The large terracotta statues of St. Jerome and of the Madonna with the Child in the Seville museum are the only preserved works of his Spanish sojourn. He died in July or August 1528 while in prison at Seville, held under charge of heresy by the Inquisition.

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TORRINGTON, ARTHUR HERBERT, EARL OF (1647–1716), British admiral, was the son of a judge, Sir Edward Herbert (*c.* 1591–1657). He entered the navy in 1663, and served in the Dutch wars of the reign of Charles II, as well as against the Barbary pirates. From 1680 to 1683 he commanded in the Mediterranean. The known royalist sentiments of his family and his reputation as a naval officer ensured the favour of James II, who appointed him rear admiral of England and master of the robes. But Herbert refused to support the king's proposal for the repeal of the Test act, and was dismissed from his places. He now entered into communication with the agents of the prince of Orange. After the acquittal of the seven bishops in 1688 he carried the invitation to William of Orange. After the Revolution Herbert was named first lord of the admiralty, and took the command of the fleet at home. In 1689 he was at sea attempting to prevent the French admiral Château-Renault (*q.v.*) from landing the troops sent by the king of France to the aid of King James in Ireland. Though he fought an action with the French in Bantry bay May 10 he failed to baffle Château-Renault, who had a stronger force. In May 1689 he was created earl of Torrington. In 1690 he was in the channel with a fleet of 56 English and Dutch vessels, when he found himself confronted with the much more powerful French fleet. He proposed to retire to the Thames, but the council of regency, knowing that the Jacobites were preparing for a rising, and only waiting for the support of a body of French troops, ordered him not to lose sight of the enemy, but rather than do that to give battle "upon any advantage of the wind." On July 10 Torrington made a half-hearted attack on the French off Beachy Head in which his own ship was kept out of fire, and severe loss fell on his allies. Then he retired to the Thames. The French pursuit was fortunately feeble, and the loss of the allies was comparatively slight. Torrington was brought to trial before a court martial in December, and acquitted. He died April 14, 1716.

The unfavourable account of his moral character reported by Dartmouth to Pepys is confirmed by Bishop Burnet, who had seen much of him during his exile in Holland. Torrington originated the phrase "a fleet in being."

See Charnock's *Biog. Nav.,* i 258. The best account of the battle of Beachy Head is to be found in "The Account given by Sir John Ashby Vice-Admiral and Rear-Admiral Rooke, to the Lords Commissioners" (1691).

TORRINGTON, GEORGE BYNG, VISCOUNT (1663–1733), English admiral, was born at Wrotham, Kent, and entered the navy in 1678. In 1688 he helped to win the fleet over to the prince of Orange; appointed to the command of the "Nassau" in 1702 he was present at the burning of the French fleet at Vigo, and in 1703 was made rear admiral of the red. He served in the Mediterranean (1704) and at the battle of Malaga, after which he was knighted. In 1708, as admiral of the blue he prevented the Old Pretender from landing in Scotland; and ten years later defeated the Spaniards off Passaro, after which the king sent him full powers to negotiate with the princes and states of Italy. To his conduct it was owing that Sicily was subdued and the king of Spain forced to accept the terms prescribed by the Quadruple alliance. On his return to England in 1721 he was made rear admiral and a member of the privy council, and was created Baron Byng of Southill in Bedfordshire, Viscount Torrington in Devonshire and a Knight Companion of the Bath (1725). George II made him first lord of the admiralty in 1727. He died Jan. 17, 1733.

See *Memoirs relating to Lord Torrington,* Camden Soc. new series 46, and *A True Account of the Expedition of the British Fleet to Sicily, 1718–1720,* published anonymously, but known to be by Thomas Corbett of the admiralty in 1739. Forbin's *Memoirs* contain the French side of the expedition to Scotland in 1708.

TORRINGTON (GREAT TORRINGTON), a market town and municipal borough in the Torrington parliamentary division of Devon, Eng., on the Torridge, 36 mi. N.W. of Exeter by road. Pop. (1951) 2,873. Area 5.6 sq.mi. From early times Torrington, or *Toritone* as it is called in the Domesday survey, has occupied a prominent place among the borough towns of Devon, for it was a self-governing community at least three and a half centuries before it received its first royal charter of incorporation from Mary I in 1554. Some precharter mayors or *praepositi* are recorded, the first in 1183. The borough had a fair in 1221. Recognition of its early importance is shown by the fact that it had been granted a parliamentary franchise from 1295 to 1369, when the borough sent two members to parliament. On the petition of the burgesses, the town was relieved of the burden. Of Torrington castle nothing remains. It was probably first erected by the baronial owner of the manor, William de Toriton (1130–*c.* 1185). A royal mandate was issued in 1228 for its destruction, the castle having been built without a royal licence. It was rebuilt by De Toriton's successor Sir Richard de Merton, who was licensed to crenelate it in 1338–39. During the Civil Wars, the parish church suffered severely by an explosion of gunpowder on Feb. 16, 1645, when some 200 persons perished; and at the eastern end of the town the victorious parliamentarians, under Sir Thomas Fairfax, fought a battle in which several hundred royalists mere slain and the town captured. The parish register contains the names of many of those who perished and were buried in the churchyard. The chief manufactures are milk products and gloves.

See J. J. Alexander and W. R. Hooper, *The History of Great Torrington. . . .* (Sutton, Surrey, 1948).

TORRINGTON, a city of Connecticut, U.S., is located 23 mi. W. of Hartford on the Naugatuck river, surrounded by the Litchfield hills in a region of great natural beauty. First settled in 1735 as part of the town of Windsor, Torrington was organized as a town in 1740, incorporated as a borough in 1887 and chartered as a city in 1923. At the time of first settlement the community was isolated and in danger of attack by the Mohawk Indians; a fort was erected in 1744 at a cost of £70. During the American Revolution the entire male population over 20 years (169 in all) enlisted in two companies for service in the Continental army. Samuel J. Mills, Jr. (1783–1818), founder of the American Board of Commissioners for Foreign Missions (Congregational), was born in Torrington. In the 19th century Torrington was a centre of abolitionist sentiment and was, appropriately enough, the birthplace of John Brown (*q.v.*). Torrington's earliest industry was shipmast production. This was the town's industrial mainstay until the exhaustion of the pine forests about 1813 when the first textile mill was built. Abundant water power led to production of brass articles (particularly kettles and wire), German silver and other metal products. Torrington is the market and banking centre for west-central Connecticut. For comparative population figures *see* table in CONNECTICUT: *Population.* (GL. W.)

TORSTENSSON, LENNART, COUNT (1603–1651), Swedish soldier, son of Torsten Lennartsson, commandant of Elfsborg, was born at Forstena in Vestergotland. At the age of 15 he became one of the pages of the young Gustavus Adolphus and served during the Prussian campaigns of 1628–29. In 1629 he was set over the Swedish artillery, and contributed to the victories of Breitenfeld (1631) and Lech (1632). The same year he was taken prisoner at Alte Veste and shut up for nearly a year at Ingolstadt. Under Banér he rendered distinguished service at the battle of Wittstock (1636) and during the energetic defense of Pomerania in 1637–38, as well as at the battle of Chemnitz (1638) and in the raid into Bohemia in 1639. Illness compelled him to return to Sweden in 1641, when he was made a senator. The sudden death of Banér in May 1641 recalled Torstensson to Germany as generalissimo of the Swedish forces and governor-general of Pomeraniz. He was at the same time promoted to the rank of field marshal. The period of his command (1641–45) forms one of the most brilliant chapters in the millitary history of Sweden. In 1642 he marched through Brandenburg and Silesia into Moravia, taking all the principal fortresses on his way. On returning through Saxony he well nigh annihilated the imperialist army at the second battle of Breitenfeld (Oct. 23, 1642). In 1643 he invaded Moravia for the second time, but was suddenly recalled to invade Denmark, when his rapid and unexpected intervention paralysed the Danish defense on the land side, though Torstensson's own position in Jutland was for a time precarious owing to the skilful handling of the Danish fleet by Christian IV.

In 1644 he led his army for the third time into the heart of Germany and routed the imperialists at Jiiterbog (Nov. 23). At the beginning of Nov. 1645 he broke into Bohemia, and the brilliant victory of Jankow (Feb. 24, 1645) laid open before him the road to Vienna. Yet, though one end of the Danube bridge actually fell into his hands, his exhausted army was unable to penetrate any farther and, in December the same year, Torstensson, crippled by gout, was forced to resign his command and return to Sweden. In 1647 he was created a count. From 1648 to 1651 he ruled all the western provinces of Sweden, as governor-general. On his death at Stockholm (April 7, 1651) he was buried solemnly in the Riddarholmskyrka, the Pantheon of Sweden.

See J. W. de Peyster, *History of the Life of L. Torstensson* (Poughkeepsie, 1855); J. Feil, *Torstensson before Vienna* (trans. by de Peyster, New York, 1885); Gustavus III, *Eulogy of Torstensson* (trans. by de Peyster, New York, 1872). (R. N. B.)

TORT, the technical term, in the law of England, of those dominions and possessions of the British empire where the common law has been received or practically adopted in civil affairs, and of the United States, for a civil wrong, *i.e.,* the breach of a duty imposed by law, by which breach some person becomes entitled to sue for damages. A tort must, on the one hand, be an act which violates a general duty. The rule which it breaks must be one made by the law, not, as in the case of a mere breach of contract, a rule which the law protects because the parties have made it for themselves. On the other hand, a tort is essentially the source of a private right of action. An offense which is punishable, but for which no one can bring a civil action, is not a tort. It is quite possible for one and the same act to be a tort and a breach of contract, or a tort and a crime; it is even possible in one class of cases for the plaintiff to have the option—for purposes of procedural advantage—of treating a real tort as a fictitious contract; but there is no necessary or general connection. Again, it is not the case that pecuniary damages are always or necessarily the only remedy for a tort; but the right to bring an action in common law jurisdiction, as distinct from equity, matrimonial or admiralty jurisdiction, with the consequent right to damages, is invariably present where a tort was committed.

This technical use of the French word *tort* (which at one time was near becoming a synonym of *wrong* in literary English) is not very ancient, and anything like systematic treatment of the subject as a whole is very modern. From about the middle of the 19th century there was a current assumption that all civil causes of action must be founded on either contract or tort; but there is no historical foundation for this doctrine, though modified forms of the action of trespass—actions *in consimili casu,* or "on the case" in the accustomed English phrase—did in practice largely supplant other more archaic forms of action by reason of their greater convenience. The old forms were designed as penal remedies for manifest breach of the peace or corruption of justice; and traces of the penal element remained in them long after the substance of the procedure had become private and merely civil. The transition belongs to the general history of English law.

In England the general scope of the law of torts was never formulated by authority. But there is no doubt that duties enforced by the English law of torts are broadly those which the Roman institutional writers summed up in the precept *Alterum non laedere.* Every member of a civilized commonwealth is entitled to require of others a certain amount of respect for his person, reputation and property, and a certain amount of care and caution when they go about undertakings attended with risk to their neighbours. Under the modern law, it is submitted, the question arising when one man wilfully or recklessly harms another is not whether some technical form of action can be found in which he is liable, but whether he can justify or excuse himself. This view, at any rate, is countenanced by a judgment of the supreme court of the U.S. delivered in 1904. If it be right, the controverted question whether conspiracy is or is not a substantive cause of action seems to lose most of its importance. Instead of the doubtful proposition of law that some injuries become unlawful only when inflicted by concerted action, we shall have the plain proposition of fact that some kinds of injury cannot, as a rule, be inflicted by one person with such effect as to produce any damage worth suing for.

The precise amount of responsibility can be determined only by full consideration in each class of cases. But what makes the law of torts effective, especially with regard to redress for harm suffered by negligence, is the universal rule of law that every one is answerable for the acts and defaults of his servants (that is, all persons acting under his direction and taking their orders from him or some one representing him) in the course of their employment. The person actually in fault is not the less answerable, but the remedy against him is very commonly not worth pursuing. But for this rule corporations could not be liable for any negligence of their servants, however disastrous to innocent persons, except so far as it might happen to constitute a breach of some express undertaking. We have spoken of the rule as universal, but, in the case of one servant of the same employer being injured by the default of another, an unfortunate aberration of the courts, which started from small beginnings in the second quarter of the 19th century, was pushed to extreme results, and led to great hardship. A partial remedy was applied in 1880 by the Employers' Liability act; and in 1897 a much bolder step was taken by the Workmen's Compensation act (superseded by later amendment and extension now consolidated in an act of 1925). The Workmen's Compensation act includes cases of pure accident, where there is no fault at all, or none that can be proved, and therefore goes beyond the reasons of liability with which the law of torts has to do. In fact, it establishes a kind of compulsory insurance, justifiable only on wider grounds of policy.

There are kinds of cases, on the other hand, in which the law, without aid from legislation, has imposed on occupiers and other persons in analogous positions a duty stricter than that of being answerable for themselves and their servants. Duties of this kind are called "duties of insuring safety." Generally they extend to having the building, structure, or works in such order, having regard to the nature of the case, as not to create any unusual danger to persons lawfully frequenting, using or passing by them, which the occupier knows or ought to know and could prevent by reasonable care; but in some cases of "extra-hazardous" risk, even proof of all possible diligence—according to English authority, which is not unanimously accepted in America—will not suffice.

Classification.— The classification of actionable wrongs is perplexing. We may start either from the character of the defendant's act or omission, with regard to his knowledge, intention and otherwise; or from the character of the harm suffered by the plaintiff. Whichever of these we take as the primary line of distinction, the results can seldom be worked out without calling in the other. Taking first the defendant's position, the widest governing principle is that, apart from various recognized grounds of immunity, a man is answerable for the "natural and probable" consequences of his acts; *i.e.,* such consequences as a reasonable man in his place should have foreseen as probable. Still more is he answerable for what he did actually foresee and intend. Knowledge of particular facts may be necessary to make particular kinds of conduct wrongful. Such is the rule in the case of fraud and other allied wrongs, including what is rather unhappily called "slander of title," and what is now known as "unfair competition" in the matter of trade names and descriptions, short of actual piracy of trade-marks. But where an absolute right to security for a man's person, reputation or goods is interfered with, neither knowledge nor specific intention need be proved. This rule was known some time ago to apply to the exercise of rights of property, and such speculative doubt as remained was removed by the decision of the house of lords in the leading case of Allen v. Flood (1898, A.C. 1). We now know that it applies to the exercise of all common rights. The exceptions are very few, and must be explained by exceptional reasons. Indeed, only two are known to the present writer—malicious prosecution, and the misuse of a "privileged occasion" which would justify the communication of defamatory matter if made in good faith. In each case the wrong lies in the deliberate perversion of a right or privilege allowed for the public good, though the precise extent of the analogy is not certain at present. It was formerly supposed that an action by a party to a contract against a third person for procuring the other party to break his contract was within the same class, *i.e.,* that malice must be proved. But since Allen v. Flood, and the later decision of the house of lords in *Quinn* v. Leathern (1901, A.C. 495), this view ceased to be tenable. The ground of action is the intentional violation of an existing legal right; which, however, from 1906, may be practised with impunity in Great Britain "in contemplation or furtherance of a trade dispute": Trade Disputes act, sec. 3. It must be remembered, however, that the presence or absence of personal ill will, and the behaviour of the parties generally, may have an important effect, when liability is proved or admitted, in mitigating or aggravating the amount of damages awarded by juries and allowed by the court to be reasonable. It may likewise be noted, by way of caution, that some problems of criminal law, with which we are not here concerned, require more subtle consideration. However, it is hardly ever safe to assume that the bounds of civil and criminal liability will be found coextensive. Perhaps we may go so far as to say that a man is neither civilly nor criminally liable for a mere omission (not being disobedience to a lawful command which he was bound to obey), unless he has in some way assumed a special duty of doing the act omitted.

We have already had to mention the existence of grounds of immunity for acts that would otherwise be wrongful. Such grounds there must be if the law is to be enforced and justice administered at all, and if the business of life is to be carried on with any freedom. Roughly speaking, we find in these cases one of the following conditions: Either the defendant was executing a lawful authority; or he was justified by extraordinary necessity; or he was doing something permitted by legislation for reasons of superior utility, though it may produce damage to others, and either with or without special provisions for compensating damage; or he was exercising a common right in matters open to free use and competition; or the plaintiff had, by consent or otherwise. disabled himself from having any grievance. Pure accident will hardly seem to any one who is not a lawyer to be a special ground of exemption, the question being rather how it could ever be supposed to be a ground for liability. But it was supposed so by many lawyers down to recent times; the reason lying in a history of archaic ideas too long to be traced here. Exercise of common rights is the category where most difficulty arises. Here, in fact, the limits of man's freedom must be fixed by a sense of policy not capable of formal demonstration.

As Justice Holmes of the supreme court of the U.S. said, we allow unlimited trade competition (so long as it is without fraud) though we know that many traders must suffer, and some may be ruined by it, because we hold that free competition is worth more to society than its costs. A state with different economic foundations might have a different law on this, as on many other points. This freedom extends not only to the exercise of one's calling, but to choosing with whom and under what conditions one will exercise it. Also the law will not enquire with what motives a common right is exercised; and this applies to the ordinary rights of an owner in the use of his property as well as to the right of every man to carry on his business. The rule that a man's motives for exercising his common rights are not examinable involves the consequence that advising or procuring another, who is a free agent, to do an act of this kind can, a fortiori, not be an actionable wrong at the suit of a third person who is damnified by the act, and that whatever the adviser's motives may be. This appears to be included in the decision of the house of lords in Allen v. Flood. That decision, though not binding in any American court, is approved and followed in most American jurisdictions. It is otherwise where a system of coercion is exercised on a man's workmen or customers in order to injure him in his business. The extension of immunity to such conduct would destroy the value of the common right which the law protects: Quinn v. *Leathem.*

Individual Rights.--Owners and occupiers of immovable property are bound to respect one another's convenience within certain limits. The maxim or precept **Sic** utere tuo ut *alienum* non laedas does not mean that I must not use my land in any way which can possibly diminish the profit or amenity of my neighbour's. That would be false. It is a warning that both his rights and mine extend beyond being free from actual unlawful entry, and that if either of us takes too literally the more popular but even less accurate maxim, "Every man may do as he will with his own," he will find that there is such a head of the law as nuisance.

From the point of view of the plaintiff, as regards the kind of damage suffered by him, actionable wrongs may be divided into four groups. We have some of a strictly personal kind; some which affect ownership and rights analogous to ownership; some which extend to the safety, convenience and profit of life generally—in short, to a man's estate in the widest sense; and some which may, according to circumstances, result in damage to person, property or estate, any or all of them. Personal wrongs touching a man's body or honour are assault, false imprisonment, seduction or "enticing away" of members of his family. Wrongs to property are trespass to land or goods, "conversion" of goods (*i.e.,* wrongful assumption of dominion over them), disturbance of easements and other individual rights in property not amounting to exclusive possession. Trespass is essentially a wrong to possession; but with the aid of actions "on the case" the ground was practically covered. Then there are infringements of incorporeal rights which, though not the subject of trespass proper, are exclusive rights of enjoyment and have many incidents of ownership. Actions, in some cases expressly given by statute, lie for the piracy of copyright, patents and trade-marks. A wrong to a man's estate in the larger sense above noted is defamation —not a strictly personal wrong, because according to English common law the temporal damage, not the insult, is, rightly or wrongly, made the ground of action and the defendant's intention is immaterial. It is even possible to write an actionable libel without knowing that one's words can be thought to reflect on the plaintiff, or (it seems) that there is any such person: so the house of lords decided in *Hulton & Co.* v. *Jones* in 1910. Others are deceit, so-called "slander of title" and fraudulent trade competition which are really varieties of deceit; malicious prosecution; and nuisance, which, though most important as affecting the enjoyment of property, is not considered in that relation only. Finally, we have the results of negligence and omission to perform special duties regarding the safety of one's neighbours or the public, which may affect person, property, or estate.

The law of wrongs is made to do a great deal of work which, in a system less dependent on historical conditions, we should expect to find done by the law of property. We can claim or reclaim our movable goods only by complaining of a wrong done to our possession or our right to possess. There is no direct assertion of ownership like the Roman *vindicatio.* The law of negligence, with the refined discussions of the test and measure of liability which it introduced, is wholly modern; and the same may be said of the present working law of nuisance, though the term is of respectable antiquity. Most recent of all is the rubric of "unfair competition," which is fast acquiring great importance.

It will be observed that the English law of torts answers approximately in its purpose and contents to the Roman law of obligations *ex delicto* and *quasi ex delicto.* When we have allowed for the peculiar treatment of rights of property in the common law, and remembered that, according to one plausible theory, the Roman law of possession itself is closely connected in its origin with the law of delicts, we shall find the correspondence at least as close as might be expected a *priori.* Nor is the correspondence to be explained by borrowing, for this branch of the common law seems to owe less to the classical Roman or mediaeval canon law than any other. Some few misunderstood Roman maxims have done considerable harm in detail, but the principles were worked out in all but complete independence.

A list of modern books and monographs will be found at the end of the article on "Torts" by the present writer in the *Encyclopaedia of the Laws of England* (2nd ed.). Among recent editions of works on the law of torts and new publications the following may be mentioned here: Addison, by W. E. Gordon and W. H. Griffith (8th ed., 1906); Clerk and Lindsell, by Wyatt Paine (7th ed., 1921); J. W. Salmond, *The Law of Torts* (7th ed., 1928); Pollock (13th ed., 1929). In America: T. A. Street, *The Foundations of Legal Liability* (1906), 3 vols of which vol. i is on Tort; F. M. Burdick, *The Law of Torts* (4th ed., 1926). (F. Po.)

TORTOISE: *see* TURTLE.

TORTOISE SHELL. The tortoise shell of commerce consists of the epidermic plates covering the bony carapace of the hawksbill turtle, *Eretmochelys imbricata,* the smallest of the sea turtles. The plates of the back or carapace, technically called the head, are 13 in number, five occupying the centre, flanked by four on each side. These overlap each other to the extent of one-third of their whole size, and hence they attain a large size, reaching in the largest to 8x13 in., and weighing as much as 9 ounces. The carapace has also 24 marginal pieces, called hoofs or claws, forming a serrated edge round it: but these, with the plates of the plastron, or belly, are of inferior value. The plates of tortoise shell consist of horny matter, but they are harder, more brittle and less fibrous than ordinary horn. Their value depends on the rich mottled colours they display—a warm translucent yellow, dashed and spotted with rich brown tints—and on the high polish they take and retain. The finest tortoise shell is obtained from the Eastern Archipelago, particularly from the east coast of Celebes to New Guinea; large supplies come from the West Indian islands and Brazil.

Tortoise shell is worked precisely as horn; but, owing to the high value of the material, care is taken to prevent any waste in its working. The plates, as separated by heat from the bony skeleton, are keeled, curved and irregular in form. They are first flattened by heat and pressure, and superficial inequalities are rasped away. Being harder and more brittle than horn, tortoise shell requires careful treatment in moulding it into any form, and as high heat tends to darken and obscure the material it is treated at as low a heat as practicable.

For many purposes it is necessary to increase the thickness or to add to the superficial size of tortoise shell, and this is readily done by careful cleaning and rasping of the surfaces to be united, softening the plates in boiling water or sometimes by dry heat, and then pressing them tightly together by means of heated pincers or a vise. The heat softens and liquefies a superficial film of the horny material, and that with the pressure effects a perfect union of the surfaces brought together. Heat and pressure are also employed to mould the substance.

Tortoise shell was a prized ornamental material from very early times. It was one of the highly esteemed treasures of the far east brought to ancient Rome by way of Egypt, and it was eagerly sought by wealthy Romans as a veneer for their rich furniture. In modern times it is most characteristically used in the elaborate inlaying of cabinetwork known as buhl furniture, and in combination with silver for toilet articles. It is also employed as a veneer for small boxes and frames. It is cut into combs, moulded into snuffboxes and other small boxes, formed into knife handles, and worked up into many other similar minor articles. The plates from certain other tortoises, known commercially as turtle shell, possess a certain industrial value, but they are either opaque or soft and leathery, and cannot be mistaken for tortoise shell. A close imitation of tortoise shell can be made by staining translucent horn or by varieties of celluloid.

TORTONA (anc. *Dertona*), a town and episcopal see of Piedmont, Italy, in the province of Alessandria, from which it is 14 mi. E. by rail, on the right bank of the Scrivia, at the northern foot of the Apennines, 394 ft. above sea-level. Pop. (1951) 15,775. Tortona is on the main line from Milan to Genoa; from it a main line runs to Alessandria, which branches to Novi and Castelnuovo Scrivia, and a steam tramway to Sale. Its fortifications were destroyed by the French after Marengo (1800); which was fought not far off, as were the battles of Novi (1799) and Montebello (1800–1859). The cathedral contains a remarkably fine Roman sarcophagus.

Dertona is spoken of by Strabo as one of the most important towns of Liguria. It stood at the point of divergence of the Via Postumia (*see* LIGURIA) and the Via Aemilia, while a branch road ran hence to Pollentia. The local museum contains Roman antiquities found here. In the middle ages Tortona was zealously attached to the Guelphs, on which account it was twice laid waste by Frederick Barbarossa, in 1155 and 1163. In 1176 it made a treaty with Barbarossa and the people of Pavia, and was taken back into favour by Henry VI in 1193. It was the base headquarters of the British force in Italy in 1917–19.

See F. Gabotto, *Per la Storia di Tortona* (Biblioteca della Società Storica Subalpina, fasc. 96, 1922).

TORTOSA, a fortified city of Spain, in Tarragona province; 40 mi. by rail W.S.W. of Tarragona, on the Ebro 22 mi. above its mouth. Pop. (1950) 45,903 (mun.). Tortosa, the *Dertosa* of Strabo and the *Colonia Julia Augusta Dertosa* of numerous coins, was a city of the Ilercaones in Hispania Tarraconensis. Under the Moors it was of importance as the key of the Ebro valley. It was taken by Louis the Pious in 811, but was soon recaptured. Having become a haunt of pirates, it was made the object of a crusade proclaimed by Pope Eugenius III in 1148, and was captured by Ramon Berenguer IV, count of Barcelona, assisted by Templars, Pisans and Genoese. An attempt to recapture the city in 1149 was defeated by the women folk, who thenceforth received many privileges. Tortosa fell to the duke of Orleans in 1708; during the Peninsular war it surrendered in 1811 to the French under Suchet, who held it until 1814. Tortosa is a walled town with crooked and ill-paved streets, and lofty, granite-built houses. There is a modern suburb on the opposite side of the Ebro. The cathedral occupies the site of a Moorish mosque built in 914. The present structure (1347), has its Gothic character disguised by a classical façade with Ionic pillars. There are manufactures of paper, hats, leather, ropes, porcelain, majolica, soap, spirits and ornaments made of palm leaves and grasses. The river fisheries are important. Corn, wine, oil, wool, silk, fruits and iiquorice (a specialty of the district) are exported. The city is connected with Barcelona and Valencia by the coast railway, and with Saragossa by the Ebro valley line; it is also the terminus of a railway to San Carlos de la Rápita.

TORTURE, the general name for innumerable modes of inflicting pain, and especially for those employed as an incident of judicial process. From this point of view torture was always inflicted either as a means of eliciting evidence from a witness or from an accused person either before or after condemnation; or as a part of the punishment. The second was the earlier use.

Its development in mediaeval times may be traced to the decline of the ordeals and trial by battle. While the appeal to God (which is so marked a feature of the ordeals) exists, confession is unnecessary. Thus, the capitularies of Charlemagne make no provision for torture, while including the earlier modes of procedure. When the fourth Lateran council, in 1215, prohibited the clergy from participating in the ordeal, English law developed trial by jury for crime, and thus rendered the extraction of a confession of guilt from the prisoner unnecessary. Continental law, on the other hand, considered a confession the best of all evidence, and all the machinery of the law was organized to obtain it.

Even when torture was a normal incident of judicial procedure, enlightened lay opinion was overwhelmingly opposed to its employment. Cicero (Pro *Sulla*), Seneca and St. Augustine condemn it, although the latter regards it as a necessity, while Ulpian, in Justinian's Digest, declares: "Torture (quaestio) is not to be regarded as wholly deserving or wholly undeserving of confidence; indeed, it is untrustworthy, perilous and deceptive. For most men, by patience or the severity of the torture, come so to despise torture that the truth cannot be elicited from them; others are so impatient that they will lie in any direction rather than suffer torture, so it happens that they depose to contradictions and accuse not only themselves but others." Among later writers, Montaigne, Montesquieu, Bayle, Voltaire, Sonnenfels, Beccaria, Verri and Manzoni all condemn it. The influence of Beccaria in rendering the use of torture obsolete was undoubtedly greater than that of any other legal reformer. He emphasizes the unfair incidence of torture, as minds and bodies differ in strength. Moreover it is to confound all relations to expect that a man should be both accuser and accused, and that pain should be the test of truth, as though truth resided in the muscles and fibres of a wretch under torture. Apologists of torture may be found chiefly among jurists, but authors of books of practice, and notably Damhouder, von Rosbach, von Boden and Voet, are aware of its deficiencies. Muyart de Vouglans derives torture from the law of God. Other apologists are Simancas, bishop of Badajoz, Engel, Pedro de Castro, and in England Sir R. Wiseman.

Greece. — Both Aristotle and Demosthenes regard torture as the surest means of obtaining evidence. At Athens slaves, and probably at times resident aliens, were tortured, but free citizens only rarely, the practice being forbidden by a psephism passed in the archonship of Scamandrius. Torture was sometimes inflicted in open court, and the rack was employed, even for free citizens. A list of tortures is given in the Ranae of Aristophanes (V. 617) and the wheel is alluded to in Lysistrata (V. 846). Isocrates and Lysias refer to torture under the generic name of στρέβλωσις but it was generally called βάσανοι in the plural (cf. Lat. *tormenta*). Torture was frequently inflicted by Greek despots, and both Zeno and Anaxarchus are said to have been put to it.

Rome. — The Roman system was the basis of all subsequent European systems which recognized torture as a part of their procedure, and the rules attained a refinement beyond anything approached at Athens. Cicero declares that the law of torture rested originally on custom, and no existing fragment of the Twelve Tables alludes to it. It is mentioned frequently by writers both of the republic and the empire. During the republic, a master had power to torture his slaves. In the early empire, however, restrictions were imposed. A lex Petronia forbade masters to punish slaves by making them fight wild beasts, without magisterial authorization, while Antoninus Pius required a master who ill-treated his slave to sell him. Not until the later empire was the killing of a slave by excessive punishment made homicide. The law of the later empire, relating to torture, is set forth at length chiefly in the titles De quaestionibus of the Digest and the Code—the former consisting largely of opinions from the *Sententiae receptae* of Paulus, the latter being largely a repetition of constitutions contained in the Theodosian code. Both substantive law and procedure were dealt with, but a large discretion was left to the judges. Torture was used both in civil and criminal trials, but in the former only upon slaves and freedmen or infamous persons (after *Nov.* xc. ii upon *ignoti* and obscuri if they showed signs of corruption)—*e.g.,* gladiators—and in the absence of ulia *manifesta* indicia, as in cases affecting inheritance. Only slaves were tortured during the republic, but in the empire it was extended to freemen accused of crime. Certain persons were exempt by a constitution of Diocletian and Maximian from the liability to torture, *e.g.,* soldiers, nobles of high rank, and their descendants to the third generation — decuriones — and their children under 14 and pregnant women. These exemptions did not extend to accusations of treason or sorcery. A freeman could be tortured only where he had been inconsistent in his depositions, or where there was a suspicion of lying. There were detailed rules concerning the torture of slaves, and the Romans believed that this was the most efficacious means of obtaining the truth. Unlike freemen, they could be tortured as witnesses, always on behalf of their master, against him only in treason, adultery, frauds on the revenue, coining and similar offenses, attempts by a husband or wife on the life of the other, and in cases where a master had bought a slave in order that he should not give evidence against him. The exemption from accusation by a slave extended to the owner's father, mother, wife or tutor, and a former master; but a slave-owning corporation was not privileged. Where a charge of adultery was brought against the wife, her husband's, her own and her father's slaves could be tortured. Detailed rules governed" the application of torture. Other modes of proof must first be exhausted, and the evidence (*argumentum* and indicium) must have advanced so far that the slave's confession alone was required to complete it. The amount was at the discretion of the judge, but it must not injure life or limb, otherwise the judge became *infamis.* Except in treason, the unsupported testimony of a single witness was not a sufficient ground for torture. Leading questions could not be asked. The quaesitor asked the questions, the *tortores* applied the instruments. The principal forms of torture were the *equuleus,* or rack, the plumbatae, or leaden balls, the ungulae or barbed hooks, the lamina, or hot plate, the *mala* mansio (comparable with the "Little Ease" of the Tower of London) and the *fidiculae,* or cord compressing the arm. As a part of punishment, torture existed in Rome from earliest times, when it was permitted in respect of defaulting debtors. Later, crucifixion, mutilation, exposure to wild beasts in the arena, and other modes were in common use. Through the leges *barbarorum,* Roman doctrines relating to torture were transferred, with modifications, to mediaeval Europe.

The Church. — The Church, although adopting a good deal of Roman law, was at first definitely opposed to torture. Thus the synod at Rome in 384 condemned it. In 1252, a bull of Innocent IV directed the civil power to torture heretics, but the canon law had little to say upon the subject, holding that although it was no sin in the faithful to inflict torture, a priest might not do so with his own hands. In later times, torture was inflicted by the Inquisition. Torquemada's code of instructions (1484) provided that an accused might be tortured if *semiplena* probatio existed against him, *i.e.,* so much evidence as to raise a grave presumption of guilt. Confessions extracted during torture required subsequent confirmation, but retractation involved further torture or extraordinary punishment. One or two inquisitors, or a commissioner of the holy office, were bound to be present at all examinations. Following certain abuses, a decree of Philip II in 1588 forbade torture without an order from the council, but the decree was not fully observed. An edict of the Inquisitor-General Valdès, in 1561, left torture to the prudence and equity of the judges. They must consider motives and circumstances before decreeing torture, and must declare if it were to be employed in caput *proprium, i.e.,* to extort a confession, or in *caput alienum, i.e.,* to incriminate an accomplice. Torture was not to be decreed until the termination of the process and after defense heard, and the decree was subject to appeal, but only in doubtful cases, to the Council of the Supreme. It was only in doubtful cases that the inquisitors were bound to consult the council. On ratification 24 hours afterward of a confession made under torture, the accused might be reconciled, if sincerely repentant, or if convicted of bad faith he might be delivered to the secular power to be burned. Torture ceased to be inflicted before the suppression of the Inquisition, and a papal bull in 1816 decreed its abolition. The actual rules, *e.g.,* Torquemada's, were not so cruel as the construction put upon them by inquisitors. Thus Torquemada's direction that torture should only be renewed for retractation was evaded by terming renewed torture a continuation. Besides the two sets of rules already mentioned, those of Nicholas Eymenico, grand inquisitor of Aragon about 1368, and of Simancas, two centuries later, deserve mention. In 1545 and 1550, Charles V issued instructions for the guidance of inquisitors. Abuses, however, were exceedingly frequent.

England. — The English common law never recognized the legality of torture (except perhaps in the early ordeals) and Coke, commenting on Magna Carta, cap. 29, observes: "No man destroyed, etc., that is, forejudged of life or limb, disinherited, or put to torture or death" (2. *Inst.* 48. b). The Bill of Rights also provided that cruel and unusual punishments ought not to be inflicted. Judicial opinion was always in theory opposed to it, and in Felton's case (1628) a resolution of the judges declared "that he ought not by the law to be tortured by the rack, for no such punishment is known or allowed by our law." Accordingly, in only two instances was a warrant to torture issued by a common law judge, although it was an incident in criminal procedure for several centuries, being ordered either by the crown or council, or some extraordinary tribunal, and especially by the star chamber. Cases occur as early as the 13th century, and continue down to 1640. One case only is recorded after this date, three Portuguese being tortured at Plymouth during the Commonwealth. The rack was introduced in the reign of Henry VI by the duke of Exeter, and was hence known as "the duke of Exeter's daughter." Other varieties of torture were "the scavenger's daughter," or manacles, which pressed the victim's head to his feet, the iron gauntlets or bilboes, and the cell called "Little Ease." In Elizabeth's reign, the rack was in constant use. Witnesses were never tortured.

One peculiar form of torture was not unknown to the common law—the peine forte et *dure.* If a prisoner refused to plead, remaining mute of malice, he was stretched upon his back, and pressed with heavy weights, until he either consented to plead, or died. This practice was abolished by 12 Geo. III c. 20, a case having occurred so late as 1726. Tying the thumbs with whipcord was frequently used instead of the peine. Witch trials also involved incidents of torture, such as throwing the accused into a pond to discover whether she would sink or swim.

As a part of punishment, torture by mutilation appears in pre-conquest codes and in the assize of Northampton (1176). Later examples are burning to death for heresy, drawing and quartering for treason, branding in the hand for felony, the pillory, the stocks, branks and ducking stool. All these have now been abolished, although corporal punishment for robbery with violence and for juvenile offenders still exists.

Scotland. — Torture was long a recognized part of Scottish criminal procedure. Numerous instances occur in the Register of the Privy Council. The last warrant was issued in 1690, and it was finally abolished in 1708. Among the most celebrated forms employed in Scotland was the "boot." The "boot," comprising a long iron boot in which the foot was inserted, wedges being then driven between the limb and the boot, was not peculiar to Scotland for records are found in French criminal trials, and again in Ireland, where in 1583, Hurley, a priest, was tortured in Dublin by "toasting his feet against the fire with hot boots"; this species of torture was employed, not only for crime, but as an incident in religious persecution (Lecky, Rationalism in Europe, 1865, ii, p. 45), and sometimes by the nobility for their own ends. Thus in 1605, a suit was brought against the earl of Orkney, for putting a son of Sir Patrick Bellenden in the boots. Other Scottish methods of torture were the rack, the pilniewinkis (known in England as the thumbikins, and resembling the thumbscrew), the caschielaws (an instrument drawing the body and limbs together, heat being applied in some cases), the lang irnis (heavy weights, sometimes exceeding 50 stones), the harrow bore (perforations through which the teeth of harrows were inserted), the pynebankis (a variety of the rack) and the artificial prevention of sleep.

Ireland. — Torture was recognized in Ireland neither by statute nor by common law, and few cases are recorded of its infliction. In 1566, however, the president and council of Munster, or any three of them, were empowered to inflict torture "upon vehement presumption of any great offense in any party committed against the queen's majesty."

British Colonies and Dependencies. — In any British possession, the infliction of torture was usually regarded as contrary to law. In 1806, however, Sir Thomas Picton, the governor of Trinidad, was tried for subjecting Luisa Calderon to the torture of the piquet, in which the sufferer was supported only on the great toe, which rested on a sharp stake, and by a rope attached to one arm. One of the grounds for defense was that torture was authorized by the Spanish law of the island. The accused was convicted, but sentence was respited. Warren Hastings was also charged with extortion from the begums of Oude by means of the torture of their servants. The Indian penal code now expressly forbids torture. In Ceylon it was formerly allowed by the Dutch, but was abolished by royal proclamation in 1799.

United States. — In 1692, Giles Cory of Salem, accused of witchcraft, refused to plead, and was subjected to the peine forte et dure. The constitution of the U.S. forbids cruel and unusual punishments, on which there have been numerous decisions.

CONTINENTAL EUROPEAN STATES

These fall into four main groups, the Latin, Teutonic, Scandinavian and Slav states. The principles of Roman law were generally adopted in the first and second groups.

France. — In France, torture does not seem to have existed as a recognized practice before the 13th century. From then until the 17th century it was regulated by a series of royal *ordonnances,* and was applied only in the royal courts, its place in the seigneurial courts being supplied by the judicial combat. The earliest ordonnance was that of Louis IX in 1254, for the reformation of the law of Languedoc. It enacted that persons of good fame, though poor, were not to be put to the question on the evidence of one witness. In 1670, an ordonnance of Louis XIV regulated the infliction of torture for more than a century. Two kinds were recognized, the question *préparatoire* and the question *préalable.* The first was abolished by royal decree in 1780, but in 1788 the parlements refused to register a decree abolishing the *préalable.* Torture of all kinds was abolished by an ordonnance of Oct. 9, 1789, however, and the modern code *pénal* enacts that criminals employing torture to further their ends shall be guilty of assassination, while it is also an offense to torture a person under arrest.

Italy. — The law as it existed in Italy is contained in a long line of authorities chiefly supplied by the school of Bologna, beginning with the glossatores and continued by the post-glossatores until the system attained its perfection in the vast work of Farinaccius, in the early 17th century, where every possible question that could arise is treated with revolting completeness. The writings of the jurists were supplemented by a large body of legislative enactments in most of the Italian states, extending from the constitutions of the Emperor Frederick II down to the 18th century.

Farinaccius was procurator general to Pope Paul V, and the principal feature of his work is the minute and skilful analysis of *indicia, farna, praesumptio,* and other technical terms. For every infliction of torture a distinct *indicium* is required. A single witness or an accomplice constitutes an *indicium.* This rule does not apply where torture is inflicted for discovering accomplices or a crime other than that for which it mas originally inflicted. Torture may be ordered in all criminal cases, except small offenses, and in certain civil cases, such as denial of a *depositum,* bankruptcy, usury, treasure trove and fiscal cases. It may be inflicted on all Persons, unless specially exempted (*e.g.,* clergy and minors) and even those exempted may be tortured by command of the sovereign.

There are three kinds of torture, *levis, gravis* and *gravissima,* the first and second corresponding to the ordinary torture of French writers, the last to the extraordinary. This last was as much as could possibly be borne without destroying life. The judge could not begin with torture; it was only a *subsidum.* If inflicted without due course of law, it was void as a prooi.

Among other important writers was Julius Clarus of Alessandria, a member of the council of Philip II. Generally, he follows Farinaccius. He puts the questions for the consideration of the judge with great clearness. These are—whether (1) a crime was committed, (2) the charge is one in which torture is admissible, (3) the fact can be proved otherwise, (4) the crime was secret or open, (5) the object of the torture is to elicit confession of crime or discovery of accomplices. The clergy can be tortured only in charges of treason, poisoning and violation of tombs.

Other Italian writers of less eminence are Guido de Suzara, Paris de Puteo, Aegidius Bossius of Milan, Casonus of Venice, Decianus, Follerius and Tranquillus Ambrosianus. Torture was abolished in Tuscany in 1786, largely owing to the influence of Beccaria, and other states followed. The *puntale,* or piquet, however, existed in practice at Naples until 1859. Savonarola, Machiavelli, Giordano Bruno, Campenella are among those subjected to torture in Italian history. Galileo appears only to have been threatened with the *esame rigoroso.* The historical case of the greatest literary interest is that of the persons accused of bringing the plague into Milan in 1630 by smearing the walls of houses with poison.

Spain.— In Spain, Roman law was carried through the Visigothic code and the *Fuero juzgo* down to the *Siete partidas,* compiled by Alfonzo the Wise in 1243, and promulgated in 1256. Torment is defined as a manner of punishment which lovers of justice use, to scrutinize by it the truth of crimes committed secretly, and not provable in any other manner. Repetition was allowed in case of grave crimes. There were the usual provisions for the infliction of torture only by a judge having jurisdiction, and for the liability of the judge for exceeding legal limits. Subsequent codes did little more than amend the *Partidas* in matters of procedure. In Aragon, while it was an independent state, torture was not in use to the same extent as in other parts of Spain. It was abolished in the 13th century by the General Privilege of 1283, except for vagabonds charged with coining. A statute of 1335 made it unlawful to put any freeman to the torture. On the other hand, the Aragonese nobility had power to put a criminal to death by cold, hunger and thirst. The jurists dealing with the subject are not as numerous as in Italy, no doubt because Italian opinions were received as law in all countries whose systems were based on Roman law. Among them are Suarez de Paz, Antonio Gomez and Alvarez de Velasco. The Peruvian, Juan de Hevia Bolanos, who wrote at the beginning of the 19th century, should also be noted.

The principal Spanish tortures, according to Suarez de Paz, were the water and cord, the pulley or *strappado,* the hot brick, and the *tablillas,* or thumbscrew and boot combined.

Teutonic States.— Germany (including Austria) possesses the most extensive literature and legislation on the subject. The principal writers are Langer, von Rosbach, von Boden, Ulrich Tengler, Remus, Casonus and Carpzow. Legislation was partly for the empire, partly for its component states. Imperial legislation dealt with the matter in the Golden Bull (1356), the Ordinance of Bamberg (1507), the Carolina (1532) and the *Constitutio criminalis thevesiana* (1768). Torture was formally abolished in the empire in 1776. In Prussia it was practically abolished by Frederick the Great in 1740, formally in 1805. Even before its abolition it was in use only to discover accomplices after conviction. In some other states it existed longer, in Baden as late as 1831.

The Netherlands.— The principal legislative enactment was the code of Philip II, known as the *Ordonnance sur le style* (1570). One of its main objects was to assimilate the varieties of local custom, as the *Nueva recopilacion* had done in Spain three years earlier. Certain cities of Brabant, how-ever, still claimed the privilege of torturing in certain cases not permitted by the ordinance, *e.g.,* where there was only one witness. This law continued to be the basis of criminal procedure in the Austrian Netherlands until 1787, and in the United Provinces until 1798. The principal text writers are Damhouder, van Leeuwen and Voet, who took the same view as St. Augustine as to the uselessness of torture, and compared its effect with that of trial by battle.

Scandinavian Countries.— There is a notice of torture in the Icelandic code known as the Grágás (about 1119). Judicial torture is said to have been introduced into Denmark by Valdemar I in 1157. In the code of Christian V (1683) it was limited to cases of treason. It was abolished by the influence of Struensee in 1771, but notwithstanding this he was threatened with it, though it was not actually inflicted, before his execution in 1772. In Sweden torture never existed as a system, and in the code of 1734, it was expressly forbidden. It was, however, occasionally inflicted, as in England, by extrajudicial authorities, called secret committees. The "cave of roses," where reptiles were kept for the purpose of torture, was closed by Gustavus III in 1772.

Slav Countries.— The earliest mention of torture is that of the mutilation provided for certain offenses by the code of Stephen Dushan in 1349. In Russia torture does not occur in the recensions of the earlier law. It was possibly of Tatar origin, and the earliest mention of it in an official document is probably in the *Sudebnik* of Ivan the Terrible (1497). In the ordinance of 1556 there are elaborate regulations, which were not always observed in periods of political disturbance, and torture was used even as a means of enforcing payment of debts. The reaction begins with Peter the Great and culminates with Catherine II, who was largely influenced by the opinions of Beccaria and Voltaire. In the instructions to the commission for framing a criminal code (1776) it is declared that all punishments by which the body is maimed ought to be abolished, and that the rack violates the rules of equity and does not produce the end proposed by the laws. It was formally abolished by Alexander I in 1801, and in 1832 the *Svod Zakonov* subjected to penalties any judge who presumed to order it. But as late as 1847 it was inflicted in one or two exceptional cases.

ASIATIC COUNTRIES

Numerous accounts of tortures inflicted by Asiatic monarchs survive in the narratives of early travelers. Oi these, Olearius' *Voyages and Travels of the Ambassadors,* translated by John Davies (1662), is informative. From these accounts it is apparent that torture was used regularly in the east both as an incident in judicial process, and as a part of punishment, and in some countries at least there seem to have been few checks on its employment beyond the whim of the monarch. In Persia, Olearius records that such punishments as mutilation and sawing asunder were in use. In India, again, the local despots employed torture as a mode of extracting evidence.

Japan.—Japanese law was particularly severe, both procedurally and in its punishments. In trials for theft, a piece of red-hot iron was placed in the hands of the accused, who then flung it away. If his hand was unburned, he was innocent; if burned, guilty. The punishment for theft involved tying the offender to great canes in the iorm of a cross, and his body was then twice run through diagonally by a spear. Confession was usually necessary before conviction, and in order to extract it, a "boot" consisting of heavy wooden planks was employed, and also the bowstrings. As a punishment, crucifixion was in general use, and accounts of fiendish tortures inflicted on Christians in the 17th century survive. (*See* Olearius 154–155, and Murdoch's *History of Japan.*)

China.— In China, and other countries where the Chinese criminal code was accepted with local modifications (*e.g.,* Annam and Burma), some regulation of the use of torture was attempted, although abuses were frequent. As in Japan, confession by the accused was necessary before punishment. The Ta *T'sing Lu Li,* the code of the Manchu dynasty, therefore, prescribes certain forms of judicial torture. These were applicable to witnesses also, and include the "boot" (which appeared in two forms: [1] boards between which the leg of the accused was crushed, and [2] a receptacle in which the leg was placed and boiling oil poured); the finger-compressor, kneeling on chains and beating the face. Those below 15 years of age, or over 70, were exempt from torture, also those suffering from permanent disease or other infirmity.

Other forms, more cruel than those sanctioned by the code existed, although according to the code, a magistrate who applied torture wantonly or arbitrarily was liable to prosecution. Among the illegal tortures, reported by the *Chinese Repository* (vol. IV) to be in use at the beginning of the 19th century were nailing to boards, beds of iron, red-hot spikes, boiling water, knives for cutting the tendon Achilles, the beauty's bar (so named after the wife of a judge, and comprising three crossbars to which the breast, the small of the back, and the legs bent up were fastened), the parrot's beam (in which the prisoner was raised from the ground by strings round the fingers and thumbs, attached to a beam) and the refining furnace. Torture was an incident in many punishments, such as execution by slow cutting to pieces. There were Bogging (with heavy and light bamboo) and the cangue, an instrument resembling the pillory. (J. WIL.; G. W. K.)

TORY, GEOFFROY (*c.* 1480–*c.* 1533), French publisher, printer, author, orthographic reformer and prolific engraver, was born in Bourges about 1480. He was mainly responsible for the French Renaissance style of book decoration and played a leading part in popularizing in France the roman letter as against the prevailing gothic. His important publications include a number of "Books of Hours" and his famous philological work Champ *Fleury* (1529). In this work Tory put forward the idea of accents, the apostrophe, the cedilla and simple punctuation marks. He was appointed *imprimeur du roi* ("printer to the king") by Francis I in about 1530. He died in Paris about 1533. (J. C. MN.)

TORY: see WHIG AND TORY.

TOSCANINI, ARTURO (1867–1957), Italian orchestral conductor, who was unquestionably the greatest conductor of the first half of the 20th century and one of the most astonishing musical interpreters of all time, was born at Parma, Italy, on March 25, 1867. He studied at the conservatory there and at that of Milan, intending to become a violoncellist. At the age of 19. when playing in the orchestra at the opera house at Rio de Janeiro. he was called upon to deputize for the conductor at a moment's notice and conducted the whole performance of G. Verdi's Aida from memory. This feat, combined with other evidence of genius. quickly brought him fame in Italy and elsewhere. and he excelled equally in opera and in concert work. He was a strict disciplinarian, but he more readily obtained obedience from others because he most unsparingly imposed his will upon himself. His phenomenal memory stood him in good stead when he began to suffer from extremely poor eyesight and had to memorize every work he conducted. His detailed knowledge of a vast number of different works never ceased to astonish the artists who worked under him, and his incomparable insight into matters of style and interpretation inspired them with a devotion that often made them reach something like his own fervour and understanding.

Toscanini was appointed conductor in chief of the Milan Teatro alla Scala in 1898 and of the New York Metropolitan opera in 1907. He was also in charge of the New York Philharmonic Symphony orchestra during 1929–36. and conducted famous orchestras all over the world as a visiting artist, except those of Italy during the Fascist regime, of which he passionately disapproved, and of Germany after Adolf Hitler's rise to power.

Toscanini died at New York on Jan. 16, 1957.

(E. W. BM.)

TOSTIG (d. 1066), earl of Northumbria, was a son of Earl Godwine, and in 1051 married Judith, sister or daughter of Baldwin V, count of Flanders. In the year of his marriage he shared the short exile of his father, returning with him to England in 1052, and became earl of Northumbria after the death of Earl Siward in 1055. He was intimate with his brother-in-law, Edward the Confessor, and in 1061 he visited Pope Nicholas II at Rome in the company of Aldred. archbishop of York. Tostig introduced a certain amount of order into the wild northern district under his rule, but his severity made him exceedingly unpopular, and in 1065 Northumbria broke into open revolt. Declaring Tostig an outlaw and choosing Morkere in his stead, the rebels marched southward and were met at Oxford by Earl Harold, who, rather against the will of the king, granted their demands. Tostig sailed to Flanders and thence to Normandy, where he offered his services to Duke William. He harried the Isle of Wight and the Kentish and Lincolnshire coasts and later joined Harald III (Hardraha) of Norway in a descent upon York. But Harold, now king, surprised the invaders at Stamford bridge, and in the battle on Sept. 25, 1066. both Tostig and the Norwegian king were slain.

TOTEMISM. The term "totemism" is used for a feature of the religion and social organization of widespread occurrence among primitive peoples. The name *totem* is derived from an Ojibway word, but has now been generalized by anthropologists to describe an institution, the Ojibway form of which is not typical. Unfortunately, many writers have used the term totemism very loosely for any beliefs and practices dependent upon some supposed connection between animals and persons. The term should be restricted to those cases where a systematic association of groups of persons with species of animals (occasionally plants or inanimate objects) is connected with a certain element of social organization. In the widest use of the term, we may speak of totemism if: (1) the tribe said to be totemic consists of a number of groups (totem groups) comprising the whole tribe, each of which groups has a certain relationship to a species (totem), animate or inanimate; (2) the relation between each group and species is of the same general kind for each group; and (3) a member of one of these totemic groups cannot (except under special circumstances) change his membership.

By this definition one essential peculiarity of totemism is the association of groups of persons with groups of animals or objects, not of individual persons with individual animals, a common enough phenomenon, which, however, it is desirable not to include under totemism. Another peculiarity is the division of the tribe into several totemic groups, so that, while every member of the tribe has a totem, persons living in the same locality may yet differ as to their totems.

As to the determination of the membership of the totem-group, *i.e.,* the social side of totemism and the nature of the relationship between totem-group and totem, *i.e.,* the religious side of totemism, one kind of totem-group is commoner than any other, viz., the clan, an exogamous group (*i.e.,* a group within which marriage is forbidden), determined by descent, either through the father (patrilineal descent), or through the mother (matrilineal descent).

The clan (*q.v.*), is a group of great importance in primitive society, for it determines behaviour in a variety of ways, and is often of more importance than smaller groups, such as the family, or wider groups, such as the tribe. Members of a clan generally regard themselves as closely related, whether or not they can trace relationship genealogically, and frequently hold themselves and are held by others to be mutually responsible for the actions of their clan-brothers. In some parts of the world, where clans are widely dispersed, the totem serves as the only sign of clan-relationship, and a man will be welcomed, on account of his totem, as a clan-brother by distant members of his clan, whom he has never seen, and will also avoid sexual relations with the women of that group, though unable to trace relationship. The discovery of this association of totemism with the clan has given rise to one of the most interesting problems of anthropology, for it would seem that any theory of origin of totemism must also explain exogamy.

Although totemism is generally associated with the clan, the tribe is also sometimes divided into totemic groups, which are not exogamous. For example, the Arunta (*q.v.*), of central Australia are divided into totemic groups, membership of which depends upon the accident of position of the mother at the moment of realization of pregnancy, and there is no exogamic restriction on the members of these groups. There are also totemic groups in Africa and elsewhere that are more or less endogamous (*i.e.,* required to marry within the group). Furthermore, a tribe may be divided in more than one way into totemic groups; for example, in Australia we sometimes find, in addition to totemic clans, moieties (exogamous halves of the tribe, each of which includes a number of clans), and marriage-classes (groups with indirect descent, which are specially connected with the regulation of marriage), which may be more or less totemic, and even a division of totems according to sex.

Variations of the relationship between totem-group and totem,' are considerable in different parts of the world. In the first place, the totem shows extraordinary variety. While an animal-species is the most usual form of totem. plant-species are by no means uncommon, and classes of material objects are occasionally found: even abstract qualities, such as "pride," the totem of a clan of a weaver caste in Madras, and "red," the totem of an Omaha clan. A peculiar variety of totem is the split totem, in which only part of a thing is the totem; *e.g.,* instead of buffaloes, buffalo tongues occur as the totem of one Omaha sub-clan. No doubt, split totems are the result of division of a totemic group into several groups. Cross-totems, however, are less intelligible. A cross-totem consists of one part of more than one kind of thing; *e.g.,* the ends of things are the cross-totem of a certain Samoan group. the ears of animals of any species the totem of a Mahili clan, Bengal. Again, one totemic group may have a number of totems, which are then called linked totems; *e.g.,* clans in south-east New Guinea are always associated with a species of bird, of plant, of fish and of snake, the last three being subordinate to the bird totem.

Although there are considerable differences in the relation between totem-group and totem, owing to differences in the kind of totem, there are also great differences between tribes, apart from this. In one tribe we may find a strong avoidance of the totem-animal, which may neither be killed nor eaten, while in other tribes the same animal may be killed with comparative impunity. Nevertheless, this tabu on killing or eating the totem seems to be typical of totemism, and some avoidances in connection with the totem are probably present in all cases. But although these tabus may be of great severity—an offender may be severely punished by his totem-group, and, if not punished by his own totem-group, may yet be' supposed to suffer through the action of the totem itself—they apply only to the particular totem-group. For example, an Australian, whose totem is the witchetty-grub, will respect and avoid this animal, but will not hinder his friends and relations of other clans from making use of this food, and will even conduct ceremonies of which the avowed object is the increase of the totem, so as to provide food for other clans in the tribe. In some cases, the totemic tabus must be observed by persons outside the totem-group; *e.g.,* in south-east New Guinea, where a man is a member of the totem-group of his mother, the totems of the father are even more rigidly tabu than his own totems; and amongst the totemic peoples of Africa, it is common for a woman to adopt the torem-avoidances of her husband. Curiously enough, associated with severe tabus on the killing of the totem a totemic sacrifice has been reported from Australia, in which the totem-animal is cruelly killed and eaten.

The totemic tabu is usually associated with a belief in some sort of kinship between the totemic group and the totem, which makes the tabu more intelligible. In line with this is the frequent belief in descent from the totem, or of totem and totem-group from some common ancestor. Another expression of this altitude towards the totem is the performance of ceremonies, in which the totem is represented symbolically or realistically Badges, masks and mutilations may also be used to make this identification. Finally, although worship of the totem or prayer never occurs—animal worship has little in common with totemism—it is not unusual for the totemic group to believe that members of the totem species assist the group by means of omens, or in other ways. Such being the general characteristics of totemism in all those cases which it is convenient to regard as totemism, a survey of the chief areas of totemism will reveal the diversity of form which totemism takes.

Australia.—Totemism has generally been regarded as occurring in Australia in its most complete and original form, not so much on account of the elaborateness of Australian totemism, but because totemism has been regarded as the most primitive religion, and Australians are the most primitive people that we know. Both these propositions can be disputed, but Australian totemism is of exceptional interest, for the greater part of Australian religion may be brought under the heading "totemism." Australian totemism has an equally important economic and social side. Among the tribes of central Australia all those important happenings, such as the origin of man and his customs, and the recurrence of death and birth, are well explained in totemic terms, for in olden (alcheringa) days there were only totemic beings, emu, grub, and so on, half animal in form, half human. These spirits were creative and made the stock of souls, which have ever since been the souls of human beings by continual reincarnation, these souls themselves being totemic in nature. Birth is thus due to the entry of one of these spirits into the womb of a woman, death to its departure from the body. Between incarnations these spirits abide in certain centres, known as totem-centres, and tend to be associated with certain objects, which are kept in these centres, and which are used in totemic ceremonies. It might seem that such a theory of birth and death would offer difficulties, except in such cases as the Arunta, where the totem of the child is not determined by descent, but the native gets over the difficulty by supposing that these localized spirits, when their time for reincarnation arrives, wander from the totem-centre until they find a woman of the right totem, or a woman whose husband is of the right totem, according as descent is matrilineal or patrilineal. In the ceremonies of initiation into manhood, also, totemic ideas are dominant. Initiates become conversant with various sacred objects, such as those connected with the soul, and symbolic objects, constructed for particular ceremonies symbolizing in one way or another the totems of the group. Elaborate decorations of the person, dramatic representations of the activities of the totemic ancestors in *alcheringa times*, continuing often for days, and other symbolic activities, all with more or less of a totemic motive, take place on these occasions. At certain times of the year, most Australian tribes conduct elaborate rites the object of which is to increase the totem species. These appear to be mainly of the nature of sympathetic magic.

Melanesia and Polynesia.—In this region we find every degree of totemism, from an institution containing the main features mentioned above, to complete absence of all these features. For example, in the Santa Cruz islands we find exogamous clans, each possessing one or more totems, usually animals; the totem may not be killed or eaten, and there is usually a definite belief in descent from the totem. In the extreme west of Papua (where there are two moieties) and in south-east New Guinea and parts of the Solomons we find totemism of similar form, yet in other parts of the Solomons and in the New Hebrides and Banks islands totemism is absent, though there are customs which suggest survivals of an earlier totemism; in fact, the Banks islanders, while lacking totemic clans, have certain beliefs very similar to those of the Arunta of central Australia, but unsystematic. A number of men and women strictly avoid killing certain species of animals or plants on account of a supposed kinship with them. This belief is based on the belief that the mother owed her pregnancy in some way to the entry into her womb of an animal of the species avoided. This belief appears to be maintained alongside some understanding of the true nature of the process of procreation. In Polynesia we find a religious system, which in places, such as Samoa, appears to have developed out of totemism, for many totemic characters are discernible.

India.—As a social system, if little more, totemism appears in parts of India. For instance, the Santals of Bengal are divided into a number of patrilineal clans, exogamous and totemic, and each of these into a number of sub-clans, also exogamous and totemic. There is avoidance of the totem, in some form or another, by the clan or sub-clan. Totemism also occurs in Assam, in Central India and Madras, with traces elsewhere.

Africa.—Except for the region of the great lakes, totemism is sporadic in Africa. The Baganda of Uganda may be cited as an example of well-developed totemism. The Baganda are divided into some 40 patrilineal exogamous clans. Each of these has a principal and a secondary totem, usually an animal or plant, neither of which is killed or eaten by the clan. There are other avoidances, more or less connected with the totem; for example, members of the leopard clan may not eat meat which has been torn or even scratched by an animal. We do not find traditions of descent from the totem amongst the Baganda, and the belief in descent from the totem is uncommon elsewhere in Africa. A nominalistic explanation of the origin of the Baganda totems is given; for example, the lion clan of the Baganda, with the eagle as secondary totem, explain their totems as follows: Kimtu, a royal ancestor of the clan, killed a lion and an eagle, and had their skins made into royal rugs, since when the beast and the bird have been regarded as sacred. There is one curious anomaly in Baganda totemism. While a man normally takes his totem from his father, there is an exception in the case of royalty, a man taking the totem of his mother in addition, and rarely maintaining the royal totem.

North America.—Throughout the greater part of North America we find totemism in a more or less typical form, and the frequent grouping of totemic clans into moieties reminds one of the Australian variety. Other features of American totemism, however, mark it off clearly from the Australian variety. While the tie between members of the totemic group may be as strong as anywhere else in the world, the attitude towards the totem is usually quite different, and the theory of totemic souls is wanting. Often, in America, the totem is little more than a clan-badge, and the totem is often killed by the totemic clan. Nevertheless, elaborate and picturesque legends of the origin of totemic clans from the totem by some sort of descent are common enough. Totemism is not particularly associated with the less developed tribes of North America—rather the reverse; and we find both matrilineal and patrilineal descent of the totemic clans. Amongst the strongly matrilineal Iroquois of the east we find a straightforward division of the various tribes into a small number of exogamous clans, of which the totems are animal species, the clans usually being grouped into two moieties. Although a few traditions of direct matrilineal descent from an animal of the totemic species have been recorded, the clans usually aeny relationship with their totems, and show no regard whatever for them. Passing westward, some of the Siouan tribes provide examples of a more complex totemic system. For example, the Ponkas are divided into moieties, the moieties into phratries, the phratries into clans, and the clans into sub-clans, each of these classes being more or less totemic and exogamous. Here definite tabus are connected with the totems of the clans. In the west, particularly the north-west coast, totemism is not clearly distinguishable from another socio-religious institution, peculiar to North America, the cult of guardian spirits. The guardian spirit is acquired individually, sometimes quite late in life, by a process usually of fasting and religious exercise, which causes the guardian spirit to appear to the candidate in a dream or vision. Since the guardian spirit usually has an animal form, it is sometimes called an individual totem—clearly a misnomer. Sometimes the guardian spirits capable of acquirement by members of the tribe are divided out between the clans, or other social groups of the tribe, and sometimes the guardian spirit is not clearly individual in nature, but is rather of the nature of a species of animal. In so far as this is the case we have an approximation to totemism. A complication of this sort is found in the totemism of the north-west coast peoples, who make the so-called totem-poles. The student will find a mass of data on totemism arranged geographically in Sir J. G. Frazer's work *Totemism* and *Exogamy* (1910).

Prominence was given to the association of totemism with exogamy, found throughout the world with few exceptions. Where totemism is not associated with exogamy it is not difficult to suppose that exogamy has been lost. With considerably less confidence it may be supposed that tribes, containing exogamous groups, have lost their totemism. Finally there are some peoples, *e.g.,* the Andaman islanders, and the Eskimo, at a primitive level of culture, who have neither exogamous groups nor totemism. From this distribution of totemism and exogamy it follows that any theory of totemism must either be a '[psychological" theory, explaining both totemism and exogamy, or a "historical" theory, which regards totemism, wherever it occurs, as the result of a spread of cultural influence from some one centre where the totemic complex originated. By a "psychological" explanation is meant an explanation in terms of observed facts about the behaviour of groups, or by means of generalizations about the behaviour of groups deduced from known psychological principles. If, antecedently to the development of a given institution, it could be stated on psychological grounds that an institution of that sort would probably develop, then such an institution can be said to be explained psychologically. Early theories of totemism have not explained in this sense, for totemism and exogamy have only been shown to be probable, independently of the development of the one or the other, from which it follows that the distribution of totemism and exogamy, assumed above, would not occur; *e.g.,* if, owing to the nature of man and his attainment of some very simple form of society, it were probable that he should develop totemic ideas and practices, and also that he should develop exogamous groups, but for reasons other than those which lead to his developing totemism, then it would be indeed surprising that most peoples who have the one institution have the other, while those who, although in a primitive state of society, do not have the one do not have the other. The difficulty can be got over by supposing that totemism and exogamy are necessarily developed by man in the course of his evolution; but it is difficult in this case to offer a plausible explanation of the disappearance of totemism and exogamy among some very primitive peoples, and its retention by others at a more advanced stage of civilization.

Two theorists may be mentioned for their attempts to provide a psychological explanation of both totemism and exogamy; viz., Durkheim and Freud. For Durkheim the totem results from the action of the group on the individual. The group is the nearest and most powerful coercive force to which the individual is subject, particularly when the group is in violent activity and the individual is conscious of this overpowering influence, when he loses himself completely in the group. Symbolic expression alone can be given to such a force; hence the totem is a sacred symbol, symbolizing that very real force, the clan. Hence totemic symbols are sacred rather than the totem-species itself (and this, it must be admitted, is true, at least for Australia).

But why, it may be asked, should there be many clans and totems, and not one totemic group? Here Durkheim becomes obscure. If there are already several groups, then only in so far as the effective unity of each group is felt should there be more than one totemic group within the tribe. Passing over this difficulty, we have still to enquire why the totemic group is exogamous: the answer is not very convincing. It would take too long to follow the various steps which give unity and intelligibility to the scheme, but it is the tabu on the blood of the clan which is ultimately responsible for exogamy.

Freud attempted to give a single explanation of totemism and exogamy, and he appeared to have indicated the direction in which we are to seek an explanation, whatever the adequacy of his presentation.

Prior to the development of culture, man is supposed to have lived in "cyclopean" families, containing a principal male who monopolized the women, including his own daughters, and prevented his sons from having intercourse within the family. What more natural than that the sons should combine and kill the father? But the attitude of the sons is ambivalent, combining both affection and hostility. The murder committed, the sons deny themselves the fruits of the deed, owing to the operation of a psychological process familiar to psycho-analysts, and the group becomes exogamous. The affective ambivalence towards the father has also provided the beginnings of totemism. By substituting an animal for the father, a process of symbolism which psycho-analysts consider fundamental in human nature, the animal becomes a vehicle for that affective attitude towards the father which is for the moment repressed. With the killing of the father by the momentary release of this repressed *Oedipus complex,* both totemism and exogamy are born. The group with one father, and therefore one totem, is exogamous, and the totem becomes the object of observances, which are really the expression of the *Oedipus complex,* which has now become more completely repressed by means of a social mechanism. The difficulties in the way of this theory are considerable, and have been critically analysed by Profs. Kroeber and Malinowski. Doctor Freud's theory has been elaborated and modified in a comprehensive study of Australian totemism on psycho-analytic lines by Dr. Géza Roheim. While the search for a "psychological" explanation of totemism does not reward us with any convincing theory of its origin, an "historical" explanation is equally elusive, though it has been maintained by one school that the distribution of totemism can only be explained on the assumption of diffusion from a single centre, a conclusion which, as we have already seen, follows if no psychological explanation of totemism combined with exogamy can be found. No evidence for the existence of exogamy, and only the most slender evidence for totemism is provided in the Egyptian centre from which the totemic complex is supposed to have spread; in fact, on this theory totemic exogamy is derivative in the various parts of the world to which totemism spread from a kind of dual organization with marriage injunctions. The only "historical" explanation of totemism which has been elaborated is, therefore, no more, if no less, convincing than the numerous "psychological" explanations which have been offered.

Dissatisfied with this impasse that the search for explanations leads to, both in the case of totemism and in that of many other primitive institutions, many anthropologists have renounced the search for psychological or historical explanations, and confine themselves to the search for the functions of institutions. Possibly this is the only kind of explanation of totemism within our grasp, and, although there is reason to suppose that totemism without function (occurring as a survival merely) occurs in some places. it must be admitted that, until totemism is understood in this functional sense in those cases where it appears to be a significant part of the culture of the group, it is premature to attempt to account for its origin.

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TOTENTANZ: see DANCE OF DEATH.

TOTILA, or BADCILA, king of the Ostrogoths (541–552), embodied the spirit of Gothic resistance to Byzantium and fought the last great battle against the reconquest of Italy by Justinian's generals. Under Theodoric (d. 526) men like Cassiodorus and the senatorial class had co-operated in the rule of the Gothic kingdom; after his death, the Roman and Gothic parties struggled for predominance. When the regent Amalasuntha, educated in the classical tradition and favouring submissive relations with Justinian, was assassinated, a Byzantine army under Belisarius was sent to invade Italy (536); the Goths fought stubbornly but, under their leaders Witigis, Hildibald and Hereric, were successively defeated. Then Eaduila, surnamed Totila, was elected king and proved an indomitable leader. Between 541 and 546 he drove the Byzantines from northern and central Italy and recovered Naples and even Rome. When he failed to win senatorial support there, he drove out the citizens and left the city desolate. By 550 he had also recovered Sardinia, Corsica and parts of Sicily and Dalmatia, provoking Justinian to send against him a very much larger army under the eunuch Narses. This force crossed the head of the Adriatic, marched through Venetia southward to Umbria, and surrourided and crushed Totila's smaller force at Taginae (*q.v.*; now Gualdo Tadino) in 552. Totila was killed and the Gothic cause lost, though resistance dragged on till 555. The earlier Ravenna mosaics, the Cesena treasure, an illuminated manuscript and a few palimpsests of the Gothic Bible survive to show the character of the civilization for which Totila fought.

See E. Gibbon, *Decline and Fall of the Roman Empire*, ed. by J. B. Bury (London, 1909); T. Hodgkin, *Italy and Her Invaders*, vol. iv (Oxford, 1896); F. Lot, *Les Invasions germaniques* (Paris, 1935), L. Halphen, *Les Barbares* (Paris, 1936). (M. DY.)

TOTNES, GEORGE CAREW, or CAREY, EARL OF (1555–1629), English politician and writer, son of George Carew, dean of Windsor, and Anne, daughter of Sir Nicholas Harvey, was born on May 29, 1j55, and was educated at Broadgates hall, Oxford, where he took the degree of M.A. in 1589. After long service from 1j74 onward, chiefly as a soldier in Ireland, where he held a number of responsible offices and rose to be master of the ordnance (1588), he was appointed lieutenant general of the ordnance in England in 1592. He accompanied Essex in the expedition to Cadiz in 1596 and to the Azores in 1597. In 1598 he attended Sir Robert Cecil, the ambassador, to France. In 1600 he was appointed president of Munster, where his vigorous measures enabled the new lord deputy. Lord Mountjoy, to suppress the rebellion. He returned to England in 1603 and was well-received by James I, who gave him many honours. In 1610 he revisited Ireland to report on the state of the country; and in 1618 pleaded in vain for his friend Sir Walter Raleigh. He received his earldom in 1626. He died on March 27, 1629, leaving no issue. Besides his fame as president of Munster, Carew had a considerable reputation as an antiquary.

Carew made large collections of materials relating to Irish history and pedigrees, which he left to his secretary. Sir Thomas Stafford,author of *Pacata Hibernia* (1633) and reputed on scanty evidence to be his natural son; while some portion has disappeared, 39 volumes after coming into William Laud's possession are now at Lambeth (see *Calendar* of *the Carew* mss., 6 vol., ed. by J. S. Brewer and W. Bullen, London, 1867–73), and 4 volumes in the Bodleian library. His correspondence with Sir Robert Cecil was edited in 1864 and his letters to Sir Thomas Roe (1615–1j) in 1860. both by Sir John Maclean for the Camden society. London.

TOTNES, a market town and municipal borough in the Totnes parliamentary division of Devonshire, Eng., on the Dart, 24 mi. S.S.W. of Exeter by road. Pop. (1961) 6.064. Area 2.2 sq.mi. It stands on the west bank of the river, and is joined by a bridge to the suburb of Bridgetown. It was formerly a walled town commanding the lowest crossing of the Dart, and two of the four gates remain. Many old houses are also preserved, and in High street their overhanging upper stories, supported on pillars, form a covered way for pedestrians. The castle, founded by the Breton Juhel, lord of the manor after the Conquest, was dismantled under Henry VIII; but its keep and upper walls remain. Close by are the remains of St. Mary's priory, which comprise a large Perpendicular gatehouse, refectory, precinct wall, abbot's gate and still-house, also the Perpendicular church of St. Mary. The guildhall is formed from part of the priory. Vessels of zoo tons can lie at the wharves near the bridge. The industries include brewing, flour milling and the export of agricultural produce, chiefly corn and cider. Trout and salmon are in the river.

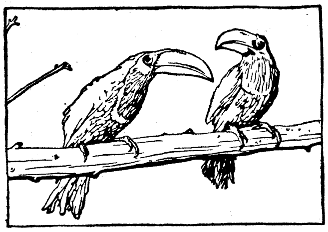
Totnes (Totanæs on Cnut coins of 979) was a place of considerable importance in Saxon times; it possessed a mint in the reign of Aethelred, and was governed by a portreeve. In the Domesday Survey it appears as a mesne borough under Juhel (Judhael) of Totnes. Its earliest charter dates from 1205.

TOTONICAPÁN, the capital of the department of Totonicapdn. Guatemala, on the same high plateau as Quezaltenango, from which it is 12 mi. E.N.E. Pop. (1957 est.) 7,380. Totonicapdn is inhabited mainly by Quiché Indians, employed in the making of cloth, furniture, pottery and wooden musical instruments. There are hot mineral springs in the neighbourhood. In 1538 Totonicapan was declared an independent republic, in which the adjoining departments of Sololá and Quezaltenango were included. This state existed for two years, and was then again merged in the republic of Guatemala. The city suffered greatly in the earthquake of April 18. 1902.

TOTTENHAM, a municipal and parliamentary borough (1934) of Middlesex, Eng., and inner suburb of London, astride the main road to Cambridge, $6\frac{1}{2}$ mi. N. of London bridge. Continuous with Stoke Newington to the south and Edmonton to the north, the eastern boundary is the river Lea. Pop. (1961) 113.126. Area 4.7 sq.mi. It is a residential and industrial area with a very large furniture factory. It has a famous football club (Tottenham Hotspurs) and at Harringay is a popular stadium and sports arena. There are in the borough 379 ac. of open space. All Hallows church, Tottenham, was given by David, king of Scotland (c. 1126), to the canons of the church of Holy Trinity, London, and parts of the old building still remain. A modern erection marks the site of the old High cross, original nucleus of Tottenham. Formerly Tottenham was noted for its "greens." In the centre of one stood the famous old elm trees called the "Seven Sisters," which were removed in 1840 and whose name is preserved in the Seven Sisters road. The manor was given by William I to Judith, wife of Waltheof, earl of Huntingdon, who built a castle which through Judith's daughter Maud and others passed to Robert Bruce. The present Bruce castle is a 16th-century mansion built on the site by Sir William Compton. In 1827 it was a boarding school founded by Rowland Hill, famous as the postmaster general who introduced the "penny post." Now public property, it houses a museum (with a proper emphasis on postal history), the grounds forming a public park.

TOTTORI, Japanese prefecture in western Honshū on the Sea of Japan, was formed from Inaba and Hōki provinces after the Restoration of 1868. It has an area of 3,489 sq.km. (1,347 sq.mi.) and in 1955 the population was 614,259. Hot springs and ski resorts are associated with the great volcanoes of this prefecture. The largest volcano, Daisen, is in Dai-sen National park. Small quantities of copper, zinc, uranium and iron ore are mined. There is some production of iron and steel. Textile and mining machinery and cotton textiles are exported. Sites of ruined castles, historic temples and famous gardens reveal the part this area played in Japanese history.

The capital of the prefecture is Tottori, which lies near the mouth of the Sendai river. Between 1940 and 1958 the city absorbed adjacent villages and increased in area from 42 to 227 sq.km. (16 to 88 sq.mi.) and in population from 49,300 to 104,880 (1955). The chief products of the city are lumber, paper and silk. (C. A. MR.)



TOUCANS, FOUND ONLY IN THE WESTERN HEMISPHERE

TOUCAN, the Brazilian name for a bird of the tropical American family *Ramphastidae,* characterized by their huge but light beaks.

The type of the family is *Ramphastes toco,* of Guiana and Brazil. The beak, 8 in. long and 3 in. high at the base, is deep orange with a large black spot near the tip. The eye is surrounded by a bare orange space; the plumage is black except for the white throat, edged beneath with red. The tail is nearly square. In many allied species, the bill is parti-coloured. R. *vitellinus* inhabits Trinidad, but all the remaining members of the family are confined to the mainland, ranging from Paraguay to Mexico. In the Andes, they reach an elevation of 10,000 ft. (K. P. S.)

TOUCH, SENSE OF. In the environment of every animal, the solid, impenetrable objects with which it may collide play an important part. Sensitiveness to touch, comparable to our own, is, therefore, generally developed. The manner in which an animal reacts to contact stimuli depends, principally, on the force of the contact. All such stimuli which exceed a certain degree act as repellants, and feeble, defenceless animals seek to escape from them. This is evident already in the simplest animals, such as the amoeba. It is sufficient to touch one of the protruded pseudopodia of an amoeba with a pointed, glass needle to bring about its immediate retraction. Already in many infusorians there are extraordinarilv developed tactile cilia; if another animal comes into contact with them, it causes the infusorian to swim hastily away (fig. 1).

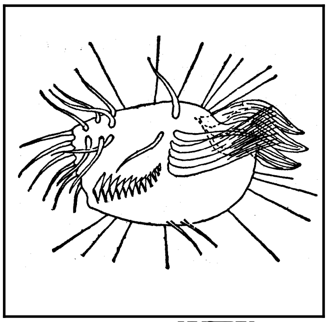


FIG. 1.—DIOPHRYS HYSTRIX, AN INFUSORIAN WITH PARTICULARLY LONG TACTILE CILIA (AFTER VON BUDDENBROCK)

In multicellular animals the reaction to mechanical impulses differs very much, in accordance with the defensive powers of the individual. This is sufficiently well known in the higher animals. Defenceless animals, such as earthworms, or gasteropads, flee, or withdraw into their protective shells; on the other hand, those capable of defending themselves, such as the large Crustacea, cuttlefishes or sea-urchins meet the assault by active defensive movements. The example last mentioned is, perhaps, of sufficient interest for it to be discussed more particularly.

If we touch a sea-urchin on any part of its surface, one of three things happens. In the first case, all the spines which are situated in the neighbourhood of the part stimulated bend towards it. If some animal were the cause of the contact it would, thus, be grievously stung by the sharp spines, and put to flight. In the second case the pedicellariae come into action (fig. 2). These are pincers consisting of three small snapping blades on a pliant stalk. They turn towards the place whence the contact stimuli proceed, and wave their gaping jaws rapidly to and fro. They bite firmly into the skin of the enemy, or into its hairs, and assist, either in putting it to flight, or in holding it fast and bringing it into contact with the tube-feet round the mouth, where it is consumed. Lastly, in a third case, the whole sea-urchin moves in a direction calculated, if possible, to take it out of the sphere of the stimulus.

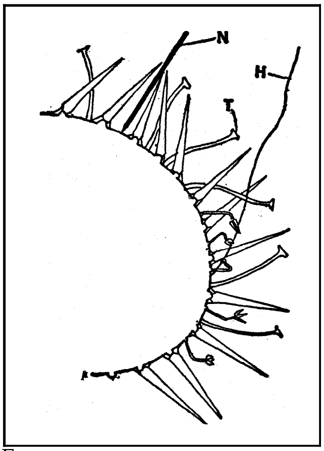


FIG. 2.—SURFACE OF SEA-URCHIN UNDER MECHANICAL STIMULATION S, NEEDLE N AND HAIR H; S A TUBE-FOOT

The common crab, particularly the male, reacts to strong contact stimuli by assuming its very characteristic defensive attitude. It turns towards its opponent and presents its widely-opened pincers. If the enemy still continues to approach, it strikes at it with great force.

Some animals are able to assume an appearance of death when attacked. The most pregnant examples of this are furnished by insects. The death-feigning reflex usually consists in the animal drawing in its legs, and remaining perfectly motionless, continuing thus even if maltreated in the most violent manner. In such a case, the assailant, a bird for example, thinks it is dealing with a dead thing instead of a food animal, and gives up the attack. Insects such as these, which feign death, usually resemble very closely some inanimate object, such as a piece of wood or a twig. The stick-insects provide the best known examples of this.

As was mentioned at the beginning, the sense of touch often serves to prevent an animal dashing itself against hard objects when moving from place to place. The whirligig beetle, *Gyrinus,* which we see skimming rapidly to and fro over the surface of the water in summer, bears eloquent witness to the degree of sensitiveness attained. The careful observer will soon perceive that these lively little creatures never collide with any object which may be floating on the surface of the water; they also do not run against one another, although, often, many may be skimming about in a restricted space. The sense organs which render this possible are situated in the feelers, as Eggers has proved. The antennary flagella are borne free in the air; their amputation does not cause alterations in the animal's conduct. On the other hand, the second basal joint rests on the water like a float (fig. 3). It contains numerous sensory cells, bearing stylets, which are

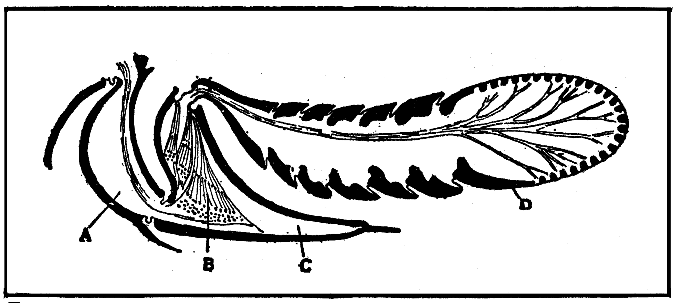


FIG. 3.—ANTENNA OF WHIRLIGIG BEETLE: (A AND C) BASAL JOINTS OF ANTENNA, (B) JOHNSTON'S ORGAN. (D) ANTENNARY FLAGELLUM

grouped together in "Johnston's organ." With the assistance of these the animal perceives in some way the proximity of solid objects; it may, perhaps, react to the waves of water reflected to it by these objects.

Among vertebrates, bats are able to perform a, perhaps, even greater feat. As was known already to the naturalists of the 18th century, even blind bats are able to avoid all obstacles which may be placed in their path.

An opposite condition to that discussed hitherto prevails in not a few cases in which the animal seeks to establish contact with a solid object, and is uneasy if it cannot do so. This phenomenon has been given a special name, and is known as "thigmotropism." In most animals the soles of the feet are usually placed in constant contact with solid bodies. The vigorous attempts at "righting" which are made by almost every animal if it falls upon its back, until it regains its feet once more, are due, in many cases, to the effort to bring the feet again into contact with solid bodies. This may be seen particularly well in insects. If we put a caterpillar upon its back it immediately rights itself. If, however, we place between its feet a twig to which it can adhere, it remains peacefully upon its back, and even eats in this position. The following experiment is easily carried out, and shows this very clearly. A thread is gummed firmly on to the back of a fly, and is then attached to a stand, the feet of the insect being allowed to hang down free. If, now, a small ball of paper is placed between them, the fly begins at once to run about upon it.

The normal running movement, therefore, follows contact of the feet with the solid object. In leeches, contact stimuli are of particular importance in locomotion. Uexkuell showed that in these animals a quite definite co-ordination exists between the action of the suckers and the contraction of the muscles of the body. When the leech is adhering by means of its posterior sucker, it stretches out its body at full length, searching thus for a suitable surface on which to fasten its anterior sucker. When the anterior sucker is attached, the posterior sucker relaxes its hold, and immediately a reflex contraction of the longitudinal muscles of the body takes place. Both phases, taken together, give rise to the characteristic looping motion of the leech. *(See* fig. 4.) If, however, we throw the leech into water without giving

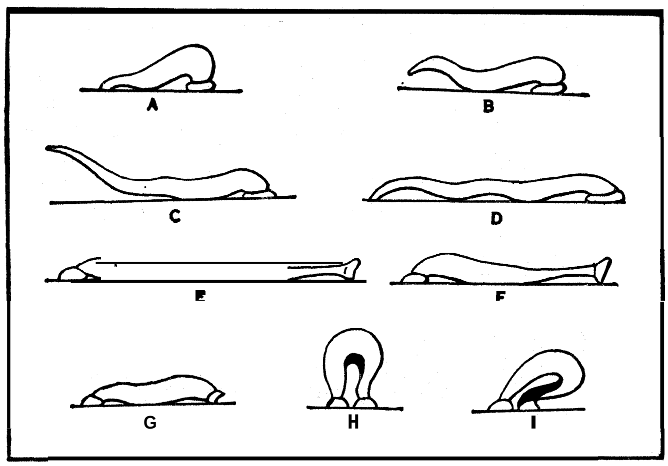


FIG. 4.—CRAWLING MOVEMENT OF A LEECH: (A–D) POSTERIOR SUCKER IS ATTACHED, AND THE WORM EXTENDED: (E–G) ANTERIOR SUCKER IS ATTACHED, POSTERIOR IS FREE, ANIMAL IS CONTRACTED: (H–I) RE-ATTACHMENT OF THE POSTERIOR SUCKER

it an opportunity of attaching itself by one of its two suckers, swimming movements at once take place.

Thigmotropism, however, appears also in quite another form. It was thought at first that many animals which are in the habit of dwelling in narrow tubes (such as many worms), or in crevices in wood, or under bark are led to seek out their hiding places through an aversion to light. The truth of the matter is that such an animal feels comfortable only if its body is in contact, as much as possible, on all sides, with solid surfaces. Thigmotropic worms will also creep into glass tubes, and some insects hide between glass slides, in spite of being fully exposed to daylight when in these retreats. Under natural conditions, the thigmotropic animal thus avoids the covetous eyes of its enemies, since in nature there are no transparent solid objects.

Sensitiveness to mechanical stimuli has a very important use in the sense which in higher animals makes them aware of the relative position of the parts of the body. To the majority of human beings it certainly appears quite as a matter of course that they are able to take hold of their noses with their hands. Science teaches, however, that this is possible only through stimulation of numerous sensory cells in the skin, which are pulled or pressed when the arm or the hand is moved. If the skin is narcotized, the power of touching any particular part of the body is lost.

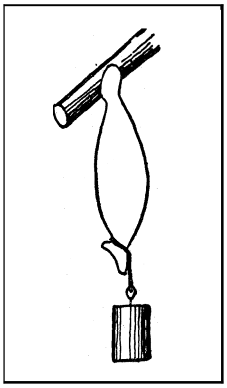


FIG. 5.—LEECH SUPPORTING WEIGHT (AFTER CAHNHEIM AND UERKÜLL)

It is of interest that some of the lower animals, particularly arthropods, possess a similar sense. Insects and Crustacea show this in the very vigorous way in which they clean the limbs and the body, making use of legs specialized for this purpose. The precision with which the decapod Crustacea, after moulting, place fresh statoliths in their statocysts is astonishing. *(See* also EQUILIBRIUM, SENSE OF.) They seize grains of sand, or similar material in their delicate pincers, and are able to introduce them into the statocyst through its minute opening.

As regards the lower animals, we do not yet know anything for certain about the localization of the sensory cells which function in these movements. In Crustacea, this faculty is distributed apparently among sensory hairs in the region of the joints; in insects we know that there are free nerve endings in the skin of the joints.

To the mechanical sense belongs also the sense of "strength." When a rnsn lifts a weight, he notices exactly if it is heavy or light, and, according to this sensation, he regulates the amount of energy to be expended. The leech shows that a similar sense is present also in the lower animals. It has been mentioned already that this animal contracts when the anterior sucker is attached and the posterior sucker is free. When the animal is in this position we can force it to lift fairly heavy weights, which, under certain circumstances, it will support for hours together. *(See* fig. 5.) If we cautiously hold up the weight with one hand, the worm experiences a sensation of considerable relief, and alters the impulse it sends to its muscles. This is clearly proved by the fact that, as soon as we withdraw our hand again, the worm is drawn out by the weight which it formerly had supported.

Stimulation of the Nervous System by Mechanical Influences.—Every organism, in order to be able to move vigorously, requires constant stimulation from without. To man this statement does not appear very credible, but it can occasionally be proved quite clearly in the lower animals. In the article on EQUILIBRIUM, ANIMAL, the statocysts of the lower organisms, which usually act as balancing organs, are described. It has been generally proved by experience, that the animals fall into an enduring state of debility-after these statocysts have been removed by an operation. They are no longer able to make powerful movements; we can express mathematically the amount of diminution in the gripping power of the chelae of a crustacean caused by the removal of the statocyst. It is not yet determined for certain how this connection between the statocysts and the muscular strength is to be explained. Apparently, the mechanical stimulation of the sensory cells of the statocyst by the statoliths affects the central nervous system of the animal, thus, as we may say, rousing it into activity in a somewhat similar manner to that in which coffee stimulates a tired man.

Flies furnish a particularly remarkable instance of this. In these insects, the posterior wings are transformed into oscillating clubs or "halteres," which, during flight, move simultaneously with the wings, with great rapidity (figs. 6a, 6b). If these clubs are removed or stuck down firmly, the insect is no longer capable of flight. It can neither rise from the ground nor maintain itself in the air. It appears from this that the active movement of the halteres is essential. Formerly, it was thought that the halteres were a kind of balancing organs, and it was believed that the fly lost its power of balance after they had been removed. This, however, is excluded by the extremely minute size of the

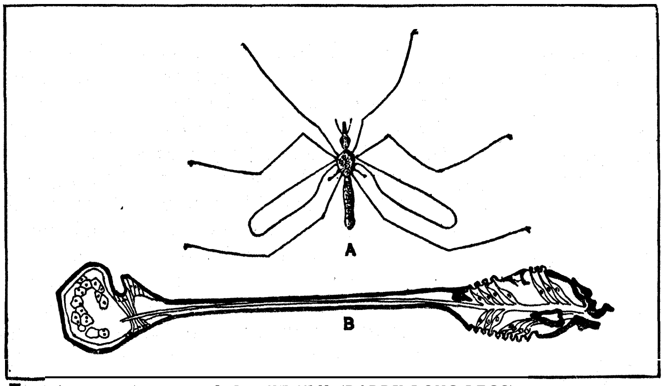


FIG. 6.—(A) TIPULA, A CRANE-FLY (DADDY-LONG-LEGS) SHOWING HALTERESES BEHIND THE WINGS; (B) LONGITUDINAL SECTION THROUGH A HALTERE, SHOWING SENSE ORGAN AT THE BASE (AFTER PFLUGSTEDT)

halteres. Now, however. numerous sensory cells affected by mechanical stimuli have been found on the basis of the halteres. These are so arranged that they must be vigorously stimulated by the movement of the halteres, which, apparently, has this stimulation as its object. We may assume that this affects the nervous system of the fly in a similar way as stimulation of the statocyst affects crustaceans. The fly is able to send the necessary impulses to the muscles of flight only if this constant stimulation is present.

Wille has recently discovered a similar, and, considered as a whole, certainly still very problematical contrivance in the Brazilian locust, *Rhipipterix chopardi*. This insect bears sense organs on the under side of its hind legs; if these are put out of action by being stuck down, the insect is prevented from springing and flying.

Structure of Tactile Organs.—There is not very much to be said on the subject of the anatomy of the sensory cells which serve for the transmission of mechanical stimuli. It has been mentioned alreadv that. even among unicellular animals (infusoria) tactile cilia are occasionally to be found. (See fig. I.) In multicellular animals there are frequently found, projecting from the surface of the body, groups of cells bearing small hairs like cilia, which are usually considered to be tactile organs (fig. 7 and 8). Several of these organs from the skin of different kinds of Echinoderms are shown in fig. 7. In fig. 8 is represented a "sensilla" from the skin of the leech. In yet other cases we find what are called free nerve-endings (fig. 9), the nerve cells, which are deeply situated beneath the skin, sending one or many fine processes up to the outer surface. Unfortunately, in no case can it be proved definitely that the groups of sensory cells mentioned really serve for the perception of mechanical stimuli. The only way in which this might be determined, namely by removing the organs by an operation and experimenting with the animals thus treated, is not practicable, owing to the large number of the organs, which usually are distributed over the whole surface of the skin. This difficulty of proof occurs also when dealing with arthropods, in which the tactile organs exhibit an astonishing

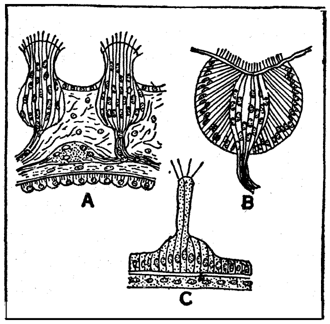


FIG. 7.— EPITHELIALSENSE-ORGANS OF ECHINODERMS
(A) Ophuroid, transverse section through the wall of an ambulacral foot; (B) Sea-cucumber, epithelial sense-organ from a tentacle; (C) Sensory papilla from an ambulacral foot of a feather-star

diversity. The rule that the cuticle is particularly thin where the sensory cells are situated (see fig. 10) applies to all these creatures (insects, crustaceans, spiders). When a sensory cell is quite separated from the exterior by a layer of chitin, it is impossible that it can perceive chemical stimuli, and we may assume, with some degree of probability, that it is an organ for the perception of mechanical stimuli.

Among Crustacea the most general form in which these occur is the sensory hair; in insects we find in addition sensory cones

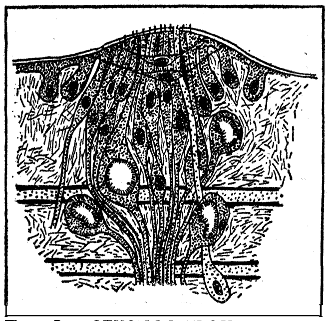


FIG. 8.—SENSILLA FROM THE SKIN OF A LEECH WITH OPTIC CELLS, AND APPARENTLY TACTILE CELLS (AFTER HACHLOFF)

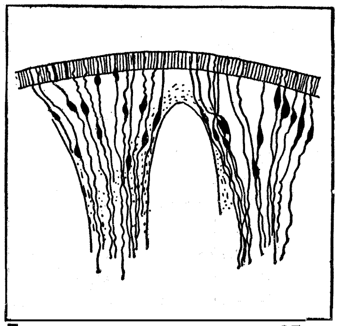


FIG. 9.— ANTERIOR END OF A SHORT HORN OF A SLUG (ARION), SHOWING FREE NERVE ENDINGS (AFTER RETZIUS)

(fig. 10 B), sensory pits (10 C), cup-shaped sense organs (fig. 10 D), and so forth. In insects only there is found also a particular kind of sense organ, the chordotonal organs. In form they are like a cord stretched between two flat surfaces of the body wall, and, doubtless, function when these surfaces are displaced in any way. The following parts may be distinguished in them:—the sensory cell with the proximal enveloping cell, the distal enveloping cell (cap cell) which connects the peculiar stylet (scolopala) with the hypodermis, and, lastly, the ligament which spans the whole apparatus. Such organs are found singly or in groups on the body and extremities of insects. The organs which most resemble them are "Johnston's organs" in the feelers. (See fig. 4.)

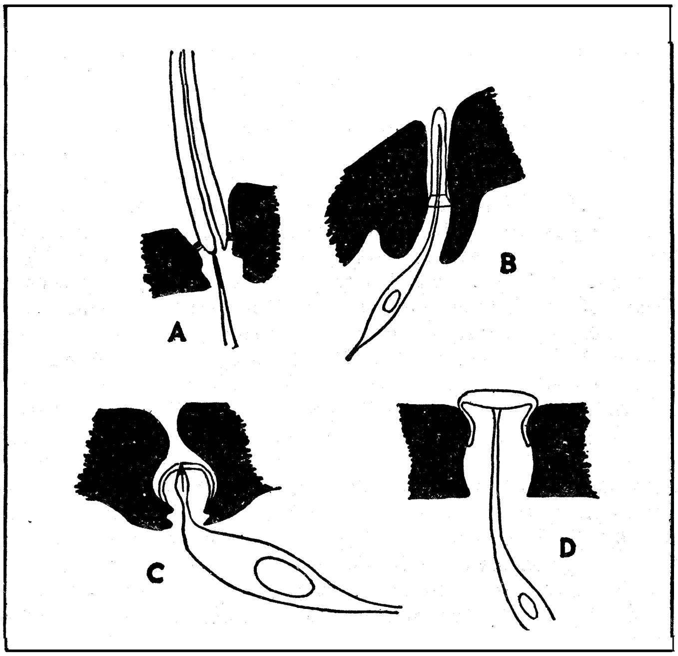


FIG. 10.— FOUR DIFFERENT KINDS OF TACTILE ORGANS FROM THE WATER-BEETLE (AFTER HOCHREUTHER)

In the auditory organs of insects the chordotonal organs certainly receive the sound waves; what purpose they serve in Johnston's organ, or in the simpler organs, is not yet known.

The Sense of Temperature.—Since heat, as is well known, consists in a mechanical vibration of molecules, the sense of temperature, also, must be included in the mechanical sense. It goes without saying that the higher animals possess a sense of temperature which is very similar to that of human beings. It is of greater interest to prove its presence in the lower animals. The simplest method of deciding whether an animal reacts to heat stimuli is by the use of the temperature organ. This consists of a narrow box, about a meter in length, the bottom of which is heated at one end, and, at the other, is cooled with ice. If a number of small animals, such as ants, are placed in the box, they avoid both the hot and the cold ends, and seek for a part in which a temperature prevails which suits them best.

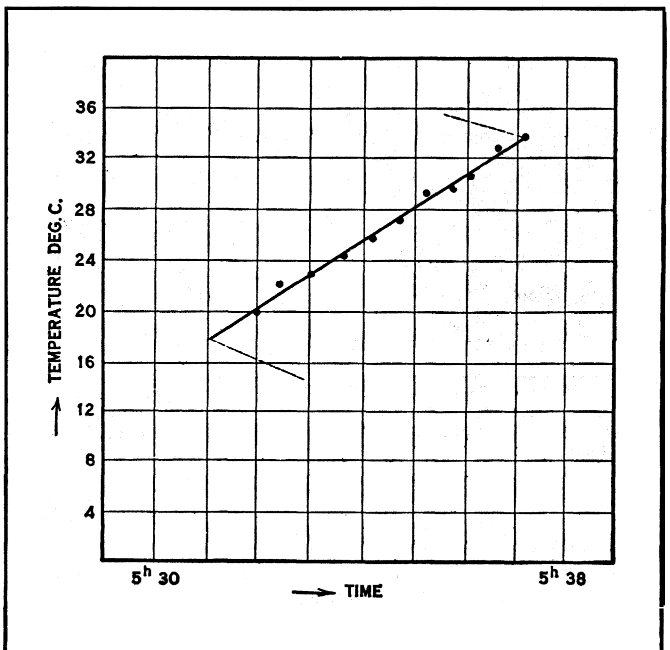


FIG. 11.—RISING OF THE TEMPERATURE OF THE BODY OF A MOTH DURING VIBRATORY MOVEMENTS OF THE WINGS (AFTER DOTTERWEICH)

Bees furnish a very fine example of an extraordinarily developed temperature sense. During the time when the eggs are hatching, they keep the interior of the hive at a very constant temperature of 35° (Hess, Himmer). The observed variations often lie within half a degree, that is to say, bees regulate the warmth of the hive just as exactly as mammals regulate the temperature of the blood.

It goes without saying that they must possess sensory cells by means of which they perceive heat. They raise the temperature of the hive apparently by muscular movements; over-heating they counteract by carrying in water and allowing it to evaporate.

Nocturnal Lepidoptera regulate the temperature of the body before flying. As a result of the heat produced by muscular activity, they attain, during flight, a temperature of about 36–40°. Before they fly off, they make very rapid, vibratory movements with their wings, buzzing or whirring. This is simply to raise the body temperature. As soon as the flight temperature is reached, they fly off. Fig. 11 represents, graphically, the raising of the body temperature during this vibration. Little is known of heat perception in the rest of the Invertebrata. (W. v. BUD.)

For the sensory function of touch in man *see* SKIN, SENSORY FUNCTIONS OF.

TOUCH-ME-NOT, any plant of the genus *Impatiens* (family Balsaminaceae), so called from the fact that the fruits burst explosively—the valves roll up inward and scatter the seeds—when touched. The genus includes about 350 species, found in tropical and north temperate regions, and especially abundant in the mountains of India and Ceylon. A few are cultivated ornamental flowers, among them garden balsam (*I. balsamina*) and sultana (*I. sultani*). Some American species are known as jewelweed. *See* IMPATIENS.

TOUL, a garrison town of northeastern France, in the *département* of Meurthe-et-Moselle, 21 mi. W. of Nancy on the Eastern railway. The population in 1954 was 11,140. Toul (*Tullum*) was originally capital of the Leuci, in the Belgic confederation, and acquired great importance under the Romans. It was evangelized by St. Mansuy in the 4th century, and became one of the leading sees of northeast Gaul. After being sacked successively by Goths, Burgundians. Vandals and Huns, Toul was conquered by the Franks in 450. Under the Merovingians it was governed by counts, assisted by elective officers. The bishops became sovereign counts in the 10th century, holding only of the emperor, and for 300 years (13th to 16th centuries) the citizens maintained a long struggle against them. Together with Verdun and Metz, the town and its domain formed the territory of the Trois-Evêchés. Toul was forced to yield for a time to the count of Vaudémont in the 12th century, and twice to the duke of Lorraine in the 15th. Charles V made a solemn entry into the town in 1544, but in 1545 it placed itself under the perpetual protection of the kings of France. Henry II took possession of the Trois-Evêchés in 1552, but the territory was not officially incorporated with France till 1648. Henry IV was received in state in 1603, and in 1637 the parlement of Metz was transferred to Toul. In 1700 Vauban rebuilt the fortifications of the town. In 1790 the bishopric was suppressed and the diocese united to that of Kancy. Toul capitulated in 1870.

The church of St. Étienne, which was formerly a cathedral, has a choir and transept of the 13th century; the nave and aisles are of the 14th, and the fine façade of the last half of the 15th. There are two western towers. The two large lateral chapels of the nave are in the Renaissance style. South of the church there is a fine cloister of the end of the 13th century which was much damaged at the Revolution. The church of St. Gengoult, chiefly late 13th- or early 14th-century, has a façade of the 15th century and a 16th-century cloister in Flamboyant Gothic. The *hôtel de ville* occupies a building of the 18th century, once the episcopal palace. Toul is the seat of a sub-prefect. The industries include the manufacture of porcelain; trade is in wine and brandy.

TOULON, a seaport and first-class fortress and naval station of France, *département* of Var, capital of the *arrondissement* of Toulon, on the Mediterranean, 42 mi. E.S.E. of Marseilles. Pop. 125,572. The Roman Telo Martius is supposed to have stood near the *lazaretto*. The town was successively sacked by Goths, Burgundians, Franks and Saracens. Until conquered by Charles of Anjou in 1259, it was under lords of its own, and entered into alliance with the republics of Marseilles and Arles. St. Louis, and especially Louis XII and Francis I strengthened its fortifications. It was seized by the emperor Charles V in 1524 and 1536. Henry IV founded there a naval arsenal which was further strengthened by Richelieu, and Vauban made the new dock, a new enceinte, and several forts and batteries.

The bay, which opens to the east, has two divisions, the Grande Rade and the Petite Rade; it is sheltered on the north and west by high hills, closed on the south by the peninsula of capes Sicié and Cépet, and protected on the east by a huge breakwater. The forts of St. Marguerite, of Cap Brun, of Lamalgue and of St. Louis to the north, and the battery of the signal station to the south, the battery of Le Salut to the east, and the forts of Balaguier and L'Aiguillette to the west protect the entrance. The bay of La Seyne lies west of the Petite Rade, and is defended by the forts of Six-Fours, Napoléon (formerly Ft. Caire), and Malbousquet, and the batteries of Les Arènes and Les Gaus. To the north of Toulon rise the defensive works of Mt. Faron and Ft. Rouge to the east the forts of Artigues and St. Catherine, to the north-east the formidable fort of Coudon, and to the south-east that of Colle Noire, respectively dominating the highway into Italy and the valley of Hyères with the Bay of Carqueiranne. The modern quarter lies to the north of the old town. The chief buildings are the former cathedral of St. Marie Majeure, the church of St. Louis, the naval and military hospital, a naval school of medicine, a school of hydrography, and large barracks. The imports are corn, wood, coal, hemp and salt provisions; the exports are salt, figs, raisins, almonds, oranges, cloth, bauxite ore, cork, soap and oils. The principal industries, apart from the arsenal, are shipbuilding, fishing and wine making. The interesting buildings and gardens of the hospital of St. Mandrier stand on the peninsula of

Cape Cépet, and near them is the *lazaretto.* Toulon is the seat of a sub-prefect, of a chamber of commerce, a board of trade-arbitrators and of a permanent maritime tribunal.

Toulon is the most important of the French dockyards, and is the headquarters of the Mediterranean fleet. The arsenal, which was created by Louis XIV, lies on the north side of the Petite Rade. This is approached from the Grande Rade by passages at the north and south ends of a long breakwater which extends from the direction of Le Mourillon towards the Cépet peninsula. Outside in the Petite Rade is a splendid protected anchorage for a great fleet, the whole being commanded by many forts and batteries. There are four great basins approached from the Petite Rade—the Vieille Darse, to the east, on the side of Le Mourillon; the Darse Vauban, next to it; and the Darse de Castigneau and the Darse Missiessy, farther to the west. Shipbuilding and its accessory trades are carried on at Toulon. (H. J. F.)

The Battle of Toulon (1744).—This battle was fought off the port from which it takes its name on February 11, 1744. An allied Franco-Spanish fleet of 28 ships was in harbour, commanded by M. de Court, and was being watched by a British fleet of similar size under Admiral Mathews.

England and Spain had been at war since 1739, but England and France, though on opposite sides, had not yet actually declared war on one another. Spain was employed at this time in sending troops to North Italy for an attack on Austria's Italian possessions, and France was helping her by placing Toulon at her disposal and also by providing about two-thirds of this fleet which was to convoy them.

Mathews felt he would be justified in attacking the French as well as the Spaniards, should the former's proffered assistance with their Mediterranean fleet materialize. The combined fleet put out of Toulon on February 9, and to Mathews' surprise, made off on a southerly course. If he were to follow them, he would uncover Toulon and the transports would slip out; on the other hand, if he waited for the transports, the enemy's fleet would not be brought to action. The English admiral decided in these circumstances to go after the fleet and bring it to action quickly, and then to double back and intercept the transports. He himself was commanding the centre, Lestock, the second-in-command, the rear, and Rowley the van.

According to the fighting instructions of the day, it was Mathews' duty first, if possible, to obtain the windward position. This he did. Then, before he bore down on the enemy to what distance he considered suitable, he was so to arrange his line that the ends would be conterminous with those of the enemy, so that, when parallel battle was finally joined, each ship would be opposed to the corresponding ship in the enemy's line. Clearly, however, Mathews' plan was hardly compatible with such instructions. If he was to wait until his whole line was covering the allies before attacking, he was the less likely to be back off Toulon in time to deal with the transports. Consequently, when Rowley's squadron was opposite the allied centre, and his own opposite the allied rear, Mathews signalled the attack. He was further influenced to this course by the fact that the British rear was far behind and to the east, owing, so its commander said, to variable breezes and adverse currents: in this connection, however, it must be noted that there was bad blood between Lestock and Mathews. Previous to the attack, Mathews had been flying the signal for the line—obviously applicable to Lestock—but when the commander-in-chief flew also the signal for battle, clearly meaning that Lestock should come up and take on the unengaged allied van before it should get about to assist the centre and rear, the second-in-command hove to and did nothing, on the grounds that Mathews was already filling his place opposite the enemy's rear and that consequently there was nothing for him to do.

The remainder of the British fleet was also puzzled at being ordered to attack before the whole enemy line was covered. The centre bore down on the enemy eventually, but in considerable confusion. Some of Rowley's squadron likewise attacked. but they were fearful of being doubled by the unoccupied allied van, and the leading ships correctly beat to windward to prevent this. Eventually M. de Court, realizing that the Spaniards who formed his rear were hard pressed, ordered his whole fleet about, and as the fresh ships came into action, Mathews' broke off the battle. The only prize was the "Poder," taken by Captain Hawke.

A record number of courts-martial followed. Lestock was acquitted on the technical grounds indicated above, but Mathews was sentenced to dismissal from the service. He had, with such ships as supported him properly, fought energetically, but was dismissed because, in trying to force a decision in difficult circumstances, he had trespassed against the fighting instructions of his day. Thanks to such measures and other reforms Great Britain's sea power was greatly increased.

The Siege of Toulon (1792).—In 1792 the royalists of the town sought the support of the English-Spanish fleet cruising in the neighbourhood under Vice-admiral Samuel Hood (*q.v.*). The Convention having replied by outlawing the town, the inhabitants opened their harbour to the English. The army of the republic at the end of Aug. 1793 laid siege to the town, and on this occasion Napoleon Bonaparte first made his name as a military expert. The forts commanding the town having been taken on Dec. 17 the English ships retired after setting fire to the arsenal and destroying a large part of the French fleet. Under the directory Toulon became the most important French military port on the Mediterranean; there Napoleon organized the Egyptian campaign. (*See* NAPOLEON I.) (G. A. R. C.; J. G. B.; X.)

World War II.—The Franco-German armistice of 1940 left the French fleet in the hands of the Vichy government, and at the time of the Anglo-American invasion of North Africa on Nov. 8, 1942, the greater part of this fleet was stationed at the Toulon naval base.

On Nov. 11 Hitler abrogated the terms of the armistice and ordered his forces to take over the unoccupied part of France, and on Nov. 27 his troops occupied Toulon and attempted to seize the French fleet.

The French were prepared for such a move, however, and under the command of Adm. Jean de la Borde scuttled or otherwise sabotaged the majority of their warships. Of more than 60 ships aggregating about 225,000 tons, only about 25,000 tons of smaller vessels remained intact.

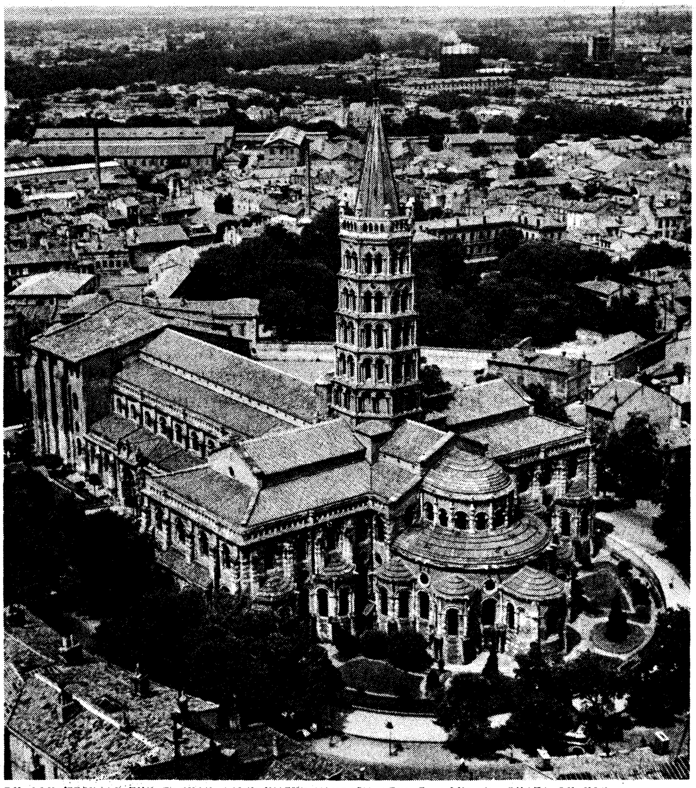
TOULOUSE, the capital of the *département* of Haute-Garonne, France, lies at the foot of the Pyrenees in the Aquitaine basin, a natural depression which runs from the Atlantic to the Mediterranean and is formed by the valleys of the Garonne and the Aude rivers. Toulouse is 443 mi. S.S.W. of Paris, 159 S.E. of Bordeaux, 264 W. of Marseilles and 227 N.N.W. of Barcelona by rail. The area of the city is over 45 sq.mi., of which approximately one-fourth is built up. Pop. (1954) 217,667.

The City.—Toulouse is built on both banks of the Garonne (there 650 ft. wide) where it changes its course from the Pyrenees to flow northwest to the Atlantic. Three-quarters of the town's buildings, all of which are of brick, are on the right bank; one-quarter is on the left, which is 40 ft. lower and exposed to floods. The old city, on the right bank, was built entirely during the middle ages and forms the heart of the modern town. It is bounded by the Garonne and by the site of former ramparts, now the boulevards Duportal, Lascrosses, d'Arcole, de Strasbourg and Carnot, and *allées* (flower- and tree-lined avenues) François Verdier and St. Michel

Almost one-fifth of the inhabitants live on the 375 ac. of the old city, which also houses many businesses and offices. Two large streets, opened at the end of the 19th century and lined with tall houses and large stores, cross the district: the Rue d'Alsace Lorraine, becoming the Rue de Languedoc, running north-south, and the Rue de Metz running east-west. The other byways, which are left from the middle ages. are generally narrow, but often picturesque and bordered by tall houses and shops. There are numerous monuments.

The Gothic cathedral of St Étienne dates from the beginning of the 13th century, its rectangular bell tower being of the 16th century. The basilica of St. Sernin, the largest extant Romanesque church, was built between the 11th and 13th centuries.

The present boys' school was formerly the Dominican monastery; the 13th- and 14th-century church is the ancient mother church of the Dominican order. Sacked during the Revolution, the monastery was being restored in the 1950s. The old Augustinian monastery. now occupied by the Museum of Fine Arts, was built during the 14th to 16th centuries. Its main contents are medieval sculptures from destroyed Toulousian monuments, and paintings of various periods. Other notable religious buildings are the churches of Notre-Dame du Taur (14th-century), Notre-Dame la Dalbade (16th-century), St. Pierre (17th- and 18th-centuries) and Notre Dame la Daurade (18th-century).



BY COURTESY OF THE FRENCH GOVERNMENT TOURIST OFFICE, LONDON; PHOTO BY YAN

ST. SERNIN BASILICA. TOULOUSE, THE LARGEST ROMANESQUE CHURCH EXTANT

Among the civil buildings is the Capitole, at one time the town hall and municipal theatre. It has a keep, a Renaissance courtyard and an 18th-century façade which overlooks a large square. The interior was decorated in the 20th century. The St. Raymond museum. a Renaissance building, contains antique sculpture. Approximately 100 private houses in Renaissance style, and many others dating from the 17th and 18th centuries, form one of the most complete groups of this kind in France. They are mainly in the Rues des Changes and St. Rome, de la Dalbade, Mage, Nazareth, Ninau and Ozenne. The most beautiful houses are de Bernuy. du Vieux Raisin. d'Espie, de Pierre and the Hôtel d'Assézat, finished in 1560, which now holds the Académie des Jeux Floraux. which has! since its foundation in 1323, yearly presented to poets flowers of wrought metal.

Most of the theatres and cafés are around the oval Place Wilson, built in the 19th century. The municipal library (1935) and the university library are near St. Sernin, as are also the faculties of law and letters and the three *lycées*. The school of fine arts is on the 18th-century brick embankments of the Garonne. Not far from the river is a 16th-century convent occupied by the Catholic institute.

Toulouse is an intellectual and administrative centre. The public offices of the *département* are located there, including those of the chief officer of the military region and the court of appeal. It is an archbishopric with about 40 religious houses.

The ancient *faubourgs* (suburbs incorporated into a city as it grows beyond its walls) of the right bank surround the old city between the boulevards and the Canal du Midi on the north and east to the Garonne on the south. In the southern part of this area. just beyond the walls, are the principal promenades. the *allées* François Verdier. Frédéric Mistral and St. Michel and the three gardens, Grand Rond, Jardin Royal and Jardin des Plantes, as well as the faculties of medicine and science. two university schools of engineering and the veterinary school. The houses are generally low, but! since 1950, higher ones of ten stories and more have been built. These quarters, largely residential, are interspersed with industrial areas, chiefly in the north and south. On an island on the Garonne an amusement park and municipal pool (1933–48), an exhibition hall (1948) and the residences for university students (1953) have been built.

On the left bank. the faubourg St. Cyprien, which houses one-fifth of the population of the city, is joined to the right bank by four bridges: the 17th-century Pont Neuf (New bridge) and three others built or rebuilt in the 20th century, St. Michel, St. Pierre and des Catalans. The centre of the *faubourg* contains the 17th-century Hôtel-Dieu and an 18th-century hospital, both on the edge of the river, and the 15th-century church of St. Nicolas. Farther out among the new developments, are several large factories and apartment buildings, as well as the Purpan hospital (1908–47). The city is surrounded by agricultural land where violets in particular are cultivated.

Communications and Industry.— Toulouse has land, water and air transport services. Six railways connect the town directly with Paris. Bordeaux, Pau and the Spanish frontier at Irun; Foix and the Spanish frontier at Puigcerda; Marseilles; Milan and Rome: Lyons and Geneva. The Canal du Midi and the canal to the Garonne transport nothing but hydrocarbons; the two ports are l'Embouchure and St. Sauveur. The airport is situated $5\frac{1}{2}$ mi. from Toulouse at Blagnac; it is connected by regular flights with Paris. Bordeaux, Nantes, Algeria, and Morocco.

Toulouse has become, since 1915, a large industrial city. Its principal factories produce nitrogenous fertilizer, airplanes, and cartridges and powder for the army. The minor products are confectionery, knitted goods. shoes. milled flour, paper and tobacco. It is also a centre of trade. chiefly in agricultural products. eggs and poultry, milk, grains. farinas and leather, and it is also a centre for the internal redistribution of cloth from abroad. The city has a chamber of commerce. banks and a stock exchange.

History.— The town came into being between the 4th and 3rd centuries B.C. as a stopping place on the shores of the Garonne. It became a real town after the Roman conquest and developed considerably in the 4th century A.D., the period in which it was fortified. In the 5th century it was the capital of the Visigoths, masters of southern Gaul and Spain. It was taken in 508 by Clovis, who reunited it with the French realm. In 721 the Saracens besieged the town without success.

About 850 the countship of Toulouse was secured by a family that was to rule it until the 13th century. Among these counts, Raymond IV commanded the Provençal contingent of the first crusade. It was his son, Alphonse, who gave Toulouse its communal freedom (1141). Raymond VI was a patron of the troubadours and also a protector of the Catharist heretics, and it was principally against him that Pope Innocent III declared the Albigensian crusade (*see* CATHARI), in the course of which Languedoc was devastated. Toulouse was captured by the crusaders in 1215. The countship was reunited with the crown of France in 1271.

After the crusade, numerous religious houses and the university (1229) were founded. A parliament was first opened in 1444. After the Hundred Years' War, which relatively spared the city, the Renaissance was marked by intense commercial activity based on the production of a dye (pastel) made from woad (*Isatis tinctoria*) grown locally. During the Wars of Religion, Toulouse evicted the Protestants (1562) and took the side of the Catholic league. It was ravaged by epidemics during the entire 17th century. In the 17th century the building of the Canal du Midi brought increased trade to the town. After the revolution, which took away from Toulouse its prerogatives as capital of Languedoc, Marshal Soult and the duke of Wellington fought, beneath the city walls, the last battle of the Peninsular War, April 10, 1814. The

19th and 20th centuries were, above all, characterized by industrial expansion, the increase of the population (from 50,000 in 1801 to 217.664 in 1954) and the considerable and disorderly growth of buildings. The area covered by the town increased tenfold between 1801 and 1954.

Occupied by the Germans in Nov. 1942 and liberated on Aug. 19, 1944, Toulouse came out of World War II with its population increased by 50,000 people.

See H. Ramet, *Histoire* de Toulouse (Toulouse, 1935); J. Coppolani, Toulouse, *étude* de *géographie* urbaine (Toulouse, 1954). (J. Ci.)

TOULOUSE-LAUTREC, HENRI DE (HENRI MARIE RAYMOND DE TOULOUSE-LAUTREC MONFA) (1864–1901), French painter. who vividly portrayed the character of Parisian entertainment and night life at the close of the 19th century. was born on Nov. 24, 1864. at Albi. At an early age he started to draw. When he was 15, as a result of two falls, he was left permanently crippled and deformed, and this physical disability was to influence his life, his character and his art. He worked first with René Princeteau. a painter of sporting pictures. and then studied under Fernand Cormon in Paris, where he associated with Vincent van Gogh. An eclectic, he admired Japanese drawings. Degas and El Greco. In 1886 he settled in Montmartre, whose characters and night life he painted. In large rhythmical compositions he presented a comprehensive picture.of an environment—at the dance halls of the Moulin de la Galette or of the Moulin Rouge. at bars and at the circus. In precise scenes are depicted the features and personalities of friends or star artistes: his cousin Tapié de Céleyran, the singer and song writer Aristide Bruant. the dancers La Goulue and Jane Avril, the singers Yvette Guilbert, May Belfort and May Milton and the clonn Chocolat.

BY COURTESY OF THE ART INSTITUTE OF CHICAGO

LITHOGRAPH OF ARISTIDE BRUANT BY TOULOUSE-LAUTREC, 1893

His untiring curiosity led him to frequent big trials. hospitals, racecourses and sporting events where in numerous sketches he captured the gestures and attitudes of people. His very assured technique went hand in hand uith the sharpness of his vision. From his accumulated notes he extracted a linear design so expressive that often it required only a coloured drawing in which use was made of gray cardboard or of thin oil colours so placed as to avoid opposing values. In his last works he painted with a thicker palette, building up large contrasting surfaces. The influence of the theatre is evident in his canvases where faces are brought into relief under the glare of the footlights. Characteristic in his composition was an original sense of placing the central figure in the picture. His many works include essentially paintings which reveal a free-flowing line; lithographs where the stylization becomes pure arabesque; posters made powerful bv the extreme simplification in outline and movement and by the use of large areas of simple colours. Inspired by all sorts of milieus. his interest was above all in the human face. His pitiless draftsmanship produced portraits sometimes of a cruel truthfulness. their psychology being illuminated by the background.

In 1898 Toulouse-Lautrec's health started to deteriorate. He was taken to undergo a cure for alcoholism at a sanatorium. where he executed from memory a series of pastel drawings of circus subjects. He died at Malromé, Gironde, on Sept. 9. 1901. He influenced the painters of the Revue Blanche and the circle of artists of the "modern style" at Barcelona. where Picasso was beginning to paint. The Bibliothèque Nationale in Paris has a fine collection of his lithographs. The most important collection of his paintings is at the museum at Albi to which the painter's family bequeathed the works remaining in his studio. See also PAINTING: Postimpressionism.

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TOUNGOO or TAUNG-NGU, a town and district of Burma, until World War II in the Tenasserim division and thereafter in the Pegu division. The town is on the right bank of the Sittang river: 166 mi. N. of Rangoon by rail. Pop. (1953) 31,589. From the 14th to the 16th centuries Toungoo was the capital of an independent kingdom.

The district of Toungoo has an area of 6,456 sq.mi.; pop. (1941) 474,858. The main Rangoon-Mandalay railway is the chief means of communication. The rainfall is between 60 and 90 in. Rice is the staple crop; there are some plantations of rubber. Large areas of forest were reserved.

TOURACO, a vernacular name applied to the birds of the family Musophagidae, also known as plantain eaters, which is the meaning of *Musophaga*, the typical genus. The most widespread genus is Tauraco. The family. with 6 genera and about 20 species, is confined to Africa south of the Sahara. Its relations are with the cuckoos.

Touracos are mainly fruit eaters but vary their diet with insects and other animal matter.

The various touracos are usually bright coloured. with short wings and a long neck. and with a striking crest (absent in one species). The red wing feathers have a peculiar pigment. containing copper, known as turacin. (K. P. S.)

TOURAINE, a French province, bounded on the north by Orléanais. west by Anjou and Maine, south by Poitou and east by Berry. and corresponding approximately to the modern *département* of Indre-et-Loire.

Touraine took its name from the Turones, the tribe by which it was inhabited at the time of Caesar's conquest of Gaul. The capital city. Caesarodunum. was made by Yalentinian the metropolis of Lugdunensis. which included roughly the later provinces of Touraine, Brittany, Maine and Anjou.

The ecclesiastical province of Tours was apparently created during the episcopate of St. Martin (fl. 375–400), who founded the abbey of bfarmoutier. near Tours, and whose tomb in the city became a celebrated shrine. Tours was included in the territory of the Visigoths. but the Tourangeaux refused to adopt the Arian heresy of their conquerors and easily accepted the conquest of the province by Clovis (*c.* 507).

The possession of Touraine was constantly in dispute between different Merovingian princes. and the province enjoyed no settled peace until the reign of Charlemagne. Charlemagne established Alcuin as abbot of St. Martin of Tours. under whom the school of Tours became one of the chief seats of learning in Caul. During the 10th century and the earlier half of the 11th, Touraine was entrusted to counts, at first appointed by the crown but later (from 940 or 941 onward) hereditary, paying homage to the kings of France only. The countship then became the object of fierce competition between the houses of Xnjou and of Blois, till in 1044 Geoffrey Martel of Anjou took hold of the region, which remained in his family till 1204. After the accession of the Angevins to the English throne. Touraine became a battieground for John Lackland and Philip Augustus; and the latter conquered it in 1204 and had it formally ceded by John in 1206. Philip had appointed William des Roches hereditary seneschal in 1204, but the dignity was ceded to the crown in 1312. Touraine was granted from time to time to princes of the blood as an appanage of the crown of France. It was held by Joan of Burgundy, queen of France, in 1328; by Philip. duke of Orléans. in 1344; and in 1360 it was made a peerage duchy on behalf of Philip the Bold. afterward duke of Burgundy. Charles YII bestowed the duchy successively on his wife Mary of Anjou. on Archibald Douglas and on Louis III of Xnjou. It was the dower of Mary Stuart as the widow of Francis II. The last duke of Touraine was Francis, duke of Alençon (d. 1584). Plessis-les-Tours had been the favourite residence of Louis XI, who granted many privileges to the town of Tours and increased its prosperity by the establishment of the silk-weaving industry.

The Reformed religion numbered many adherents in Touraine, who suffered in the massacres following on the conspiracy of Amboise. Many Huguenots emigrated after the massacre of St. Bartholomew, and after the revocation of the Edict of Nantes the silk industry, which had been mainly in the hands of the Huguenots, was almost destroyed. This migration was one of the causes of the extreme poverty of the province in the 18th century.

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TOURCOING, a town of northern France in the *département* of Nord, less than a mile from the Belgian frontier, and 8 mi. N.N.E. of Lille on the railway to Ghent. Pop. (1954) 82,753. Famed since the 12th century for its woolen manufactures, Tourcoing was fortified by the Flemings in 1477, when Louis XI of France disputed the inheritance of Charles the Bold with Mary of Burgundy, but in the same year was taken and pillaged by the French.

In 1794 the Republican army, under Moreau and Souham, gained a decisive victory at Tourcoing over the Austrians. Tourcoing is practically one with Roubaix to the south, being united thereto by a tramway and a branch of the Canal de Roubaix. Public institutions established there include a tribunal of commerce, a board of trade arbitrators, a chamber of commerce, an exchange and a conditioning house for textiles. Together with Roubaix, Tourcoing ranks as one of the chief textile centres of France. Its chief industry is the combing, spinning and twisting of wool, spinning of cotton and the manufacture of all kinds of woolen, cotton and silk goods, notably carpets. To these industries must be added those of dyeing and the manufacture of hosiery, textile machinery and soap.

TOURGÉE, ALBION WINEGAR (1838–1905), U.S. judge and author, who wrote novels on the problems of the south during the reconstruction, was born in Williamsfield, O., on May 2, 1838. He attended the University of Rochester, N.Y., and during the American Civil War served as an officer in the Union army.

He was admitted to the Ohio bar in 1864 and after the war lived in Greensboro, N.C., where he practised law. Elected judge of the North Carolina superior court in 1868, Tourgée, who was an advocate of Radical reconstruction policies, was widely criticized in the south for using his post for political advantages and styled a carpetbagger. He later moved to New York and in 1881 settled in Mayville. U.S. consul at Bordeaux, France, from 1897 to 1903, he died there on May 21, 1905.

Tourgée contributed articles to various publications, edited a weekly literary magazine, lectured frequently and wrote several didactic novels. His books were romantic and sensational in plot but often accurately depicted the contemporary south in the backgrounds.

His most popular novel was *A Fool's Errand* (1879), a semi-autobiographical account of the experiences of a former Union officer in the south. *Bricks Without Straw* (1880) concerned the problems of Negro emancipation.

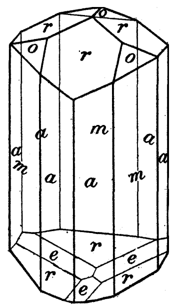
TOURJÉE, EBEN (1834–1891), U.S. musician and educator, born at Warwick, R.I., on June 1, 1834, founded with Robert Goldbeck the New England Conservatory of Music in Boston, Mass., in 1867. He introduced the class system of instruction in music and was the first dean of the College of Music of Boston university. Tourjée died in Boston on April 12, 1891.

TOURMALINE, a borosilicate mineral of complex and variable composition. The name is from the Singhalese *toramalli*, applied to brown gem stones found in Ceylon early in the 18th century.

Although sometimes occurring in granular masses, tourmaline is usually in crystals, which may be slender needles or rods, sometimes in bundles or radiating groups, but more commonly in well-formed crystals. Iron tourmalines are jet black in colour and are known as schorl. The coloured varieties when transparent and free from flaws are cut as gem stones. Tourmaline may be colourless and water clear. A pink variety is known as rubellite, a green variety as Brazilian emerald, a blue as indicolite, etc. Bicolour crystals are found, pink at one end and green at the other. Concentric colour zoning may also be found.

Composition and Crystal Forms. — X-ray studies showed that tourmaline has a structure based on a six-sided silicate ring (Si_6O_{18}) and BO_3 groups, and a basic formula may be written as $NaMg_3Al_6(OH)_4(BO_3)_3Si_6O_{18}$. Extensive replacements occur. Calcium (Ca) commonly replaces part of the sodium (Na), lithium and aluminum (Li,Al) or ferrous iron (Fe) may partially replace magnesium (Mg), and ferric iron (Fe) the aluminum (Al), and fluorine (F) the hydroxyl group (OH). Potassium, chromium and manganese may also be present. Thus rather than a single mineral species, it is actually an isomorphous series. It is common practice to recognize three types according to the predominance of certain elements: iron tourmaline, black in colour; magnesium tourmaline, brown; and alkali tourmaline, pink, green and colourless.

In spite of the wide range in composition, the crystal forms and angles are remarkably constant. The crystals belong to the ditrigonal pyramidal class of the hexagonal system. The vertical trigonal axis is polar, with different faces developed at opposite ends, and tourmaline is thus said to be hemimorphic. The illustration shows a common type, with two trigonal pyramids r and o at the upper end, and at the lower the trigonal pyramids *r* and *e*. The crystals are usually prismatic, with a hexagonal prism a and a prominent trigonal prism m, which gives a triangular aspect to the cross section. Additional narrow prism faces and conspicuous vertical striations give curving convex sides, resulting in a spherical-triangular cross section which is characteristic.



CRYSTAL OF TOURMALINE SHOWING HEMIMORPHIC DEVELOPMENT

Electrical Properties. — An interesting feature of tourmaline is the pyroelectric property, which is intimately related to the hemimorphic or polar development of the crystals mentioned above. When a crystal is heated, one end acquires a positive electrical charge and the other end a negative charge. On cooling these charges are reversed. This can be easily demonstrated by a method devised by August A. Kundt. A mixture of finely powdered red lead and sulfur is blown through a cloth screen. By friction. the sulfur particles acquire a negative charge and are attracted to the positive end of the crystal, and positively charged red lead goes to the negative end. Tourmaline also shows the related phenomenon of piezoelectricity. When a plate cut perpendicular to the vertical axis is subjected to change in pressure, it develops positive and negative charges on the opposite surfaces. This property can be used for detecting variations in pressure, as in depth-sounding apparatus. Such plates have been used to measure blast pressures, both in air and under water. For these purposes it does not need to be as free from flaws as crystals used for radio frequency control, for which purpose quartz (*q.v.*) is better suited.

Optical Properties. — The optical properties of tourmaline are of great interest. Coloured crystals are very strongly dichroic, that is, light is absorbed much more in some directions than in others. Since tourmaline is hexagonal, and therefore doubly refracting, a ray of light entering the crystals is separated into plane polarized rays, one, the ordinary ray, vibrating perpendicular to the vertical axis, and the other. the extraordinary ray, vibrating parallel to this axis. In coloured tourmaline the ordinary ray is almost completely absorbed. Plates cut parallel to the vertical axis of the crystal allow only the extraordinary ray to pass through, and if two such plates are placed in crossed position, the light is entirely cut out. A pair of such plates form a very simple polarizing apparatus known as tourmaline tongs Since the effect is limited to deeply coloured crystals, not much light is transmitted, even in the favourable direction. Thus this device is far inferior to other polarizing instruments, such as the Nicol and Ahrens prisms (see CALCITE) or polaroid.

Tourmaline is optically uniaxial and negative, and the refractive indexes vary with the chemical composition. for the ordinary ray 1.6315–1.6854, and for the extraordinary ray 1.6123–1.6515 for sodium light. The specific gravity shows a corresponding range from 3.0 to 3.2. The hardness is 7 to 7.5.

Occurrence. — Tourmaline is most abundant and has the best developed crystals in pegmatites and in metamorphosed limestones in contact with granite magmas. It appears to have originated in most cases by the interaction of boron emanations from the granite magma on the surrounding rocks. Since it is resistant to weathering processes the mineral accumulates in detrital deposits. Gem tourmaline comes from the gem gravels of Ceylon and is obtained from pegmatites in the Urals, southern California, Maine and Madagascar. See also GEM. (L. S. RL.)

TOURNAI (Flemish DOORNIK), city, province of Hainaut, Belgium, on the Scheldt. Pop. (1955 est.) 33,117. The cathedral of Notre-Dame dates from 1030, the nave is Romanesque of the middle of the 12th century, with much pointed work. The transept was added in the 13th century. The first choir was burned down in 1213, but was rebuilt in 1242 at the same time as the transept, and is a superb specimen of pointed Gothic. There are five towers with spires. There are several old pictures of merit, and the shrine of St. Eleuthère, the first bishop of Tournai in the 6th century, is a remarkable product of the silversmith's art. The belfry on the Grand Place, the oldest in Belgium, was built in 1187, partly reconstructed in 1391 and finally restored and endowed with a steeple in 1852. The church of St. Quentin in the same square as the belfry is almost as ancient as Xotre-Dame. In the church of St. Brice is the tomb of Childeric discovered in 1653. Among the relics mere 300 small golden models of bees. These were moved to Paris, and when Napoleon was crowned emperor a century and a half later he chose Childeric's bees for the decoration of his coronation mantle. In this manner the bee became associated with the Napoleonic legend just as the lilies were with the Bourbons. The Pont des Trous over the Scheldt, with towers at each end, was built in 1290, and some old houses still in occupation date back to the 13th century. On the Grand Place is the fine statue of Christine de Lalaing, princess d'Epinoy, uho defended Tournai against Parma in 1581.

The actual site was occupied under Julius Caesar and called Nerviorum or Turnacum. In the reign of Augustus, Agrippa fixed the newly mixed colony of Suevi and Menapii at Tournai. In the 5th century the Franks seized Tournai, and Merovaeus made it the capital of his dynasty. This it remained until the subdivision of the Frank monarchy among the sons of Clovis. When feudal possessions, instead of being purely personal, were vested in the families of the holder after the death of Charlemagne, Tournai was specially assigned to Baldwin of the iron Arm by Charles the Bald, whose daughter Judith he had abducted, on receiving the hereditary title of count of Flanders. During the Burgundian period it was the residence of Margaret of York, widow of Charles the Bold; and the pretender Perkin Warbeck, whom she championed, if not born there, was the reputed son of a Jew of Tournai. In the early 16th century Tournai was an English possession for a fea years and Henry VIII sold it to Francis I. It did not long remain French, for in 1521 the count of Nassau, Charles V's general, took it for Spain. Part of Tournai was destroyed in May 1940 during the German invasion. Industries include hosiery mills, weaving, tanning and cement works.

TOURNAMENT or TOURNEY. Of medieval, French origin, the term tournament described the military exercises in which knights engaged one another in order to display their skill and courage in combat. The tournament in this sense had practically died out by the end of the 16th century, by which time it had largely ceased to be a trial of arms and had become a pageant. The term is still in use somewhat in the latter sense, for instance, in the Royal Tournament, an annual naval and military display held in London, and in the Pasadena (Calif.) New Year's day Tournament of Roses.

In the early years of the 20th century the word tournament came to be applied to certain methods of conducting competition in sports events. In the most common modern tournament the contestants are matched in pairs with the losers in each test being eliminated and the winners paired anew until one remains as the champion of the tournament. In some tournaments the contestant is not eliminated until defeated a second time. These are called double-elimination tournaments. A third form of the modern tournament is called a round robbin. Each contestant opposes every other contestant and the one with the best percentage of victories (usually referred to as the best won-and-lost record) is declared the champion.

The tournament in its earliest form apparently originated in France about the middle of the 11th century. Several chroniclers credit a French baron, Geoffroi de Preulli, with having "invented tournaments " Subsequently the tournament, according to Roger of Hoveden (Charles Du Cange's *Glossarium, s.v.* "Tourneamentum"), became "military exercises carried out, not in the spirit of hostility (nullo interveniente odio), but for practice and display of prowess (pro solo exercitio, atque ostentatione *virium*)."

By the 12th century the tournament notwithstanding the condemnation of the ecclesiastical councils of Lateran in Rome had spread to England and grown so popular that Henry II found it necessary to forbid the sport which gathered in one place so many barons and knights in arms. From that age comes the famous description by William Fitz-Stephen of the martial games of the Londoners in Smithfield. He tells how on Sundays in Lent a noble train of young men would take the field well mounted, rushing out of the city with spear and shield to ape the feats of war. Divided into parties, one body would retreat, while another pursued striving to unhorse them. The younger lads, he says, bore javelins disarmed of their steel, by which it is inferred that the weapon of the elders was the headed lance. William of Newbury tells how the young knights. balked of their favourite sport by royal mandate, would pass over sea to win glory in foreign lists. Richard I relaxed his father's order, granting licences for tournaments, and Jocelin of Brakelond wrote about the great company of cavaliers who held a tournament between Thetford and Bury St. Edmund's in defiance of the abbot. From that time onward unlicensed tourneying was treated as an offense against the crown, which exacted heavy fees from all taking part in them even when a licence had been obtained.

In 1299 life and limb were declared to be forfeit in the case of those who should arrange a tourney without royal licence, and offenders were to be seized with horse and harness. As the tournament became an occasion for pageantry and feasting, new reason was given for restraint: a simple knight might beggar himself over a sport which risked costly horses and carried him far afield. Jousters traveled from land to land, offering and accepting challenges. Thus Edward I, before coming to the throne, led 80 knights to a tournament in Europe. Before the jousts at Windsor on St. George's day in 1344 heralds published in France, Scotland, Burgundy, Flanders, Hainault and Brabant (Belg.) and the domains of the emperor the king's offer of safe-conduct for competitors. At the weddings of princes and magnates and at the crowning of kings the knights gathered to the joustings — as much a part of such high ceremonies as the banquet and the minstrelsy.

Regulations. — About 1292 a "Statute of Arms for Tournaments" enacted new laws. Swords with points were not to be used. nor pointed daggers. nor club nor mace. None was to raise up a fallen knight but his own appointed squires, clad in his device. The squire who offended was to lose horse and arms and lie three years in jail. Disputes were to be settled by a court of honour of princes and earls. That such rules were needful had been shown at Rochester in 1251, when foreign knights were beaten by the English and so ill-treated that they fled to the city for refuge. On their way the strangers were faced by another company or knights who thrashed them with staves in revenge for the doings at a Brackley tournament. Even as early as the 13th century some of these tournaments were mere pageants of horsemen. For the Jousts of Peace held at Windsor park in 1278 the sword blades were of whalebone and parchment, silvered; the helms were of boiled leather and the shields of light timber. But the game could make rough sport. Many a tournament had its tale of killed and wounded in the chronicle books: how Roger of Lemburn struck Arnold de Montigny dead with a lance thrust under the helm; the first of the Montagu earls of Salisbury died of hurts taken at a Windsor jousting, and in those same lists at Windsor the earl's grandson Sir William Montagu was killed by his own father; William Longéspee in 1256 was so bruised that he never recovered his strength, and he is among many of whom the like was written. Injuries were often caused when dismounted adversaries continued the combat on foot. Blunted lance points came early into use, and by the 14th century the coronall or cronell head (crown shaped and intended to unhorse but not to wound) was often fitted in place of the point. Alter 1400 the armourers began to devise harness with defenses specially wrought for service in the lists. But the joust lost its chief perils with the invention of the tilt, which was at first a cloth stretched along the length of the lists. The cloth became a stout barrier of timber, and in the early 16th century the knight ran his course at little risk. Locked up in steel harness, he charged along one side of this barrier, seeing little more through the pierced sightholes of the helm than the head and shoulders of his adversary on the other side of the barrier. His bridle arm was on the tilt side, and thus the blunted lance struck at an angle upon the polished plates. Still mishaps might befall. At the close of the tournament which formed part of the rejoicings for the peace of Cateau-Cambrésis in 1559 Henry II of France died from the stroke of Gabriel de Montgomeri, who failed to cast up in time the truncheon of his splintered lance. The result of this tragedy was a considerable diminution in the popularity of the tournament. But the 16th-century tournament was, in the main, a bloodless meeting, as befitted a spectacle arranged as much for the delectation of women as of men. Prizes, consisting of arms and armour, rich robes and great silver vessels were presented to the victors by the Lady of the Tournament.

Pageantry. — In the 15th century the tournament had the aspect of a pageant. The great meeting at Bruges, when the jousting of the Knights of the Fleece was part of the pageant of the Golden Tree, the Giant and the Dwarf, may stand as a magnificent example of many such gay gatherings. When Henry VIII was scattering his father's treasure the pageant had become an elaborate masque. For two days after the crowning of the king at Westminster, Henry and his queen viewed from the galleries of a fantastic palace set up beside the tiltyard a play in which deer were pulled down by greyhounds in a paled park, in which the Lady Diana and the Lady Pallas came forward, embowered in moving castles, to present the champions. Such costly shows fell out of fashion after the death of Henry VIII; and in England the tournament remained, until the end, a martial sport. In France it degenerated to the carrousel, which became an unmartial display.

The tournament was, from the first, held to be a sport for men of noble birth, and in Europe, where nobility was more exactly defined than in England, the lists were jealously closed to all combatants but those of the privileged class. In the German lands, questions as to the purity of the strain of a candidate for admission to a noble chapter were often settled by appeal to the fact that this or that ancestor had taken part in a tournament. The heraldic manuscript of Konrad Griinenberg shows the *Helmschau* that came before the German tournament of the 15th century— the squires carrying each his master's crested helm, and a little scutcheon of arms hanging from it, to the hall where the king of arms stands among the ladies and judges each blazon.

Revivals. — An attempt to revive the tourney was made at Eglinton castle, Ayrshire, in 1839. Archibald, 13th earl of Eglinton, found an ideal setting for his tournament in the grounds of Eglinton castle. On Aug. 28, 1839, the lists were dressed in the park. Each knight, with his esquires and attendants, had a separate pavilion. The lists were splendidly decorated and richly hung, and temporary adornments of Westminster abbey at the then recent coronation were again used. At Lord Eglinton's request many of the ladies wore the costume of the 14th and 15th centuries. The marquess of Londonderry was King of the Tournament and Lady Seymour, afterward duchess of Somerset, was Queen of Love and Beauty. The official list contained the names of 15 knights. . The crown of victory was bestowed upon Lord Eglinton. The second day there was a series of mimic tilts between Prince Louis Napoleon, afterward Napoleon III, and Charles Lamb, both of whom were in armour. On the third day there was a series of tourneys in which eight knights, armed with swords, were engaged. A good description of the Eglinton tournament will be found in chapters 59 and 60 of Disraeli's novel *Endymion*.

When Prince Humbert, afterward Humbert I, king of Italy, was married at Turin in 1868 to Princess Margherita of Savoy, the festivities included a tournament.

See also ARMS *AND* ARMOUR. (O. B.; WM. J. F.)

TOURNEUR, CYRIL *(c.* 1575–1626), English dramatist whose reputation rests upon two plays, *The Atheist's Tragedie* and *The Revengers Tragedie,* was perhaps the son of Capt. Richard Turnor, water bailiff and subsequently lieutenant governor of Brill in the Netherlands. Cyril Tourneur also served in the Low Countries, for in 1613 there is a record made of payment to him for carrying letters to Brussels. He enjoyed a pension from the government of the United Provinces, possibly by way of compensation for a post held before Brill was handed over to the Dutch in 1616. In 1625 he was appointed by Sir Edward Cecil, whose father had been a former governor of Brill, to be secretary to the council of war. This appointment was canceled by the duke of Buckingham, but Tourneur sailed in Cecil's company to Cádiz, Spain. On the return voyage he was put ashore at Kinsale with other sick men, and died in Ireland on Feb. 28, 1626.

The first fixed date concerning Tourneur is the publication in 1600 of his poetical satire, *The Transformed Metamorphosis.* In 1609 he wrote *A Funerall Poeme on the Death of Sir Francis Vere, Knight,* who had been governor of Brill. In 1612 he joined with John Webster and Thomas Heywood in *Three Elegies on the Most Lamented Death of Prznce Henrie;* in the same year he wrote a prose *Character* of Robert Cecil, the first Lord Salisbury, which remained in manuscript until 1930.

It is however as a dramatist that he is chiefly remembered. An early play, *The Nobleman,* entered to him in the Stationer's register, Feb. 15, 1612, has disappeared. In 1611 was published *"The Atheist's Tragedie: or The Honest Man's Revenge.* As in divers places it hath often beene Acted. Written by Cyril Tourneur." Four years before, in 1607, there had appeared *"The Revengers Tragedie.* As it hath beene sundry times Acted by the Kings Majesties Servants." This play is anonymous and it was not until 1656 that the bookseller Edward Archer entered it to Tourneur on his list and was followed by Thomas Kirkman in 1661 and 1671. This later attribution is not decisive, and the internal evidence of authorship is conflicting.

In *The Atheist's Tragedie,* D'Amville, the atheist (in the Elizabethan sense of rejecting all morality), acknowledges obedience only to nature. To enrich his heirs, he stops short of no crime until he accidentally kills himself and confesses, "Nature is a fool. There is a power above her." In the other play, Vindice, the revenger, takes vengeance on the duke who had seduced his beloved, and on the members of the duke's family, until he is himself ordered to execution to which he goes boasting, "Is there one enemy left alive?" Thus the two plays differ in their attitude to private revenge and *The Revengers Tragedie,* although earlier, is more mature in its mechanical mastery and its sombre brilliance. Its authorship remains doubtful.

The *Complete Works of Cyril Tourneur* were edited by Allardyce Nicoll (1930) and *Plays and Poems of Cyril Tourneur* by J. Churton Collins, 2 vol. (1878).

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TOURNON, a town of southeastern France, capital of an *arrondissement* in the *dkpartement* of Ardèche, on the right bank of the Rhône, 58 mi. S. of Lyons by rail. Pop. (1954) 5,215. Tournon preserves a gateway of the 15th century, a Renaissance college founded in 1536 by François Cardinal de Tournon and an old castle containing a Gothic chapel and museum. The church of St. Julian dates chiefly from the 14th century and contains Gothic frescoes.

Tournon had its own counts as early as the reign of Louis I.

It is the centre of a wine and fruit district.

TOURS, a town of France, capital of the dkpartement of Indre-et-Loire, 145 mi. S.W. of Paris by rail. Pop. (1954) 80,261.

Tours (see TOURAINE), under the Gauls the capital of the Turones or Turons, originally stood on the right bank of the Loire, a little above the village of St. Symphorien. At first called Altionos, the town was afterward known as Caesarodunum., The Romans moved the town from the hill to the left bank of the river.

Tours became Christian about 250 through the preaching of Gatien, who founded the bishopric. The first cathedral was built 100 years later by St. Litorius. The bishopric became an archbishopric when Valentinian I made Tours the capital of Lugdunensis Tertia, though the bishops did not adopt the title of archbishop until the 9th century. In the 5th century the official name of Caesarodunum was changed to Civitas Turonum. St. Martin, the apostle of the Gauls, was bishop of Tours in the 4th century.

Affiliated to the Armorican confederation in 435, the town fell to the Visigoths in 473. It became part of the Frankish dominions under Clovis. At the end of the 6th century the bishopric was held by St. Gregory of Tours. Tours grew rapidly in prosperity under the Merovingians, but abuse of the right of sanctuary led to great disorder. Charlemagne re-established discipline in the disorganized monastery and set over it Alcuin, who established one of the oldest public schools of philosophy and theology. The arts flourished at Tours in the middle ages and the town was the centre of the Poitevin Romanesque school of architecture. The abbey was made into a collegiate church in the 11th century and was for a time affiliated to Cluny but soon came under the direct rule of Rome. The suburb in which the monastery was situated became important under the name of Martinopolis. The Normans pillaged it in 8j3 and 903. Walls were erected from yo6 to 910, and the name was changed to that of Chbteauneuf. In the 14th century Tours was united to Chbteauneuf within a common wall, of which the Tour de Guise remains, and both towns were put under the same administration. The numerous and long-continued visits of Charles VII, Louis XI, who established the silk industry, and Charles VIII during the 15th century favoured commerce and industry. In 1562 Tours suffered from the violence of both Protestants and Catholics. In the 17th and 18th centuries it was the capital of the government of Touraine. Its manufactures, of which silk weaving was the chief, suffered from the revocation of the Edict of Kantes (1685). In 1772 its mint, whence were issued the "livres" of Tours, was suppressed. During the Revolution the town formed a base of operations of the Republicans against the Vendéans. During World War II, it was at Tours that Winston Churchill met Paul Reynaud cn June 13, 1940, and decided that Great Britain would continue the war against Germany. Tours was partly destroyed; in the postwar reconstruction an attempt was made to preserve its architectural type.

Tours lies on a flat tongue of land between the Loire and Cher just above their junction. The right bank of the Loire is bordered by hills at the foot of which lie St. Cyr and St. Symphorien. The river is crossed by one bridge and one suspension footbridge.

The cathedral of Tours is dedicated to St. Gatien. The lower portions of the west towers belong to the 12th century; the choir to the 13th; the transept and east bays of the nave to the 14th; the remaining bays. a cloister on the north and the façade, decorated in the Flamboyant style, to the 15th and 16th; the upper part of the towers to the 16th. In the choir there is fine 13th-century stained glass. The 16th-century tomb of the children of Charles VIII is attributed to the brothers Juste. The square tower of the church of St. Julien is Romanesque, the rest being in the early Gothic style of the 13th century. with the exception of two apses added in the 16th. Two towers and a Renaissance cloister are the chief remains of the celebrated basilica of St. Martin. Two other churches are Notre-Dame-la-Riche, originally built in the 13th century, rebuilt in the 16th and magnificently restored in the 19th; and St. Saturnin, of the 1jth. Of the old houses of Tours the Hôtel Gouin and that wrongly known as the house of Tristan l'Hermite (both of the 15th century) are the best known. Tours has a valuable library, including among its manuscripts a gospel of the 8th century on which the kings of France took oath as honorary canons of the church of St. Martin. Honor6 de Balzac was a native of Tours. Tours is the seat of an archbishop, of a prefect, and of a court of assizes and has tribunals of first instance and of commerce, a board of trade-arbitrators and a chamber of commerce. As a cultural centre, Tours has a faculty of medicine; schools of law and of the fine arts; an institute where foreigners can study the French language; and a musical academy. Printing and silk manufacture are important industries. The town also has steelworks and iron and tin foundries. Other products include machinery, oil, cement, stained glass, boots and shoes and porcelain. A considerable trade is carried on in the wine of the district and in brandy, dried fruits and confectionery. **(X.)**

BATTLE OF TOURS

The battle of Tours (A.D. 732), sometimes called the battle of Poitiers, marks the turning point in the northern advance of the Moors; the victory of the Franks checked once and for all the expansion of Islam in western Europe. In 711 the Arabs had crossed the Straits of Gibraltar and attacked the weak Visigothic kingdom of Spain; within seven years they had overrun most of the peninsula and crossed the Pyrenees; and in 720 they captured Narbonne, which became the base for their further progress into Gaul. The plan of extending their power to the north was rendered more possible by the political rivalry which subsisted between the dukes of Aquitaine and the Merovingian mayors of the palace. However, in 720, Eudo, duke of Aquitaine, had made his peace with Charles Martel and was therefore free to deal with the impending danger. In 721 he relieved Toulouse, which was being besieged, and won a decisive victory over the Arabs. But after a short respite the attack was renewed in 725. A strong army crossed the eastern Pyrenees, captured Carcassonne and Nîmes and occupied the greater part of Septimania. In the same year the Arabs made a raid into Burgundy and destroyed Autun. Internal dissensions among the Arabs themselves, the hostility between the Ma'ddites and the Yemenites, prevented them, however: from following these successes up; and it was only after the appointment in 731 of the popular and energetic governor of the Yernenite party, Abd ar-Rahman, that the offensive was resumed. The situation in Gaul was favourable for the enterprise, for war had again broken out between Eudo and Charles. In 732, with a large army, Abd ar-Rahman crossed the Pyrenees and captured and burned Bordeaux. Eudo, who hastened to check him, was defeated, with the loss of most of his army, between the Garonne and the Dordogne. The Arabs pressed forward, plundering as they went, along the line of the Roman road which ran northward from Bordeaux through Poitiers to Orléans. At Poitiers they destroyed the basilica of St. Hilary; their next objective was Tours, whither they were attracted by the riches of the church of St. Martin. Before they reached it they were met by Charles, to whom Eudo, despite his previous hostility, had fled for assistance after his defeat.

Charles, at the head of a large army, engaged with the enemy south of Tours, perhaps at the little town of Cenon, near the junction of the Clain and the Vienne, and not far north of Old Poitiers. For seven days the two armies stood facing each other. Then on a Saturday in October serious fighting began. Charles had taken up a defensive position in close formation; and the light Arab cavalry broke before the "immovable wall" of Frankish soldiers who stood, we are told, firm "as a rock of ice" (Isidorus Pacensis). The Arabs were hurled back with heavy loss; Abd ar-Rahman himself was killed on the field. Fighting continued until nightfall; and when, on the next morning, the Franks prepared to resume the battle, they found the Arab tents deserted.

The battle of Tours is commonly regarded as one of the decisive battles of the world's history. In a sense this is true; it dealt a check to the advance of the Arabs into Gaul. Rut there were causes other than Charles' victory which in part account for the cessation of the Arab advance. The revolt of the Berbers in North Africa was as decisive a factor as the battle of Tours in putting an end to the advance of the Arabs into western Europe.

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TOURVILLE, ANNE-HILARION DE COTENTIN (or COSTANTIN), COMTE DE (1642–1701), French admiral and marshal of France, was the son of César de Cotentin, or Costantin, who held offices in the household of the king and of the prince of Condé. Destined by his family to enter the Order of Malta, he served for eleven years with the galleys of the Order against the Barbary pirates. In 1667 he was incorporated in the corps of officers of the French Royal navy and in 1689 he left the Order. In the French navy he served in the Mediterranean for some years. In 1670, Tourville commanded the "Page" (50), in the squadron of the comte d'Estrées (1624–1707) sent to co-operate with the duke of York against the Dutch. He was present at the battle of Solebay (June 7, 1672), and in the action on the coast of Holland in the following year, when Prince Rupert commanded the English fleet. When England withdrew from the alliance, the scene of the naval war was transferred to the Mediterranean, where Holland was co-operating with the Spaniards. Tourville served under Abraham Duquesne in his battles with De Ruyter. By this time he was known as one of the best officers in the service of King Louis XIV. By 1689 he had been promoted lieutenant-général des armées navales, and was named vice-admiral du Levant or of the East. In June of that year he became commander-in-chief of the French naval forces in the war against England and her continental allies.

From this time till the failure of his resources compelled King Louis XIV. to withdraw his fleets from the sea, Tourville continued to command the naval war in the Channel and the Atlantic. His conduct and example during this period were the source of the system of manoeuvring to gain an advantage by some method other than plain fighting. In 1690 he had an opportunity which might well have tempted the most cautious, and he missed it out of sheer care to keep his fleet safe against all conceivable chances, aided perhaps by a pedantic taste for formal, orderly movement. He was opposed in the channel by the allies, who had only fifty-six ships, while his own force was from seventy to eighty sail strong. He was feebly attacked by Admiral Arthur Herbert, earl of Torrington, off Beachy Head on July 10. The Dutch ships in the van were surrounded. The allies retreated in disorder, and Tourville followed in "line of battle" which limited his speed of pursuit to that of his slowest ship. In 1692 the Mediterranean fleet having failed to join him, he was faced by a vastly superior force of the allies. The French king had prepared a military force to invade England, and Tourville was expected to prepare the way. He made a resolute attack on the centre of the allies on May 29, off Cape Barfleur, and drew off before he was surrounded. This action, with the pursuit of the following days, made up what is called "the battle of La Hogue." His flagship the "Soleil Royale" and fifteen other ships were cut off and destroyed. In 1693 he was again at sea with a great fleet, and had a chance to capture the Smyrna convoy off Gibraltar. Again he kept his fleet in battle order, and a large part of the convoy escaped. Tourville was made Marshal of France in 1693. He died in Paris in 1701.

TOUSSAINT L'OUVERTURE (or LOUVERTURE), **PIERRE-DOMINIQUE** (*c.* 1746-1803), one of the liberators of Haiti, claimed to be descended from an African chief. His first surname Breda was afterwards changed to L'Ouverture in token of his valour in causing a gap in the ranks of the enemy. He obtained his master's confidence and was made superintendent of the other negroes on the plantation. After the insurrection of 1791 he joined the insurgents and acted as physician to the forces. His rapid rise aroused the jealousy of Jean François, who caused his arrest on the ground of his partiality to the whites. He was liberated by the rival insurgent chief Raissou, and a partisan war ensued, but after the death of Baissou he placed himself under the orders of Jean François. Subsequently he joined the Spaniards, but, when the French government ratified the act declaring the freedom of the slaves, he came to the aid of the French. In 1796 he was named commander in chief of the armies of St. Domingo, but, having raised and disciplined a powerful army of Negroes, he made himself master of the whole country, renounced the authority of France, and announced himself "the Buonaparte of St. Domingo." He was captured by the French and died in the prison of Joux, near Besançon, on April 7, 1803.

See Toussaint l'Ouverture's own *Mémoires,* with a life by Saint Remy (1850); Gragnon-Laconte, *Toussaint Louverture* (1887); Schölcher, *Vie de Toussaint Louverture* (1889); and J. R. Beard, *Life oj Toussaint Louverture* (1853).

TOUT, THOMAS FREDERICK (1855–1929), British historian, was born in London on Sept. 28, 1855, and educated at St. Olave's school, Southwark, and at Balliol college, Oxford. In 1881 he was appointed professor of history at St. David's college. Lampeter, and from 1890 to 1925, held a similar appointment at Manchester university. He was a fellow of Pembroke college, Oxford, from 1883 to 1890. He took a prominent part in the work of various historical societies and educational committees, and in 1911 was elected fellow of the British Academy. In 1925 he was elected president of the Royal Historical Society, and from 1927 to 1928 was messenger lecturer at Cornell university. He died in London on Oct. 23, 1929.

His works include *History of England for Schools* (with Prof. York Powell), vol. iii. (1890); vol. ii. (1898); *The Empire and the Papacy* (1898). He was first editor with H. Johnstone of *Select Trials of the Judges and Ministers, 1289–92* (Camden Series, *Royal Hist. Soc.,* 1906); and has written *Chapters in the Administrative History of Mediaeval England* (vols. i. and ii., 1920); *France and England, their Relations in the Middle Age and Now* (1922); and many school text books and articles in historical reviews.

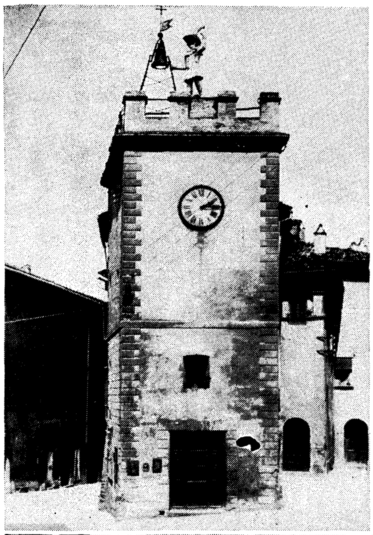
TOVEY, SIR DONALD FRANCIS (1875–1940), English pianist, composer and writer on music, was born on July 17, 1875. at Eton, where his father, the Rev. Duncan C. Tovey, was a master. He was trained as a pianist by Sophie Weiss. In 1900 he definitely took up music as a career and began to give recitals, in which his own compositions were included, in London and on the Continent. From 1914–1940 he was Reid professor of music at Edinburgh university. The Reid orchestral concerts, which he conducted, owe their existence to his initiative. He contributed a large number of articles to the present edition of the *Encyclopædia Britannica.*

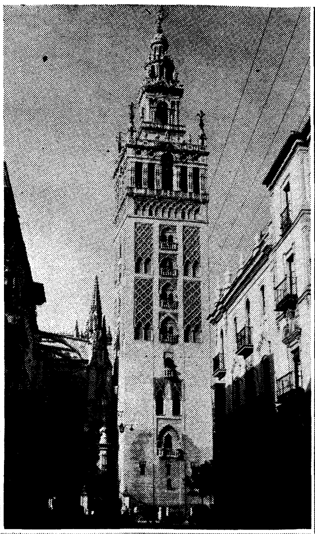
The orchestral compositions include a symphony in D, performed at Aix-la-Chapelle in 1913, a pianoforte concerto in A, prelude and entr'actes for Maeterlinck's *Aglavaine et Sklysette* (for string orchestra), and an opera, *The Bride of Dionysus* to R. C. Trevelyan's text. In chamber music he wrote two sonatas for violin alone; a sonata for two violoncellos; a pianoforte trio and a quintet; a trio in C minor for pianoforte, clarinet and horn; two string quartets; variations on a theme by Gluck for flute and strings. He also wrote three anthems and 25 rounds for equal voices. He was knighted in 1935.

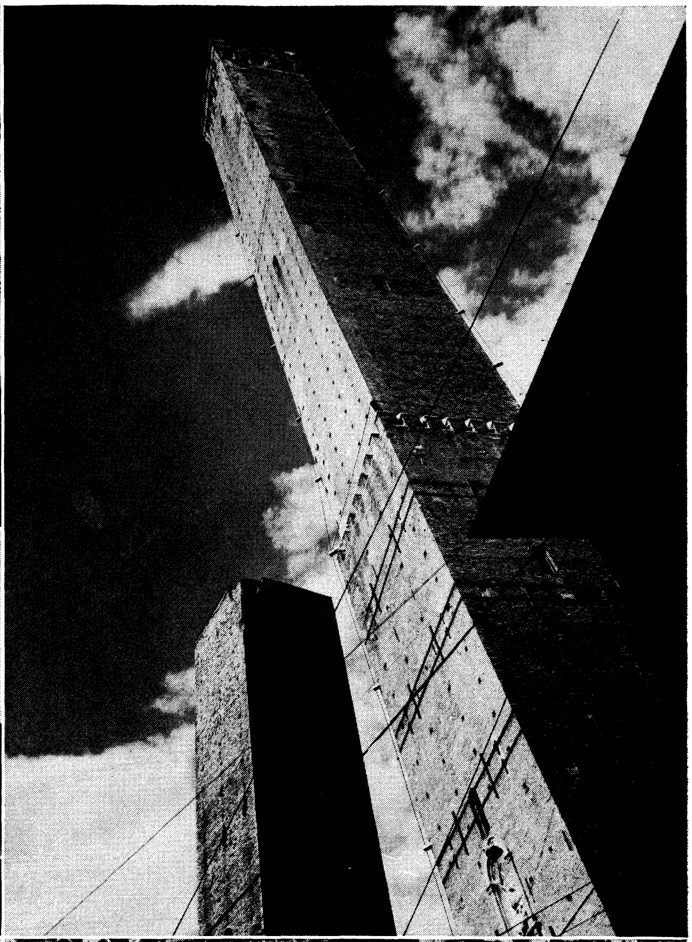
TOWER, the term originally given to a tall building designed for defense. hence, any structure whose height is its most important dimension, whether isolated or forming part of another building. The two earliest uses of tall buildings were military and religious; in the one case constructed to give a raised platform from which a defending force could advantageously discharge missiles upon an attacking force. at the same time remaining protected from it; in the other case, always in connection with sun, moon or star worship, apparently in the effort to raise the worshiper or the priest as near heaven as possible.

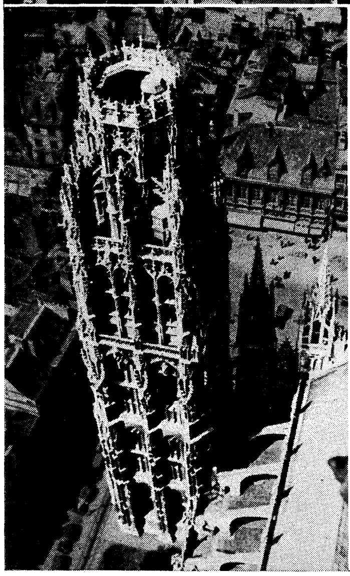
However, towers are not iimited to either military or religious uses. Many were built in connection with town halls, others to carry clocks. The greater number of the *hôtels de ville* of France, Germany and the Netherlands had towers, serving as belfrys; the fantastic tower of the *Rathaus* at Rothenburg (13th century) is characteristic of the German examples.

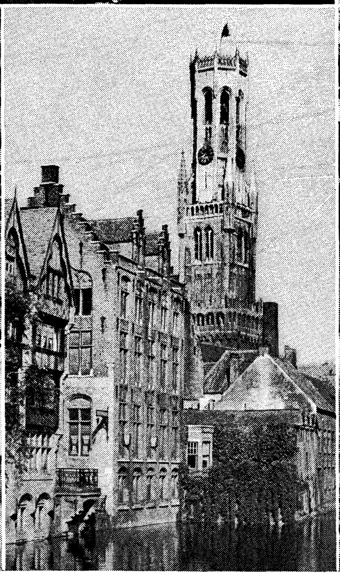
Military. — The Mesopotamian peoples seem to have built the first highly developed masonry-towered fortifications. In Egypt

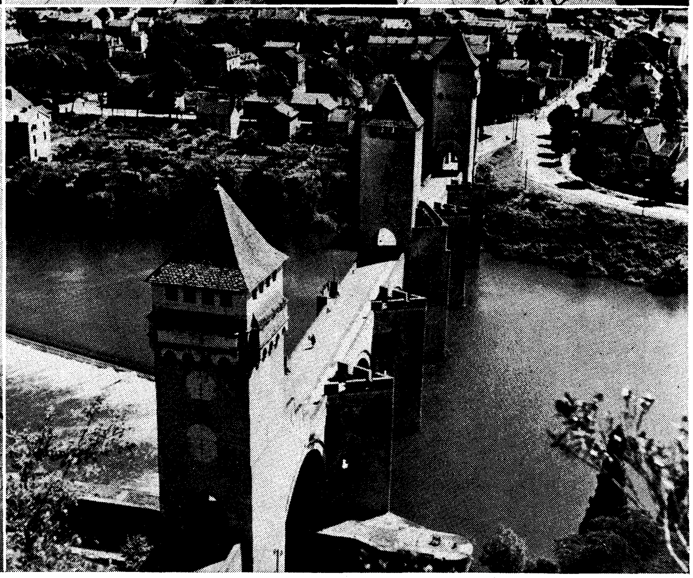












BY COURTESY OF (TOP RIGHT) ENTE PROVINCIALE PER IL TURISMO. BOLOGNA (BOTTOM LEFT, PRESS AND INFORMATION DIV., FRENCH EMBASSY: PHOTOGRAPHS, (TOP LEFT) BURTON HOLMES FROM EWING GALLOWAY (TOP CENTRE) EUROPEAN, (CENTRE LEFT) MUSTOGRAPH AGENCY. (BOTTOM CENTRE) PEECE WINSTONE (BOTTOM RIGHT) AUTHENTICATED NEWS

EUROPEAN TOWERS, 12TH TO 17TH CENTURIES

Top left: Medieval clock tower at Montepulciano, Italy

Top centre: Giralda or belfry, Seville, Spain: the lower part was built in the Moorish style between 1180 and 1200; the upper part was completed during the reign of Philip II (1556–98)

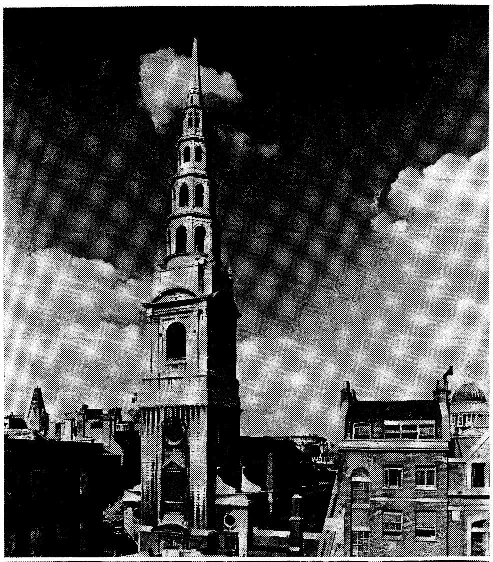
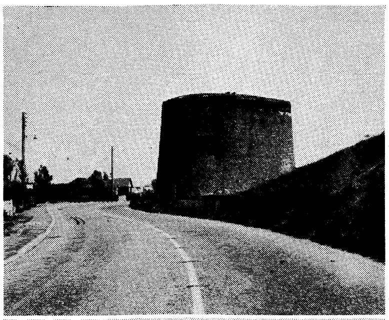
Top right: Pair of leaning towers, Bologna, Italy. The Asinelli tower. right, was built in 1109 and stands 320 ft. high; the Garisenda tawer, unfinished, was built in 1119 and stands 163 ft. high

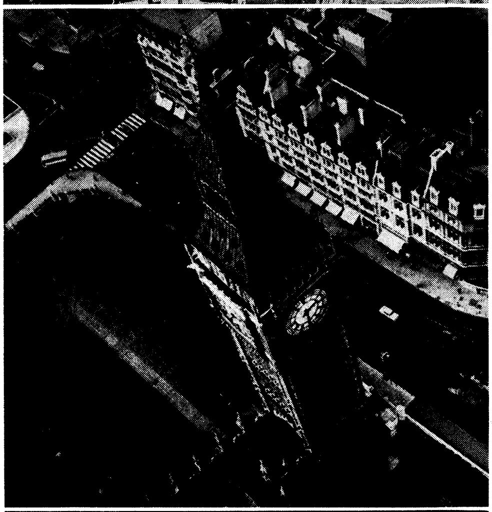
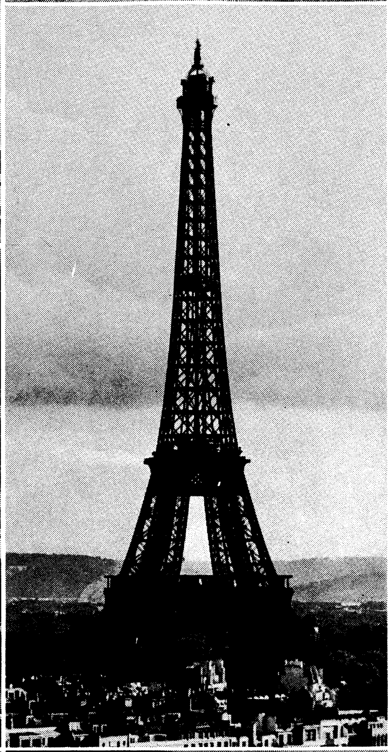
Centre left: Wallace tower, Ayr, Scotland: 17th century

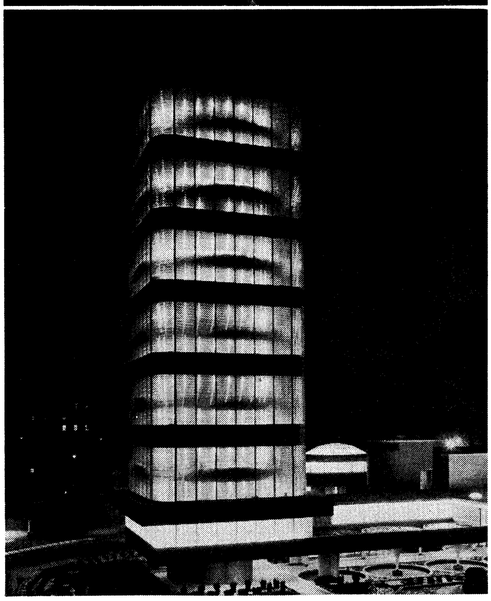
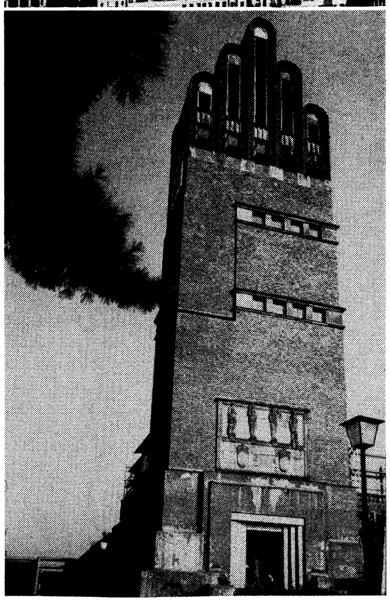
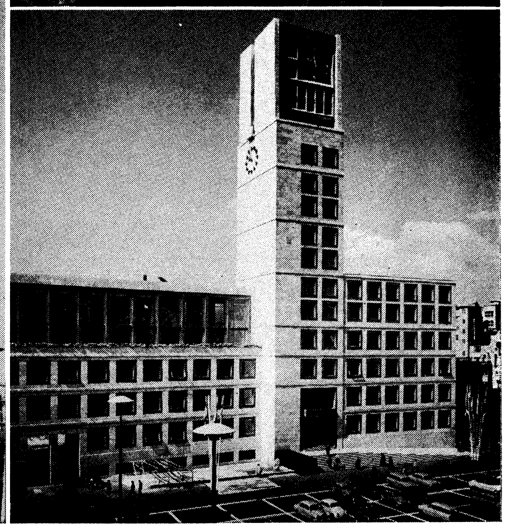
Bottom left: "Tour de Beurre" of Rouen cathedral, France; 16th century. It was damaged during World War II

Bottom centre: Belfry tower, Bruges, Belgium; late 13th century

Bottom right: Three-towered bridge, the Pont Valentré, Cahors, France; early 14th century

BY COURTESY OF (BOTTOM LEFT) RACINE (WIS.) CHAMBER OF COMMERCE, (BOTTOM CENTRE) DER MAGISTRAT DER STADT DARMSTADT, (BOTTOM RIGHT, VERKEHRSFÖRDERUNGSAMT, STUTTGART; PHOTOGRAPHS (TOP LEFT CENTRE RIGHT) A F KERSTING, (TOP CENTRE) KENT COUNTY COUNCIL, ENG., (TOP RIGHT) DE COU FROM EWING GALLOWAY, (CENTRE LEFT) "EVENING STANDARD, LONDON, (CENTRE) PATRICE MOLINARD CAMERA PRESS, LONDON

TOWERS OF THE 17TH TO 20TH CENTURIES

Top left: St. Bride's church, London, by Sir Christopher Wren (1632–1723)

Top centre: A Martello tower at Dymchurch. Kent; late 18th or early 19th century

Top right: Husainabad clock tower, Lucknow, India; 18th century

Centre left: Clock tower of the British Houses of Parliament, London, which contains "Big Ben"; 19th century

Centre: Eiffel tower, Paris. 1,056 ft. high; 19th century

Centre right: Westminster cathedral (1895–1905), London

Bottom left: Administration and Research centre of S. C. Johnson & Son, Inc., Racine, Wis. By Frank Lloyd Wright, 20th century

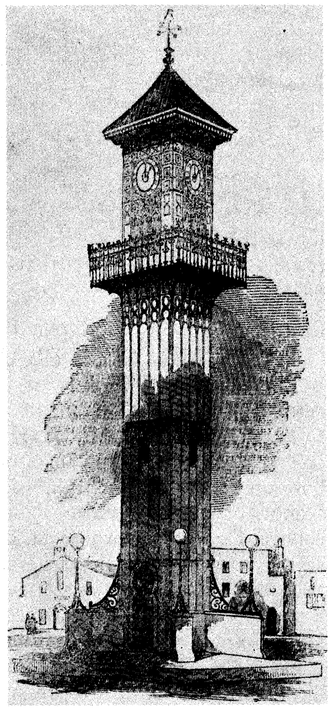
Bottom centre: Hochzeitsturm tower, Darmstadt, Germany; 20th century

Bottom right: Clock tower of the Rathaus, Stuttgart. Germany; 20th century great pylons flanking the entrance to temples were the commonest form of towers; they probably originated in mud-brick towers guarding the entrance to great chiefs' houses in primitive Egyptian times. Of Greek towers, the most famous was the Pharos, or lighthouse tower, outside Alexandria. An extensive use of military to ers began only with the Romans, however; they, and the Byzantines who followed them, made towers an integral part of every developed fortification. The Roman twin-towered city gate passed into medieval symbolism; it was with the idea of showing forth the gate of the heavenly city that Abbot Suger, for example, designed the façade of St. Denis in the early 12th century, with Roman-type twin towers and crenelations.

In the medieval period, from the 13th century on, the military tower received its greatest development in city walls (*e.g.,* Aigues Mortes and Carcassonne in southern France), in defensive keeps or donjons (*e.g.,* the White tower of the Tower of London), and sometimes as private towers of refuge (*e.g.,* S. Gimignano in Italy).

In the near east the great towers of the fortifications built on either side of the Bosporus at Rumeli Hissar and Anatol Hissar during the siege of the city (middle 15th century) are still landmarks. In China great masonry towers crown each gate of a city wall, topped with garrison buildings that give much additional height; towers of a simpler and strangely European type form the most conspicuous features of the famous Great Wall of China.

With the appearance of firearms, and particularly of large cannon, the use of towers as fortifications practically vanished. (See FORTIFICATION; MARTELLO TOWER; CASTLE.)



"THE ILLUSTRATED LONDON NEWS"
PREFABRICATED IRON AND GLAZED TERRA-COTTA CLOCK TOWER IN GEELONG, AUST.

Religious. — The tower built for religious purposes appeared in an early developed form in the ziggurat (*q.v.*) of Mesopotami — the great stepped pyramid, with stairs or inclined planes connecting the levels, and an open terrace with an altar or a shrine at the top. A ziggurat was attached to nearly every temple. Similar high buildings, the so-called pyramids, were frequently associated with temples in Middle America. The early Persians seem also to have used raised platforms on small towers in connection with their fire worship. In the classic world towers do not appear as important religious buildings, and it was not until the 8th century, and probably with the wide introduction of bells that they came to be associated with churches. (See CAMPANILE.)

By the end of the 11th century the use of church towers was almost universal. In France the earliest examples were placed at the crossing of nave and transepts. often taking the form of a lantern in several stages or levels, with a pyramidal top. In England, on the other hand. a position at the west end of the nave had become common during the Saxon period. as at Earl's Barton and Barnack. In the Norman period central towers became usual, as well as towers flanking the main entrance. Particularly picturesque were the grouped towers common in the Rhineland as in the 12th-century churches of Mainz and Speyer. Romanesque tower design was generally simple. Shallow corner buttresses were occasionally found, but the main effect was gained by a succession of stories of arcaded windows; arcaded cornices or corbeled (bracketed) cornices were much used. Interesting examples of Romanesque towers are: St. Front, Périgueux; Loches; St. Pierre, Vienne; St. Paul, Issoire; the cathedral at Le Puy en Velay; and St. Germain des-Prés, Paris, all of the 12th century, in France. In England, the west towers of Durham cathedral (lower part 1128, upper part 1220); the central tower at Tewkesbury (c. 1125) and the 12th-century church at Castor are noteworthy.

The Gothic period produced profound changes in tower design. Windows and arcades were much lengthened; buttresses increased in size and complexity; corner buttresses were much emphasized, frequently crowned with pinnacles, and offsets were arranged to vary the silhouette. Although the Gothic tower was often designed to carry a spire (*q.v.*) a large number have flat roofs with rich battlemented or traceried parapets and many pinnacles and finials. Sometimes octagonal turrets rose continuously from the ground to the top at one or more corners of the tower. The number of towers contemplated for great churches increased with their complexity. Thus in Reims, seven towers with crocketed spires were originally planned: and at Chartres, eight; Tournai cathedral (the only scheme of the three completed) in Belgium has seven. Of flat-topped towers the Tour St. Jacques, Paris (1508–22) is a graceful example. The most beautiful of English Gothic towers are Canterbury cathedral (central tower 1495); Lincoln (western towers c. 1250, completed c. 1400), central tower (lower portion 1240–50, upper portion 1307–1311); Gloucester (central tower middle 15th century); and York (central tower 1400–1423, southwest tower begun 1432, northwest tower finished 1474). Of the smaller towers, those of Wrexham church (1506) and the famous Magdalen tower at Oxford (1492–1505) are both beautiful examples of Perpendicular richness.

The best Renaissance to ers are those of comparatively late date, for it required the imaginative freedom of the baroque spirit to combine classic detail with the nonclassic verticality a rich tower requires. Of these baroque towers the most striking were those of south Germany, Austria and Italy, in all of which comparatively simple bases were crowned with several stages of rich, colonnaded detail, the whole topped with some sort of fantastic, curved roof. Spanish baroque towers differ from those already mentioned in being crowned by a lantern, usually smaller than the tower below, with frequently a low dome at the top of the entire composition; sometimes two or more stages occur, each smaller than the one below. Such towers were common, not only in Spain itself, but also in the Spanish colonies in America, existing in rich and highly developed examples in Mexico, as in the cathedral at Mexico City, and in much simplified form in the mission churches of California, as in San Luis Rey, completed 1802. English baroque towers are best exemplified in the London churches of Sir Christopher Wren; his designs came to the U.S. both directly (as at Williamsburg) and through the inedium of the Book of Architecture by his pupil J. Gibbs, and became the basis for the standard type of tower on U.S. churches well into the 19th century.

Modern. — In modern architecture, the tower has taken on new importance, as in it the structural innovations possible with new materials may be given impressive demonstration. It mas in the Eiffel tower, Paris, by Gustave Eiffel (1889; 1,056 ft. high, including a 55-ft. television antenna) that the potentialities of steel construction were first strikingly revealed; the possibilities of ferroconcrete were likewise shown in towers like that on Xuguste Perret's church of Notre Dame at Raincy (1924). In Germany, the effectiveness of pure steel and glass construction was shown particularly at the Werkbund exhibition (Cologne, 1914) in the stairway towers of Walter Gropius' model factory; the tower as an expressive shape was demonstrated by E. Mendelsohn in the Einstein tower, an observatory at Pdtsdam (1921). But more than any other modern architect, perhaps, Frank Lloyd Wright has excelled in tower design — in churches, like the Ann Pfeiffer chapel at Lakeland. Fla.; in commercial buildings, like the research laboratory tower of the Johnson Wax factory at Racine, Wis., or the Price tower at Bartlesville, Okla.; and in public buildings, like the Solomon R. Guggenheim museum of nonobjective art in New York. (See ARCHITECTURE; GOVERNMENTAL ARCHITECTURE; MONUMENTS AND MEMORIALS; RELIGIOUS ARCHITECTURE.)

Oriental. — Islamic architects rank with the greatest medieval tower designers! but except for a few examples in palaces, such as the 14th-century Comares tower in the, Alhambra at

Granada, Spain, the greater number were purely religious and served for places from which the call to prayer was given. The greatest of them all is the Giralda tower at Seville, originally a mosque minaret (1195), but in its present form it is crowned with a Renaissance top, built in the 16th century by the architect Hernan Ruiz. The Kutb Minar at Delhi (early 13th century) is the most important Indian example. *(See* MINARET.)

Towerlike structures play an important part in the Brahmin temples of India and in other religious architecture of the iar east. Thus many of the temples are entered through gateways under enormous piles of masonry which take the form of oblong pyramids. lavishly covered with tier on tier of sculptured figures, carved moldings, little projecting shrines and the like. Characteristic examples are those at Madurai (17th century) and Kanchipuram. Sometimes a square. pyramidal tower is placed over the holy of holies of a temple. as at Rfadurai.

In China the tower is chiefly developed as the pagoda (*q.v.*), whose characteristic, repeated roofs and galleries iorm an interesting silhouette, typically Chinese. Japanese pagodas are similar but for small details. *See* CHINESE ARCHITECTURE; INDIAN ARCHITECTURE ; JAPANESE ARCHITECTURE. (T. F. H.; AN. G.)

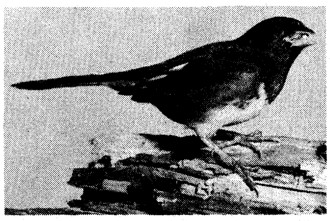
TOWER OF LONDON, THE, an ancient fortress on the east side of the City of London, on the north bank of the river Thamcs. On a slight elevation now called the Tower hill. well protected by the river and its marshes, and by woods to the north, there was a British stronghold. Tradition, however: pointed to Julius Caesar as the founder of the tower (Shakespeare. *Richard III*, iii. 1 and elsewhere), and remains of Roman fortifications have been iound beneath the present site. The tower contains barracks, and is the repository of the regalia. It covers an irregular hexagonal area, and is surrounded by a ditch, formerly fed by the Thames, but now dry. Gardens surround it on the north and west, and an embankment borders the river on the south. Two lines of fortifications enclose the inner bail. in which is the magnificent White tower or keep, flanked by four turrets. This was built by Gundulf. bishop of Rochester. about 1078. Its exterior was restored by Sir Christopher Wren, but within the Norman work is little altered. Here may be seen a collection of old armour and instruments of torture, the rooms said to have been Sir Walter Raleigh's prison, and the magnificent Norman chapel of St. John. Among the surrounding buildings are the modern barracks (1845), and the chapel of St. Peter ad Vincula, dating from the early part of the 12th century, but rebuilt in the early 14th and much altered in Tudor times. The Ballium wall, the inner of the two lines of fortification, is coeval with the keep. Thirteen towers rise from it at intervals. in a chamber of one of which, the Wakefield tower. the regalia or crown jewels (*see* CROWN AND REGALIA) are kept; this room was formerly the oratory: and it is said that it was here that Henry VI met his death (1471) while at prayers.

The chief entry to the fortress is through the Middle tower on the west (near which was a menagerie from Norman times until 1834), across the bridge over the moat, and through the Byward tower. On the south: giving entry from the river through St. Thomas's tower and the Bloody tower, is the iamous Traitors' gate, by which prisoners oi high rank were admitted. The chief historical interest of the Tower lies in its association with such prisoners. The Beauchamp tower was for long the principal place of confinement for captives of rank. but dungeons and other chambers in various parts of the buildings also have similar associations; as, for instance, the Bell tower with Queen Elizabeth when princess. Bishop Fisher and Sir Thomas More; the Bowyer tower with the duke of Clarence oi the butt of Malmsey legend; the Salt tower and Broad Arrow tower with Roman Catholic prisoners of Elizabeth's time, and the hlartin tower with Colonel Blood. who, in 1671, nearly succeeded in carrying off the crown and regalia, which were then kept there.

Executions took place both within the tower and on Tower hill, Many of those executed were buried in the chapel of St. Peter ad Vincula. such as Sir Thomas More, Henry VIII's queens Anne Boleyn and Katharine Howard. Lady Jane Grey and her husband Dudley and the duke of Monmouth. The tower was not only a prison from Norman times until the 19th century, but was a royal residence at intervals from the reign of Stephen, if not before. The royal palace was demolished by order of Cromwell. The tower is under the governorship of a constable. The attendant staff. the Yeoman Warders of His Majesty's Tower of London, familiarly called "Beeieaters," still wear Tudor costume.

See W. Hepworth Dixon, *Her Majesty's Tower* (1869); Lord Ronald Sutherland Gower, *The Tower of London* (1901); Sir George Younghusband, *The Tower Front Within* (1918) and *The Jewel House* (1920); W. G. Bell, *The Tower of London* (1921).

TOWHEE (*Pipilo erythrophthalmus*), a well-known North American bird belonging to the family of the finches. The back and breast are black, the sides chestnut, the belly white in the male, the female being brown on the back and breast. The song is loud, but scarcely musical. The towhee breeds east of the Great Plains and may often be seen on the ground near brush and in the woods, where it makes its nest. In the north of its range it is migratory.



ALLAN D. CRUICKSHANK FROM NATIONAL AUDUBON SOCIETY

TOWHEE (PIPILO ERYTHROPHTHALMUS)

The allied spurred towhee (P. *maculatus*) breeds in the western mountains and Great Plains.

TOWN AND CITY PLANNING: *see* CITY PLANNING.

TOWNSEND (family of joiners): *see* GODDARD AND TOWNSEND.

TOWNSEND, SIR JOHN SEALY EDWARD (1868–1957), Irish physicist who studied the ionization of gases, was born on June 7, 1868, at Galway, Ire. He was educated at Corrig school and Trinity college, Dublin, and in 189j he entered Trinity college, Cambridge. where he became one of J. J. Thomson's research students. In 1898 he was Clark Maxwell scholar and in 1899 he was elected a fellow oi Trinity college, Cambridge. There he made the first direct determination of the elementary ionic charge. He made early studies of the part played by electrons and positive ions in the initiation and continuation of electric discharges in gases at low pressure. In 1900 Townsend was elected to the newly founded Wykeham chair of experimental physics at Oxford, where he continued his studies on the ionization of gases until his retirement in 1941. He was elected fellow of the Royal society in 1903 and received many honours, being knighted in 1941. He died on Feb. 16, 1957, at Oxford.

Townsend's publications include *Electricity in Gases* (191j), *Motion of Electrons in Gases* (1925), *Electricity and Radio Transmission* (1943), *Electrons in Gases* (1947) and *Electromagnetic Waves* (1951). (D. McK.)

TOWNSEND PLAN: *see* PENSIONS.

TOWNSHEND, AURELIAN (*c.* 1583–*c.* 1642). English poet whose best lyrics have been justly praised for their "manly gallantry and wit wedded to manly music." mas the son of Sir John Townshend of West Dereham, Norfolk. In 1600 he attracted the notice of Sir Robert Cecil. who sent him to Paris and Italy. After getting into financial difficulties, Townshend was summoned home and was in England in April 1603. In 1608 he went to France with Sir Edward Herbert. and on his return re-entered Cecil's service; attending him in his last illness. At an unknown date he married Anne Wythies, by whom he had six children. In 1632 he appears as a composer oi two court masques in collaboration with Inigo Jones. In 1642 he was described, as "a poore and pocky poet" and on March 3, 1643, was petitioning the house of lords for protection against debt. He may be a "Mr. Townshend" who was allowed to leave England after the fall of Oxiord in 1646.

Townshend's poems, together with his two masques and extant letters, were first collected and published with a biographical introduction by Sir E. K. Chambers in *Aurelian Townshend's Poems and Masks* (1922).

See G. C. Moore Smith in *Modern Language Review*, xii (1917); *Times Literary Supplement* (Oct. 23, 1924). (V. DE S. P.)

TOWNSHEND, CHARLES (1725–1767), English politician, the second son of Charles, 3rd Viscount Townshend, was born on Aug. 29, 1725, and was educated at Leyden and Oxford. He represented Great Yarmouth in parliament from 1747 to 1761, when he found a seat for the treasury borough of Harwich. After holding minor offices he was summoned to the privy council.

With the accession of George III in 1760 Townshend transferred his support from Pitt to the young king's favourite, Bute, and in 1761, at the latter's instance, was promoted to the post of secretary-at-war, which he did not throw up until Dec. 1762. In the dying days of Grenville's cabinet, and throughout Rockingham's administrat~onhe held the post of paymaster-general, refusing to identify himself more closely with its fortunes as chancellor of the exchequer. He accepted the latter position from Pitt in 1766, and was admitted to the inner circle of the cabinet.

The defeat of his proposal to continue the land tax at four shillings in the pound, by William Dowdeswell and the landed gentry caused Lord Chatham to meditate Townshend's removal, but before this could be accomplished Chatham's mind became impaired, and Townshend, who was the must determined and influential of his colleagues, swayed the ministry as he liked, pledging himself to find a revenue in America with which to meet the deficiency caused by the reduction in the land tax. His wife was created (August 1767) baroness of Greenwich, and his elder brother George, the 4th viscount, was made lord-lieutenant of Ireland. He himself delivered in the house of commons many speeches unrivalled in parliamentary history for wit and recklessness, and one of them still lives in history as the "champagne speech."

His last official act was to carry out his intention by passing through parliament resolutions, which even his colleagues deprecated in the cabinet. for taxing several articles such as glass, paper and tea, on their importation into America, which he estimated would produce the insignificant sum of £40,000 for the English treasury. and which shrewder observers prophesied would lead to the loss of the American colonies. Soon after this event he died somewhat suddenly on Sept. 4. 1767.

The universal tribute of Townshend's colleagues allows him the possession of boundless wit and ready eloquence, marred by an unexampled lack of judgment and discretion.

A Memoir by Percy Fitzgerald was published in 1866.

TOWNSHEND, CHARLES TOWNSHEND, 2ND VISCOUNT (1674–1738), English statesman, was the eldest son of Viscount Townshend of Raynham (c. 1630–87), of an old Norfolk family descended from Sir Roger Townshend (d. 1493) of Raynham, who acted as legal adviser to the Paston family. Charles Townshend succeeded to the peerage in Dec. 1687, and was educated at Eton and King's college, Cambridge. At first a Tory when he took his seat in the house of lords, he afterwards went over to the Whigs. In Nov. 1708 he was appointed captain of the yeomen of the guard, having in the previous year been summoned to the privy council. As ambassador extraordinary and plenipotentiary to the states-general (1709–11) he took part in the negotiations preceding the treaty of Utrecht. In Sept. 1714, George I selected him as secretary of state for the northern department.

Townshend's policy, after the suppression of the Jacobite rising in 1715, was one of peace at home and abroad; he promoted defensive alliances with the emperor and with France. But in 1716 he was dismissed from his position owing to the intrigues of Sunderland, who persuaded George and Townshend's colleague, Stanhope, that Townshend and Walpole were plotting to place the prince of Wales on the throne.

Early in 1720 a partial reconciliation took place between the parties of Stanhope and Townshend, who was president of the council from June 1720 until Feb. 1721, when, after the death of Stanhope and the forced retirement of Sunderland, a result of the "South Sea Bubble," he was again appointed secretary of state for the northern department, with Walpole as first lord of the treasury and chancellor of the exchequer. The two remained in power during the remainder of the reign of George I (see ENGLISH HISTORY).

Townshend secured the dismissal of his rival, John Carteret, afterwards Earl Granville, but soon differences arose between himself and Walpole. Although disliking him, George II retained him in office, but the predominance in the ministry passed gradually from him to Walpole. Failing, owing to Walpole's interference, in his efforts to procure the dismissal of a colleague and his replacement by a personal friend, Townshend retired on May 15, 1730. His remaining years were passed at Raynham, where he interested himself in agriculture. He died at Raynham on June 21,1738.

TOWNSHIP. The civil township is a governmental subdivision of the county found in portions of the United States, principally in the northeast and north central regions. It is to be distinguished from the so-called congressional or survey township of six miles square, which is not governmentally organized but has influenced the size and configuration of the civil subdivision. Most civil townships have an area of approximately 36 sq.mi., and many have boundaries which coincide with those of congressional townships. As of 1957, according to the U.S. bureau of the census, 15,771 civil townships were in existence in 16 states. In some of these states all counties were divided into townships while in others townships were found in some counties only.

In some states a township meeting, patterned after the New England town meeting, levies township taxes, makes appropriations, enacts bylaws and serves in general as the policy-determining organ of the township. A township board, constituted on an elective or ex officio basis, ordinarily appoints certain township officers and performs other administrative duties. In addition, the board customarily acts as the township's policy-determining agency where there is no township meeting. A principal administrative officer, usually known as supervisor or trustee, is found in some states. Other township offices — elective, appointive or ex officio — commonly include those of clerk, treasurer, assessor, road commissioner and supervisor of public assistance. Justices of the peace and constables, though state rather than local officers in legal contemplation, are commonly elected from the townships.

Township functions vary widely, but the major services most commonly performed are maintenance of local roads and administration of public assistance. Property assessment is a township function in some instances; and in a few states the township serves as an area for school administration.

As a unit of local government the U.S. township was in the second half of the 20th century steadily declining in importance. Township meetings were poorly attended and township functions were gradually being transferred to the county. In some areas where once maintained, township government had been entirely eliminated.

See Clyde F. Snider, ***Local Government in Rural America*** (1957). (C. F. S.)

TOWNSVILLE, a city and port of Queensland, Austr., on the west side of Cleveland bay in the northeast of the state, 832 mi. N. of Brisbane. Pop. (1954) 40,471. It is built upon the banks and near the mouth of Ross creek and is dominated by Castle hill, a great rock mass 937 ft. high. It is the outlet for a wide area of country of varied economic potentialities and the port, which is one of the best on the Queensland coast, is the terminus for 1.308 mi. of railway which extends westward to the gold fields of Charters Towers, the sheep and cattle of Hughenden and the mines of Cloncurry and Mt. Isa. The estuary of Ross creek has been straightened and deepened and ships of 15,000 tons can berth alongside the quays. Behind Townsville lies an immense area of sheep lands which provide merino wool, one of the chief exports of the port. Others are concentrates, preserved and frozen meats, sugar. timber and silver lead. Industries include dairying, meat canning and preserving, mining, shipbuilding, the manufacture of bricks, glass, motor bodies, cement, steel and railway equipment.

Townsville was founded by Robert Towns, an English seafarer, in 1864, and became a city in 1866.

TOWTON, BATTLE OF, fought on March 29, 1461, near the Yorkshire village of that name which is 2½ mi. S. of Tadcaster and 10 mi. S.W. of York. It was remarkable among the battles of the Wars of the Roses for three reasons. First, the numbers engaged were unusually large; the best estimates are 40.000 for Lancaster and 36.000 for York. Second, the fight was prolonged and ferocious, while the casualties were immense; probably 28 000 killed. Finally it represented a supreme military effort by both sides and. as a Yorkist victory, it was decisive in securing the English kingdom for Edward IV. After failing to follow up their victory at St. Albans (Feb. 17, 1461) by seizing London. the Lancastrians had been forced slowly northward by converging Yorkist columns under the earl of Warwick, Baron Fauconberg and the newly proclaimed Edward IV. Henry VI and his queen, now at York, met this growing threat by a Lancastrian concentration around Towton under the duke of Somerset, the duke of Northumberland and Lord Dacres. Early on March 28, covering troops clashed at Ferrybridge on the river Aire, 2 mi. N. of Pontefract. Edward forded the river 4 mi. upstream at Castleford. The Lancastrians thereupon withdrew to their main body drawn up athwart a ridge between Towton and Saxton. The Yorkists closed up to the enemy on a neighbouring ridge during the day. but their movement was not completed for the duke of Norfolk's division was still at Ferrybridge. and both armies bivouacked in the open with snow in prospect. Next day. March 29, Palm Sunday, the fight was joined. Nothing definite is known of the order of battle or of the actual positions. Indeed there is surprisingly little contemporary testimony as to the course of the action. It appears that the front was short and that. after some preliminary shooting, footmen with bills and spears fought savagely at close quarters. They were hampered by mounting piles of dead and wounded, and were continually reinforced by fresh troops to fill the gaps and relieve the exhausted. Hindered by heavy snow, the battle raged all day with the Lancastrians holding a slight advantage. Then Norfolk's Yorkists arrived. They slowly turned the enemy's left flank. and suddenly Lancastrian morale broke. The flight was checked beyond Towton, where the old road to Tadcaster crosses the Aire, then probably in spate, by the great congestion of fugitives, who were slaughtered indiscriminately by the pursuing Yorkists. An attempted stand at Tadcaster was quickly overwhelmed, and by nightfall the Lancastrian army had ceased to exist. (GY. T.)

TOXICOLOGY, the name of that branch of science which deals with poisons, their chemistry, effects. antidotes and tests for detection. See POISON and MEDICAL JURISPRUDENCE.

TOXIN. Toxins are complex organic substances, protein in nature, that are produced by living organisms and are poisonous for other living organisms They are to be differentiated from the simple chemical poisons such as arsenic and the cyanides, and from the poisonous alkaloids such as strychnine. The phytotoxins are produced by higher plants; the zootoxins are the snake (*q.v.*), scorpion (*q.v.*) and spider (see BLACK WIDOW) venoms; and the bacterial toxins are the exotoxins such as those formed by the diphtheria, tetanus and botulinus bacilli. Toxins are separated roughly into two groups on the basis of their action: (1) the hemotoxins, which lyse the red blood cells, and (2) the neurotoxins, which poison nerve tissue to produce paralysis. The naturally occurring toxins are often mixtures of these two kinds, with one or the other predominating to give symptoms characteristic of the disease produced by them. The toxicity of the bacterial toxins is destroyed by treatment with formaldehyde to give formol toxoid, which may be used without further alteration (fluid toxoid) or after precipitation with alum (alum-precipitated toxoid, APT) to produce a high degree of immunity to diseases caused by the toxigenic bacteria. The venoms are not successfully detoxified by such treatment. See also ALKALOIDS; ANTITOXIN; POISON. (W. Bc.)

TOY. A toy is a plaything, often an instrument used in a game, primarily for children but also for adults. The toy may be abstract in design, as a ball, or a representation of a person, as a doll, or of animals, plants or artifacts.

Toys may be divided into two basic types: child-made toys are often not representational, but rather screens onto which the child's imagination may be projected; adult-made toys are usually instructive representations of objects of adult interest or use. A child finds or makes toys from almost any natural or man-made scrap of material or from a part of an object not originally intended as a toy. Depending upon his imagination, he will give it an individual special meaning; magically, the orange crate becomes a castle or the stick a steed. Many things not originally intended as instruments of play have been adopted by children and subsequently produced as toys by adults who realize the potential of the children's selection.

Toys. playthings and games survive from the most remote periods in the past and from a great variety of cultures. They vary from the simplest to the most complex, from the natural stick selected and imagined into a "hobbyhorse" by a child to the sophisticated and complex mechanical automata that entertained both young and old in the royal courts of 18th-century Europe. The potential range is unlimited. Museums in many countries exhibit antique objects whose original purpose may be controversial. but which children may well have used or adopted for playthings. A pre-Columbian clay animal on wheels, from an early Mexican culture where no record of the wheel has otherwise been discovered, may have been a toy. One of the most ancient toys is the ball. Near-perfect spheres found in nature may have been highly treasured by primitive man and. later, made by hand and developed into the symbolic objects of competition. Today, as apparently throughout the past, a ball plays an important role in many competitive games.

The penalties. forfeits and handicaps of play provide an introduction through enjoyment to the understanding of many facets of practical life. Childhood play continues into adult life, or may be recaptured in later life as when a father shares his son's enjoyment of an electric train. The extension of playing into adult life becomes interwoven with adult activities and preoccupations and is therefore difficult to identify as pure play; the same is true of the instruments for play.

Toys may be divided into the static and the dynamic. Play with toys follows two main directions, imitative and instructive. The earliest types of play probably developed from the instinct for self-preservation, Instinctive animal play is practice for survival: the kitten's ball of yarn is tomorrow's mouse. In many human cultures. one of the first things taught to the young was the use of weapons. The natural club or stick was the prototype of drumsticks, golf clubs, hockey sticks, billiard cues and many other instruments of play. Most physical-action games and sports derived from competition and warfare. the instruments of which were weapons. Toy soldiers and weapons dating from the middle ages are extant; the types probably originated very early in human history. The latest developments in warfare are represented among contemporary toys.

Another basic type of toy is the human or animal doll (*q.v.*) and all the related domestic activities that start with child raising and homemaking. Each epoch and culture has provided its girl children with miniatures of the artifacts used in daily living, including dollhouses and shelters. Many of the static toys are of this type: treasures to be admired and cherished rather than used.

Moving toys include a wider and more dramatic variety. It is probable that many experiments with basic physical principles were first realized in the form of toys as in Hellenistic and Islamic automata which are known through literary description. Explosive weapons and rockets developed from the early use of gunpowder for fireworks by the Chinese. Balance and counterbalance, the wheel, the swing. the pendulum, flight, centrifugal force, magnetism, the spring and a multitude of other devices appear in a great assortment of toys.

Many skills develop from cumulative childhood experiences received from the manipulation of toys—marbles, Yo-Yos and other toys requiring apt hands and bodies. Mental skills, beginning with childhood, are developed by games of position such as checkers and chess and puzzles of spatial relationships.

The element of chance has also played an important part in games. Roman children and adults threw knucklebones, the precursors of dice. Dice. in turn. are the essential tools for snakes and ladders and a host of other games. Other forms of toys probably derive from magical artifacts and fetishes that played a prominent part in primitive religions. In the Mexican festival of the Day of the Dead, elaborate and beautiful objects of sugar are made in the shapes of skulls, tombs and angels; they are essentially religious symbols, but in the hands of children they become toys which are played with and finally eaten. Christmas tree decorations, peephole Easter eggs. the Neapolitan *presepio* (crèche) with its wealth of elaborate figures. are other examples of toys of religious origin. A modern relic of primitive culture, the Hopi Indian katcina dolls, while essentially instructive sacred objects, inevitably are played with by children. Under the pressure of industrialization, folk culture and tradition are rapidly disappearing. In many countries, such as India, China, Japan, Mexico, Portugal and Peru. however, an extraordinary wealth and variety of folk toys are still to be found.

Modern western toys continue to reflect their antecedents in folk cultures; however, the machine age is fast erasing the recognizable traces.

Toys and play necessarily follow the slow or rapid changes of mores and customs. Besides representing physical environment, they express many dreams which remain in the child or adult imagination. Thus, a comprehensive collection of toys might better express the history of man's aspirations and dreams than the real objects of utilitarian culture they occasionally represent. (A. H. Gi.)

TOYAMA, a Japanese prefecture and city in central Honshu on the Sea of Japan. The prefecture (Toyama-ken) was formed from the province of Etchu after the restoration of 1868. Area 1,642 sq.mi., pop. (1960) 1,032,614. Its coastal plain is an important surplus rice area and its mountainous interior is a source of hydroelectric power and minerals. The former is the basis for the chemical. textile (synthetic fibres, cotton and wool), machinery. wood pulp and paper, and steel industries.

Toyama ([1960] pop. 207.266). the capital of Toyama-ken, is an old castle town located at the mouth of Jinzū river, which since the 17th century has been the chief centre for the production of patent medicines and drugs in Japan. The city is also an important chemical and textile centre, producing cotton, rayon and synthetic textiles. (C. A. Mr.)

TOYNBEE, ARNOLD (1852–1883), English social reformer and economist, second son of the distinguished surgeon Joseph Toynbee (1815–66), was born in London on Aug. 23, 1852. After contemplating careers in the army and the law, he ultimately devoted himself to the study of economics and economic history. He was a practical social reformer, taking part in public work and lecturing in the large industrial centres. He died on March 9, 1883.

Toynbee had a striking influence on his contemporaries, not merely through his intellectual powers but also by his strength of character, love of truth and ardent and active zeal for the public good. He was the author of some fragmentary but influential pieces. published in 1884 under the title of *The Industrial Revolution*. Toynbee's interest in the poor and his desire to be personally acquainted with them led to his close association with the district of Whitechapel in London. commemorated after his death by Toynbee hall. the first of many institutions for social betterment. *See* Social Settlements. (D. F. Do.)

TOYNBEE, ARNOLD JOSEPH (1889–). English historian, best known for his comparative study of civilizations, was born in London on April 14, 1889, the nephew of the social reformer Arnold Toynbee. Educated at Winchester and at Balliol college, Oxford, he worked for the British foreign office during World Wars I and II, and he was a member of the British delegations to peace conferences at Paris in 1919 and 1946.

Toynbee was Koraes professor of Byzantine and modern Greek language, literature and history at the University of London. 1919–24; from 1925 until his retirement 30 years later he was research professor of international history there and director of studies at the Royal Institute of International Affairs.

His major work, *A Study of History* (1934–54), was published in ten volumes; an abridgment of the first six volumes was published in 1946 and of the last four in 1957. Toynbee's thesis is that societies or civilizations (not nations or periods) are the significant units of historical study. Civilizations, 26 of which he distinguishes, including arrested societies; grow by responding successfully to challenges under the leadership of creative minorities; they decline when the leaders fail to respond creatively. *(See* also Civilization and Culture: *Concepts of Civilization and Culture.)*

Other books by Toynbee include *Greek Historical Thought* (1924), *Civilization on Trial* (1948), *The World and the West* (1953), *An Historian's Approach to Religion* (1956), *East to West: a Journey Round the World* (1958) and *Hellenism: the History of a Civilization* (1959). Toynbee also lectured widely in the United States and Canada.

TOYNBEE HALL. Founded in London by Canon S. A. Barnett (*q.v.*), then rector of St. Jude's, Whitechapel, in 1884, and named after Arnold Toynbee (*q.v.;* 1852–1883), Toynbee hall, the pioneer university settlement. inaugurated an important movement *(see* Social Settlements). In his early years at St. Jude's, Barnett had succeeded in creating interest at Oxford and Cambridge in the problems of east London and had brought undergraduates to Whitechapel to spend their holidays with him and learn about social conditions. This prepared the universities for Barnett's plan to found a settlement (that is. a house of residence for university undergraduates who might wish to live in an industrial area) which was at once warmly supported. With money collected mainly at Oxford he was able to purchase and reconstruct premises next to St. Jude's and with the help of a band of settlers to begin activities which left an enduring mark on the social history of the period. These activities were mainly concerned with the collection of social data, with social experimentation and with the amelioration of social and industrial conditions; but Barnett's underlying aim was to bring the generosity and learning of the young and the universities into effective relation with the industrial population so that both communities might come in time to serve ideals of citizenship and neighbourliness. In this stage of its existence Toynbee hall was associated with the publication of two books of profound importance — Life *and Labour of the People in London,* edited by Charles Booth, and *Unemployment*, a *Problem of Industry* by William Beveridge (later Lord Beveridge) — and with the founding of the Whitechapel Art gallery and the Workers' Educational association.

After World War I the educational activities of Toynbee hall were enlarged; the John Benn hostel and the Workers' Travel association were founded, the former for homeless boys and the latter to promote foreign travel for wage earners and the increase of friendliness between the common peoples of Europe. These two institutions, and the American seminar started in 1921 and attended every year by clergymen, educationists and social workers, had great success in their respective spheres. During World War II Toynbee hall played a prominent part in organizing food and entertainment in air raid shelters and assisting in the evacuation of the elderly and the very young. It was the centre of administration of the Anglo-American Relief Fund for Mothers and Children, and toward the end of the war, the birthplace of the Toynbee Hall and Glyndebourne Children's theatre. (J. J. M.)

TOYOHASHI, formerly called Yoshida, is a textile centre in Aichi prefecture, Honshu, Japan, on Atsumi bay. Pop. (1960) 215,515. This castle town was the scene of much fighting in the 16th century and changed hands often during the Tokugawa period. After the restoration it became one of the largest silk manufacturing centres of Japan. With the decline in silk consumption after World War II, the main production shifted from silk to cotton and synthetic textiles. (C. A. Mr.)

TOZZI, FEDERIGO (1883–1920), Italian poet and novelist who achieved international reputation with his novel *Tre croci* (1920; Eng. trans., *Three Crosses,* 1921). The son of an innkeeper, he was born at Siena, Jan. 1, 1883. His poverty-stricken, frustrated life is described in his autobiographical novels, *Bestie* (1917), *Con gli occhi chiusi* (1919) and *Ricordi di un impiegato* (1927), and in his letters, *Novale* (1925). In 1913, with D. Giuliotti, he founded the Catholic review *La Torre.* His two volumes of poetry. *La zampogna verde* (1911) and *La città della Vergine* (1913) show the influence of D'Annunzio. Of his plays only *L'incalco* (1923) was published. He died in Rome, March 21, 1920.

See P. Cesarini, *Vita di Federigo Tozzi* (1935).

TRACERY, the term given in architecture to the upright curving or intersecring bars or ribs. used in a window or other opening to give beauty and variety to its silhouette. The term is also applied to similar forms used in relief, as wall decoration (sometimes called wall tracery), and hence. figuratively, to any intricate line pattern. The word is often restricted to the elaborate system of window decoration, with its derivative forms, developed in Europe during the Gothic period, but it may, with equal validity, be applied to the pierced marble screens common in the Mogul work of India, or to the pierced plaster windows of Persia. Turkey. Syria and Egypt.

Origin of European Tracery.—Pierced marble screens, with the openings glazed, were used occasionally in Byzantine work. The Byzantines also used, commonly, groups of two, three or even more narrow, arched windows, placed close together, under a single, large, relieving arch. (See BYZANTINE ARCHITECTURE.) In this they were followed by most of the Romanesque styles. In such groups, the supports between the adjacent openings of each group usually consisted of single colonnettes; hence the arches were thin and shallow, and the tympanum (*i.e.,* section of wall filling the space between and the great enclosing or relieving arch over the whole group) was necessarily thin also. Such windows are found in the greater number of Italian campaniles and Romanesque towers, as well as in many Romanesque triforium arcades. To decorate the tympanum, piercing was an obvious and simple method. The result was the germ of tracery. (See ROMANESQUE ARCHITECTURE.)

Plate Tracery is found in early Gothic work both in France and England. In its simplest forms the tympanum is pierced with a single opening, usually circular, but occasionally taking a four-lobed or quatrefoil form. The points between the lobes, known as cusps, later became an important element in much Gothic ornament. In time, greater elaboration was sought by increasing the number and complexity of the piercings, and thus both the size and beauty of the entire unit. The climax of plate tracery appears in France in the group of magnificent windows of Chartres cathedral (1194–1212); and in England in the rose window (*q.v.*) at Lincoln cathedral (1220), known as the Dean's eye. (See GOTHIC ARCHITECTURE.)

Bar Tracery.—As skill in stonecutting and desire for complexity increased, the area of the tympanum. wall left solid grew continually smaller, finally leaving only thin bars of stone separating the adjacent openings. Moreover, in Notre Dame cathedral. Paris, certain small, interior, round windows constituting a sort of upper triforium in the original design, carried decorations of little inverted arches built of stone—a sort of rudimentary tracery. About 1220 the next ineviiable step in the development was taken, and a window was considered not as a group of lights carrying a little piece of pierced tympanum wall, but as a group of lights where arches are formed of a bar of stone similar in section to that of the mullion or support between them, with the space between these arches and the enclosing arch—the old tympanum—occupied by a pattern of similar stone bars. In early work this pattern usually consists of a circle, sometimes cusped, tangent both to the enclosing arch and to the small arches of the lights below it. The cusps are usually of the type known as soffit cusping, cut on separate pieces of stone set into grooves in the inner faces of the circle.

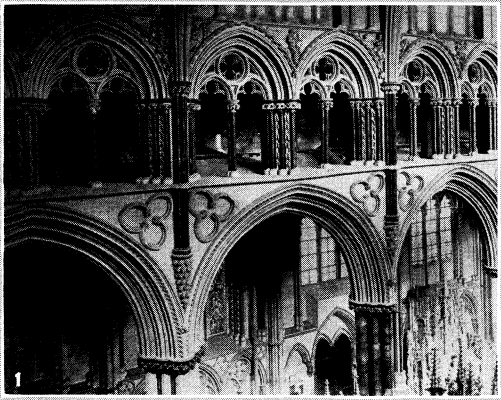
French **Rayonnant** Tracery.—In France. bar tracery occurred in the rebuilt clerestory of Notre Dame (between 1220 and 1230) in the simplest possible form. and in a more developed type, with cusps. in the apse chapels of Reims cathedral (prior to 1230). From about 1240 on, it became common, rapidly increasing in lightness and complexity. In general, the pattern types are restricted. There are two, three or four lights. In two-light windows, a single cusped circle is the crowning feature. In three-light windows three smaller cusped circles fill the space above. Four-light windows are formed of two 2-light windows. with an additional cusped circle above. In France the spring of the arches of the lower lights is kept far below that of the enclosing arch, so that the crowning circle is large. During the late 13th century, curved-sided triangles, and trefoil and quatrefoil forms, without enclosing circles, were occasionally used. In four-light windows, the central mullion is often heavier than the side mullions, both in depth and width, and this additional size carried around the enclosing arches of the side pairs. This heavier bar has a section or profile. part of which is a duplicate of the smaller bars or mullions. Thus tracery of two planes and two molding types was developed—one, that of the smaller bars, and the other, that of the larger. Each molding-type plane is known as an order, and such a window is said to have tracery of two orders. The climax of French Rayonnant tracery can be seen in St. Urbain at Troyes (1270), Ste. Chapelle in Paris (1246–48) and St. Nazaire at Carcassonne (early 14th century). Rose windows, such as those of Notre Dame at Paris (c. 1270). designed with radiating patterns using similar combinations of forms—arches. circles: cuspings, etc. —are perhaps the most remarkable traceried windows of this style. During the later Rayonnant period. tracery forms came to be used decoratively, for wall surfaces, pinnacles, gables, etc. Especially noteworthy is the filling of the gables of porches, above the door arches, with tracery forms. At first this was done simply, with little piercing; later, as in the Portail des Libraires, at Rouen cathedral (c. 1280), the gable became a mere decorative screen of lacelike open tracery. French Rayonnant tracery was the controlling influence in all continental tracery outside Italy. (See RAYONNANT STYLE.)

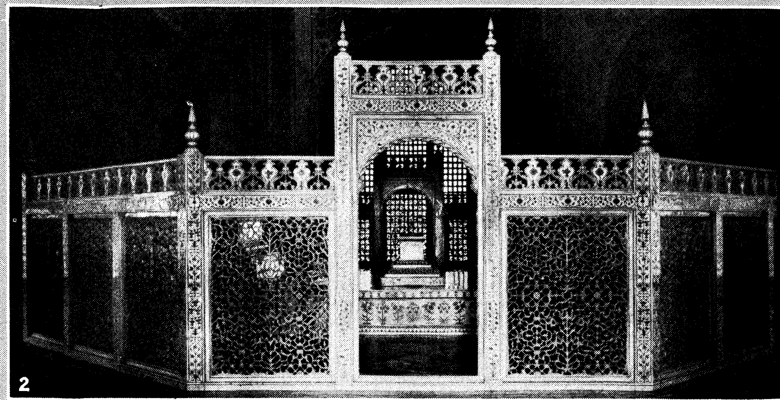
English Geometric Tracery.—Based on the same simple arch, circle and cusp forms as the French tracery, the English geometric tracery is infinitely richer and more varied. The great east end and west windows of the cathedrals allowed the development of four-. 'six- or eight-light windows, designed in two or three orders, carefully systematized, like the east window of Lincoln cathedral (c. 1280), in eight lights with three orders. But the greatest change was in single-order windows of smaller size. In these the use of cusps without circles became common, and all sorts of star-shaped, triangular and other geometric forms occurred.

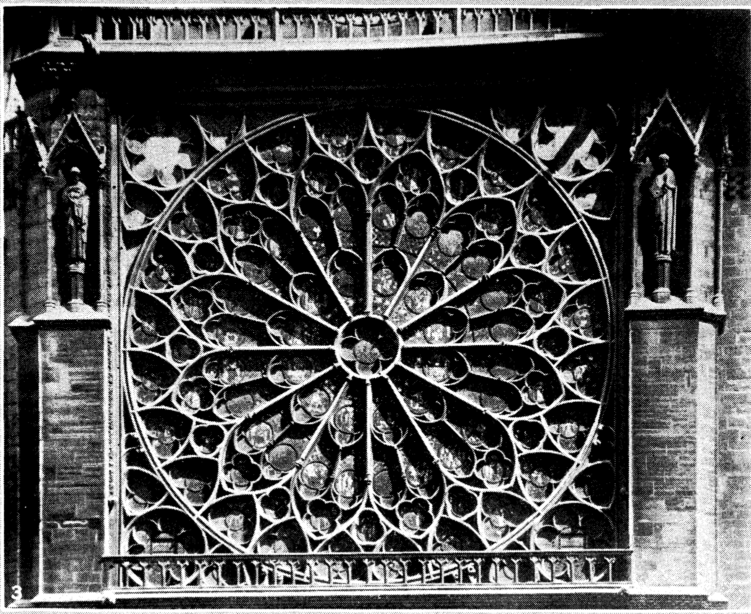
English Curvilinear Tracery.—In the early years of the 14th century the English architects discovered that by the use of the ogee curve, or curve of double curvature, the occasional harsh angularities of the geometric style could be avoided, and wavy-lined tracery of great beauty produced. This gave rise to the so-called curvilinear tracery. Its simplest form is the reticulated, or network window in which the entire upper part is filled with a regular all-over pattern of waving bars, rhythmically tangent and then separating. But the introduction of the reverse curve set free the imagination of the designer, and an infinite number of varying types resulted, such as the rose window at Lincoln cathedral (1350), or the great west window at York (c. 1338). (See DECORATED PERIOD.)

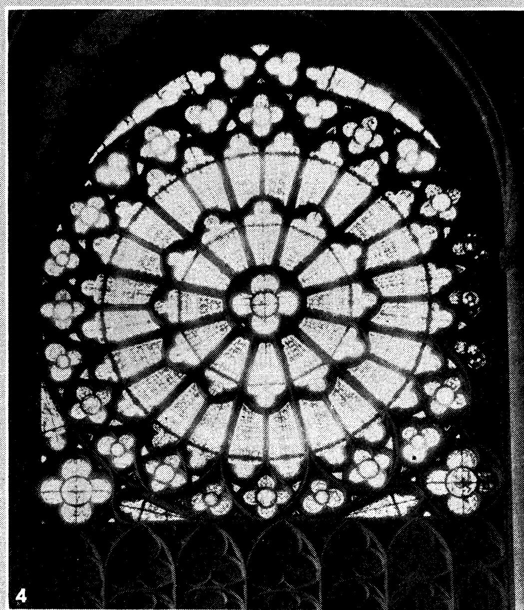
Perpendicular Tracery.—By the end of the third quarter of the 14th century a reaction had set in against this flowing curvature, and the 15th century saw the new style—the so-called Perpendicular—triumphant. It was based on one controlling idea—verticality. Mullions were run through unbroken from bottom to top. At intervals they were connected by horizontal bars running across the window, supported on little arches between the mullions, thus dividing the whole window into tiers of little arch-headed lights. At the top there was great variety of treatment, but almost always the upper lights were smaller than those below; and there was frequent use of curved bars intersecting the verticals, and to some extent recalling the arched forms of the earlier styles. This new feeling appeared in the transept window of Gloucester cathedral as early as 1335, and in a more developed form in the east window of the choir, which fills the entire east end, about 1350. During the 15th century the lines became more and more rectangular and the window heads had flatter and flatter arches. The climax of this development was reached in such enormous end windows as those of the King's College chapel, Cambridge, and St. George's chapel, Windsor (c. 1525).

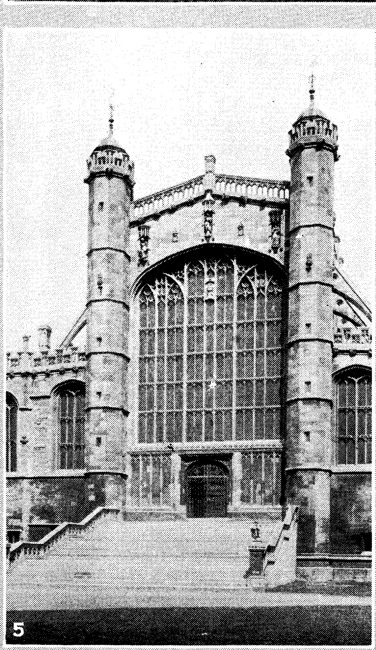
Wall tracery of Perpendicular character was widely used both for exterior and interior work during the 15th and early 16th











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EXAMPLES OF TRACERY

1. Geometric decorated English Gothic tracery; Angel Choir, Lincoln Cathedral, 1250–80. 2. Mogul pierced marble tracery; screen in the Taj Mahal, Agra, India, 1632. 3. Rayonnant French Gothic tracery; transept rose window, Notre Dame Cathedral, Paris, c. 1270. 4. Rayonnant French Gothic tracery; rose window from St. Nazaire, Carcassonne, France, beginning of the 14th century. 5. Perpendicular English Gothic tracery; west front. St. George's Chapel, Windsor, begun 1474. 6. Early Perpendicular English Gothic tracery; east window, York Minster. 1408. 7. Curvilinear Decorated English Gothic tracery; west front, York Minster, 1338

centuries. Great areas were sometimes filled with tiers of traceried panels. as in the Henry VII chapel, Westminster abbey (begun 1502). In some cases, where flint was common, a tracery of cut stone, filled in with dark flints. was used to decorate church exteriors, as in Long Melford church and St. Laurence at Ipswich. Traceried forms were also the basis of much screen, stall and tomb design of the 1jth century; rood screens were particularly rich. Tracery was also the basis of the decorative rib treatments of fan vaulting. (See PERPENDICCLAR PERIOD.)

French Flamboyant Tracery. — In the last years of the 14th century the reverse curve came into use in French tracery, probably as the direct result of English curvilinear models. The French, however. soon gave tracery of this kind an individual spirit. In the best Flamboyant work, such as the tracery of St. Maclou, Rouen (begun 1432). and the west front of Rouen cathedral (begun 1481), all of the forms are slimmer and more flamelike than is usual in English work. Particularly interesting is the application of Flamboyant tracery to rose windows. like that of the south transept of Beauvais cathedral (1500–48). in which the radiating character of the earlier types is maintained, although combined with the reverse curve. Flamboyant tracery forms the chief decoration of many gorgeous choir stalls and screens. The screen at Albi (c. 1500) has tracery of unbelievable lacelike delicacy in its canopies, as well as larger patterns covering wall surfaces; the wood choir stalls of Amiens (1508–19) are even more delicate and the tracery is of the utmost richness and intricacy. Noteworthy, also, is the application of Flamboyant tracery forms to exterior detail. as in the porch of St. Maclou, Rouen, and the west front of St. Wulfran at Abbeville (1480). (See FLAMBOYANT STYLE.)

Italian Tracery. — The Italians lacked understanding of Gothic structural principles and tracery never achieved in Italy the logical development of the north. The nearest approach to this is in the bands of tracery of Venetian palace windows, such as those of the Ca' d'Oro (1430), by G. and B. Bon. Elsewhere, tracery was only understood as beautiful pattern, and much oi it, even when copying the forms of bar tracery, is pierced from large sheets of marble. as in the triforium of the cathedral at Lucca (c. 1400) and the cloister of Sta. Maria della Verita. at Viterbo.

Tracery in the Orient. — The Islamic designers not only followed Byzantine precedent in using pierced marble screens for windows but also, by the development of a new technique, invented a characteristic type of tracery. which combined the functions played by both leading and stone tracery in western work. This technique consisted in filling the window area with a pierced sheet of cement, each piercing being filled with a piece of coloured glass. Results of jewellike intensity and brilliance were thus obtained, and being made of a plastic material, tracery of this type could have unlimited variety of pattern. The usual types found were basically floral. with the leaf shapes in glass, carefully arranged to give a sense of flow and growth. Such cement tracery is found particularly in the later work of Cairo. such as the mosque of Barkouk (c. 1384) and in the imperial Turkish work, such as the brilliantly jeweled windows in the 17th-century mosque of Suleiman. Constantinople. In India. where ventilation is required, rather than floods of light. a different type was developed, without glass, and in a richer material—carved and pierced marble. Thus, in almost all of the great Mogul palaces, and in many of the tombs, large, pointed arch openings are filled with sheets of white marble, pierced in the most elaborate patterns, of the finest scale. The most delicate example of this pierced. marble tracery is that of the screen around the sarcophagi in the Taj Mahal (*q.v.*), at Agra (1632–4i). (See also ISLAMIC ARCHITECTURE; STALACTITE WORK; INDIAN XRCHITECTURE.)

Modern Types. — Church architects of the 20th century, working, frequently, in a modernized Gothic style, found in tracery a congenial means of free expression. Both geometric and curvilinear forms furnished inspiration, but patterns of a freshness and individuality frequently quite different from the medieval custom were developed. Foliated ornament was frequently added to the tracery basis. One modern development was the use of precast cement tiles. pierced in geometric patterns and glazed, built up into large windows, as in the church of Notre Dame at Raincy, Fr. (1924). by Perret Frères. Screens perforated with tracerylike patterns became widely admired around mid-century, notably in the work of Edward D. Stone, as in the U.S. embassy at New Delhi, India (begun in 1956). (T. F. H.; X.)

TRACHEOTOMY, the operation of opening the trachea or windpipe (*see* RESPIRATORY SYSTEM, ANATOMY OF) and inserting a tube to provide a means of breathing when the natural air passage is obstructed above this level by injury, disease or foreign bodies. The operation is not easy when performed on a small child. for the windpipe is deeply placed among important structures. The chief anxiety is in connection with hemorrhage, for the vessels are large and generally overfull because of the impairment of the respiration. Formerly. it was frequently performed in diphtheria (*q.v.*) but since the introduction of diphtheria antitoxin it has rarely become necessary.

TRACHIS, a city of ancient Greece, at the head of the Malian gulf in a small plain between the Xsopus and Melas rivers. enclosed by Mt. Oeta which there descends close to the sea and at the Trachinian cliffs commanded the main road from Thessaly. The position was well adapted as an advanced post against invaders from the north, and furthermore guarded the road up the Asopus gorge into the Cephissus valley. Its citadel, Heracleia, was a subject of dispute between the Spartans and the Thebans at the end of the jth century B.C. In Strabo's time the citadel alone was inhabited.

BIBLIOGRAPHY.—Strabo p. 428; Herodotus vii, 198–203; Thucydides iii, 92, v, 51–52; Diodorus xiv, 38, 82; Livy xxxvi. 22–24. W. Leake, *Travels in Northern Greece*, iii, 24–31 (1835); G. B. Grundy, *Great Persian War*, pp. 261–264 (1901).

TRACHOMA is a chronic inflammatory disease of the eye caused by *Chlamydia trachomatis*, one of the largest viruses. The conjunctiva becomes thickened and roughened and extension of the disease to the cornea may cause scarring leading to opacity and blindness. Transmission occurs during the acute stage by infective ocular secretions transferred by personal contact or by some indirect means such as use of a common towel. Trachoma is seen especially under conditions of poverty, crowding or poor sanitation and is oiten complicated by other eye infections of bacterial origin. One of the oldest diseases known to man, trachoma is present in most areas of the world but is especially prevalent in parts of Asia and north Africa. In the United States. most cases are now seen in a few restricted localities, particularly among native Indian populations. The sulfonamide drugs, as well as some of the antibiotics. are curative provided treatment is sustained over a sufficiently long period. Efforts initiated by the World Health organization to promote mass treatment in selected areas may be expected to advance the control of this disease. Beginning in 1957 an important advance occurred when it was found possible to maintain the virus by culturing in the tissues of embryonated chicken eggs. (F. B. G.)

TRACHYTE, a light-coloured. very fine-grained to dense volcanic rock composed chiefly of alkali feldspar (*q.v.*) with minor amounts of dark (mafic) minerals such as biotite, amphibole or pyroxene (*qq.v.*). Compositionally trachyte is equivalent to the plutonic rock syenite (*q.v.*).

Rapid cooling and solidification of trachytic lava produces the fine texture of the ground mass, and cooling may be so rapid locally that small quantities of glass are formed. Most trachytes show porphyritic texture in which abundant, large, well-formed crystals (phenocrysts) of early generation are embedded in a very fine-grained matrix. The phenocrysts are usually sanidine, a glassy potash feldspar commonly rich in soda. and may range up to one or two inches across. Smaller phenocrysts of mafic minerals may also abound.

Like many volcanic rocks, trachyte shows a streaked or banded structure due to flowage of the congealing lava. This structure may be revealed by a conspicuous parallel arrangement of large tabular phenocrysts. Microscopic examination of thin slices shows the fine matrix to possess trachytic texture in which tiny lath-shaped sanidine crystals are closely packed in parallel fashion and form lines of flow more or less wrapping around the large phenocrysts. Where the tiny feldspars exhibit a stumpy or square outline, the texture is known as orthophyric.

Two types of trachyte are commonly recognized. In potash or normal trachyte, sanidine or orthoclase is the dominant feldspar, and the plagioclase is generally oligoclase. In soda or alkali trachyte the alkali feldspar and mafic minerals as well are rich in soda. As the ratio of alkali feldspar to plagioclase decreases, trachyte passes into latite. The constituent sanidine possesses peculiar optical properties which can be detected under the microscope and which mark the mineral as a high-temperature phase. Orthoclase, considered to be a sanidine partially converted to a low-temperature phase of potash feldspar, is also common in trachyte.

Brown biotite is a common mafic constituent, and the flaky grains are often observed to be so intensively resorbed that nothing remains but patches of dusty magnetite outlining the earlier crystals. Amphibole is also common and may be represented by somewhat corroded or resorbed hornblende in normal trachytes and by soda-rich varieties (arfvedsonite, barkevikite and riebeckite) in alkali trachytes. Normal trachytes may carry diopside; whereas alkali types may show pyroxene crystals with diopsidic cores surrounded by concentric shells and zones progressively enriched in sodium and iron (aegirite). Accessory minerals include zircon, apatite, sphene, ilmenite and magnetite.

Silica-rich trachyte may carry small amounts of quartz which is interstitial to feldspar; whereas tridymite and cristobalite are commonly found lining the small cavities which developed as expanding gas bubbles in the molten lava. With increase in content of free silica, trachyte passes into rhyolite (*q.v.*). Marked decrease in silica favours the formation of silica-deficient minerals (feldspathoids) such as leucite, nephelite, sodalile and analcite. As the quantity of feldspathoids increases, trachyte passes into phonolite (*q.v.*).

Trachyte is a widespread but not abundant volcanic rock and is most commonly associated with other lavas in volcanic regions. There the trachytic lava is believed to have formed from a basaltic one by the crystallization and abstraction of large quantities of minerals rich in iron, magnesium and calcium. Contamination of certain lavas by incorporation of foreign rock material may be a factor in the formation of some trachytes. Some trachytic rocks, notably certain keratophyres, may have been converted from andesitic rocks by chemical changes involving the removal of calcium and introduction of sodium. Such a substitution could increase the ratio of alkali feldspar to plagioclase.

Trachytic rocks formed in sills and dikes are generally rich in phenocrysts and are represented by various types of porphyry (*q.v.*).

An average chemical analysis (in weight per cent) of trachyte is as follows: SiO_2, 60.68; Al_2O_3, 17.74; Fe_2O_3, 2.64; FeO, 2.62; MgO, 1.12; CaO, 3.09; Na_2O, 4.43; K_2O, 5.74; H_2O, 1.26; and TiO_2, 0.38.

See also OBSIDIAN; PUMICE. (C. A. CN.)

TRACK AND FIELD SPORTS, called athletic sports in England and other parts of the British Commonwealth, consist of competitions in running. jumping and throwing various objects.

The following article is concerned with a brief outline of the events of a track and field meet; the origins and early history of the sports and their development and organization during the 19th and 20th centuries. There is also a section dealing with women's track and field sports.

For a fuller discussion of the individual events see the separate articles RUNNING; POLE VAULTING; DISCUS THROWING; PENTATHLON; etc.

MODERN TRACK AND FIELD

Events. — Modern athletic events are best divided into eight main categories. On the track these are the sprint events up to 300 yd.; the middle distances from 400 m. (437.44 yd.) to 10,000 m. (6 mi., 376.12 yd.); the long distances, notably the marathon; the hurdling events and the steeplechase; and the relay events. In the field there are the four standard jumping events (pole vault, high jump, broad jump and hop, step and jump) and the five throwing events (shot-put, weight, discus, hammer and javelin). In a category of its own is the decathlon which comprises ten varied events in a two-day trial.

Field and Equipment. — Inmodern meets, the track events are run on a surface of cinders, clay, plain dirt or grass. The field events are usually staged on the infields of the tracks or on an adjacent grass field. Firm runways and soft landing pits are needed to avoid injury in the jumping and vaulting events. Hard-surface circles of exact measurement are used for putting the shot and throwing the weight, discus and hammer. Since running to develop momentum is permissible in javelin throwing, a hard-surfaced or grass runway is used with a line at its end serving as a base from which to measure the throws.

Indoor Track. — Indoor tracks, for other than training purposes, are featured in the U.S., France, the German Federal Republic, Great Britain and the U.S.S.R., but indoor performances are not recognized for world record consideration. During the winter months meets are held either on the dirt, cinder or clay floors of university field houses; on the hard, flat floors of armouries or on specially built oval wooden tracks, banked on the turns, in the arenas of major U.S. cities. The sizes of these indoor tracks vary from 8 to 12 laps to the mile. An eight-lap track is the minimum for U.S. indoor record consideration.

Purposes. — In addition to being used for competition, track and field sports are also used as developers of strength and stamina. The armed forces of several countries sponsor track and field sports, supplying the equipment and fields required. The U.S. armed forces conduct track and field meets at most training camps and bases, leading to annual intraservice championships.

Organization. — Amateurism rules for the most part in track and field. A few attempts to promote professional track meets in the U.S. were short lived, and only Scotland and Australia remain as havens for a handful of professional performers (see also AMATEUR).

The International Amateur Athletic federation (I.A.A.F.) is the world-wide organization for amateur track and field sports. Each country sponsoring track and field sports has its own national organization which sends representatives to the I.A.A.F. The U.S. organization is the Amateur Athletic Union of the United States (A.A.U.). The organization for the United Kingdom is the British Amateur Athletic board (B.A.A.B.).

A minimum of paid workers are employed, the majority of the organizational and officiating work necessary to conduct track and field sports, up to the international level, being done by volunteers. Most national organizations exist on registration and sanction fees, individual and group donations and net receipts from their own promotions. Government grants are used in some nations.

HISTORY

The actual movements in the various events of track and field sports go back to the efforts of primitive man to survive. With no truly effective weapons available, earliest man had to develop speed of foot, muscular power, dexterity of motion and the ability to jump and leap in order to evade his natural enemies. When not doing these things to save his own life it can be assumed that he practised with his fellow men in order to improve his skills. From such practice the idea of athletic competition may have emerged.

EARLY DEVELOPMENTS

Classical Athletics. — The first trace of track and field sports goes back to various sports cultivated before the Christian era by the Egyptians and several Asian countries. Greece played a part (see GAMES, CLASSICAL; OLYMPIC GAMES) and the Irish, too, had a great festival known as Lugnas, or the Tailtean games, celebrated several centuries B.C.

Many believe the ceremonies of the Olympic games, including some track and field events. started in the 14th century B.C. and historical records were kept from 776 B.C. The games survived the conquering of Greece by Rome and were carried on until 394 A.D., when they were abolished by order of the Roman emperor

Theodosius.

Middle Ages.—Following classical times, the next record of track and field sports is not found until A.D. 1154 when athletic practice fields were provided in London.

Affecting the development of track and field in medieval England was a ban against athletic events promulgated by Edward III because they interfered with archery. Athletics were permitted again in the following century and were generally approved from the reign of Henry VIII, who was himself proficient in throwing the hammer.

Great Britain

Early Meets.—Distance races for cash stakes flourished in England at the start of the 19th century. Amateur races were held at Uxbridge in 1825 and also at Lord's cricket ground, London. Eton college originated a 100-yd. hurdle race in 1837 and added sprints and a steeplechase in 1843 in connection with its interclass athletics.

The first regularly organized athletic meeting of modern times in England was promoted by the Royal Military academy, Woolwich, in 1849. A year later Exeter college. Oxford, inaugurated sports which continued annually. The Exeter college meeting was undoubtedly the precursor of the Cambridge sports. founded in 1857, and the Oxford sports which were begun in 1860. The Oxford and Cambridge meetings commenced in 1864 and the English championships in 1866.

The second Royal Military academy meet in 1850 brought the first perpetual trophy for the team winning the most events. It was a silver bugle presented by Captain Eardley-Wilmot. Events at the Exeter college meet that year were: 100. 330 and 440 yd., 1 mi., 140-yd. hurdles. The high jump and broad jump were added in 1851.

In 1852 Kensington grammar school began to hold regular meets. Harrow. Cheltenham college and Durham university followed a year later. and from these early meets athletics in English schools continued to grow. This reached its climax in the Public Schools Challenge cup meeting promoted annually by the London Athletic club (L.A.C.), which came into being in June 1863 under the name of the Mincing Lane Athletic club. a majority of the founders having their businesses in that centre of London trade.

The Amateur Athletic club was formed in 1866 to "supply the want of an established ground upon which competitions in amateur athletic sports might take place between gentlemen amateurs." It conducted the first English championship meet that year although the active athletes continued to ally themselves with the L.A.C. rather than the A.A.C.

The Amateur Athletic Association.—The year 1879 marked a point of cleavage and two championship meetings were held. One was promoted by the A.A.C., which had previously been in the habit of holding its championships immediately after the Oxford and Cambridge sports in the spring. The other was held later in the summer under the L.A.C. for the greater convenience of non-university athletes. In 1880. in order to overcome the difficulties of competing in two separate championships, officers of the Oxford University club and the Northern and Midlands Amateur associations called a meeting of 40 amateur clubs. This led to the formation of the Amateur Athletic association (A.A.A.) whose objectives were to organize an annual championship meeting and improve management of sports meetings.

The A.A.A. championships, open to foreigners as well as British amateur athletes, were held every year thereafter apart from war years. With the growth of athletics in Great Britain. championships came to be held in the various events on a county basis leading to the area championships, athletes reaching a specified standard being allowed to compete in the A.A.A. junior and senior championships.

Other Meets.—Annual national meetings are also held by the affiliated associations for the army, banks, civil service, hospitals, insurance, police, Royal Air Force, Royal Navy, schools of all grades. universities and various youth organizations. In addition, most athletes belong to athletic clubs whose membership is open to athletes, irrespective of trade or profession, and is drawn mainly from those living in a specific locality.

The Oxford and Cambridge sports were held regularly after their inception, apart from war years, and in 1920 there was instituted an annual relay meeting between the two universities. Relay colours instead of blues (school athletic badges) are awarded for this match, which comprises 440 and 880 yd., 1 mi., 2 mi., 4 mi., 480-yd. high hurdles (42 in.) and 880-yd. low hurdles (24 in.). Four runners, each covering a quarter of the distance, represent each university in each event.

Challenge Cups.—While championships were abandoned in Great Britain from 1914 to 1919 because of World War I, athletic meetings of a sort continued to be held. The L.A.C. contrived to carry on the Public Schools Challenge cup meeting right through the war, thus assuring Great Britain the nucleus of a fine supply of athletes of international standing when the days of war ended. This Public Schools Challenge cup meeting, which did more than anything else to induce British boys to pay more attention to athletics, commenced in 1890. in which year C. H. Mason presented a quarter-mile challenge cup to be competed for annually by public-school boys at an L.A.C. meeting. In subsequent years other cups were given, and in 1897 a number of L.A.C. members presented public schools challenge cups to commemorate the diamond jubilee of Queen Victoria. This meeting became the most important fixture in the public-schools season.

The Four-Minute Mile.—While England played host to the Olympic games in 1908 and again in 1948, perhaps the greatest day in England's impressive athletic history came on May 6, 1954. On that day Roger Bannister, a medical student who finished fourth in the 1,500-m. run at the 1952 Olympic games, achieved the long-sought goal of running the mile in four minutes or less. racing the mile around the Oxford track in 3 min. 59.4 sec. Although that mark stood as a world record for only 46 days—being reduced to 3 min. 58 sec. by Australian John Landy on June 21, 1954, at Turku, Fin.—it was England's most impressive athletic achievement to that time and was hailed throughout the world.

United States

Early Athletic Clubs.—It is taken for granted that track and field events were informally introduced into the United States by athletes migrating from Great Britain. However, the start of amateur competition is credited to the New York Athletic club (N.Y.A.C.), which was founded in 1868 and conducted the first U.S. track and field meet, indoors, on Nov. 11 of that year. A Caledonian sports program was held in New York city the previous year, but the only track and field report on it is that the pole vault was won with a vault of 9 ft. 3 in. Organized in 1860, the Olympic Club of San Francisco is considered to be the first athletic club in the U.S., but it did not enter a team in track and field competition until 1877. The year 1876 was one of significance with the first U.S. National Amateur championships, the first Intercollegiate Association of Amateur Athletes of America (I.C.4-A) meet, and with Horace H. Lee of the University of Pennsylvania becoming the first American to run 100 yd. in 10 sec.

Full credit for the birth of track and field competition in the United States is rightfully given to the New York Athletic club. The start of this club, according to its historical documents, was a meeting of three former soldiers of the Civil War on June 17, 1868. They were John C. Babcock, William B. Curtis and Harry E. Buermeyer. The club was officially organized on Sept. 8 with 14 charter members.

Only two short months after its organization, the N.Y.A.C. sponsored the first set of games open to amateurs ever held in the United States at the new Empire City skating rink at Third avenue and 63rd street. The building lacked a roof which necessitated spreading canvas as a temporary cover. Since a floor had not as yet been laid in the building, an eight-laps-to-a-mile running track was staked out on the firm ground in the centre of the rink. The first pair of spiked running shoes seen in the U.S. was worn by Bill Curtis at this meet and loaned by him to some friends competing in other events.

The N.A.A.A. and **A.A.U.**—The first meets to be considered national outdoor championships of the U.S. were sponsored by the

N.Y.A.C. at its Mott Haven grounds. 155th street and the Harlem river, in 1876, 1877 and 1878. The N.T.A.C. won the team championship in all three meets.

Early in 1879 the N.Y.A.C. decided to give up the management of the national championships and started the movement which led to the formation of the National Association of Amateur Athletes of America. The clubs forming the organization were: American A.C.. New York city; Clinton A.C., Brooklyn; Elizabeth A.C., Elizabeth, N.J., Empire City A.C., New York city; Harlem A.C., New York city; Jersey City A.C., Jersey City: N.J.; Manhattan A.C., New York city; New York A.C., New York city; Olympic A.C., San Francisco; Plainfield A.C., Plainfield, N.J.; Scottish American A.C., New York city; Short Hills A.C., Short Hills, S.J.; Staten Island A.C., New Brighton, N.Y., and Union A.C., Boston, Mass. The first championships conducted by the N.A.A.A. were at the N.Y.A.C. Mott Haven grounds on Sept. 24, 1879. The best U.S. performances on record going into those championships were: 100 yd., 10 sec.; 220 yd.. 23.75 sec.; 440 yd., 49.2 sec.; 880 yd., 2 min. 2.8 sec.; 1 mi., 4 min. 37.4 sec.; 3 mi.. 16 min. 21.5 sec.; 120-yd. hurdles, 17.25 sec.; running high jump, 5 ft. $8\frac{1}{4}$ in.; running broad jump, 21 ft. $2\frac{1}{2}$ in.; pole vault. 10 ft. $5\frac{5}{8}$ in.; shot-put, 37 ft. 10 in.; hammer throw, 87 ft. 1 in.; 56-lb. weight throw, 23 ft. $1\frac{1}{4}$ in.

The N.A.A.A. continued to conduct the national championships, all in New York city, for ten years. As a result of laxity in enforcing the amateur code, the Amateur Athletic Union of the United States (A.A.U.) took control in 1888. That brought about two championship meets that year, one by the N.A.A.A. in New York city and the second by the A.A.U. in Detroit, Mich. Annual indoor championships were started in 1906.

College Competition. — College track and field championships in the U.S. began in 1876; the pioneering body was called the Intercollegiate Association of Amateur Athletes of America. popularly abbreviated as I.C.4-A. Charter members included Amherst, Columbia. Cornell, Harvard. Princeton, Trinity, Union, Wesleyan, Williams and Yale. A month later they were joined by Bowdoin, Brown, College of the City of New York. Dartmouth and Pennsylvania. These 15 member colleges increased more than fourfold in the next 80 years and participated in outdoor collegiate track and field championships every year from 1876, except for 1917. The I.C.4-A also sponsored indoor championships every year from 1922, usually each February.

Another major national collegiate body is the National Collegiate Athletic association (known as the N.C.A.A. or N.C.2-A), with more than 300 member colleges. Though known mostly for its supervision of other sports. the N.C.A.A. plays an important role in track and field, having sponsored outdoor championships every year from 1921. Western and midmestern colleges concentrate on the S.C.A.A. annual meets rather than those of the I.C.4-A. The N.C.A.A. and the A.A.U. have an equal number of representatives on the track and field committee of the United States Olympic association.

Despite many serious attempts to standardize events in U.S. championships along the lines of the international metric system, the more cumbersome units of miles, yards, feet and inches apparently remained too deeply ingrained to be eradicated. The A.A.U. used metric measurements for the running, hurdles, steeplechase and walking events for its championships for one year in 1928 and then continuously from 1932 to 1952. The metric measurements were discontinued again beginning in 1953, with the understanding they only be used during Olympic years in order to train competitors over Olympic distances.

High School **Athletics.**—While college-trained athletes make up a high percentage of the Olympic and international U.S. track teams that have brought world domination in track and field! development in high schools has been very important. Few standout athletes were developed in colleges after 1920 without previous high school training and competition. Track and field is a national sport in U.S. high schools, teams being sponsored by schools in all states. Most of them conduct state championships in addition to local, county and sectional title competition. Bob Mathias proved an excellent example of the high grade of U.S. high school track and field performers, winning the decathlon in the 1948 Olympic games at London as a 17-year-old.

High school track and field in the U.S. is comparable to college and A.A.U. competition. The main differences are that the high hurdles are 36 in. high instead of 42. an 8-lb. shot is put instead of 16, a discus approximately a pound lighter than the college and A.A.U. implement is used and running events are limited to a maximum distance of one mile. The standard championship program includes 13 events: 100 yd., 220 yd., 440 yd.. 880 yd., 1 mi., 120-yd. high hurdles, 180-yd. low hurdles, high jump, broad jump, pole vault, discus throw, javelin throw and shot-put. Additional events held in college and A.A.U. championships are a 2-mi. run and hammer throw. National A.A.U. championships match the Olympic program with a 6-mi. run, 440-yd. medium hurdles and a 2-mi. steeplechase. These last three events are added to the annual S.C.A.A. chainpionships in Olympic years, the meet serving as semifinal trials for the U.S. Olympic team.

The National Scholastic federation, state associations and local governing groups enforce regulations to prevent coaches from using boys in too many events. Considering the physical capabilities of boys age 14 to 18, a limit of three events per entry is set in most cases. The rules are further strengthened to limit a boy to one race at 440 yd. or more or in no event more than two races by a sprinter and hurdler. The limit of three events can be reached by taking part in field events. Some organizations such as the Public Schools Athletic league (P.S.A.L.) of New York city limit boys to one race regardless of the distance. The necessity of heats in most sprints and hurdles brought this limitation.

Track and field development in the U.S. also goes below the high school age with the aid of a nationu-ide junior Olympic program sponsored by various districts of the A.A.U. and by national organizations such as the Catholic Youth organization (C.Y.O.) and the Young Men's Christian association (Y.M.C.A.).

Relay Meets. — Relay racing also holds an important place in U.S. track and field. Major relay carnivals conducted annually are the Penn relays (University of Pennsylvania), Drake relays (Drake university), Kansas relays (University of Kansas), Texas relays (University of Texas) and Florida relays (University of Florida). The first recorded relays in the U.S. were held in 1893 by Pennsylvania students. Later that year Penn and Princeton staged the first intercollegiate relay. Princeton won the 1-mi. relay in 3 min. 34 sec.

The Penn relays, inaugurated in 1895, is considered the largest relay carnival. Gradually built up through the years, this mammoth meet features eight races for colleges, four for high schools and two for prep schools. Included are a complete set of field events, a 100-yd. dash, 120-yd. high hurdles and 440-yd. medium hurdles and a 2-mi. run for college entrants. The remainder of the meet is composed of class races at a mile or less.

The Penn relay college championships are at 440 and 880 yd., 1 mi., 2 mi., 4 mi., sprint (1-mi.) medley, distance (2;-mi.) medley and 480-yd. shuttle high hurdles. Each of the four team members runs one-fourth of the distance except in the medleys. The sprint medley has legs of 440 yd., 220 yd., 220 yd. and 880 yd. in that order. In the distance medley the first man runs 880 yd., the second 440 yd., the third 1,320 yd. ($\frac{3}{4}$ mi.) and the fourth 1 mi. The shuttle hurdles are run over one strip of hurdles, with two men starting from each end. A touch off is used in the shuttle hurdles instead of a baton as in all of the other races.

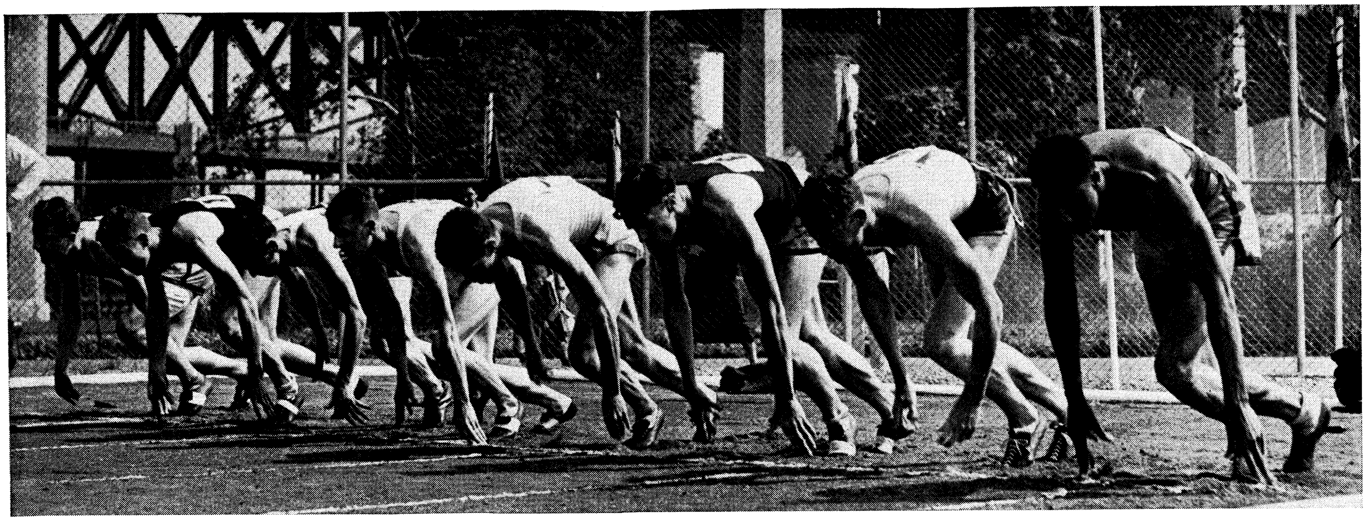
The relay idea also is used in many instances in field events. Teams of four compete against each other with the total distance or height of each team deciding the winner.

INTERNATIONAL

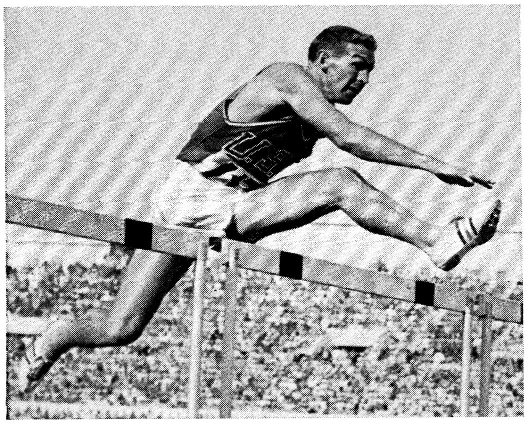
Early Meets. — Long before annual championship meetings were instituted in any country the desire to pit athletes of one nation against those of another was clearly in evidence. England was visited in 1844 by George Seward. U.S. professional runner, who achieved some signal successes, and in 1863 by Louis Bennett, called "Deerfoot," a full-blooded Seneca Indian who established running records up to 12 mi. In 1884 a team of Irish athletes, among them W. J. M. Barry, a magnificent exponent of the heavy-

TRACK AND FIELD SPORTS

PLATE I



Runners coming up from their starting positions after the gun has been fired for a 440-yd. race. In this and the short distance races, runners start from holes dug for their feet or from starting blocks to assist them in their first strides

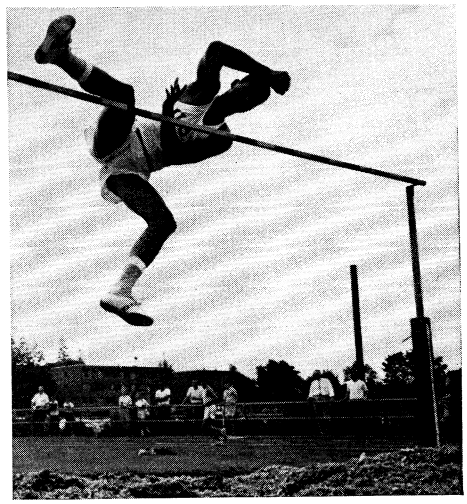


The long stretch of a champion in the 400-m. hurdles, an Olympic games event

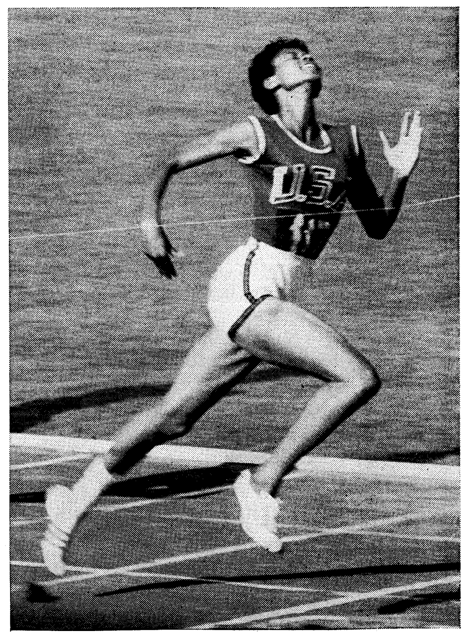
Pole vaulter just after clearing the bar. He will push the pole away from himself as he begins his fall on the far side of the bar

Championship form in the broad, or long, jump at the mid-point of the leap. Landing is usually made with feet close together, ahead of the rest of the body

RUNNING,
JUMPING
AND
VAULTING EVENTS



High jumper just after making his leap up to the bar. A moment later he will have raised his lower leg and brought his back up parallel to the bar

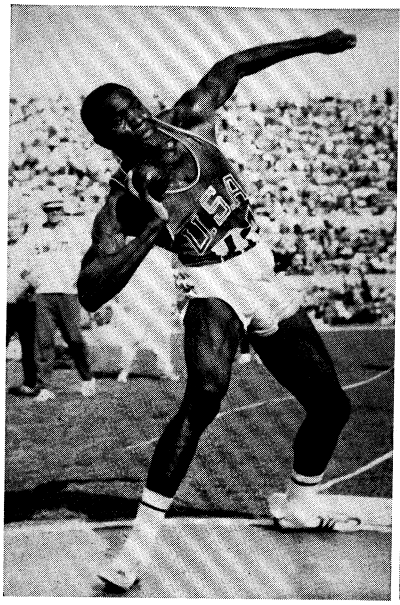


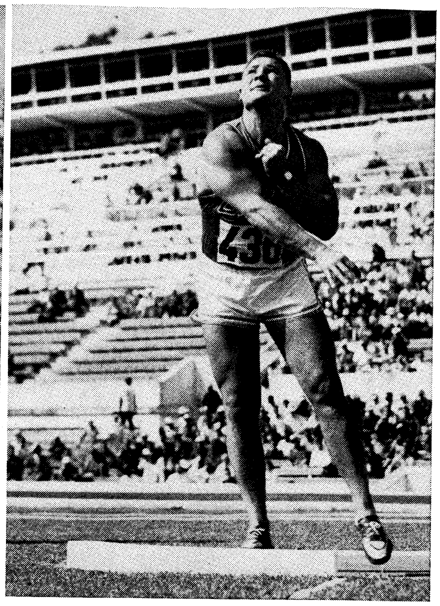
Hitting the tape in full stride at the end of the 100-m. sprint in Olympic competition

PHOTOGRAPHS, (TOP) UNITED PRESS INTERNATIONAL; (CENTRE LEFT, CENTRE, BOTTOM LEFT) WIDE WORLD, (CENTRE RIGHT) ARTHUR RICKERBY—PIX FROM PUBLIX, (BOTTOM RIGHT) MARK KAUFFMAN, COURTESY "LIFE © 1960 TIME INC.

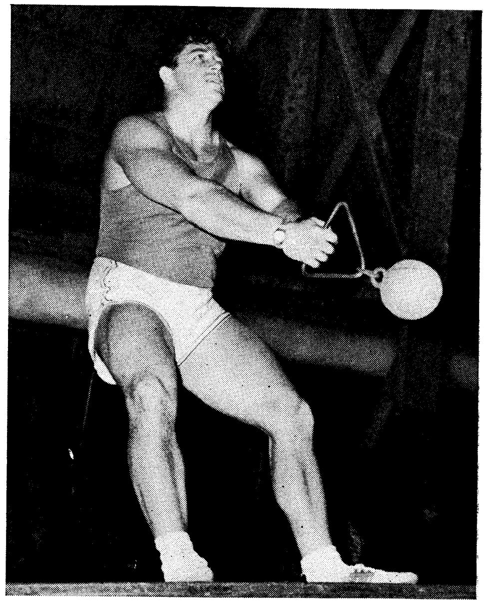
PLATE 11

TRACK AND FIELD SPORTS

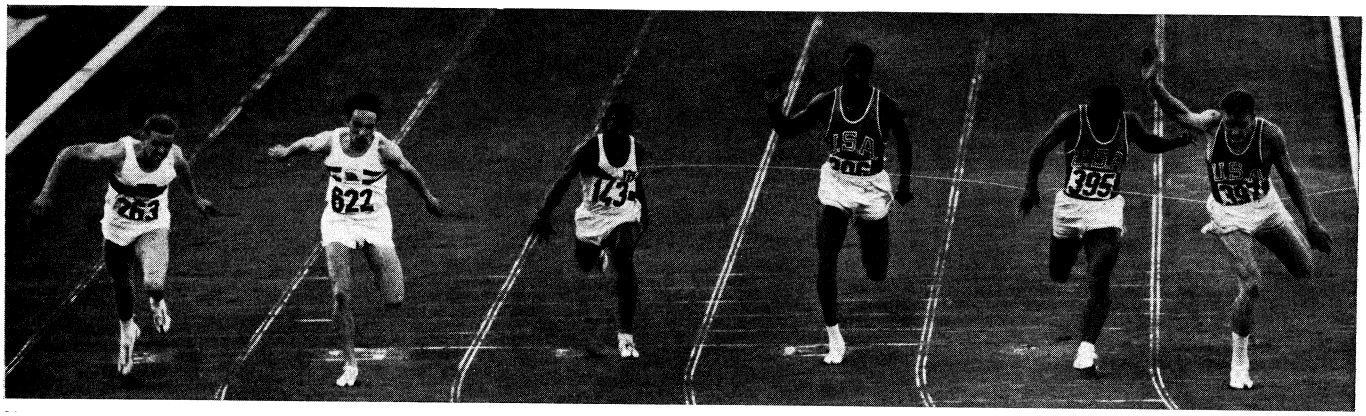




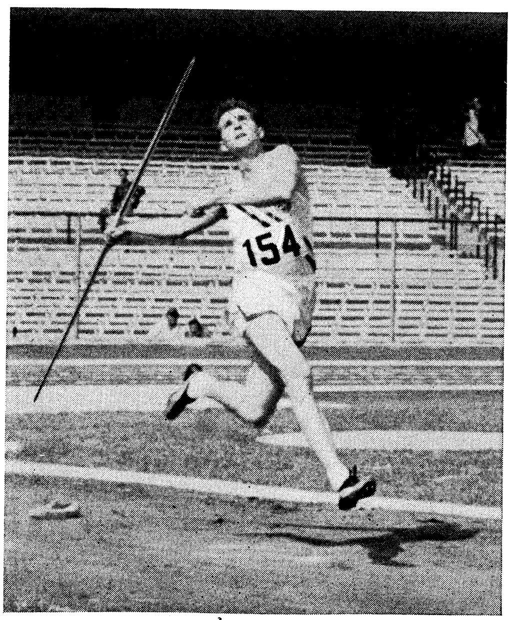
Two views of the form employed in putting the shot. At left is the position just before the weight is released; at right, position of the arms and legs in the follow-through, after the shot has been hurled



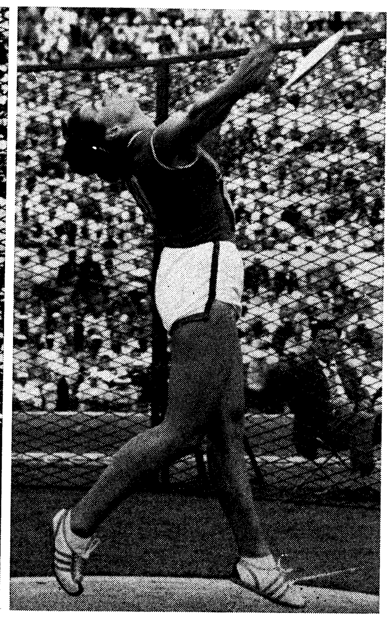
Winding up for the 35-lb. weight throw. The athlete makes several complete turns in a circle before releasing the weight



Close finish in a 100-m. Olympic race, showing all six competitors reaching the tape almost simultaneously with the winner, left



The run-UP in preparation for the javelin throw. As the athlete's right foot touches the ground, he will complete cocking his arm, set his feet and throw



Two views of the discus throw. Left, the half-turned, bent-knee position of the athlete as he prepares to throw. At right, competitor in the women's events at the moment of release of the discus after a one and three-quarter turn

RUNNING AND THROWING EVENTS

PHOTOGRAPHS, (TOP LEFT. TOP CENTRE. TOP RIGHT. CENTRE, BOTTOM RIGHT) WIDE WORLD (BOTTOM LEFT) GUILLERMO GUZMAN WEST, MEXICO. (BOTTOM CENTRE) UNITED PRESS INTERNATIONAL weight field events, visited Canada and won several championships, In 1888 the Manhattan Athletic club sent a team to England and the Gaelic Athletic association dispatched a team to the U.S. In 1890 the Salford Harriers were the guests of the Manhattan A.C. in New York, and the following year the Manhattan athletes went again to England. The first matches of a truly international character occurred, however, in 1894 and 1895 and were arranged by the famous Yale sprinter C. H. Sherrill, who invented the crouch start. In 1894 Yale and Oxford universities met in London and the English blues proved successful by winning $5\frac{1}{2}$ of the 9 events. The following year the London A.C. took to New York almost the strongest team that could be mustered in the British Isles. They competed against the N.Y.A.C. but did not win any of the 11 events. Three world records were broken and one was equaled at this meet. Two weeks later Cambridge was defeated by Yale in the U.S. by 8 events to 3. In 1899 Oxford and Cambridge combined forces in London against Harvard and Yale, who were beaten. This match was held regularly until 1938, alternately in the U.S. and England. In 1925 Oxford and Cambridge, while in the United States for the Yale and Harvard match, held their first match against Princeton and Cornell and won by 9 points to 3. The return match in 1926 also was won by Oxford and Cambridge. The subsequent matches were held in the same year and country as the Yale and Harvard matches, Oxford and Cambridge winning three and Princeton and Cornell one. The matches were resumed in 1949 in the U.S., Princeton and Cornell beating Oxford and Cambridge, which beat Yale and Harvard. When the Oxford and Cambridge team visited the U.S. in the years 1953–57, Army (the United States Military academy), instead of Harvard, teamed with Yale and Pennsylvania teamed with Cornell in place of Princeton.

It was from the enterprise of such bodies as the Salford Harriers, Gaelic A.A., London A.C., Manhattan A.C. and the New York A.C. and the early meetings between English and U.S. universities that the series of international matches between countries throughout the world, apart from the Olympic games and Pan-American games and the European and British empire championships, grew, until no track and field season passed without each country engaging in several international matches with one or more other countries.

The Modern Olympics.—The most important of international festivals was, however, the revived or modern Olympic games, first held at Athens in 1896. They were instituted by delegates from the different nations who met in Paris in 1894, principally at the instigation of Baron Pierre de Coubertin. The result was the formation of an international Olympic games committee, with Baron de Coubertin at its head, which resolved that the games should be held every fourth year in a different country (*see* OLYMPIC GAMES).

AFTER WORLD WAR II

The improvement of track and field was so great in the decade following World War II that as the year 1956 came to a close only two prewar world records remained unbroken, the pole vault and the broad jump. Cornelius Warmerdam of the U.S., first pole vaulter to clear 15 ft., had set a record at 15 ft. $7\frac{3}{4}$ in. in 1942, but fellow Californian Bob Gutowski, the 1956 Olympic runner-up, cleared 15 ft. $8\frac{1}{4}$ in. in 1957. Jesse Owens' 1935 broad-jump record of 26 ft. $8\frac{1}{4}$ in. stood for 25 years but fell in 1960 to another U.S. athlete, Ralph Boston, who jumped 26 ft. $11\frac{1}{4}$ in. Charles Dumas, a Californian, broke the seven-foot barrier in the high jump with a leap of 7 ft. $\frac{1}{2}$ in. to qualify on the U.S. team for the Olympic high jump at Melbourne (1956), which he won. Parry O'Brien, also of California, was the first man to break the 60-ft. barrier in the shot-put.

WOMEN'S TRACK AND FIELD

Track and field for women had a natural growth. With the entrance of modern women into business and the professions, it was only a matter of time until they would find their way into athletic competition. While women, with six contestants from two countries, competed in lawn tennis at the 1900 Olympic games (Paris), women's track and field had to wait until the 1928 games at Amsterdam. By the 1952 games at Helsinki, Fin., 41 nations were entering teams in women's track and field. Thereafter, however, there was a tendency, particularly among smaller nations, to drop the women's track and field teams or reduce them. Expense was a major factor in these decisions, some countries feeling that the cost of transporting women's teams could better be applied to provide entrants for what were considered more important or popular events.

The International Amateur Athletic federation (I.A.A.F.) was organized in 1913 to govern track and field events for men, but it consistently refused to deal with women's competition although the subject was discussed at almost every federation meeting. Because the I.A.A.F. had hesitated to accept control of women's events, a women's sports federation called the Fédération Sportive Féminine Internationale (F.S.F.I.) was formed in Paris in 1921. This federation conducted world track and field championships for women in Paris in 1922, Goteborg, Swed., in 1926, Prague, Czech., in 1930 and London in 1934, which followed the plan of the women in ancient Greek times (about 600 B.C.) who held their own contests in the third year of every Olympiad, midway between the men's Olympic games. Great Britain won the 1922 event with 50 points, the U.S. was second with 31 and France third with 29. Great Britain repeated in 1926 with 50 points, France 27 and Sweden 20. In 1930 the title went to Germany with 57 points, Poland 26 and Great Britain 19; and in 1934 it went again to Germany with 95 points, Poland 33 and England 31.

When the women's federation announced its plans to hold a world championship in 1922, the Belgian Athletic association proposed that the I.A.A.F. assume control of women's athletics as well as men's. Action was delayed until 1924 when a special commission for women's sports was appointed. This commission, together with representatives from the F.S.F.I., recommended that the I.A.A.F. delegate control of women's athletics to the F.S.F.I. under rules to be drawn up by the I.A.A.F. and that the International Olympic committee be requested to include five track and field events for women in the 1928 games at Amsterdam. First it was necessary for the I.A.A.F. to determine whether or not it would have anything to do with women's athletics. It was agreed to base the decision on the issue of Olympic participation. After considerable discussion the advocates for Olympic participation won by a vote of 12 to 5.

Many countries objected to the resultant dual arrangement for the control of women's athletics and insisted that both men's and women's competition be conducted under the management of a single federation. In 1934 Germany proposed that the I.A.A.F. take full control of women's athletics, but action was deferred until 1936, at which time the agreement with the F.S.F.I. was canceled and the women's federation was dissolved. Control by the I.A.A.F. of both men's and women's competition marked the beginning of a new era for women's athletics.

Under I.A.A.F. rules the Olympic games are the only world championships recognized for both men and women, but other competitions of international character are constantly held.

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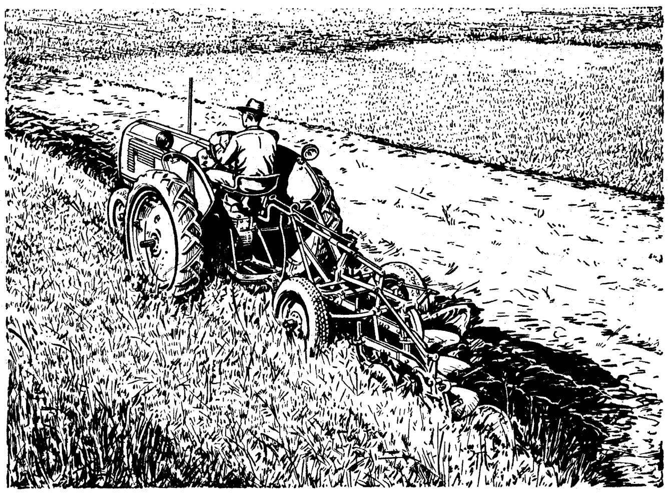
TRACTORS. The term tractor is applied to a self-propelled vehicle capable of pulling a load. A vehicle which is usually powered by an internal-combustion engine, the tractor is used on highways and in factories, but its greatest use is on agricultural land. The word was not generally known until 1906, when it was used in the advertising literature of the Hart-Parr company of Charles City, Ia., although the word had been used in describing a patent in 1890. The phrase gasoline traction engine was shortened to gasoline tractor. A power vehicle driven by steam is called a steam traction engine; the term tractor does not apply to such a unit.

Tractors can be classified according to their main function, such as farm tractors, industrial tractors and highway tractors.

FARM TRACTORS

The farm tractor has revolutionized the mode of farming wherever it has been used. It has relieved farmers of arduous work and made possible great increases in production. Through the use of the tractor, farmers can control power that is equivalent to many horses and men. The average man is rated at $\frac{1}{10}$ h.p., but when he drives a 20-h.p. tractor across his fields he is doing



COURTESY OF THE OLIVER CORPORATION

FIG. I.— PLOWING WITH A THREE-FURROW PLOW. TRACTOR EQUIPPED WITH LIGHTS FOR NIGHT WORK

the work of 200 men.

Early Development.—The tractor had its birth and its greatest growth in the U.S. In 1910 there were 1,000 tractors on U.S. farms; in 1920, 246,000; in 1930, 920,000; in 1940, 1,545,000; and by 1950. 3,615,100, In 1954 there were 4,310,091.

The tractor age or era began in 1889 in the U.S. when a single-cylinder Charter engine was installed in a steam traction engine chassis in South Dakota. During the same year, the Charter Gas Engine Co. built six such gasoline tractors. The steam traction engine era began earlier, in 1876, and reached its peak in 1912, after being beaten by contemporary gasoline-kerosene tractors in the famous Winnipeg trials (*see* below). Thereafter the number of steam traction engines declined on U.S. farms, preceding the peak and decline of farm work horses by only a few years.

In 1892 the Case Threshing Machine Co. pioneered with their first gasoline tractor. It had a two-cylinder opposed-type engine. During the same year, John Froelich produced one of the first successfully operated tractors. It was the forerunner of the Waterloo Boy and the later John Deere line. Experimentation continued as N. A. Otto, the German inventor, built and sold 15 gasoline tractors from 1894 to 1896 in the U.S. In 1897 in Great Britain, tractors with oil-burning engines were being produced.

In 1901 Charles W. Hart and Charles H. Parr built a huge, oil-cooled, slow-speed, two-cycle tractor. They sold the tractor the next year and built and sold 15 more in 1903. They were so well built that one-half of them were still in service in 1920. The Hart-Parr Co. eventually became the Oliver Corp.

In 1904 the first track-type gasoline tractor was produced in the U.S., using blocks of wood on the tracks. And the large-scale tractor industry was born in 1906 when 11 companies began production almost simultaneously.

In 1907 there were 600 tractors made in the U.S. A typical tractor of that time was used for prairie plowing. It had from 90 to 100 belt horsepower, pulled 12 to 14 plow bottoms, weighed 20.000 lb., and about one-half of its horsepower was available at the drawbar. The change from a heavy, cumbersome tractor to a lighter, more versatile tractor came in 1908 when Henry Ford placed a car engine on a light, tractor chassis.

In the period from 1908 through 1912, in Winnipeg, Can., a series of annual trials or tests of steam traction engines versus gasoline tractors were made. In the first plowing demonstration, with five steam traction engines and five tractors entered, the tractors won first and second places. This 1910 demonstration signalled the final surrender of steam power and marked the emergence of kerosene and gasoline as tractor fuels.

The first frameless tractor was introduced in 1913. This unit design became popular almost immediately. Tractors up to that time were made primarily for heavy field work, but, as the result of much earlier experimentation, the first motor cultivator for corn was introduced in 1915. The weak vear for farm horses in the U.S. was in 1918. That year also marked the beginning of mass production of farm tractors. An all-purpose, nontricycle type of tractor was also introduced in that year. In 1919 Henry Ford mass-produced a tractor which was low in cost, had an air cleaner (a novelty at that time) plus enclosed transmission gears. Its sales were 75% of the industry's total. A built-in power take-off shaft was introduced on a tractor during the year, opening a new field of power application. This first power take-off shaft was used to operate the binder.

Improvements.— In 1920 mechanical tool lifts were placed on tractors, and starters and electric lights were first used. In 1923 and 1924 the International Harvester Co. introduced a tricycle all-purpose tractor which sold extensively. This tractor had adjustable tread and mounted tools, and was well-suited for cultivating corn in the central areas of the U.S. Garden tractors first became popular in the period from 1925 to 1929.

In 1930 manufacturers began using the 14-in. plow bottom rating for their tractors. This took the place of the old rating where the symbol 30/60 meant 60 h.p. on the belt and 30 h.p. at the drawbar. By 1930 tractors. because of efficient transmission systems, were developing as much as 85% of their power at the drawbar.

In 1931 the Caterpillar Tractor Co. installed a diesel engine in their crawler tractors for the first time. In 1932 rubber pneumatic tires were used. Factors such as 25% more power, 50% more speed and 25% fuel savings as compared to steel-tire tractors made rubber tires a popular feature on tractors, and many farmers converted their tractors to rubber tires.

Ford had exported some tractors to Great Britain since 1917, but in 1933 he established a factory in that country at Dagenham for production of the Fordson tractor. About the same time, in Great Britain. the David Brown Co. began making tractors with a Ferguson-type three-point implement hitch.

By 1935 high-compression engines had been introduced in the U.S. to use the high octane (73–83) fuels that became available. Hydraulic lift equipment was added to the tractors to raise and lower cultivating equipment. In 1937 the American Society of Agricultural Engineers standardized the specifications for power take-off and drawbar systems. This made it easier to adapt different tractors to different implements. Because of the extra power being used in tractors, calcium chloride and water solutions were used in tires to provide additional weight and greater pulling ability.

Later Developments.— The age of tractor-mounted equipment began in the U.S. with the introduction of the new Ford tractor in 1939. Harry Ferguson, an Englishman and one of the greatest inventors of farm machinery, designed a three-point drawbar linkage for the tractor. The linkage and the implement could be raised and louered by a hydraulically operated rockshaft by merely moving a small lever near the tractor seat. The linkage also provided automatic draught and depth control, making it possible for a relatively light tractor to do the work of heavier tractors. During the next ten years, almost 60 different implements or attachments were developed to be mounted on farm tractors. By the 1950s almost every tractor manufacturer in Great Britain, Europe and the United States was making tractors with three-point drawbar hitches.

The continuous or independent power take-off shaft was introduced on tractors in the U.S. in 1941. Battery ignition for tractors became popular, taking the place of the more expensive and

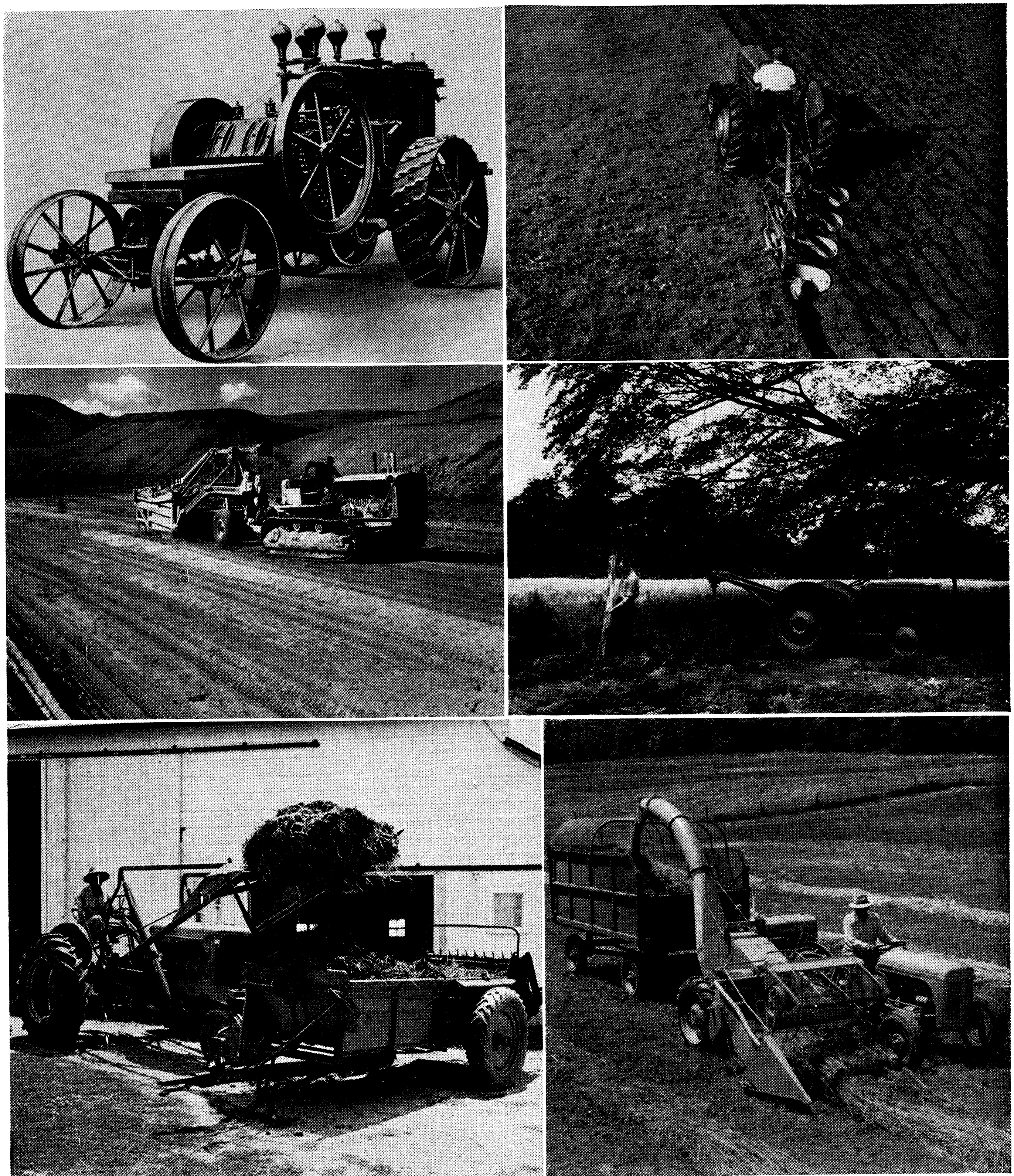
TRACTORS

BY COURTESY OF (1) KING-WYSE CO., (2) ALLIS-CHALMERS MFG. CO., (3, 5, 6) CATERPILLAR TRACTOR CO., (4) INTERNATIONAL HARVESTER COMPANY

TRACTORS IN AGRICULTURE AND INDUSTRY

1. Large garden tractor disking farm land
2. Seeding and fertilizing with a tractor-mounted grain drill
3. A tractor-pulled combine which covers $3\frac{1}{2}$–4 ac. per hour
4. Small tractor which permits unobstructed view of plants being cultivated
5. Shovel mounted on tractor loading nitrate into dump truck
6. Tractor hauling casting on industrial railwav

TRACTORS



BY COURTESY OF (TOP LEFT) OLIVER CCRP., (TOP RIGHT, CENTRE RIGHT, BOTTOM RIGHT) MASSEY-FERGUSON (GT. BRITAIN) LTD., (CENTRE LEFT) CATERPILLAR TRACTOR CO., (BOTTOM LEFT) NEW IDEA FARM EQUIPMENT CO.

TRACTOR OPERATIONS

Top *left:* "Old No. 1" Hart-Pnrr tractor, built in 1901, the first successful gas tractor built. It developed 22–45 h.p.

Top right: Farm tractor pulling a four-furrow mounted plow

Centre left: Tractor and carry-all moving earth in highway construction

Centre *right:* Digging post-holes with tractor-powered equipment

Bottom left: Tractor with mounted loader attachment loading a manure spreader

Bottom right: Side-mounted harvester and tractor pulling a forage wagon harder-to-service magnetos. Hydraulic cylinders were used to operate trailing equipment effectively and easily. During 1941 one manufacturer produced a tractor to operate on liquid petroleum gas. a gas which had become plentiful near U.S. oil-producing areas. Fuel conversion kits were manufactured and sold to convert gasoline tractors to liquid petroleum gas tractors.

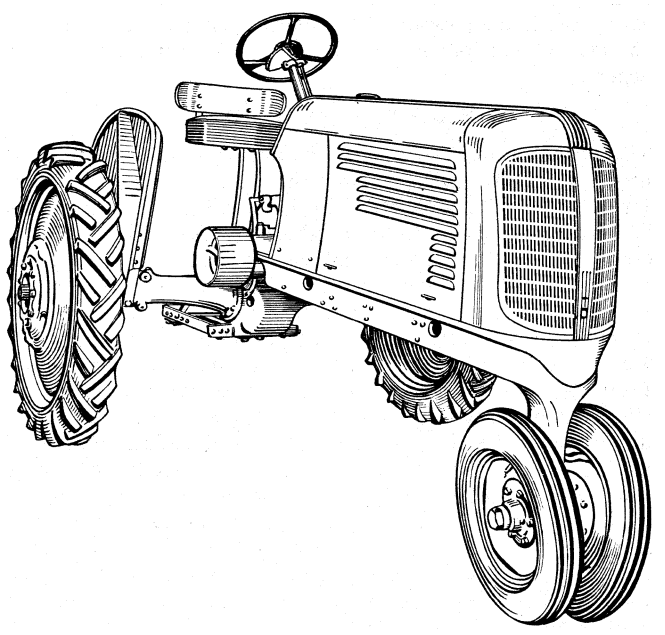
After World War II there was a tremendous increase in the use of garden tractors on U.S. farms. The year 1954 saw the introduction of trailing and mounted electrical generators on an experimental basis; the showing of an experimental tractor gasoline engine with a compression ratio of 12:1; and experimentation with tractors powered by gas-turbine engines. During that year, a British mechanized farming centre at Chelmsford, Essex, was opened to nationals of all countries. Facilities for study and discussion were provided. The great farm machinery exhibition, The Salon International de la Machine Agricole. was held in Paris, Fr.. with 130 tractor models made by 60 different manufacturers on exhibit.

The International Harvester Co. introduced a "torque amplifier" on one tractor model in 1954. This is a planetary drive unit which provides additional forward and reverse travel speeds. The tractor operator can instantly reduce travel speed 33% and at the same time increase drawbar pull up to 45% in any selected gear without stopping, declutching, shifting or touching the throttle.

Sources of Power.—An important advance in tractor farming was the introduction of mounted implements. After World War II, integral implements became popular because of greater manoeuverability, easier transportation, lower cost and ease of attachment. Mounted tools can normally be sold at lower cost since n-heels. raising and lowering devices, side. ahead and depth adjustments are largely eliminated. By the mid-1950s a mounted implement cost about 60% of the cost of a comparable trailing implement.

At first the tractor was essentially a pulling implement, delivering power by traction: But tractor pulleys have been a feature from the beginning. The X.S.X.E. standard for pulley rim speed was set at 3,100 ft. per minute. plus or minus 100. The pulley must be wide enough to accommodate a 6-in. belt.

In addition to obtaining power by traction and belt; the farmer finds the power take-off shaft desirable. In Great Britain and the C.S. the standard power take-off shaft speed n-as set at j36 r.p.m.,



COURTESY OF THE OLIVER CORPORATION

FIG. 2.—A WHEEL-TYPE TRACTOR

plus or minus 10. The shaft diameter was set at $1\frac{3}{8}$ in.. and the shaft must be located near the tractor centre at the rear. Standardization of this device permits the tractor to be used nith an assortment of machines. The independent or "live" power take-off shaft displaced the earlier transmission-operated power take-off shaft. The independent poner take-off permits the tractor operator to operate trailing power take-off implements at a constant speed while varying the tractor travel speed. This is useful in many forage harvesting operations

The fourth source of power on the farm tractor is the hydraulic cylinder operated by an oil pump located at some point in or on the tractor. The cylinder may be mounted on the tractor for operating integral equipment. or it may be located on a trailing tool and connected to the tractor system with breakaway couplings and hose. One of the most common uses of the hydraulic system is in operating a mounted attachment called the manure loader. The cylinders raise and lower the boom and tip or angle the bucket. Grader, dozer and snow blades may also be used on this attachment. The first use of the hydraulic system was to raise and control mounted plows and cultivators. The 1950s saw the application of hydraulics to the steering mechanism, by attaching a cylinder to the tractor frame and to the steering rods. This made it much easier to turn and hold the front wheels of a heavy, slow-moving tractor in loose, rough ground.

Tractor Tests.—The first tractor testing laboratory was established in Lincoln, Neb , in 1919, as the result of state legislation making it mandatory for one tractor of each make to be tested before being sold in that state. The two main features of the test are the drawbar and belt horsepower ratings made with a trailing test car and a stationary electric cradle dynamometer. The ratings are adjusted to standard atmospheric conditions. Hundreds of tests were made after the Twin City tractor was partially tested in the fall of 1919. The ratings of current tractor models were made available on one large sheet and individual ratings mere compiled by the Agricultural Engineering department of the University of Nebraska at Lincoln.

The National Institute of Agricultural Engineering. an agency of the British government, established a tractor-testing installation at Wrest Park, Siloe, Befordshire, where data comparable to the Nebraska tests could be obtained for British tractors.

Tractor Types.—Tractors can be classified by the means of obtaining traction, that is, by wheels or by tracks. In the U.S. in 1952, 96% of the total tractors on farms were of the wheel types; only 4% were crawler or track-type tractors. The same proportion existed throughout most of the other countries of the world. The crawler tractor is useful where the soil is unstable and great pulling or pushing ability is needed. Since the tracks of the crawler are not adjustable sidewise. it is difficult or impossible to use them in many row crops. It is difficult, moreover. to move the crawler tractors over roads without a carrier. The wheel tractors, although not having as much pulling ability. have adjustable treads, except on standard or orchard models, and can readily operate on highways at speeds up to 20 m.p.h.

Garden tractors became popular in the U.S. after World War II. There were 68.000 such tractors on farms in 1945 and 294,000 in 1952. The garden tractor may have an engine with a horsepower rating from 1 to 6 h.p. The engines are invariably of the air-cooled four-stroke cycle type. Some garden tractors have no n-heels, the tractor resting and operating on whirling tines. The larger. wheel models usually have a reverse gear for convenience, and many can be connected to a trailer so that the operator can ride. Among the jobs garden tractors can do are spraying. moving earth and snow, mowing grass and meeds and tilling garden plots.

Tractors throughout the world can also be classified by the fuel that they use into four categories. each requiring a special engine. These are the gasoline, the diesel, the liquid-petroleum gas and the dual-fuel tractors. In the U.S in 19j3. 3,025,jjo gasoline engines (except outboard and miniature): 117,628 diesel engines, 9,61j liquid-petroleum gas engines and 8.972 dual-fuel engines were produced. The popularity of each of the different types depends upon the availability and cost of the various fuels. In the C.S. gasoline fuel proved readily available and reasonable in price. But diesel fuel also became available at favourable cost and many farmers changed to diesel tractors when they had sufficient work to offset the higher initial tractor cost. In Great Britain and parts of Europe, diesel fuel is more plentiful than gasoline. Almost all the tractors in those areas operate on the cheaper diesel fuel.

Fuels.—In the oil-producing areas of the U.S., the gases propane and butane, by-products of gasoline refineries. have been combined to form a tractor fuel that is competitive with gasoline. Because of the low cost and desirable combustion characteristics of this fuel, farmers purchased adapter kits for their gasoline tractors, converting them to gas tractors. The gas burns cleanly, leaving no carbon residue, and has a high octane (antiknock) rating. Most of the principal tractor companies in the U.S. were making liquid-petroleum gas (LPG) tractors in 1954. In order to obtain the most efficient use of the LPG fuel it was necessary to raise the engine's compression ratio to 8:1.

The dual-fueled tractors use gasoline for starting. and kerosene, distillate or tractor fuel for operation after warming up. The engines have a lo compression ratio because of the poor ignition qualities of the fuels, which causes excessive detonation at higher ratios.

The diesel engine operates at the higher compression ratios. about 16:1, and is therefore efficient in the use of the diesel fuel. The engines do not require an ignition system because the high pressures (500 lb. per square inch) warm the incoming air to temperatures high enough (1,000° F.) to ignite the fuel as it is injected. The higher compression ratios require high-voltage starters and many diesels are equipped with 12- and 24-volt batteries. All the diesel engines used in the U.S. in the mid-1950s were of the four-stroke cycle type, except those of one manuiacturer. In Europe, however, the two-stroke cycle diesel. which gives more power per unit of engine weight than the four-stroke diesel, is more popular.

The compression ratio of tractor engines using gasoline was constantly increased, resulting in about 3% more power each year as an average. Some tractors have ratios as high as 7:1, but they go down to 4.5:1 for the dual engines. In 1954 a U.S. company placed an experimental engine in one of its regular tractors with a compression ratio of 12:1. Such a high ratio requires a fuel with an octane rating of 100 or more. In the U.S the regular gasoline antiknock qualities as indicated by Motor Method octane numbers rose from 60 in 1931 to 79 in 1951, and by 1955 it mas 82. Premium grades of gasoline run about three to four numbers higher than "regular" gasoline.

Tires.—In 1932 tractor tires gave poor traction and did not clean well. Tires were available in two typical tread patterns—a rather closely spaced nob or button type of nondirectional design and a wider-spaced lug or bar-type of directional design. In 1936 the lug height was increased as well as the space between. After World War II tractor tire manufacturers made the treads flatter and the cleats or lugs higher at the shoulders. This gave better traction. In 1938, an 84% ratio of rim width to tire diameter was standardized in the C.S. Formerly tires were on 6- or 8-in. rims. Wider rims permitted a larger volume of air in the tire and greater load capacity. By the mid-1950s there were 11 section widths and 8 rim diameters available for farm tractor tires. Special tires for rice and cane fields were also available.

Costs.—The average time of use per year of U.S. farm tractors steadily rose from less than 400 hrs. in 1930 to more than 600 hrs. in 1950. This meant a decline in operating costs as shown in the table below.

The table is based on 7,500 total hours of tractor life, allowing 15 years for the tractor to become obsolete. The repair cost is figured at 35% of the new cost. The cost per hour is based on

Cost Per Hour Per $100 New Cost

Hours used per year	Cost per hour	Hours used per year	Cost per hour
60	$ .175	750	$ .023
150	.073	1,000	.022
300	.039	1,500	.020
500	.025		

Source: American Society of Agricultural Engineers Handbook, 1954.

3.5% of the new cost as a total for such annual charges as interest, housing, taxes and insurance. From the table the cost per hour for using a tractor can be calculated if the cost of the tractor and the hours it has been used are known.

Production.—The gasoline tractor had its greatest development in the United States. Because of a scarcity of gasoline but larger quantities of fuel oil available to Great Britain, that country led the world in the percentage of tractors using diesel fuel.

The number of tractors produced in Great Britain in 1953 was 137,000. Of that number, about 85,000 were exported to Canada, Australia, New Zealand, South Africa, Denmark and Italy. The Fordson Major diesel tractor was exported in large numbers to the U.S. for the first time in 1953, competing successfully in price and quality with U.S. made diesel tractors. About 80% of the tractors produced in Great Britain in 1954 for home use were diesel-engine tractors.

In 1953, 330,091 wheel-type tractors were produced in the U.S. for domestic farm use; 12,000 crawler tractors and 164,300 garden tractors were manufactured. In the first six months of 1954, 127,655 gasoline-engine tractors were made in the U.S. In the same period, 33,107 diesel-engine tractors were produced. The figures do not include garden tractors. Also 32,666 wheel- and crawler-tractors were exported from the U.S. during the same period.

In the early 1950s the U.S. led the world in the number of tractors on farms, but the United Kingdom, Switzerland and western Germany had the greatest concentration of tractors per acre of tillable land.

INDUSTRIAL TRACTORS

These machines are similar to and often made by the same companies that manufacture agricultural tractors. Their purpose is to haul materials and products in and near industrial or manufacturing plants.

Lift arms, lift rams, front bumper, bucket and double-acting rams are carried on a frame that is heavier than the usual farm tractors. The tires are massive for good traction and easy riding, and to carry the heavy tractor and often-used heavy ballast box at the rear.

Products such as foundry sand, chemicals, fertilizer, coal, clay. sand, gravel or other loose materials are usually handled with a hydraulically operated attached material bucket. Closed cabs for the operator are provided on tractors designed to be used out-of-doors.

Backfilling and dozing operations can be done with an industrial tractor when it is equipped with a blade. They are also used for snow removal and for driving highway mowers and street rotary sweepers.

HIGHWAY TRACTORS

The highway tractor (or tractor truck, as it is often called in the United States) was developed from the truck. It differs from the latter only in having a shorter wheelbase and in that, instead of being provided with a platform or other body for carrying loads, it is fitted with a bolster on the frame over its rear axle which carries the forward end of a semitrailer through a fifth wheel. Whereas in the conventional truck nearly all of the useful load is carried on the rear wheels, in a tractor-trailer combination it can be equally divided between the rear wheels of the tractor and the two wheels of the trailer, so that a much greater load can be carried. Moreover, by far the most expensive part of the combination is the tractor, and this need not be kept idle during periods of loading and unloading, but can be kept busy all the time, providing a sufficient number of trailers is available. When the semitrailer is being loaded or unloaded its forward end rests on jacks or folding supports with caster wheels. Coupling of the semitrailer to the tractor is effected automatically by simply backing the tractor up to the trailer, and uncoupling is an equally simple operation. Highway tractors for hauling semitrailers have been built with electric, steam, gasoline and diesel power plants.

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(H. E. GN.)

TRADE, INTERNATIONAL. International trade statistics rest on export and import records of individual countries.

Originally established for fiscal purposes, such records usually contain information on quantity and value of commodities crossing the border, often with indication of provenance of imported and destination of exported goods. Data on total value of imported and exported merchandise have been published in England (later the United Kingdom) since the end of the 17th century, in the United States since 1790 and in France since 1815. The number of countries recording their foreign trade increased in the second half of the 19th century and their records made it possible to estimate total world exports and imports.

Before World War I. systematic surveys of world trade were conducted by statistical services of different countries (for example, Germany and France). In 1910 the International Bureau of Trade Statistics (Brussels, Belg.) launched a campaign for the unification of foreign trade statistics of all countries by establishing a uniform classification of commodities. Further efforts in this direction were made by the League of Nations. It was successful in collecting and analyzing statistics of foreign trade of about 80 countries but failed in its attempts to persuade the governments to use uniform methods in classifying imported and exported commodities. The solution of the latter problem was left to the United Nations. whose Standard Industrial Trade Classification (S.I.T.C.) was widely accepted. Yet the world trade statistics compiled by the United Nations and its specialized agencies (especially the World Bank) are not inclusive. Only incomplete data are available for the U.S.S.R., its satellites and the mainland of China. There remain also some inconsistencies in records of individual countries. Some—and among them the United Kingdom and the United States—record general trade that includes in import goods designed for re-export. Others record special trade excluding re-exported goods. There is no universally accepted practice, moreover, for determining the country of destination and provenance of goods crossing the frontier. Imports are usually valued c.i.f. (cost, insurance and freight) from ship or train; exports are valued f.o.b. (free on board) of a ship or train. But the valuation is effected according to special regulations that differ widely from country to country. and the foreign trade statistics are expressed in national currency which must be converted into a universal hard currency (for example, into U.S. dollars as is the practice of the United Nations and the World Bank). The main difficulty is the handling of statistics of countries with controlled currency where special exchange rates are used for certain kinds of imports and exports and the free (black market) exchange rates may deviate from official rates.

The totals and averages in world trade statistics are therefore subject to serious reservations.

Progress of World Trade.—Ancient Times.—International trade was recorded in the monuments of the ancient world and its numerous traces have been found by archaeologists in the old burials. There was a continuous flow of exchange among the peoples of the Mediterranean basin and Red sea. Overland routes brought merchandise from the Yellow sea to India, Arabia and the shores of the Black sea. Levantine merchants met with Chinese traders in Ceylon and Java. Tyrus mas probably the main centre of international trade in the Mediterranean world. The list of merchandise brought to its markets included rare timber, metals, slaves, cattle. wheat, wine, spices, honey, oil, ivory, precious stones, embroidered fabrics, wool and many other items. As diversified was the trade between China and other areas of the far east. Large cities of antiquity could not live and grow without the continuous import of grain and building materials.

At the beginning of the Christian era, Rome was becoming the centre of trade that embraced western and central Europe, northern Africa and areas known now as the near and middle east. With the fall of the Roman empire, international trade in that area disintegrated, and the Mediterranean lost its significance as the world's busiest thoroughfare.

Middle Ages.—In the period from the 5th to the 15th century Europe was in eclipse. The chain of Moslem kingdoms had blocked the Mediterranean. The attempts of Europe to break this blockade by the direct assault of the crusaders against the stronghold of Islam in Asia Minor failed. and world trade remained in the hands of the Arabs.

In Europe the leading role in foreign trade shifted from the Mediterranean nations to those facing the open sea. Portuguese, Spanish, Dutch and British traders started the search for new routes to the east. In the 15th century Portuguese captains advanced slowly but steadily along the western coast of Africa until Vasco da Gama rounded the Cape of Good Hope and brought his ships into the Indian ocean (1497). About the same time Christopher Columbus' attempt to reach India by sailing westward from Europe brought him to the Caribbeans, the threshold of the Americas.

Modern Times.—World trade was slowly expanding along the new sea lanes—from Amsterdam, Neth.; Lisbon, Port.; Hamburg, Ger.; and London, Eng., to the Caribbean Islands and the far east. Along with spices and luxuries of the east, cotton, sugar and wool were increasing in importance. Foreign trade was essentially seaborne trade at that time and its volume could be roughly estimated from the number of ships in operation and the size of their crews. Many thousands of ships were engaged in trade, but their used carrying capacity averaged little more than 50 tons, and their crews often consisted of no more than 10 men. At the end of the 17th century the famous British economist. Sir William Petty, in the earliest attempt at international trade statistics, estimated the value of merchandise carried each year by merchant ships at £1,000 to £1,250 per ship. The estimated value of goods carried by European shipping was set at £45,000,000 a year. The Dutch were leading in European trade, followed by the British, Spaniards, Portuguese, French, Swedes and Germans.

More reliable are data for the period after the Napoleonic wars. In 1820 world exports totaled approximately £135,000,000 ($567,-000,000). Great Britain was leading (£56,000,000), France came next (£25,000,000), followed by the United States (£12,000,000), the rest (£42,000,000) being distributed among a dozen nations. With a rough correction for depreciation of all currencies in the world, it appears that the gold value of world exports in 1820 was approximately 1.5% of the value of total world exports in 1954.

Under the impact of economic growth in Europe and America, progress of industrialization and development of new means of transportation, the volume of world trade increased substantially during the 19th century and after the turn of the 20th century, until World War I. World export was estimated at $6,000,000,000

Table I.—Share of Selected Countries in Exports and Imports
(In percentages)

Country	1880	1890	1900	1913	1937	1953	1956
	Exports						
Great Britain	19.8	20.6	16.4	15.4	18.2	11.8	9.7
United States	11.9	11.5	13.8	12.8	11.7	13.0	20.6
Germany	9.9	10.2	10.4	12.1	*	6.6	8.0
France	9.5	9.3	7.6	6.7	6.4	5.3	5.0
Netherlands	3.6	5.6	6.5	6.3	3.0	3.7	3.1
Russia	3.6	4.7	3.5	4.0	*	*	*
Belgium	3.8	3.6	3.5	3.6	3.5	3.2	3.6
Canada	1.0	1.1	1.6	1.8	3.1	5.4	5.4
	Imports						
Great Britain	24.5	22.6	21.8	18.0	11.2	9.9	10.8
United States	8.3	9.0	7.6	8.9	14.1	18.7	13.0
Germany	8.1	10.9	11.7	12.3	*	7.5	6.8
France	11.9	9.5	7.8	7.8	4.1	5.8	5.7
Netherlands	4.1	5.8	6.8	7.6	2.8	3.6	3.8
Russia	4.0	3.6	3.7	4.3	*	*	*
Belgium	3.9	2.4	2.8	3.4	3.7	3.3	3.4
Canada	0.9	1.2	1.5	0.6	4.2	5.5	6.0

*Unknown

in 1867–68, $7,000,000,000 in 1880, $7,800,000,000 in 1890, $8,-500,000,000 in 189; and $19,800,000,000 in 1913. Changes in the rate of growth in total value of exported goods were partly due to fluctuations in world prices. At constant prices, as in 1890 (adjusted by the *British* Economzst index), the value of world exports was $3 600,000,000 in 1867–68, $5,600,000,000 in 1880, $7,800,000,000 in 1890, $9,900,000,000 in 1897 and $17,000,000,-000 in 1913. The value of world imports was 10% to 15% higher because it included cost of transportation, insurance and certain other items.

From the end of the Napoleonic wars to World War I Europe predominated in world trade, and Great Britain was the mainspring and clearinghouse of the world-wide flow of merchandise. International trade consisted largely of exchange between Europe and the rest of the world and between continental Europe and Great Britain. In 1913, 40% of world exports represented intra-European trade (including trade betneen continental Europe and Great Britain); 21.5% was accounted for by European exports to other parts of the world; 15.2% by exports of non-European countries to Europe; and only 23.3% by trade among non-European countries. Moreover, the last item included transactions among European colonies and dominions largely controlled by European capital.

Great Britain lead in both exports and imports, the United States and Germany competed for second place. followed by France, the Netherlands, Russia. Belgium and Canada. These eight countries together represented nearly two-thirds of the total world trade, but the share of Great Britain and France was steadily declining while that of Germany and the Netherlands was increasing between 1880 and 1913. The share of the United States fluctuated from year to year, without showing any clear upward or downward trend

The ranking of the great commercial powers changed after World War II. The United States advanced to the leading position, followed by the United Ringdom, western Germany. Canada and France. Belgium and the Netherlands competed for sixth place. The shares of these seven countries and Russia in world exports and imports changed as shown in Table I. The disparity between the share of a country in world exports and imports reflects its position in international exchange of services (invisible exports and imports). Great Britain used to offset its import balance by earnings of its marine and profits from capital invested abroad. The export balance of the United States in the 19th century served to defray the cost of foreign—mainly British—marine for carrying its trade with Europe, interest on foreign investment in the U.S., remittances of immigrants to their families,

Table 11.—Export Quantum
(1938=100)

	1938	1947	1949	1951	1953	1955	1956
World*	roo	99	110	138	145	164	181
North America	100	237	195	219	232	232	267
Latin America	100	109	99	109	114	118	..
Continental western Europe	roo	59	40	143	154	197	210
Sterling area	100	96	122	139	145	153	..
United Kingdom†	100	100	139	163	161	189	200
Middle east	100	175	262		62j	787	..
Far east	roo	64	72	384	85	93	..
Rest of sterling area	roo	104	129	138	145	194	..
Middle east, nonsterling	100	126	138	145	128	160	..
Far east, nonsterling	roo	12	30	45	47	63	..

*Excludes Soviet bloc. †Includes Ireland and Iceland.
Source: U S, *Monthly* Bulletin *of Statistics*, May 1957.

etc. France and the Netherlands had an import balance for the same reasons as Great Britain. Germany used its export balance for building up investments abroad. The position of Russia, Belgium and Canada changed from year to year. Most of the countries in Central and South America, Asia and Africa had an import balance.

Later Changes.—Changes in the volume of world trade after World War I are reflected in the index of export quantum that shows variations in the value of exports of different regions and the norld as a whole after correction for changing prices. Using 1929 as the basis of comparison (1929=100), the index for the world as a whole was 7j in 1913, reached the peak in 1929, went down to 74–75 during the depression in 1932–33 and climbed back to 89 before the outbreak of World War II (1938). It could not be computed during World War II. but at the end of the war the volume of world trade was hardly higher than in 1513—despite the tremendous growth in population and production. The index of quantum of world trade returned to 110 by 1949 and continued to grow thereafter. By 1955, ior example, it had climbed to 164. While in the 2j-year period from 1913 to 1938 the volume of world trade lagged behind the gronth of industrial production in the norld, in the subsequent period world exports probably outran industrial output. The fairly smooth gronth of quantum of world exports after World War II conceals deep and lasting dislocations in the volume of exports of single areas. The change in export quantum of selected regions in comparison with the prewar level is shown in Table II.

In the early phase of postwar recovery in world trade, when the quantum of world exports had returned to the prewar level, the exports of western Europe were some 40% below this level. and those from the far eastern nonsterling area (including Japan)

Table III.—*Distribution of World Trade*
(In percentages)

Year	Europe	North America	Latin America	Asia	Russia, Africa, Oceania
			Exports		
1913	50.9	15.8	9.1	12.5	11.7
1926	42.9	20.7	9.4	18.1	8.9
1929	47.4	19.5	9.6	14.9	8.6
1937	44.8	17.1	10.3	16.2	11.6
1947	32.2	36.1	12.5	11.2	8.0
1952	38.6	27.1	11.1	13.7	9.5
			Imports		
1913	57.9	12.4	7.6	11.8	10.3
1926	50.6	17.6	7.7	15.3	8.8
1929	54.2	16.1	7.7	13.2	8.8
1937	50.2		8.6	14.9	10.8
1947	38.8	26.4	12.4	11.3	11.1
1952	42.7	20.2	8.9	15.5	12.7

dwindled to less than half the prewar volume. In world totals, however, these losses were offset by the tremendous growth of exports from the United States and Canada.

In the following years exports from the United States—including shipments under foreign economic and military aid programs—fluctuated around a level more than twice the prewar volume. By the mid-1950s. exports of continental western Europe doubled. and those of the United Kingdom almost doubled in comparison with 1938.

Less conspicuous were gains in Latin America and the middle east sterling area. The slow recovery of foreign trade in the far-eastern countries (in both sterling and nonsterling areas) was partly due to unsettled political conditions.

Geographic Distribution of World Trade.—In the latter part of the 19th century and after the turn of the century, before the outbreak of World War I. Europe (excluding Russia) accounted for roughly 50% of world exports and nearly 60% of imports nhile the rest of international trade was distributed in four almost equal parts: 12.5% of exports and 10% of imports was the share of the United States, and about as large were the shares of other countries of the western hemisphere (Canada and Latin America). Asia. and the rest of the world (including Russia). The exact figures—if they could be computed—would have shown some fluctuations from year to year. but the general pattern remained fairly stable and appears clearly in the available statistics for 1913. After the outbreak of World War I, the distribution of world trade changed as shown in Table III.

World trade statistics published by the United Nations and its specialized agencies such as the World bank (International Bank for Reconstruction and Development) and International Monetary fund abandoned the traditional grouping of countries by continent for another classification that better answers the needs of analysis of international balances of payments. The United Nations experts felt that the border between continents is less significant, from the viewpoint of world trade. than the distinction between dollar and nondollar areas in Latin America, or between sterling and nonsterling areas in the middle and far east, or between continental western Europe and the United Kingdom, and so forth. Thus. the following regions (not necessarily contiguous) are considered: North America (United States and Canada); Latin America—dollar area, nondollar area; continental western Europe; European overseas territories; other Europe (Spain. Finland and Yugoslavia): middle east (nonsterling area); sterling area—United Ringdom. Ireland and Iceland. Australia. New Zealand and Rhodesia-Tyasaland, far east (independent), middle east, other;

China; other far east.

Occasionally some of these groups are further subdivided, or two or three groups are brought together into a single region. The whole classification may seem rather complicated and confusing to a layman accustomed to the old grouping of countries by continent but it serves well its purpose to form trade areas on the basis of features most significant for international transactions, such as the type of currency and association with a definite economic bloc.

It is a question of terminology whether a classification of this type should be regarded as geographic distribution of world trade. According to this classification, world trade was divided in 1956 among three broad groups of nations as shown in Table IV. The surplus of exports from the dollar area were due to the export balance characteristic of the foreign trade of the United States. One-sided transactions of that country also explain the surplus of exports to the area of uncommitted currencies over the exports from this area.

TABLE IV.—Distribution of World Trade by Currency Areas
(In millions of U.S. dollars)

	Exported from	Exported to
World	95,028	95,028
Sterling area	21,785	21,961
Dollar area	28,944	22,201
Othercurrencies	44,229	50,866

Distribution of world trade among individual nations and their ranking by value of exports and imports is fairly stable: the same countries remain at the top of the list, the same retain their position as the big ten or twelve of the aorld trade. the same two or three dozen follow them. (*See* Table V.) The U.S.S.R. is excluded from Table V because of lack of information. It would probably rank somewhere in the second dozen of countries enumerated.

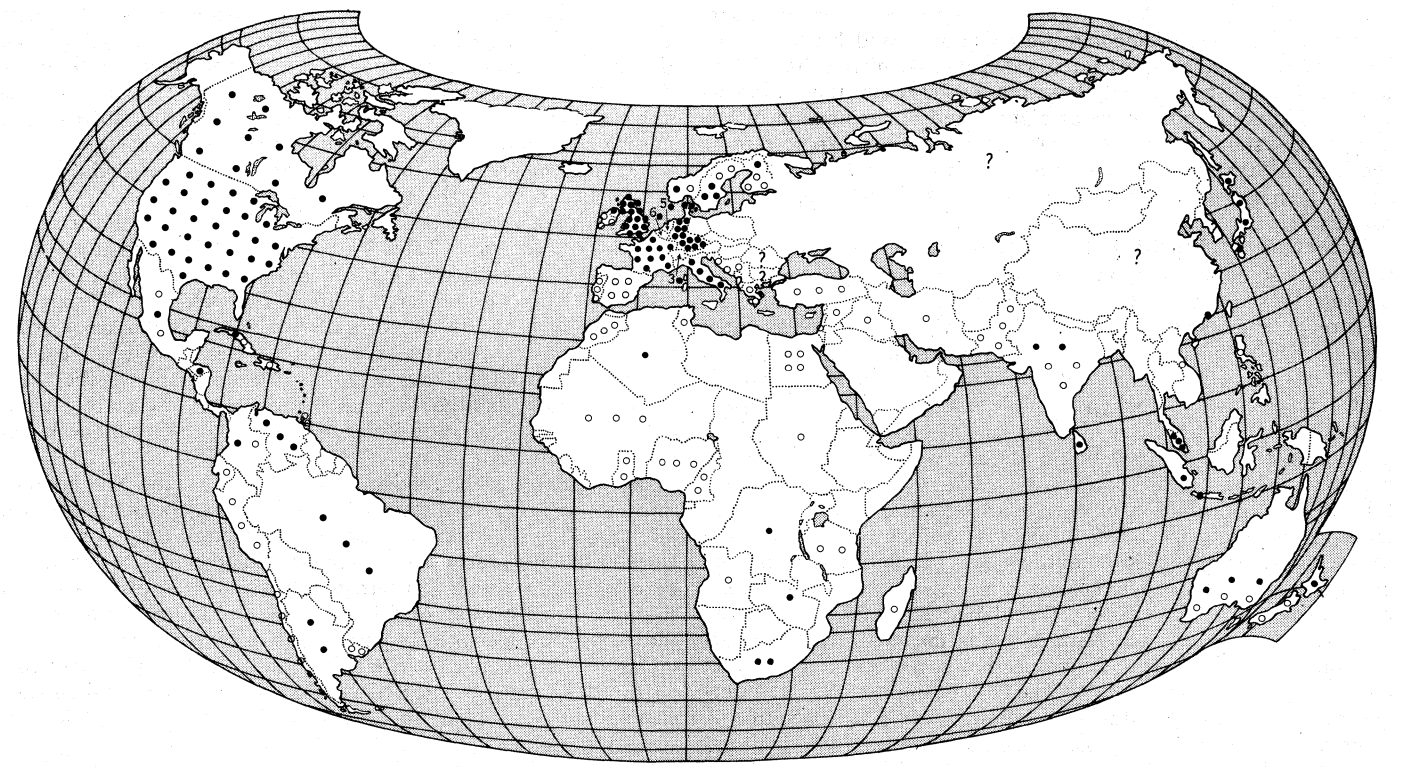
The geographic distribution of world trade can be shown graphically on a world map by indicating the value of exports of each country—or each area—by dots, each one representing a definite value of exports (*see* fig. 1). The dots are densely clustered in the United States and Canada and northwestern Europe and widely dispersed in the rest of the world. Moreover, the same two North Atlantic areas represent the largest concentration of economic activities and wealth in the world. It may be desirable, therefore, to compare the distribution of world trade with distribution of national incomes in the world. Such a comparison may be made by plotting the dots showing the export value of each country on a distorted map which shows each area on the scale of its national incomes (*see* fig. 2). On a map of this type world trade appears distributed over the world more evenly than on a conventional geographic map.

Export Rate.—A closer examination of the distorted map reveals that the dots are clustered more densely in Latin America, Africa and Malaya than in northwestern Europe while in the United States they are widely scattered. The density of dots on the distorted map of national income illustrates the ratio of the value of exports to income in the respective areas (as the density of dots representing the number of inhabitants in each area on a conventional map illustrates the rate of population per square mile). The export rate depends on the type of economy rather than the level of economic development of an area. It is particularly high in areas of specialized plantation economy, especially in colonial areas and former colonies. It is equally high in such

*TABLE V.—Leading **Export** Countries, 1955*
(In millions of U.S. dollars)

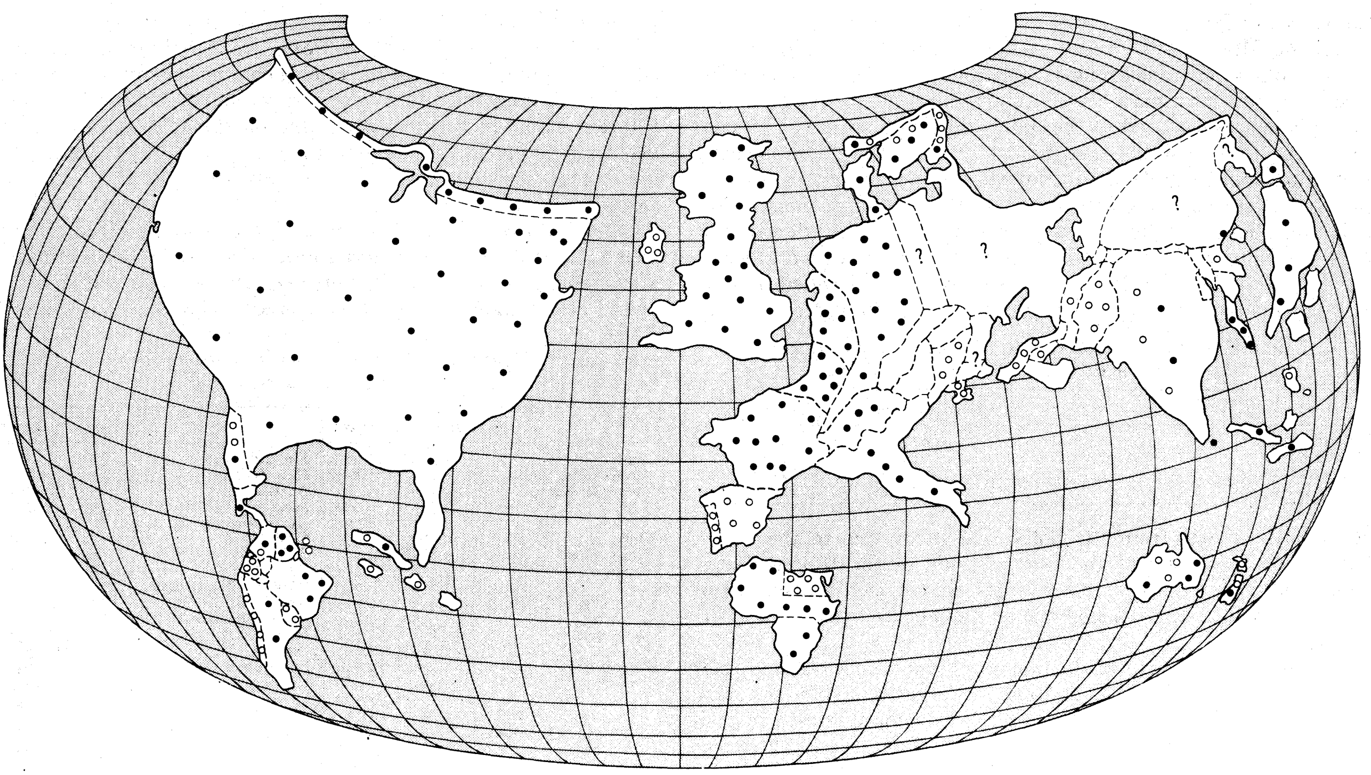
	Exnort	Import		Export	Import
United States	15,409	10,406	Finland	788	769
United Kingdom	8,135	10,557	New Zealand	724	740
West Germany	6,138	5,793	Austria	699	887
France	4,798	4,688	Mexico	669	792
Canada	4,410	4,774	Neth. Antilles	661	685
Belgium	2,765	2,830	Norway	634	1,090
Netherlands	2,687	3,208	Cuba	594	495
Japan	2,011	2,471	Colombia	584	671
Italy	1,856	2,706	Rhodesia-Nyasaland	480	388
Australia	1,753	1,933	Algeria	460	607
Sweden	1,728	1,991	Belgian Congo	454	307
Venezuela	1,538	709	Hong Kong	445	651
Brazil	1,423	1,307	Ceylon	408	307
Malaya	1,358	1,249	Philippines	405	533
Switzerland	1,307	1,489	Eeypt	397	523
India	1,238	1,295	Spain	386	543
Denmark	1,055	1,179	Chile	385	341
Argentina	1,000	1,109	Pakistan	347	276
Indonesia	934	605	Nigeria, Federation of	343	335
Union of South Africa	928	1,245	French Morocco	321	473

Source: UN, *Yearbook of International Trade Statistics, 1955.*



BY COURTESY OF W. S. WOYTINSKY AND E RAISZ

FIG. 1.— GEOGRAPHIC DISTRIBUTION OF EXPORTS. 1955. EACH SOLID DOT REPRESENTS $500,000,000; EACH OPEN DOT $100,000,000



BY COURTESY OF W. S. WOYTINSKY AND THE TWENTIETH CENTURY FUND

FIG. 2.— DISTORTED WORLD MAP SHOWING EXPORT VALUE AMONG NATIONS IN RELATION TO THEIR INCOME. 1955. EACH COUNTRY IS PLOTTED ON THE SCALE OF ITS INCOME. SOLID DOTS REPRESENT $500,000,000; OPEN DOTS $100,000,000

densely populated and economically developed countries as Belgium and the Netherlands. where it has been found that production for export is more advantageous than a broadly diversified economy.

Under more or less equal or similar conditions, a larger country has a better chance for developing a diversified economy than a smaller country. This explains the fact that comparatively small industrial countries such as the Netherlands, Belgium. Denmark. Switzerland, Sweden. Austria and Norway have a higher export rate than the United Kingdom, nest Germany and France. This also explains why. in export rate. Portugal ranks higher than Spain. Mexico higher than Brazil. Pakistan higher than India, and so forth. This same advantage of bigness and diversification of the economic system is the cause of the extremely low export rate of the Cnited States: the nation that outranks all other countries in value of exports has the lowest—or one of the lowest—export rates in the world.

Direction **of** World Trade.—Barter trade presumes an approximate equilibrium in the value of goods and services exchanged between two countries. Under conditions of a free world-wide flow of foreign trade, such equilibrium is not necessary: each country may have an import balance in transactions with certain areas and export balance with others. Before World War I such multilateral exchange prevailed. This type of international trade was disrupted by the war. But the circular movement of goods was resumed in the 1920s, and by the end of the decade world trade essentially returned to the prewar pattern. The depression of the 1930s, followed by depreciation of currencies and drastic controls over imports and exchange rates, brought a profound disorganization of the world market. The conditions began to improve in the second half of the 1930s, but recovery was slow and world trade had not returned to normalcy when World War II broke out. During the war international—especially intercontinental—trade was carried out under control of the respective governments, largely in the form of barter agreements. The first attempts to restore international exchange after the war followed the same pattern. A cumbersome machinery of governmental controls and bilateral agreements had replaced the free flow of goods. The joint efforts of the Cnited Nations and its specialized agencies, the Organization for European Cooperation, European council and other international organizations succeeded in restoring relative freedom of world trade. The General Agreement on Tariff and Trade (G.A.T.T.) and trade policies of individual countries (such as those introduced under the Trade Agreement acts in the United States) resulted in substantial reductions of tariff barriers. Certain nontariff restrictions. likewise, were partly repealed, partly released. By 1954 a new pattern of direction of world trade emerged from the chaos of the early post-war years. The new direction of international trade was largely determined by the changed political and economic conditions, and current UN statistics of direction of world trade emphasized the existence of the new currency blocs—dollar and nondollar areas in Latin America, sterling and nonsterling areas in the middle and far east, etc Adjusted for comparability, these statistical series differ slightly from the original data of the respective countries, and their use by general readers is made difficult by the somewhat complicated classification of countries Table VI shows, in a condensed and simplified form, the direction of exports and provenance of imports of the 15 countries with the largest foreign trade in 1954. It suggests that more than half the imports of the United States come from Canada and Latin America and the same area absorbs some 40% of the U.S. exports. Inversely, the United States is the main source of supply and the main outlet for exports of Canada. Likewise, the foreign trade of Brazil moves mainly within the limits of the western hemisphere.

On the contrary, the foreign trade of Belgium, the Netherlands, Sweden and Switzerland rests mainly on exchange with other European countries, including the United Kingdom. Italy is a border case—it obtains nearly half of imported merchandise from European markets and sells more than half of goods it exports within Europe. The direction of foreign trade of France is affected by extensive exchange with its possessions in North Africa.

The United Kingdom is the only country in Europe whose foreign trade is not concentrated on European markets and its own colonies but is spread all over the world, including the middle east, Asia, Africa and Oceania.

Australia's foreign trade is strongly tied with the United Kingdom and continental Europe. Japan depends mainly on the United

TABLE VI.—*Foreign Trade of Selected Countries by Direction of Exports and Provenance of Imports, 1954*

(In millions of U.S. dollars)

	World*	North America	Latin America	United Kingdom	Continental west. & south Europe†	East. Europe	U.S.S.R.	Middle east	Other Asia	Other Africa	Oceania	Miscellaneous
United States												
Exvorts	15,093	2,767	3,364	693	2,548	134	—	329	1,648	240	515	2,855
Imports	10,288	2,395	3,565	501	1,490	90	12	261	1,266	164	542	—
United Kingdom												
Exports	7,768	831	515	—	2,511	125	34	419	982	1,156	1,151	44
Imports	9,461	1,557	920	—	2,531	271	117	728	942	1,171	1,204	21
West Germany												
Exports	5,261	336	522	205	3,093	175	13	229	327	255	76	32
Imports	4,601	626	572	202	2,041	165	22	229	308	322	108	5
France												
Exports	4,189	178	303	241	1,420	100	31	152	355	1,355	37	17
Imports	4,215	420	315	164	1,025	69	40	569	160	1,189	262	—
Canada												
Exports	3,986	2,389	238	675	356	9	3	18	168	65	64	—
Imports	4,204	3,057	370	403	181	3	1	24	94	32	39	—
Netherlands												
Exports	2,412	172	151	277	1,254	72	33	63	187	112	31	58
Imports	2,857	376	219	229	1,328	54	23	205	226	127	21	47
Belgium												
Exports	2,304	215	116	145	1,332	61	24	53	114	199	28	15
Imports	2,550	313	181	214	1,256	40	28	106	69	270	72	1
Italy												
Exports	1,636	141	154	129	751	60	25	121	105	98	23	29
Imports	2,401	309	142	163	954	74	24	363	108	141	120	2
Japan												
Exports	1,629	304	208	57	97	5	—	79	723	127	35	—
Imports	2,399	972	310	37	160	39	2	179	580	22	136	—
Australia												
Exports	1,684	136	13	625	418	24	31	16	278	15	129	—
Imports	1,692	241	15	788	238	12	2	64	251	35	38	8
Sweden												
Exports	1,588	85	123	295	842	61	23	29	45	50	32	—
Imports	1,777	144	167	283	943	47	27	46	53	53	14	—
Brazil												
Exports	1,562	594	145	74	571	62	12	3	86	11	3	—
Imports	1,633	581	376	17	512	50	13	2	80	3	—	—
Switzerland												
Exports	1,227	170	117	61	629	35	7	44	89	46	28	—
Imports	1,301	202	97	74	788	35	5	24	41	29	7	—
India												
Exports	1,181	215	53	373	116	6	5	93	193	68	58	—
Imports	1,235	165	17	303	241	9	2	152	248	63	34	—
Malaya‡												
Exports	1,016	172	32	148	210	16	—	12	297	21	67	40
Imports	1,026	53	11	196	93	2	2	23	592	7	46	—

*All countries for which data on direction of trade are available. †(Organization for European Cooperation) countries, excluding the United Kingdom. ‡Including Singapore.

States and the mainland of Asia for both imports and exports. India's main sources of imports and main outlets for exports are United Kingdom, Europe and Asia. Malaya largely depends on Asia for imports but exports its products to all parts of the world.

Apart from the minor short-run fluctuations caused by changes in prices and local business conditions and international competition on the disputed markets, the general pattern in direction of world trade is fairly stable. It can be represented on a world map by marking each country according to the prevailing direction of its exports (*see* fig. 3A). For this purpose, the shortcoming of a conventional map is that it shows the densely populated areas with highly developed foreign trade on the same scale as areas of little significance for world trade. It appears preferable, therefore, to use as the basis of comparison a distorted map on which each area is plotted on the scale of its exports (*see* fig. 3B).

Composition of World Trade.— Until relatively recently each country used its own classification in recording imported and exported goods. The only universally accepted classification was a rough distinction between: (1) foodstuffs and beverages; (2) crude and partly processed materials; and (3) manufactured goods. More detailed world-wide statistics of composition of international trade were made possible by the Standard International Trade Classification, mentioned previously, which the UN Economic and Social council developed. This classification is purely empirical in the sense that it rests on the classifications used in individual countries rather than on theoretical principles. It distinguishes 570 kinds of merchandise distributed in 150 groups which represent those types of commodities for which data are normally sought. The groups are further consolidated in 10 sections which are supposed to correspond to broad economic categories. Not all of these sections are equally meaningful for the purpose of economic analysis. But the groups of the S.I.T.C. were widely accepted, in some cases with minor modifications, by leading countries outside the Soviet sphere of influence

The UN *Commodity Trade Statistics* for 1954 covered 21 countries that controlled approximately two thirds of world trade. The reports of individual countries permitted expansion of this survey on approximately 90% of world imports, making possible estimates of the relative role of certain groups of commodities in international trade (*see* Table VII).

Under machinery in Table VII are three groups of the S.I.T.C.: machinery not elsewhere classified, metal-working machinery and office machinery. It does not include electrical machinery, power machinery, agricultural machinery, tractors, motor vehicles, etc. Machinery and transportation equipment together (including ships and aircraft) represented a value of nearly $10,000,000,000 in world imports in 1954.

Next are crude petroleum and petroleum products including gasoline and lubricating oils. Aggregate value of both groups. more than $5,500,000,000, dwarfs the value of coal and coke in world trade.

Coffee is fourth by far outranking all other vegetable foodstuffs. Indeed, the value of coffee in world trade is about double that of wheat and is close to the value of all cereals.

The group of iron and steel that comes next in Table *VII* is somewhat deceiving because of the difference in classification used in different countries. It includes some but not all fabricated articles made of iron and steel.

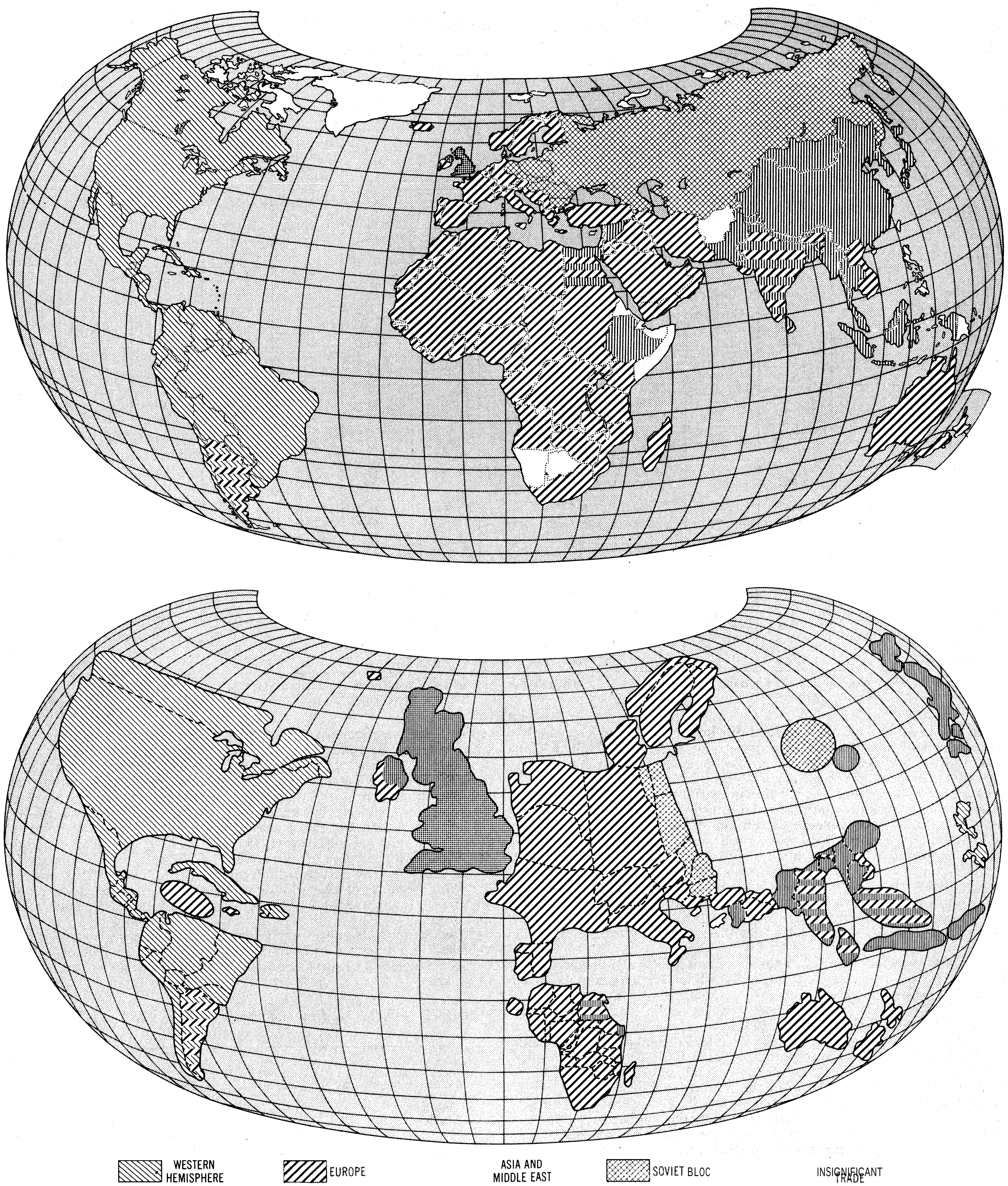
Reservation is also necessary in considering the groups of road motor vehicles. It consists mainly of motor cars, trucks and buses. Motorcycles are included in some countries but counted together with bicycles in others.

TABLE VII.—*Fifty Leading Commodities in World Trade Import, 1954*

(Value in millions of U.S. dollars)

Machinery	3,275	Cocoa	700
Petroleum, crude	2,800	Yarn	625
Petroleum products	2,775	Beverages	625
Coffee	2,750	Tea	600
Iron and steel	2,300	Minerals. crude	600
Road motor vehicles	2,150	Vegetables	575
Cotton	2,120	Power machines	575
Wool	2,000	Iron ore	550
Fabrics	1,950	Chemicals, n.e.c.	550
Wood	1,575	Vegetable fats	525
Fruits, nuts	1,500	Fish	525
Coal, coke	1,460	Drugs	525
Electric machinery	1,460	Rice	500
Paper and paperboard	1,450	Fodder	450
Copper	1,400	Tractors	450
Wheat and flour	1,350	Vegetable matter*	425
Sugar and preparations	1,225	Inorganic chemical	420
Meat, fresh and preserved	1,100	Clothes	420
Nonferrous ores	1,000	Hides	400
Metal, manufactured	1,000	Organic chemicals	400
Pulp	950	Ships, boats	400
Rubber, crude	940	Gems, diamonds	400
Oilseeds, crude	925	Soap, cosmetics	375
Tobacco	820	Aircraft	360
Dairy products	800	Instruments	360

*Not elsewhere classified.



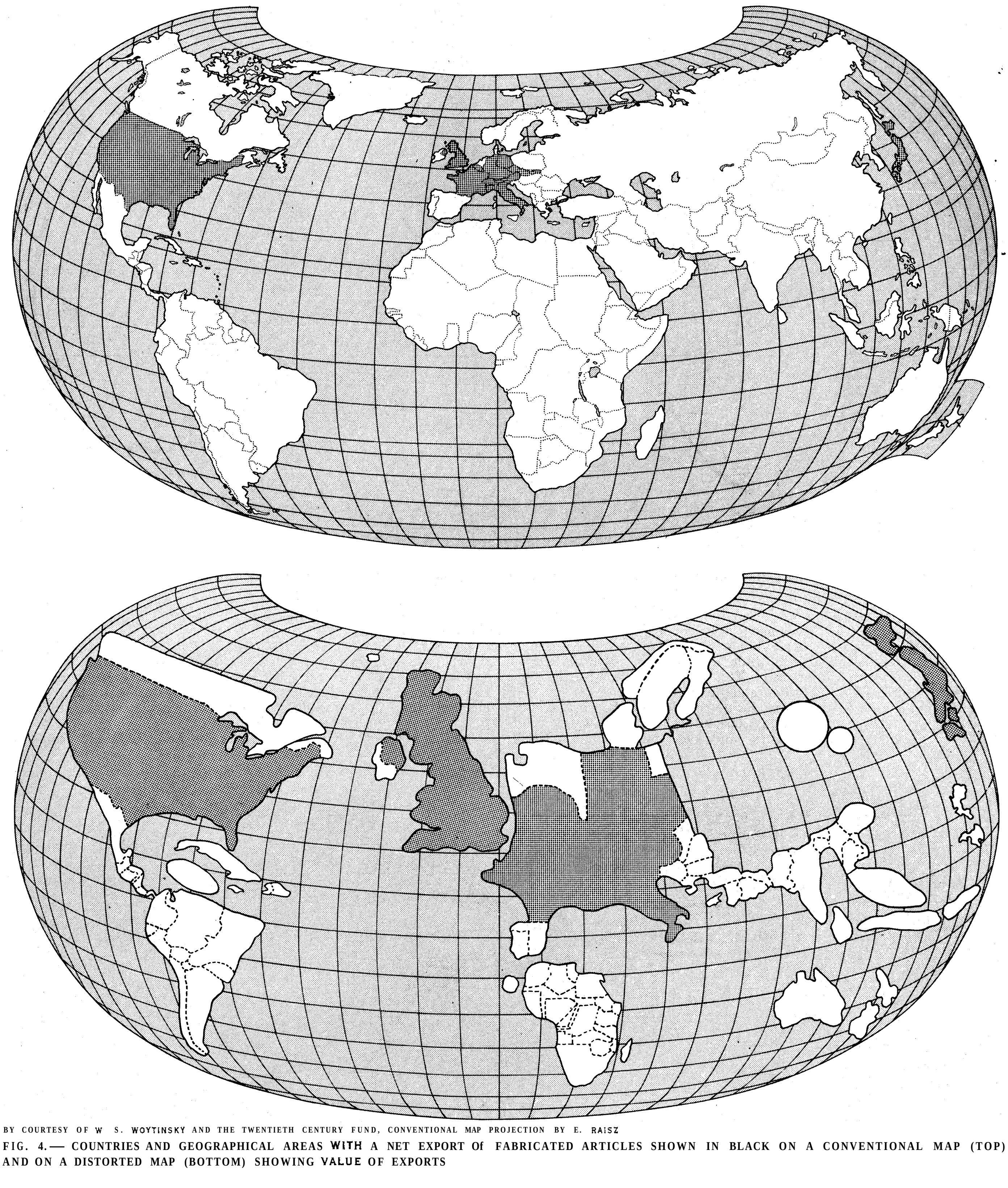
BY COURTESY OF W. S. WOYTINSKY AND THE TWENTIETH CENTURY FUND. CONVENTIONAL MAP PROJECTION BY E. RAISZ

FIG. 3.— CONVENTIONAL (TOP) AND DISTORTED (BOTTOM) MAPS SHOWING THE DISTRIBUTION OF NATIONS IN TERMS OF THE PREVAILING DIRECTION OF EXPORTS. DISTORTED MAP (B) SHOWS VALUE OF EXPORTS. THE UNITED KINGDOM IS NOT INCLUDED BECAUSE THE DIRECTION OF ITS EXPORTS IS WORLD-WIDE

In the seventh and eighth places are the natural fibres, cotton and wool. They are followed by fabrics, a fairly heterogeneous group that consists mainly of cotton and woolen fabrics but also includes fabrics of silk and rayon and some other textiles (but not all of them). The value of all textiles—fibres, yarn and fabrics including minor groups that are not listed above among the 1954 leading commodities in world imports—was probably close to $8,000,000,000.

The tenth among the big ten in world trade is wood, round and manufactured, but excluding pulp, plywood and such articles as furniture, etc.

Among other leading articles—with import value ranging between 1,000,000,000 and 1,500,000,000 U.S. dollars in 1955—are four groups of foodstuffs (fruits and nuts; wheat, sugar and meat), three groups of raw materials (coal, copper and nonferrous ores) and three groups of manufactured goods (electric machinery, paper and paperboard and manufactured metal not elsewhere classified).



BY COURTESY OF W. S. WOYTINSKY AND THE TWENTIETH CENTURY FUND, CONVENTIONAL MAP PROJECTION BY E. RAISZ

FIG. 4.— COUNTRIES AND GEOGRAPHICAL AREAS WITH A NET EXPORT OF FABRICATED ARTICLES SHOWN IN BLACK ON A CONVENTIONAL MAP (TOP) AND ON A DISTORTED MAP (BOTTOM) SHOWING VALUE OF EXPORTS

They are followed by an array of other commodities: pulp and rubber; tobacco and beverages; oilseeds and minerals; dairy products; yarn; cocoa; and tea, etc.

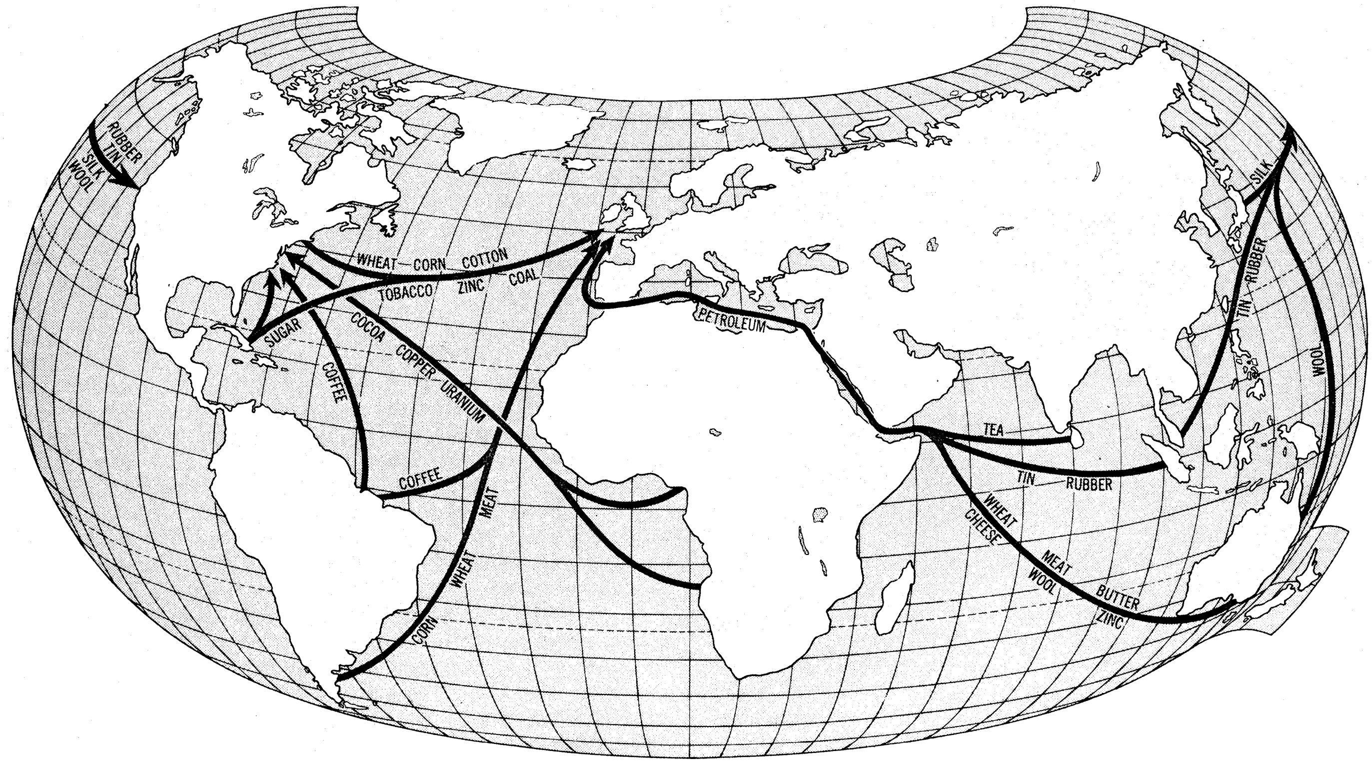
All in all, foodstuffs including sugar, tea, coffee and cocoa, spices, beverages and tobacco account for approximately 25% of the value of world imports; fuels, ores and metals, for another 25%; industrial raw materials other than fuels, ores and metals (*i.e.,* wood, fibres, oilseeds and crude minerals) represent 20% of the value; the finished goods, the remaining 30%.

Patterns of Foreign Trade.— The composition of exports and imports of each country forms what may be described as the pattern of its foreign trade. Seven patterns may be distinguished:

(1) Exchange of Foodstuffs for Fabricated Articles.—This pattern is characteristic of primarily agricultural areas on different levels of economic development. Some of them are colonies or former colonies (such as Algeria or Gold Coast [Ghana]); others, independent countries (Spain and Ireland; Cuba, Colombia, Brazil and Argentina; New Zealand).

(2) Exchange of Foodstuffs for Other *Foodstuffs* and Fabricated Articles.—This is characteristic of countries with highly specialized agriculture (*e.g.,* Denmark, Ceylon).

(3) Exchange of Raw Materials for Fabricated Articles.—This is



BY COURTESY OF W. S. WOYTINSKY AND THE TWENTIETH CENTURY FUND; MAP PROJECTION BY E. RAISZ

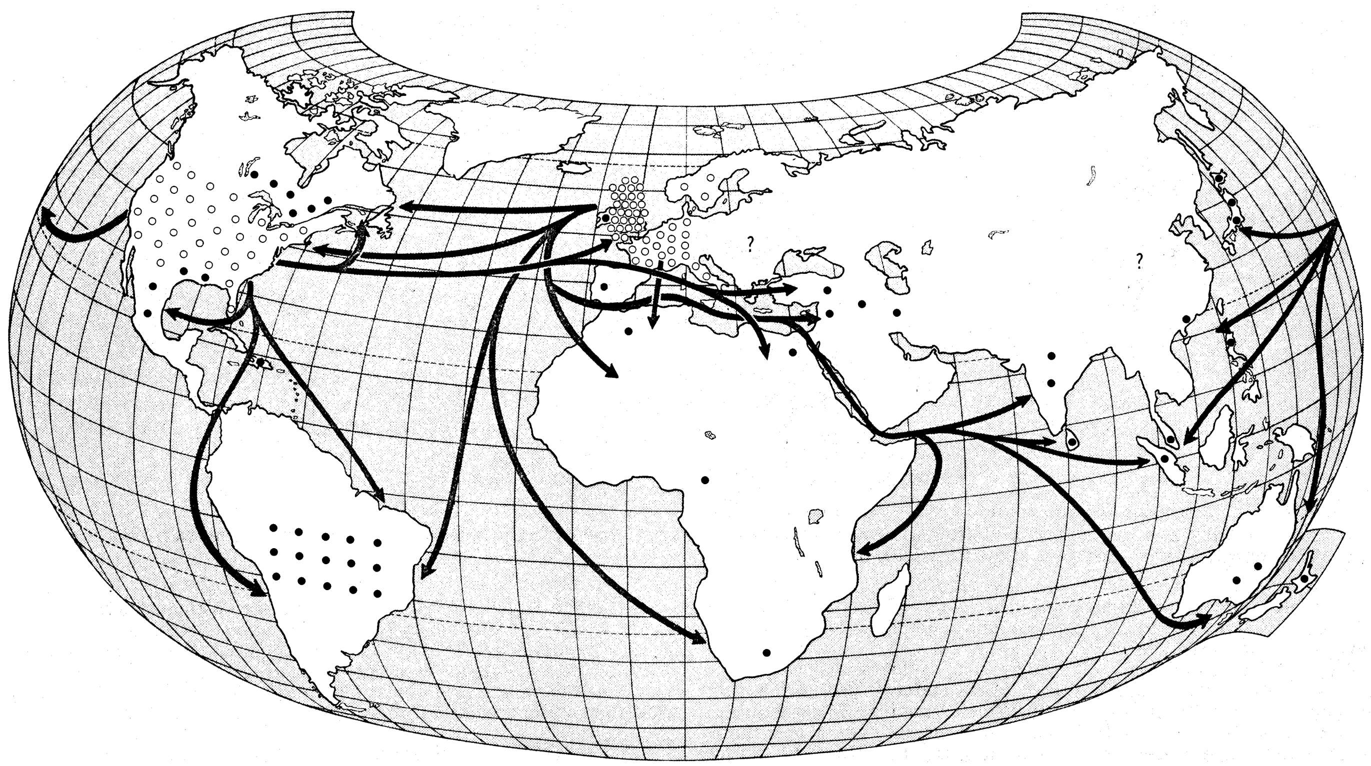
FIG. 5.— MAIN ROUTES OF PRINCIPAL FOODSTUFFS AND RAW MATERIALS IN INTERNATIONAL TRADE

characteristic of two groups of countries: those with agriculture specialized on production of fibres such as cotton or jute (Egypt, India and Pakistan) and those with abundant mineral resources (Venezuela, Peru, Chile, Saudi Arabia, Iran, Indonesia, Malaya, Belgian Congo, Union of South Africa and others). This group includes also the areas exporting wood (Norway. Sweden and Finland).

(4) Exchange *of Foodstuffs* and ***Raw*** *Materials for* Fabricated *Articles.*—This is the pattern of mainly agricultural areas exporting foodstuffs, for example wheat or corn, and such materials as oilseeds, cotton, wool (Rumania, Bulgaria, Yugoslavia; Morocco and Tunisia; Australia).

(5) Exchange of Fabricated Articles for Raw Materials.—This is a typical pattern of foreign trade of industrially developed countries with an agriculture powerful enough to provide their own population with food (United States, France) or with a greater deficiency in raw materials than in foodstuffs (western Germany, Belgium, Italy, Japan).

(6) Exchange *of* Fabricated Articles *for* Foodstuffs and Raw Ma-



BY COURTESY OF W. S. WOYTINSKY AND THE TWENTIETH CENTURY FUND; MAP PROJECTION BY E. RAISZ

FIG 6 — MAIN ROUTES OF ENGINEERING PRODUCTS IN INTERNATIONAL TRADE. PRODUCTS INCLUDED ARE MACHINERY, MEANS OF TRANSPORTATION, STRUCTURAL STEEL. ETC. EACH OPEN DOT REPRESENTS $100,000,000 OF EXPORTS. EACH SOLID DOT $100,000,000 OF IMPORTS. 1954–55 *terials.*—The outstanding example of this pattern of foreign trade is the United Kingdom.

(7) *Other and Shifting Patterns.*— In certain countries, exports and imports are highly diversified (the Netherlands, Austria, Switzerland). Only a few countries have a net export of fabricated articles (patterns 5 and 6 and some of the areas in the 7th group). On a conventional world map they appear as three spots—two at the shores of the North Atlantic and the third—Japan—in the north Pacific ocedn (*see* fig. 4A). The picture is different on a distorted map that shows countries on the scale of their exports on such a map the three areas are far larger than all the rest of the world; indeed, they control about three-fourths of world trade (*see* fig. 4B)

Principal Routes of World Trade.— The commodity trade statistics of the United Nations cast light on the pattern of trade routes (*q.v.*) that cross the seven seas of the world. Each commodity has its own route, usually with a limited number of exporting areas and a much larger number of importing markets. Thus, wheat moves from the surplus areas in North America and Australia to northwestern Europe and India; sugar, from the Caribbeans to North America and western Europe; tobacco, (1) from the United States. Egypt and Brazil to northwestern Europe, Japan, Canada and Australia; (2) from the United States, Brazil, India and the middle east to Europe, Japan and Australia and (3) from the Caribbeans and middle east to the United States; coffee, from Brazil to the United States and western Europe; tea, from Ceylon to Great Britain; rubber, from Indonesia and Malaya to North America and western Europe; and so on.

The principal routes of foodstuffs and raw materials in world trade are shown in' fig 5

The routes of fabricated articles form a still more intricate pattern. Industrially developed countries pay with fabricated articles for imported raw materials and foodstuffs and in addition exchange fabricated goods among themselves Such a double pattern is characteristic for example of the routes of the group of engineering products that contains structural steel. tools and machinery of all types and means of transportation, including railroad equipment, motor vehicles, ships and aircraft (*see* fig 6) *See* also COMMERCE, HISTORY OF; EXPORTS; IMPORTS; INTERNATIONAL PAYMENTS.

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TRADE, PRIMITIVE. The importance of trade to' primitive peoples is seldom realized. Exchange of goods among them is certainly limited in extent; often only specified classes of objects are allowed to change hands, and many commodities are exempt from such traffic. as the land of the clan or tribe. Nevertheless trade; *i.e.*, a regular series of acts of exchange. is a distinct feature in the life of primitive peoples, even the lowest. who live by hunting and collecting forest products. The principle of reciprocal transfer of goods, of giving and taking, seems in fact to be deeprooted in human nature.

Trade has two aspects, intracommunal. between members of the same community, and extracommunal, between members of different communities. The latter is of more interest, especially since, by the widely accepted theory of Karl Bücher, those few primitive folk who have advanced beyond the pre-economic stage of existence are still in a state of closed household economy. Each little group is imagined as self-sufficient, its needs and products in equilibrium, and trade between them, being unnecessary, is therefore held to be absent. More adequate study, however, shows that this idea is quite erroneous.

Types of Trade.— Silent Trade.— Most spectacular is the institution variously described as the silent trade. "dumb barter" or depot trade. Mentioned by Herodotus. this method of exchange was practised by the Carthaginians in their traffic for gold with the African tribes beyond the Pillars of Hercules, and was noted by Fa Hien, Ibn Batuta and other early travelers. In the most general form of procedure one party goes to the customary spot. lays down goods and retires into the bush or to a distance. giving as a signal a call or a gong stroke. The other persons then come, lay down what they consider to be articles of equivalent value. and retreat in their turn. The first party then comes back and if satisfied with the bargain removes the newly deposited goods; if not, these are allowed to remain until suitable additions are made. The persons of the second party then take away the original wares and the transaction is concluded. Neither party holds any communication with the other. beyond giving the customary signal, hence the name of silent trade. This widespread institution was reported from such diverse regions as north Russia, Lapland, west Xfrica. Timor, Sumatra, India. Ceylon and north New Guinea. It is found especially where people of a fairly primitive type conduct habitual exchange with those of a somewhat higher culture. Thus the Akka pygmies obtain bananas in exchange for meat from neighboring agricultural tribes, and the Veddah obtain iron implements from Singhalese smiths in return for game. Elements of shyness and fear are obviously involved in this custom, which thus secures economic benefits for people who shun foreign contacts.

Gift Exchange.— This transaction takes the form of present and counterpresent often between host and guest. A good example is afforded by the Maori of Ken Zealand. Exchange was conducted quite in the manner of gift making; no bargaining upset the proceedings; such mas not tikn ("correct"). At the same time a strict system of reciprocity nas in force. by which the recipient of the gift was bound, as he valued his name and reputation. to make adequate repayment. This was expected by the donor. Such was the idea of *utu,* "equivalence," which ran through all Maori social life. But the recipient usually tried, if possible. to give back greater value than he received. not through generosity, but since his own prestige would thereby be enhanced. Even nhere the exchange was primarily a matter of securing necessaries of life, as food or garments, the desire to obtain fame by being liberal strove with the wish to have the economic advantage. These are the twin psychological factors lying at the root of every exchange of gifts.

Barter.— This consists in the direct transfer of goods against goods. Unlike the gift exchange, it implies agreement as to rates, with the possibility of haggling over quantities and values. A system of barter in certain commodities may co-exist with gift exchange in others of greater social import. as in the Trobriands, where, as described by Bronislaw Malinowski, the *Kula,* or exchange of valuable arm shells and necklaces is conducted along polite. strictly ceremonial lines, while the *gimwali,* the barter of fish for vegetables. is carried on with haggling as to size and quantity, and even acrimonious wrangling Barter in abstract form is often supposed to be typical of primitive peoples. But rarely in any native community is the rate of exchange for goods determined by purely economic considerations of supply and demand working on the principle of rational utility alone.

Buying and Selling.— This avoids the awkwardness of barter by the use of some medium of exchange. Much of what is often described as primitive money is wrongly so termed, but in various parts of Africa, for instance, cloth. iron, cowrie shells and salt do act as true currency. as also, apparently, do coconuts in the Nicobar islands. (See CURRENCY, PRIMITIVE.)

Occasions of trade on a large scale among primitive peoples are provided by expeditions and markets.

Trading Expeditions.— In some areas itinerant traders. as the Hausa hawkers in parts of Africa. play an important role in economic life. In others their place is taken by caravans, as those of the Arabs, regularly equipped and following recognized trade routes. Of great interest, again, as being accomplished by more primitive folk. are such group expeditions as those of the Dieri and other central Australian tribes, who will travel on foot for 400 to 500 mi. to procure red ochre and the pituri plant. Noteworthy also are the trading voyages, in unwieldy dugout canoes, of the people around the New Guinea coast, as the sailing trips of the Siassi of the North, the hiri of the Motu. in which pots are taken to the Papuan gulf and exchanged for sago, and the *Kula* of the Trobriands. the ceremonial exchange of ornaments.

Primitive Markets.— These are of varied kind and wide distribution. Their great home is Africa. but they have also been described from Guiana, old Mexico and Peru, Hawaii and various Melanesian areas. A typical example at either end of the scale will serve for illustration. The inhabitants of certain small islets off the coast of Malaita, Solomon Islands, barter fish with those of the mainland for vegetables and pigs. Almost every day, at times arranged beforehand with the bush natives, the islanders resort in their canoes to recognized places on the beach. The men then stand guard with spears, while the actual bartering is done by the women, who, thus covered, advance slowly toward one another, produce in hand. Disputes at these markets are rare, though at other times the island natives cannot venture ashore without risk. In parts of Africa this institution is more imposing. Among the Akikuyu of the east. markets in a thickly populated district are no more than two-thirds of a mile apart, and are of great importance in the life of the people. They occur frequently in the week. but are so arranged as not to clash with others in the neighbourhood, so that a person may visit them all in turn About 9 o'clock in the morning the paths begin to fill with natives carrying loads of corn, firewood, beer or iron to exchange, and between 11 A.M. and 1 P.M. business is at its height, the concourse numbering perhaps 4,000–5,000 persons. Order is maintained by special officers and no weapons are allowed within the precincts. The main characteristics of a market as a mode of conducting trade are its set time and regular recurrence, the definite place of assembly and the regulations by which order is preserved.

Psychology of the Trading Process.—The motives behind primitive trade are many sided. The central factor is undoubtedly the desire for rational gain, for securing objects of economic utility otherwise unprocurable owing to variations in natural conditions or specialized skill. But the psychological background is more complex than this. Trade is often carried on in articles charged with great social and ceremonial meaning, as in ornaments, but of no direct practical interest. Moreover, the desire for renown and prestige is often a prominent element in the exchange, while the transaction itself may assist in cementing social bonds.

The value of goods, too, is determined by a complex set of factors. Even in the case of things apparently desired merely for their practical utility there is not such an objective standard of valuation as obtains in modern society; *i.e.,* personal factors enter much into the exchange. The extent to which emotional elements lie at the root of value is shown in the case of such objects as *tiki* and other greenstone ornaments of the Maori, heirlooms of great wealth and the principal articles of ceremonial exchange. Their worth lies in their historical association with dead chiefs and ancestors of renown, in their sacredness and importance as symbols of the tribal greatness rather than in their practical use for adornment.

Theory of Primitive Trade.—The principal types of trade in primitive culture were once regarded as successive products in evolutionary development. Modern research, however, tries to study each particular system of trade in its own cultural setting. The primitive market in its various forms, for instance, cannot be understood if conceived simply as an evolutionary sequence from the customs of silent trade or as a development from previous hostile relations or as the result of a recurring assemblage of people for religious or ceremonial purposes. It is explicable only as an institution which emerges in response to certain needs, and is conditioned by the natural situation and the social structure of the community which it serves. So also with primitive trade in general. It is more than a mere matter of economic trafficking on abstract principles of national advantage; it is a complex social mechanism linked to many aspects of native life. The true problem does not lie in theorizing about its historical or evolutionary origins but in disentangling the various social and psychological factors which together determine the form of the living institution.

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TRADE BOARD: see MINIMUM WAGE.

TRADE CYCLE. The phrases trade cycle, business cycle and cyclical fluctuation of trade are all convenient methods of labeling the alternating upward and downward sweeps in the volume of business activity. The most obvious manifestation of the trade cycle is a fluctuation, extending over several years, in the level of prices, the level of money profits and the level of employment. In the United States business cycles have usually taken from three to five years to run their course. In European countries the cycles have been somewhat longer and less regular. See BUSINESS CYCLE.

TRADE FORECASTS: see ECONOMIC FORECAST.

TRADE-MARKS AND NAMES. A trade-mark is a device used by a business enterprise to identify its goods and distinguish them from those made or carried by others. It may consist of fancy words and descriptive words. of pictures, figures, letters, dress labels, business equipment, etc.. and a combination of all of them; it may be a business mark, a merchandise mark or a service mark; it may be a manufacturer or a dealer mark. It is called a private brand if the dealer purchases from one or several manufacturers and causes them to place upon the article a mark selected by him. The mark may be a collective and certification mark when it is a mark reserved by an organization for the use of its members; its purpose is like that of a guild mark (see below) to preserve certain standards of quality. Such marks are standardization marks where the goods of all members have uniform peculiarities of production. Finally grade marks may be distinguished from genuine trade-marks, but the distinction may disappear where the grade mark is apt and used to indicate origin.

Trade names and other symbols such as the appearance of goods are like trade-marks if they can be registered as such. Otherwise they can be protected only if the defendant's conduct is likely to lead to "passing off" (presenting deceptively) or, especially in the United States, if there is a violation under the doctrine of unfair competition.

According to historical development. economic trends and habits of consumers. the trade-mark functions as an indication of origin or ownership, as a guarantee of the quality of goods bearing the same mark and as an advertisement. The advertising function is much more substantial than the guarantee function and the function of indicating origin is an indispensable aid to the advertising function.

In medieval times marks designating ownership were an important device; they were not trade-marks but proprietary marks. They enabled authorities and especially the guilds to control the trade and their use was compulsory. Modern parallels are the branding of horses with a proprietary mark and having the distributor's mark blown upon bottles used for the distribution of milk and other products. In the guild economy the mark was a police mark. The gold- and silversmiths in France and the Italian states, the woolen and linen weavers in England, the hammersmiths in Austria and most of the guildsmen in Germany were compelled to use a mark to enforce the guild monopoly.

Acquisition and Infringement of Trade-marks.—The trade-mark laws of the world reflect, in principle, two basically different approaches with respect to the acquisition of trade-mark rights. In the one especially dominant in the Anglo-American law and in some Roman laws, trade-mark rights arise out of appropriation and use. and the exclusive right to a particular mark belongs to the one who first appropriates and uses it in connection with a particular business; registration. being merely declaratory of title to the mark, does not affect or perfect the trade-mark right. and though it does confer certain new rights to the mark, at the outset, it grants no greater right than would have been recognized at common law without registration. Therefore, in Great Britain and the United States a claim for trade-mark protection may be founded on the common-law right to a trade-mark arising out of priority of adoption and use and the right perfected by registration based upon use in commerce. In the other approach, especially dominant in Germany, Austria and the Nordic countries. the trade-mark right is premised upon registration; use is not a condition precedent, and in principle is not even necessary, to perfecting a trade-mark right.

The English common law of trade-marks practically commences with the first years of the 19th century. The use of trade-marks was indeed of far earlier date, for in 1742 Lord Hardwicke declared that "every particular trader had some particular mark or stamp." But in the very case in which Lord Hardwicke made that statement (*Blanchard* v. Hill, 2 Atkyns. 484) he refused to protect the "Great Mogul" stamp on cards, being apparently under the influence of the notion that the legal recognition of trade-marks uould involve the creation of a new species of monopoly. But although the actual law of trade-marks cannot be traced farther back than the beginning of the 19th century, Lord Eldon repeatedly granted injunctions to restrain one trader from fraudulently passing off his goods as those of another, and thus laid a foundation on which later law has been built up. It was decided by Lord Cottenham in 1838. in the leading case of Millington v. *Fox* (3 Mylne and Craig 338). that an injunction to restrain the infringement of a trade-mark could be obtained even though the defendant had acted in ignorance and without fraudulent intent. In the common law, on the other hand, fraud was an essential ingredient in the cause of action, and remained so until the fusion of law and equity by the Judicature acts in 1873.

The theory that there may be a property right in a trade-mark and that such property may be the basis for equitable relief was first propounded in *Millington* v. Fox (see above). Equity courts have since been more favourably inclined toward the concept of a property right in trade-marks, but the precise nature of the right is still a matter of great dispute. The principle obtained from Millington v. Fox was clearly announced in three cases decided by Lord Westbury, in 1863: (Edelsten v. Edelsten, 1 De G. J. & S. 185, 10 L. T. [N.S.] 780; Hall v. Barrows, 4 De G. J. & S. 150, 32 L. J. Ch. 548; Leather Cloth Co. v. American Leather Cloth Co., 4 De G. J. & S. 137); and reaffirmed in 1882 by Lord Blackburn (Singer Mfg Co. v. Loog, L. R. S. App. Cas. 15, 33). In fact, this principle was far from well established. In 1857 it was held "now settled law that there is no property whatever in a trade-mark." (Collins Co. v. Brown, 3 K. & J. 423). In 1896, Lord Herschell, in Reddaway v. *Banham* ([1896] A. C. 199, 209) questioned the accuracy of a statement that there is a property in the common-law trade-mark, though there was no doubt that some of the rights incident to property might attach thereto, especially if it was capable of no conceivable legitimate use except by the proprietor.

In the U.S. it was still problematic in the second half of the 20th century whether the courts would recognize a property right in a trade-mark. Influenced by the function of a trade-mark as a symbol of business, most courts held that a trade-mark is not property in the ordinary sense but only a word or symbol, the owner of which acquiring the right to prevent the goods to which the mark is applied from being confused with those of others. In fact the test of infringement has been distilled out of the three functions of the trade-mark — to identify the product and its origin, to guarantee the product's unchanged quality and to advertise the product. Injury to the mark in any of these capacities would suffice to constitute an infringement thereof.

If the trade-mark owner's goods are competitive with those of the infringer, a confusion created by the infringer's use of an identical or similar mark is a confusion of goods, which means that the buyer will be caused to believe that he is buying the plaintiff's products. If the goods are noncompeting and so kindred that the maker of one might naturally be assumed to be the maker of the other (*e.g.*, electric clocks and electric razors) the implication might be, in accordance with the ordinary industrial or commercial situation, that the trade-mark owner's business has been expanded so as to include the article made or sold by the infringer. The confusion evident in such a case is a confusion of business; the deceived customer here buys the infringer's product in the belief that it originates with the trade-mark owner or that it is in some way affiliated with his business. Here, of course, the infringer is trading upon and appropriating the trade-mark owner's established reputation. Noncompeting goods may also be those which are entirely different from each other (*e.g.*, jewelry and motion pictures). There is, in all probability, no confusion in these cases at all. Here the use of the identical or very similar trade-mark by the infringer results in the dilution of the distinctiveness of the original trade-mark. (Statutes and case law against infringement by dilution exist in the U.S., Germany and other countries but not in Great Britain.)

Registration of Trade-marks. — As noted above, in the common law of England trade-mark rights originated without any registration. The development of this common law, both in England and the United States, was slow and confused. The intangible values of trade-marks, as distinguished from the tangible values of money or a house, were perplexing to the average jurist, and it was, of course, extremely difficult to prove the existence and scope of such values in a court proceeding. The businessman of both countries demanded legislative action and statutes were enacted in England, the United States and Germany, then the coming industrial centre of Europe. The English Merchandise Marks act was enacted in 1862; in the United States the first Federal Trade-Mark act was passed in 1870; and in Germany the Law for the Protection of Marks was enacted in 1874. It is extremely interesting to compare these statutes, for they proceed upon and represent three essentially different theories of trade-mark registration.

The English Merchandise Marks act of 1862 was principally concerned with the criminal law and only few provisions affected the civil law of trade-marks. It was of little practical value. In 1875, the Trade-Marks Registration act established the present register of trade-marks and revealed the English theory of protection. To facilitate, or obviate the necessity for, proof of title by use and reputation, the fact of registration was deemed prima facie evidence of the registrant's right to the exclusive use of the trade-mark in connection with goods of the class for which it was registered and used; it further provided that after five years the fact of registration is conclusive evidence of such a right, if, of course, the trade-mark has remained upon the register and the proprietor of the mark has remained the owner of the good will of the business to which it referred. As a further inducement to registration, the act provided that after a certain date no action to prevent the infringement of any trade-mark as defined by the act could be instituted unless and until that trade-mark was registered in compliance therewith. This did not, of course, defeat the possibility of a suit under the doctrine of passing off to protect an unregistered trade-mark; see *Montgomery* v. Thompson [1891] A.C. 217, 8 R. P. C. 361 (Stone Ales). Though the later statutes, including the Trade-Marks act of 1905, which repeated the whole of the statutory civil law of trade-marks, and the Trade-Marks act of 1938, introduced several significant and valuable changes, they were guided by the same principles and were primarily designed to improve the registration proceeding. The only significant change represented a deviation from a time-honoured principle in the law of unfair competition. The act expressly allowed the assignment of a trade-mark without the good will of the business to which it referred. In principle, the English law of trade-mark registration allows the first user several years in which to proceed against a registered trade-mark which allegedly invaded his common-law right; nevertheless, under the English law, the statutory rights are supplementary and similar to the common-law rights.

In the United States, the law has an entirely different history. The first Federal Trade-Mark act of 1870, like the early English laws, was characterized as "an act to revise, consolidate and amend the Statutes relating to patents and copyrights." It provided for registration of trade-marks whether or not they were used in interstate or foreign commerce. Both this act and another providing criminal penalties for counterfeiting marks registered under the act of 1870 were declared unconstitutional in the now famous Trade-Mark cases, United States v. *Steffens,* 100 U.S. 82 (1879). Congressional power with respect to trade-marks, it was held. could be derived only from the commerce clause of the constitution and not from the patent and copyright clause empowering congress "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." Congress could, therefore, legislate with respect to only those trade-marks used in interstate and foreign commerce.

In 1881 a new law provided for the registration of marks used in foreign commerce, but, strangely enough, not in interstate commerce or commerce with the Indian tribes. This act, apparently, satisfied the constitutional limitation. It presupposed the existence of a valid trade-mark which could be registered on compliance with the formal requirements, and, according to established U.S. theory, registration thereunder in no wise affected the nature or function of the mark. Edison v. Thomas *A. Edison, Jr.*, Chemical Co., 128 Fed. 1013 (C. C. D. Del. [1904]).

The act of Feb. 20, 1905 was the first comprehensive trade-mark statute. Predicated upon the theory that the ownership of a trade-mark is acquired by adoption and use, registration under the act merely affected procedural rights. The most important amendment thereto was the supplemental act of March 19, 1920, which extended the substantive rights conferred by the ten-year clause. This clause permitted the registration of marks used exclusively and in good faith for more than ten years prior to the passage of the act of 1905 even though they could not be registered thereunder, *e.g.,* secondary-meaning marks. The act of 1920 was primarily designed to protect American owners of such secondary-meaning marks in those foreign countries in which the registration was contingent upon proof of registration in the home country.

The new trade-mark act, the Lanham act, of July 5, 1946, which took effect July 5, 1947, was intended to place the old trade-mark act and its numerous amendments scattered throughout the United States statutes in one statute; to eliminate judicial obscurity created by the various conflicting and confusing interpretations; to simplify and liberalize registration and to make it legally more meaningful; to dispense with mere technical prohibitions; and to provide prompt and effective relief against infringement.

On the theory that the law of trade-marks, however its protection may be secured, is part of the law of unfair competition, a close connection follows between the common law and the statutory law, and even the superiority of the former over the latter. This the German experience amply demonstrates. The German Trade-Mark act of 1894, successor to the law of 1874, as amended, provided that registration and not prior use creates the trade-mark right. However, the statute itself granted an action against the infringement of an unregistered mark which has been vested with secondary meaning; the courts recognized the priority of secondary meaning over registration and thus held the common law of unfair competition superior to the statute.

With respect to the requirement of use as a condition precedent of registrability we can distinguish the following major systems: (1) the unconditional requirement of use (represented by the United States); (2) modification of the absolute requirement of use with respect to the initial time (represented by Great Britain and Canada); (3) a combination of use and registration as interrelated factors (France, Belgium and the Netherlands); (4) Registration as the sole requirement for the creation of rights (Germany, Austria and others).

Under the United States Lanham act, sec. 1, the applicant for registration must certify to the date of his first use of the mark in commerce or otherwise and must also certify that the mark is still in use in commerce. Furthermore, the Lanham act introduced a new technique under which inactive marks can be removed from the register. It further conditions the duration of registration upon the filing by the registrant of an affidavit within the sixth year following the date of registration, attesting to the fact that the mark is either still in use or that its nonuse is excusable because of special circumstances and not because of any intention to abandon the mark (sec. 8). Similarly, when a registrant after 20 years seeks the renewal of his registration he must file an affidavit stating that the mark is still in use in commerce (sec. 9). Nonuse of a mark for two consecutive years constitutes prima facie evidence of abandonment (sec. 45[a]). Nonuse may under certain circumstances be excused (*e.g.,* scarcity of materials, lack of demand, lack of funds, bankruptcy proceedings, reorganization of business, war, accident, etc.) The commissioner of patents, acting ex officio, is directed to cancel a registration after inexcusable nonuse for six years (sec. 8).

In Great Britain as in the United States, as a matter of principle, no trade-mark right can exist without use. The requirement of use, however, has been modified and there is even a possibility of registering reserve marks and, to a certain degree, defensive marks as well. (The Trade-Marks act of 1938 has materially changed sec. 37 of the act of 1905 which gave statutory effect to the decision *Batt* v. *Dunnett* [1899] A. C. 428; 16 R. P. C. 411. See Kerly's Law of Trade Marks and Trade Names, 7th ed., p. 275 [1951]).

At the request of any person aggrieved, a registered mark can be canceled for nonuse with respect to the goods for which it was supposed to be used according to the registration, but only if one of the following situations exists:

For nonuse for a period of less than five years, the mark can be canceled on proof that the registrant, at the time of the application for registration, had no intention of using the mark and in fact has not used it in good faith. If nonuse extends over a period of five years or more, the mark will be deemed abandoned, and registration will be canceled unless the registrant's inactivity "is shown to have been due to special circumstances in the trade and not to any intention not to use or to abandon the trademark." (Trade-Marks act of 1938, sec. 26.) The decision is at the discretion of the court and is not subject to appeal.

Defensive registration of marks is permitted for the invented word mark that has become so well known with respect to certain goods that its use in connection with other goods would be likely to cause confusion. (Trade-Marks act of 1938, sec. 26 [1] [a] [b].) It may be registered for such other goods even though the registrant has no intention to use in that connection (*e.g.,* Coca-Cola for bicycles; Kodak for knives).

Another requirement is the provision that the use of a mark by a so-called registered user (one who, on the basis of a commercial relationship, uses the mark with the permission of the owner), is considered legitimate use by the owner (sec. 28). If "permitted use" of a trade-mark by a third party is desired, the registered owner of the mark and the proposed "registered user" file a joint application, accompanied by a statement which details the proposed or existing relationship between them. As distinguished from the U.S. provision, the British statute does not require control over the nature and quality of the trade-marked goods or services, being satisfied with control over the permitted use.

The concept of use in the modern English law is somewhat broader than it is in the American law. The British act of 1905 closely paralleled the present U.S. law in requiring the mark to be "applied or attached" to the goods or used in an invoice or document accompanying the goods. Use in advertising alone was not sufficient. The act of 1938 (sec. 68 [2]) changed this requirement by electing the phrase "in relation to goods," thereby qualifying use of the mark in advertisements. It should also be noted that the circulation in Great Britain of advertisements of foreign produced goods can be relied upon only if the goods are, or are intended to be, dealt with in the United Kingdom.

The use of, or the intention to use, a mark must be "bona fide." (Trade-Marks act of 1938, sec. 26 [1] [a] [b].) "Bona fide use" or "bona fide intention" to use is synonymous not with honest use or intention but with genuine use or intention to use; *i.e.,* it cannot be pretended solely to obtain registration.

As distinguished from U.S. law, in the United Kingdom there is no cancellation of a mark ex parte or ex officio, nor is it necessary that continued use of the mark be established at certain intervals.

The Canadian law deserves special consideration. Under earlier laws (Trade-Mark & Design act of 1868 as amended in 1919, 1923, 1927, 1928; Unfair Competition act of 1932), use of the mark was a condition precedent of registrability. (Standard Brands v. Staley, Ex CR 615, 6 C. P. R. 27 [1946].) The new trade-marks act, Trade-Marks act of 1953, in effect since July 1, 1954, changed the law fundamentally and the Canadian trade-mark law became one of the best with respect to the requirement of use.

Under the new law, registration can be sought if the applicant merely intends to use the mark in the future ("proposed trade-mark"). (Trade-Marks act, sec. 16 [3].) The application can be processed up to allowance if it is accompanied by a simple statement that the applicant intends to use the mark or by the application of a registered user. (Trade-Marks act, sec. 29 [e].) Registration, however, will be allowed only after the applicant uses the mark and declares accordingly. (Trade-Marks act, sec. 39 [2].) This declaration must be filed within six months of notice from the registrar that the trade-mark is allowable. Protection against infringement will be granted after the registrar has declared the registration allowable.

Similar to U.S. law, the new Canadian trade-mark law authorizes the registrar to cancel the trade-mark because of nonuse or, at his discretion, to confine it to particular goods in connection with which it is used. This authority cannot be exercised until three years after the registration, and at that time any interested party can request an investigation with respect to the actual use of the mark.

Registers of trade-marks were established in Great Britain by the act of 1875 (sec. 1 and 7) and were continued under sec. 1 of the act of 1938. The validity of previous registrations is maintained by the third schedule to the act. The main register is kept at the patent office in London, other official records are also at Manchester, so far as the marks relate to textile goods, and at Sheffield, for trade-marks of metal goods registered by traders in Hallamshire or within six miles from it. The register is under the control of the comptroller general of patents, designs. and trade-marks who is in the act of 1938 referred to as the registrar. He is appointed by, and acts under the direction of the board of trade.

By the Trade-Marks acts of 1919, the register was divided into two parts, A and B. Under the act of 1938 the register continued to be thus divided (sec. 1 [2]) and was at all convenient times to be open to the inspection of the public. subject to certain regulations (sec. 1 [3]). In order to be registrable in part **A,** the trade-mark must consist of or contain at least one of the following essential particulars: (1) the name of a company, individual or firm, represented in a particular manner; (2) the signature of the applicant for registration or some predecessor in his business; (3) one or more invented words; (4) one or more words having no direct reference to the character or quality of the goods (descriptive) and not being in its ordinary signification a geographical name or surname; (5) any other distinctive mark; however, a name, signature or words other than such as fall within the descriptions in the foregoing sections (1 thru 4) shall not be registrable under the provisions of this paragraph (sec. 9 [1]) except upon evidence of its distinctiveness. (Distinctiveness means here that the mark has lost its primary meaning as a descriptive or geographical term or as a surname and has by reason of extensive use or advertising obtained as "secondary meaning" a genuine trade-mark significance).

In order to be registrable in part B of the register the mark, though not registrable in part A, must be capable of distinguishing the goods of the registrant from those of others. Originally part B mas designed to protect trade-marks in foreign markets by providing English trade-mark owners with the domestic registration they must show to obtain protection in foreign countries. This kind of registration has. however, declined in importance since an increasing number of countries have abandoned the requirement of proof of a foreign home registration. Xevertheless, it is apparent that registration in part B mill create a public record of first use, which becomes all-important if a registration is to be transferred from part B to part A.

In the United States registration of trade-marks rests upon legislation both of the federal government and the states. Many of the state statutes were primarily designed to protect particular industries, particular articles, labour and fraternal organizations or various forms of advertisement. The most important provisions provide penal sanctions for unlawful use, imitation and counterfeiting of trade-marks, names, labels, wrappers, bottles, boxes. etc., and for using false representations or other fraudulent means to procure registration. The penalties vary: some statutes declare trade-mark infringement a misdemeanor, while others only prescribe fines in varying amounts. State registration secures state jurisdiction over trade-mark infringement and subjects the infringer to the special penalties of state law. State registration is, moreover, of evidentiary value; it is probative of the adoption of the mark, constitutes prima facie evidence of ownership and gives notice to the public, thus denying the infringer the defense of ignorance of the trade-mark owner's right.

For revenue purposes. legislation making state registration mandatory has often been advocated and such bills have suggested that registration in a given state be the sole determinant of ownership. These proposals have been rejected. Federal registration alone is important The Lanham act, similar to the English law, provides for two registers. a principal and a supplemental register; they are like part A and part B of the English law.

The effect of the registration in Great Britain is different from that in the United States. True, the general object of the registration acts was not to create new rights in addition to the right in an unregistered common-law mark, but to regulate the use of, and the means of protecting, trade-marks. Their main effects, however, have been (1) to provide a new way in which title to a trade-mark may be acquired, namely by registration; (2) to simplify infrigement actions by making registration in part A evidence, and under certain circumstances. conclusive proof of title (sec. 4–7, 13, 46 of the 1938 act); and (3) to constitute registration — in general, a condition precedent to an action for infringement, for, as distinguished from the law of the U.S., no action lies for infringement of an unregistered trade-mark (sec. 2 of 1938 act).

Registration is for a period of seven years, but may be renewed from time to time (sec. 20); under sec. 28 of the 1905 act the period of registration was 14 years. A trade-mark may be removed from the register (1) at the instance of the registered owner or by some person entitled by law to act in his name (sec. 34); (2) by the tribunal on an application to rectify the register if the registration is a wrongful act; or (3) by the registrar on non-payment of renewal fees.

In the United States registration on the principal register is equal to knowledge (constructive notice) of registrant's claim of ownership and prima facie evidence of such ownership and of the validity of the registration. Such registration may, with certain exceptions, become incontestable and entitles the registrant to have the customs authorities stop the importation into the United States of any goods bearing an infringing trade-mark and to institute all actions based on the registration in the federal courts. Registration on the supplemental register has only this jurisdictional advantage.

Assignment of Trade-marks. — "In trade-mark matters," it has been said, "the place where the most numerous and the most costly mistakes are most frequently made is in the matter of transfers." (E. S. Rogers. *Good Will, Trade Marks and Unfair Trading,* Chicago: A. W. Shaw, 1914, p. 108). It appears, however, that these errors are the result of a judicial confusion that has characterized the law on transfers in almost all countries. Early doctrine had it that a trade-mark could be transferred only with the business to which it relates, and this was almost universally accepted. With modern commercial development, the failings of this doctrine became evident, but under the orthodox rule it was extremely difficult, if not impossible, to avoid injustice. At the Rome congress of the International Association for the Protection of Industrial Property, held in 1928, the problem was not resolved and the demand for change continued. It became increasingly obvious that a more liberal approach would be more consistent with justice. and the demand for it grew more insistent. In England the law underwent a drastic change in 1938. According to sec. 22 (1) a registered trade-mark is assignable "either in connection with the goodwill of a business or not." This provision is subject to the limitation that no assignment shall be allowed if it is likely to deceive the public or cause confusion. Moreover, sec. 28 of the 1938 act provides for the entry of a "registered user" of a trade-mark. Where it is desired to provide for the "permitted use" of a trade-mark by a third party, the registered owner and the proposed permitted user may be registered if the owner of the mark has control over the manner of use of the mark by the registered user and the register is satisfied that the use of the mark by the registered user is not contrary to the public interest.

In the United States the Lanham act did not go as far as the English revision of the old lam and was adopted only after much compromise. The new sec. 10 made only the following changes. The good will of an entire business in connection with which the mark is used need no longer be assigned with the mark. It is now permitted to assign along with the mark only so much of the good will of the business as is connected with the use of and is symbolized by the mark. If an assignee uses the mark or permits it to be used in a manner that misrepresents the source of the goods or services in connection with which the mark is used, the registration will be open to cancellation proceedings. If the parties are "related companies," within the meaning of sec. 45 of the Lanham act, which means that one controls the other in respect of the nature and quality of the goods or services in connection with which the mark is used, both companies may be registered and the legitimate use of the mark by one "shall inure to the benefit" of the other. (Sec. 5 of the Lanham act.) Thus the necessity for an assignment may in many situations be deemed eliminated by this section.

Loss of Determination of Trade-mark Rights.—The right of the trade-mark owner to the exclusive use of the mark in connection with the goods of the kind in respect of which the right existed is terminated or lost: (1) When the mark ceases to be distinctive, which may happen when the owner has used the mark as the name of the goods he deals in, and the trade or the consuming public adopts the mark as the name, to the effect that the mark has become generic and *publici* juris (*e.g.*, linoleum, maizena). (2) When a mark has been assigned without the good will of a business, the assignment shall not take effect until certain requirements (see sec. 22 [7]) have been satisfied, *e.g.*, the assignee must, not later than the expiration of six months from the date of the assignment or within an extended period, apply to the registrar for directions with respect to the advertisement of the assignment. If the assignee fails to do so the registration becomes invalid. (3) When the owner has abandoned the mark. A trade-mark owner may abandon his right, or, more correctly, forfeit his right by abandonment. In other words, he consciously transfers or surrenders his claim to the mark by consenting to its use by others. He may be stopped from challenging the use of his mark by another if, because of his laches, *i.e.*, failure to voice timely objection, the junior user developed a trade-mark in the belief that his use was unobjectionable. The latter may have been unaware of the trade-mark owner's right, or may have reasonably assumed that the trade-mark owner's failure to protest connoted acquiescence. Mere lapse of time or mere disuse does not establish abandonment; it is necessary to show not only acts indicating a practical abandonment, but an actual intent to abandon. Involuntary disuse, *e.g.*, because of scarcity of raw materials, lack of demand or of funds, bankruptcy, war, fire, etc., does not constitute abandonment. Under sec. 26 of the 1938 act nonuse for five years in connection with any goods for which the mark is registered may be a cause for removal of the mark from the register and in effect will be treated as an abandonment of the mark unless such nonuse "is shown to be due to special circumstances in the trade and not to any intention not to use or to abandon the trademark." (4) When the owner has forfeited his right to be protected against infringement by using the mark deceptively or in a fraudulent trade.

International Arrangements.—Many treaties exist by which the United Kingdom agreed to give to the subjects of other countries the same right of protection, in respect of their trade-marks, as it gave to its own subjects. Sec. 2 of the 1938 act restraining actions against infringement of unregistered trade-marks applies to the trade-marks of foreigners and therefore actions for infringement could not be brought by a foreigner without his trade-mark being registered in England. A foreigner, or any resident in a British possession may obtain registration under sec. 17 of the 1938 act. The United Kingdom and the United States are parties to the International Convention for the Protection of Industrial Property, founded in Paris on March 20, 1883, revised in 1900, 1911, 1925 and 1934. The provisions of the convention pertain to patents, utility models, industrial designs, trade-mark and other trade designations and unfair competition, and are designed to assure the nationals of the member nations a certain modicum of international protection.

Neither Great Britain nor the United States has, however, acceded to the two Madrid arrangements of 1891, one of which is for the international registration of trade-marks and the other for the repression of false indications of origin.

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TRADE ORGANIZATION. Whenever businessmen have been reasonably free to ply their trade, they have associated themselves together in commercial and industrial organizations of varied character and purpose. The gradation in types of organization, membership requirements, functions, activities, size, complexity of tasks performed. geographical coverage, influence and controls exercised is infinite. It varies imperceptibly from the local, sporadic informal meeting to the compactly organized national peak associations or *Spitzenverbände* that in many countries have wielded major influence on public policy and have controlled their membership through legal, financial or other sanctions implemented by the compulsory powers of government.

Three major types of trade organizations stand out: (1) The oldest and most widespread are the chambers of commerce which in commercial nations substantially match in coverage the important units of political power, national, state or provincial, and local. (2) The most important in their impact upon prices, sales, output and technology are frequently the associations of manufacturers and traders organized according to industries or products. (3) Most varied are those in the miscellaneous category of associations, the technical and research institutes, the professional organizations, the scientific bodies. the better business bureaus, the credit and cost bureaus. traffic associations, labour unions, farmers' organizations, producer and consumer co-operatives, etc.

Chambers of Commerce.—Known also by such names as commercial associations, boards of trade, development associations, prosperity boards, community leagues and the like, chambers of commerce are voluntary organizations embracing firms, public officials, professional men and public-spirited citizens of a locality or area. They are not only interested in publicizing, promoting and developing commercial, industrial and civic opportunities but also seek to improve community schools, streets, housing, public works, fire and police protection, parks. playgrounds, recreational and tourist facilities, etc.

International Chamber of Commerce.—Trade associations at times provide the basic instrumentality through which international industrial agreements are negotiated. They frequently engage in international activities such as serving in a consultative capacity to the United Nations Economic and Social council or having meetings with trade associations of similar interests in other countries. Indeed, several trade unions and trade associations bear the name "international" merely because they have members in as few as two countries; *e.g.*, the United States and Canada.

But the one organization comprehensively international in scope and most appropriately so named is the International Chamber of Commerce. Founded in 1919, it is a world federation of business organizations, business firms and businessmen. It frequently "acts as spokesman of the business community in the international field and presents the business point of view to governments and to world public opinion." It was correspondingly granted the highest consultative status with the Economic and Social council of the United Nations, that of category **A.** Its national committees "undertake appropriate action as regards their own governments." Its working committees and commissions, composed of qualified experts and expert business executives, look for practical solutions to problems in such fields as commercial and financial relations, production and distribution. transport and communications, and law and commercial practice. In addition to publishing quarterly a magazine called World Trade, it operates a court of arbitration which provides conciliation and arbitration facilities for the settlement of commercial disputes for members of disparate nationalities. In about 87% of the cases, on the average, its awards are accepted and executed.

Trade Associations.—Trade associations usually limit their membership to business firms engaged in a particular branch of industry, trade or service enterprise. Moreover, they rarely extend their activities beyond national boundaries. Indeed, in many cases a substantial portion of their effort is devoted to measures, legislative or associational, to keep foreign competition out, or to bring it satisfactorily under control.

In terms of function there are two main types of trade associations: (1) those which confine themselves to voicing the views of their members on matters of common interest; and (2) those which exercise some measure of control over their own members. The latter in many countries make extensive use of voluntary, voidable "live and let live" agreements for controlling prices, output and channels of distribution. In some instances trade association arrangements go beyond price and output stabilization and involve rationalization measures designed to control productive capacity.

In a few notable instances such trade association activities have been endorsed by government fiat with sanctions applicable not only to recalcitrant members but even to nonmembers.

The overwhelming majority of trade associations are of the first type. They prefer self-government of industry by consent rather than coercion. They avoid any attempts to stifle competition or to bar new entrants by means other than suasion and full information. Thereby they gain the advantages of good will, elasticity of operations and maximum possible membership.

Other Types of Associations. — The functions performed by miscellaneous trade associations organized on a voluntary basis are numerous According to a trade association survey by the Temporary National Economic committee, the activities most frequently reported by trade associations in 1941 as of major importance were (in order of rank): influencing governmental bodies, especially making representations concerning tariffs, taxes and other matters before administrative, executive and legislative groups; trade promotion. product advertising, commercial research and market development; standardization and simplification of nomenclature, product lines, specifications, quality and performance; holding of annual conventions and other meetings; propagation of accepted trade practices and elimination of unfair competition; collection and dissemination of trade information and statistics by means of bulletins. periodicals, handbooks and trade directories; education of members in employer-employee relations and techniques; issuance of special research monographs and statistical studies; technical assistance; public and consumer education including demonstrations. displays, exhibits, clinics. etc.; accounting and auditing aid, including cost estimating, inventory control, evaluation schedules and utilization of uniform accounting manuals; credit service; traffic and transportation assistance including provision of freight handbooks, routing information, trade customs, etc.; collecting and spreading information on members' prices and bids including open price filing with or without waiting period; commercial arbitration facilities; bill collection assistance; and information with respect to patents, trade-marks, designs and styles.

UNITED STATES

Chambers of Commerce. — The oldest chamber of commerce in the United States is that of the state of New York, formed in 1768 According to its charter. dated 1770, its object was "to carry into execution, encourage and promote by just and lawful ways and means such measures as will tend to promote and extend just and lawful commerce." The first city chamber mas formed in 1773 in Charleston, S.C.

The Chamber of Commerce of the United States. "a national federation working for good citizenship, good government and good business." was founded in 1912. In the mid-19 jos its membership comprised 21.000 business firms including more than 2,700 affiliated local chambers of commerce and approximately 450 local and national trade associations. It made the claim that directly or indirectly about 1.500,000 businessmen mere members. Its various departments provided information and advice on all items of controversy betneen business and government, notably regulatory measures, expenditures, tariffs, taxes. labour-management relations, etc. Its monthly magazine. *Nation's, Business,* enjoyed a large circulation as did its research publications, committee reports, special bulletins and annual booklet on policies advocated by it.

U.S chambers of commerce were established in several large foreign cities, notably London, Paris, Rome, Rio de Janeiro, Mexico City and other important commercial centres abroad. Their range of operations and effectiveness have varied with the regulatory measures imposed upon foreign commerce. Barriers to international trade mushroomed everywhere during the depression of the 1930s. They were multiplied by autarchic totalitarian regimes. In the U.S., they were continued during World War II by a variety of agencies including the Combined Raw Materials board, the War Food administration and agencies of the Office of Economic Warfare.

Despite the U S. reciprocal trade agreements program the barriers persisted after the mar because of changing currency and commodity control arrangements fostered by such forces as rising nationalism, the dollar shortage, austerity programs, restrictions on trade with countries beyond the "iron curtain" and military security measures. But by the mid-1950s in accordance with the provisions of the Marshall plan, re-enforced by ensuing U.S. foreign assistance programs, by the Schuman plan, and by numerous currency stabilization and trade liberalization measures taken by west Germany and other noncommunist members of the United Nations, such barriers to trade had been substantially reduced.

In addition there mere about 30 foreign chambers of commerce in the United States in the mid-1950s of which the largest, the French, founded in 1896, had approximately joo members.

Trade Associations. — Although several trade associations of modern character were founded prior to the Civil War, notably the National Association of Cotton Manufacturers in 1854 and the American Iron and Steel institute in 1855, they did not become common until the 1870s and 1880s.

The name institute instead of association is frequently used by trade organizations primarily engaged in technical tasks and headed by a career official with a contract running for three to five years; *e.g.,* the Cotton Textile institute or the Coal Mining Institute of America. It may also indicate an independent or subsidiary association engaged principally in educational services as, for example, the American Institute of Banking created in 1900 by the American Bankers association to conduct classes for employees and junior officers.

Many of the early associations were short-lived. Some of them were interested in price-fixing, in agreements to limit or divide output or sales territory or in arrangements to apportion profits. With the passage of the Sherman Anti-Trust act in 1890 and the advent of the holding company, the combine, the Gary dinners, (dinners. attended by steel executives, held at Judge Elbert H. Gary's home in New York, N.Y., from 1903 to about 1912; on such occasions economic conditions in the steel industry were discussed, and stabilization of steel prices ensued), etc., the trade association changed its focus to co-operation in product standardization, market research, statistical compilation, united lobbying for tariffs and other governmental aids, together with unified opposition against proposals considered directly or indirectly detrimental to the trade.

In the Standard Oil and tobacco cases of 1911, the supreme court held that only unreasonable restraints of trade were illegal. Certain trade association promoters, notably A. J. Eddy in his book *The New Competition,* published in 1912, devised an open-price scheme tailored to fit the new situation: Market information and statistics on production, sales prices, costs, inventories, bids, unfilled orders, etc., nere sent to the trade association and summarized there in the form of totals or averages which were published by the association. by its trade journal, and later by the department of commerce in its monthly *Survey* of *Current Business.* Thus members could compare their own operations with that of the trade.

By this type of co-operative competition, purposeless market instabilities resulting from ignorance were eliminated, an advantage promptly seized upon by the Bridge Builders society in the iron and steel industry in 1911, by the Yellow Pine association in 1912. and subsequently by many others.

Because of the active encouragement of the War Industries board during World War I, the number of trade associations increased from 800 in 1914 to 2.000 in 1919. During the next decade the role of fostering the associations was taken over by the department of commerce under Secy. Herbert Hoover and by the Federal Trade commission, especially through the technique of the fair trade practice conference.

With the passage of the National Industrial Recovery act in 1933, many trade association executives became code authorities. Fair trade practice codes written for the most part by trade association committees acquired the force of law. As a result their numbers grew in two years by more than a third. Despite the setback that came in 1935 when the act was outlawed by the supreme court their numbers increased greatly so that by 1938 there were about 1,000 national and trade associations and about 6,500 state and local associations.

Trade associations continued to grow during World War II exactly as they had during World War I. In 1956 the total number was estimated by the department of commerce to be close to 12,000, of which about 700 were regional in scope. 3,300 were state-wide and more than 7,000 were local. Even the American Trade Association Executives (ATAE) had more than 1,700 members and was putting out an imposing list of studies and publications. About 950 of these are executives for associations of manufacturers, from 300 to 400 for distributors and more than 100 for national retail groups.

In the metal products group there were. in addition to about 100 professional associations, about 450 trade associations. The largest, the National Automobile Dealers association, had 32.000 members. In the food and tobacco category the figure was 250 national, about 1,000 local and 60 professional organizations. In the textile, apparel and leather classification there were 280 national trade associations and 45 professional. In the lumber, furniture and paper industries the figures were 200 and 20, respectively.

In transport and public utilities there were about 100 national associations and 90 professional ones. The largest. the American Trucking associations. had 40.000 members, including 60 state and local associations. The Association of American Railroads had a staff of 625 handling such matters as tariffs, passenger and freight services. terminals, bridges, power supply, grade crossings, employee training, co-operative advertising and, of course, governmental relations.

In the chemical and rubber group about 100 national trade associations and 40 professional organizations were enumerated. chief among them, the Manufacturing Chemists' association with a staff of 35 to 40 persons. In the stone, clay and glass classification the figures were 100 and 20 respectively, one of the largest being the Portland Cement association which, with a staff of more than 500, for several years contested vigorously the Federal Trade commission proceedings against certain features of the basing point system.

Between 40 and 60 national trade associations and usually about 40 professional organizations uere listed in each of the following groups: printing and publishing, finance and real estate (including the National Association of Home Builders with 30,000 members disposed to co-operate with slum clearance and other government housing programs and the National Association of Real Estate Boards with 42.000 members, arch foe of rent and housing controls), advertising, insurance (the National Board of Fire Underwriters had a staff numbering more than 850 persons), petroleum, coal and gas, hotels and amusements (herein the Motion Picture Association of America with a staff of 150 and the Allied States Association of Motion Picture Exhibitors with about 5,000 theatres organized into 22 regional units).

Trade association activities have waxed and waned with governmental policy. After being supported by the War Industries board during World War I, they were set back when the supreme court ruled against the Hardwood Lumber Manufacturers association in 1921 and the Linseed Crushers' council in 1923. They recovered when the supreme court in 1925 marked out the permissible bounds of statistical, standardization and uniform cost accounting activities in the Maple Flooring Manufacturers association and Cement Manufacturers' Protective association cases.

At no time did trade associations enjoy as much leeway as the government permitted them to have under the National Recovery administration (NRA). They put into the codes of fair competition practically all the things they had wished to do for decades. Of the first 500 codes approved. 79% provided for practices tending to establish minimum prices and 72% prescribed uniform methods of cost accounting; 57% required open-price filing. many of them with a waiting or intimidation period; 45% fixed discount and credit terms; and 27% laid down basing point or other formula systems for handling delivered prices and freight charges. Those that complied were allowed to display the blue eagle emblem. Recalcitrants were punished. The codes, in short. gave the public a vivid, if brief, demonstration of monopolistic tendencies.

Governmental policy later swung toward vigorous enforcement of the antitrust laws. From June 1, 1935, to October 1, 1939, the Federal Trade commission and the department of justice brought more than 120 complaints or indictments against trade associations and secured convictions or consent decrees in all but three. During the next seven years the antitrust division initiated 100 additional suits involving trade associations. Not only were all forms of price-fixing, output allocation, market sharing, defensive combinations preventing free entry, and boycotts frowned upon, but the validity of antitrust prohibitions was asserted in new fields, notably in the cross-licensing of patents, in the use of uniform basing systems of price quotation, and in the activities of Webb-Pomerene associations.

National Association of Manufacturers.—The N.A.M., founded in 1895, had in the mid-1950s more than 20,000 member firms, or approximately 8% of all manufacturing establishments in the United States, employing about half of the industrial workers and producing more than half of total manufacturing output. Affiliated with the N.A.M. were about 200 local and national employers' associations having about 60,000 members. The purposes of the N.A.M. were stated to be threefold: (1) to develop and promote sound industrial practices; (2) to foster industrial trade both at home and abroad; and (3) to create favourable public and government support in matters relating to industrial interests.

During the period 1933 to 1941, the N.A.M. opposed as contrary to free enterprise 31 out of 38 major legislative enactments. The seven approved were: the Reconstruction Finance corporation loans to small business, the Housing Authority act making direct loans to business, the National Housing act of 1934, the Corporate Reorganization act (Chandler act) of 1938, the U.S. Housing act (Wagner-Steagall act) of 1937, the Miller-Tydings act and the 1939 reduction in capital gains tax and corporate surtax. In the post-World War II period the N.A.M. supported the termination of price controls and the passage of the Taft-Hartley law.

So far as federal fiscal policy is concerned, the N.A.M. almost from the date of its founding continuously urged balanced administrative federal and state budgets and substantial reductions in government expenditures. Internationally, while opposed to the Havana charter and the International Trade organization proposed therein as "in direct conflict with American principles of free competitive enterprise" it supported the European Recovery program, extension of multilateral trade, special protective measures for U.S. private capital invested abroad, removal of trade and travel barriers, free convertibility of currencies, elimination of quantitative trade restrictions and the abandonment of monopoly and cartel trade philosophy. It also advocated "reasonable effort to encourage international economic understanding and co-operation through the Economic and Social Council of the United Nations."

National Industrial Council.—The first predecessor of this organization was the Citizens' Industrial Association of America founded in 1903 to combat trade unionism. The second was the National Council of Industrial Defense founded in 1908 within the N.A.M., and renamed in 1919 the National Industrial Council. In 1918 the N.A.M. in conjunction with 18 national industrial associations organized the National Industrial Conference board (N.I.C.B.), a research agency which through the years issued a number of books, pamphlets and regular periodicals.

In 1936 the N.I.C. was reorganized and its members grouped into three classes. The first consisted of state industrial associations, carrying out on a state basis about the same program that the N.A.M. advocated nationally. The second class was employers' associations which had arisen in all the important manufacturing cities of the United States to present a locally united employer front to deal with trade unions in regard to wages, hours and conditions of labour. The third group was primarily national trade associations; *e.g.*, the National Metal Trades association.

Miscellaneous Associations.—Among the thousands of associations in the miscellaneous category appreciably affecting trade organization in the United States, only a few will be mentioned. There were at mid-20th century, for example, more than 100 general associations, such as the Cooperative League of the United States of America, a member of the International Co-operative alliance, which in the mid-1950s reported a membership of 100,000,000 families in 31 countries. Under the Cooperative league. six major national groups were reported. the Credit Union National association (14,152 credit unions, 7,000,000 members), the National Rural Electrical Cooperative association (1,906 R.E.A. co-ops, 4,000,000 members), the National Cooperatives, Inc., with 24 regional co-operative federations of wholesalers. the North American Student Cooperative league (300 campus co-ops, 50,000 members). and the National Cooperative-Mutual Housing association (50 co-op housing projects, 20,000 members).

Belonging in large part to these national groups there were in the mid-1950s more than 3,200 consumer retail co-operatives with 2,642,000 members, 779 service co-operatives uith 344,000 members. 3,330 farm-purchasing co-operatives with 3,100,000 members and about 6,650 farm marketing co-operatives with 4,400,000 members. There were in addition about 7,000 local building and loan associations, represented by the United States Savings and Loan league (see also CO-OPERATIVES).

Furthermore, in 1956 there were 98 better business bureau associations, the largest of which was the National Better Business bureau covering financial practices and national advertising. There were 65 commodity and stock exchanges, the oldest (1792) and the largest (1,300 employees and 1,375 members) being the New York Stock exchange. In addition, there were in the mid-1950s about 4,000 foundations, many of which such as the Battelle Memorial institute or the Mellon Institute of Industrial Research were engaged in business and technical research.

Farmers, too, were well-organized, there being about 55 farm organizations in the mid-1950s. The oldest, the National Grange, founded in 1867, had 7,200 local granges comprising roughly 860,000 members. The largest, the American Farm Bureau federation, founded in 1919, had about 2,600 county farm bureaus and represented more than 1,620,000 paid-up member families. Third in size was the National Farmers union. founded in 1902, with approximately 5,000 locals and 300,000 member families. Influencing the marketing of fruits, vegetables, nuts. sugar, livestock, etc., were such marketing organizations as the California Fruit Growers exchange with 14,500 members and 227 local affiliated organizations, the Hawaiian Sugar Planters association and the National Live Stock Producers association. (See also AGRICULTURAL ECONOMICS: *Agricultural* Co-operation.)

Influential, likewise, were the more than 200 labour associations, of which the oldest was the American Federation of Labor, founded in 1881. with a membership at mid-century of about 8,000,000 workers in 60,000–70,000 locals. Its chief publication was Labor's Monthly *Survey*. In 1935 about 40 national trade unions. including the steel and automobile unions, split off to form the Congress of Industrial Organizations. It reported a membership in 1951 of roughly 6,000,000 workers. Late in 1955 it merged with the AFL to form the AFL-CIO with about 15,000,000 members organized under five major departments: the Industrial Union Department, the Building and Construction Trades, the Railway Employees, the Metal Trades and Maritime departments. Their main house organ was the AFL-CIO *News*.

Most important among the unions outside the two large federations were the railway brotherhoods with more than 1,000,000 members, publishing the influential weekly newspaper Labor. Among other independent unions of national importance were the United Mine Workers of America, the International Ladies Garment Workers' union and the International Longshoremen's and Warehousemen's union (see also TRADE [LABOUR] UNIONS).

(T. J. K.)

THE UNITED KINGDOM AND THE BRITISH COMMONWEALTH

Chambers of Commerce.—The British chamber of commerce is a long-standing institution of an entirely independent and voluntary character having no support from government nor, indeed, even official recognition, apart from the provision that no chamber of commerce can be registered as such under the Companies acts if it pays any dividend to its members. The chamber of commerce should be distinguished from the chamber of trade whose province is rather retail trade (see also below). Although thus independent, and indeed often critical, of government policy, the relations of the chambers of commerce with government departments, especially the board of trade, have always been close, and grew closer in consultation and collaboration during World Wars I and II.

Interest in foreign trade stands out clearly in the provisions of the founding charters and in the typical activities of British chambers of commerce. The earliest ones were formed in Jersey in 1768 (the same year in which one was organized for the state of New York. as noted above), in Glasgow in 1783, in Dublin in 1785 and in Edinburgh in 1786. In 1794 the "Commercial Society" of Manchester was founded with the objects of obtaining increased safety for trade and more regular payments, and of co-operating jointly in all applications to government. After 1801 it ceased to hold meetings but was revived in 1820 as the Manchester Chamber of Commerce. Closely allied with it was the Manchester Importers and Exporters association. Other chambers were established at Belfast (1796), Birmingham (1813), Newcastle upon Tyne (1818), Liverpool (1851), Sheffield (18j7) and London (1881).

London Chamber of Commerce.—The London Chamber of Commerce is not only the largest but the most powerful chamber in the British commonwealth. In its direct membership are leaders of British overseas trade, and of manufacturing, merchandising, banking, insurance and shipping business; 46 affiliated associations are represented on the council.

The chamber's 57 trade sections are of two kinds. Some deal with a market or group of markets (*e.g.*, the Australian and New Zealand section, and the Anglo-German section), others with a commodity or trade (*e.g.*, the tobacco, bristle and the precious stone trade sections; the last has a laboratory). Eleven standing committees study such matters as transport, taxation and town planning. The London Court of Arbitration was formed in 1892 jointly with the corporation of London and consists of 12 representatives from each body; it does not itself hear cases but appoints qualified arbitrators to deal with disputes referred to it. The Commercial Education committee conducts examinations, awards certificates in commercial subjects and offers scholarships enabling students to study languages and commercial conditions abroad. The chamber's inquiry departments answer a great variety of questions from their members on day-to-day business problems, particularly in regard to import and export trade. In all, some 120,000 inquiries are dealt with each year, including many from overseas, seeking suppliers of U.K. goods.

The Association of British Chambers of Commerce was formed in 1860 to provide an organization capable of speaking for all British chambers of commerce in approaching the government on questions of common interest. Starting with only 16 chambers, by 1956 it had a membership of nearly 100 in the United Kingdom, and a number of British chambers overseas were also members. It thus forms the main national organ of commerce and as such is represented on the National Production Advisory Council on Industry (of uhich the chancellor of the exchequer is chairman), the British Productivity council and the Dollar Exports council. Thus, and by its continuous contact with the appropriate government departments. the association influences national trade policy, and also helps the government. The association is in close relationship with the British National committee of the International Chamber of Commerce, which has more than 20 chambers in the Cnited Kingdom as direct members and is the means of ensuring that the British point of view is advanced at the international level. (For the International Chamber see also above and separate article.)

Chambers of Commerce in the *Commonwealth*.—The earliest chamber of commerce in the colonies (after that of New York which as noted above was founded before the American Revolution) was the Commercial Exchange of Capetown, Cape Colony, founded in 1804 and renamed in 1861 the Capetown Chamber of Commerce. In the 1830s chambers were organized in British India—at Calcutta (1834), Bombay and Madras (1836) and Ceylon (1839). In 1840 chambers were formed in Australia (Adelaide) and Jamaica; in 1845 in Canada (Toronto).

National co-ordinating bodies exist in the principal British countries and there is also the Federation of Commonwealth and British Empire Chambers of Commerce, whose membership comprises 11 associations and 150 individual chambers. This federation came into being as a result of a series of congresses organized by the London Chamber of Commerce, the first being held in July 1885 at the time of the Colonial and Indian exhibition in London. Other congresses followed and by the time the seventh was held in Sydney they were accepted as triennial events. In 1911, to meet the wish for a more permanent link, the British Imperial Council of Commerce was formed, its name being changed to the Federation of Chambers of Commerce of the British Empire in 1926 and to the title given at the beginning of the paragraph in 1955. The constitution of the federation provides that the congresses shall be held alternately in London and elsewhere in the British commonwealth. The headquarters of the federation are at the offices of the London Chamber of Commerce and apart from congresses the work is carried on by a council to which every member chamber and association has the right to appoint a representative.

British *Chambers* of Commerce in Foreign *Countries* advise British firms concerned with the respective markets, assist British diplomatic and consular officers, and strive in general to promote British trade. They vary in membership, some being closed to non-British business representative~,others admitting them subject to varying conditions. Cp to World War II they flourished in all parts of the world, and were particularly strong in China The pressure of Communist-controlled governments, however, caused a number of British chambers of commerce abroad to cease operations, notably in the U.S.S.R. and China.

Foreign Chambers of Commerce in the United *Kingdom* are free to organize and to carry on normal activities in the United Kingdom and generally throughout the commonwealth. The United States is thus represented by the American Chamber of Commerce in London and similarly other leading commercial countries. Among similar bodies interested in the trade of special areas may be mentioned the China association and the British and Latin-American Chamber of Commerce.

Trade Associations.—There are three types of industrial association in Britain: (1) those which primarily devote themselves to technical, scientific and informational tasks; (2) those which are concerned with the regulation of prices, output and sales; and (3) those which exist almost solely for purposes of collective bargaining with their workpeople or trade-union representatives; *i.e.,* employers' associations.

Before World War I British trade associations were mostly of the first type. During World War I, however, the government actively promoted the formation of associations for equitable distribution of raw materials. etc. They grew so rapidly in number and influence that a committee on trusts was set up in 1919, which recommended, as did the Balfour Committee on Industry and Trade, ten years later, against antitrust laws. So in pursuance of the general policy of rationalization designed to secure much needed economies and the elimination of excessive internecine competition the formation of trade associations proceeded and these early found it useful to organize themselves into a joint body with authority over industry as a whole.

This was the Federation of British Industries whose membership grew steadily from the original 350 firms and 62 trade associations in 1916 to nearly 7,500 firms and 286 associations in 1955. It is thus the prime representative body for the productive industry of the United Kingdom, with a staff of 170 at headquarters and 50 at each of the 10 regional centres in the United Kingdom; there are also representatives at 140 British and foreign centres.

The range of topics dealt with by the federation both in respect of individual cases brought to its notice by member firms and in regard to questions of general policy is vast and varied; in fact no aspect of trade is excluded. The chief general subjects receiving particular attention in the mid-1950s included taxation, monopolies and restrictive practices, freight charges, commercial and technical education, exhibitions and customs tariffs at home and abroad: with particular reference to the repeated negotiations under the General Agreement on Tariffs and Trade (G.A.T.T.) referred to below.

Matters of policy of the Federation of British Industries (F.B.I.) are determined by the grand council, composed of one representative from each federation district, one from each association with 20,000 employers, one from each firm with 40,000 employees.

The federation, like the Association of British Chambers of Commerce, is represented on the National Production advisory council and it co-operates closely with the British Employers' confederation (see below). Its international activities include membership of various bodies concerned with such matters as the European Payments union and together with the Employers' confederation it represents British industry on the Council of European Industrial Federations, an advisory body to the Organization for European Economic Co-operation (O.E.E.C.). The federation is also represented on the Dollar Exports council. (*See* also FEDERATION OF BRITISH INDUSTRIES.)

The National Union of Manufacturers, formed in 1915, which by 1956 had a membership of 5,500 firms and 72 trade associations, represents the interests of, and affords a whole range of useful services for. the smaller industries. It too has representatives on the National Production Advisory council and on many government committees.

Closely akin to credit and collective bureaus elsewhere are the trade protection societies affording special facilities for the collection of debts. Their national body is the Association of Trade Protection Societies of the Cnited Kingdom. In addition there are chambers of trade, mostly local bodies made up of firms in the distributive trades. They are linked together by the National Chamber of Trade, organized in 189; and supplemented by the Incorporated Association of Retail Distributors, founded in 1920.

Furthermore, there are produce markets, some of which were established as far back as the middle of the 18th century; *e.g.,* the "Baltic" (Baltic Mercantile and Shipping Exchange Ltd.) dealing chiefly in shipping (charter parties) and grain, and the corn and coal exchanges of London. The Liverpool Corn Trade association, providing a future market for wheat and maize and controlling the wheat trade of the port, was established a century later (1853) and the London Corn Trade association in 1878. The London Produce Clearing House Ltd.. founded ten years later, handles forward contracts in coffee, sugar and many other items. The Liverpool Cotton association assumed its modern form in 1882.

Among other bodies qualified to deal authoritatively with the important aspects of industry and trade which their titles specifically indicate are the British Standards institution, the Council of Industrial Design, the Institute of Export, the British Institute of Management and the British Shippers council (see also STANDARDIZATION).

Co-operatives.—The modern consumers' co-operative movement began in Rochdale in 1844. Each stockholder was permitted only one vote, goods were sold at regular prices, and patronage refunds were made on the basis of volume of purchases. Gradually the co-operative began to produce some of the things it sold—flour, meat, shoes, preserves, vegetables, furniture. The Co-operative Wholesale society of Great Britain by mid-20th century had 11,316,000 members. (See CO-OPERATIVES.)

Employers' Organizations.—Arising out of the much changed general economic situation created by World War I the British Employers' confederation (which, as seen above, is closely connected with the Federation of British Industries) was formed in 1919 from the national groups of employers in the separate industries—trade associations of type (3) referred to above. It covers by far the greater part of all the country's industries other than those nationalized and gives powerful corporate strength and effectiveness to their members in regard to labour relations. It is thus represented on the National Joint Advisory council to the ministry of labour and on the National Production Advisory council. In the international sphere it appoints the representatives of British employers on the tripartite International Labour organization (*q.v.*).

Industrial Research.—In order that British industry should be able to take advantage of the great advances in applied science and technology, the government, again during World War I, set up the Department of Scientific and Industrial Research, the importance of which can be gathered from the fact that the estimate for its net expenditure in 1955–56 was more than £6,500,000. Its main operations include research with the building, chemical, fuel and engineering industries. (*See* also RESEARCH, INDUSTRIAL.)

The British Government and Trade Organization.--In the mercantilistic period of British history the government regulated business and trade at every turn. Against this regimentation Adam Smith's *Wealth of Nations,* published in 1776, amounted to an economic declaration of independence. British manufacturers and the activities of the Manchester school gradually accomplished the repeal of the corn laws, and changed government policy to one of *laissez faire*.

By 1880, however, the government began to take a renewed interest in foreign trade. It appointed commercial attachés to embassies and legations. By 1900 a commercial intelligence branch was set up in the board of trade. In 1908, in response to recommendations of the colonial conference, trade commissioners were appointed in Canada, Australia, New Zealand and South Africa. In 1917, partly because of the exigencies of World War I, the department of overseas trade was set up, a joint department of the foreign office and board of trade.

In the period between World Wars I and II the department grew steadily, and the number of trade commissioners multiplied. Imperial trade correspondents were set up. In foreign countries, the commercial diplomatic service was substituted for commercial attachés, mith commercial counsellors in the higher grades and commercial secretaries in the lower grades.

The main function of the department, which was later taken over by the board of trade, and of the three overseas services, was to promote export trade by providing full particulars of specific sales opportunities and of general economic and commercial affairs. The former are transmitted direct to interested manufacturers and traders; the latter are published in the *Board of Trade Journal,* a weekly established in 1886 whose files constitute an authoritative record of commercial events, regulations, tariffs, etc.. all over the world. Moreover, the reports made by the trade commissioners, commercial diplomatic officers, or consular officers are compiled for each district and published in regular annual series. British businessmen abroad ordinarily keep in close contact with government overseas officers, who are systematically called home to renew and widen their contacts in the department and in the business community.

As the financing of the export trade became more difficult in the chaotic conditions of the world and especially Europe after World War I a system of export credits was offered by the government in 1919 and government support of this kind proved so successful and necessary that later legislation created a large export credits guarantee department which, operating through a number of district and branch offices in London and other important commercial centres, covers a large proportion of British export trade—the aggregate of policies issued in the 1950s being of the order of £500,000,000.

At the same time the British Industries fair (*q.v.*) was inaugurated and was held annually in London and Birmingham (under the direction of the Birmingham Chamber of Commerce) from 1915 to 1957, when the London fair was discontinued. Responsibility for official participation in international exhibitions also rests with the board of trade.

In 1932 the Ottawa agreements and the consequent tariffs adopted in the United Kingdom confirmed the abandonment of the long-standing policy of free trade, and economic and financial crises forced the government to take over more and more control of trade and industry which during World War II became practically complete. Though there was later a natural tendency to relax control with reversion to a relatively "free" economy it had become the established principle that the government was primarily responsible for taking the necessary financial and other measures to secure both full employment at home and a proper balance of payments in overseas trade and finance. Whereas formerly the board of trade as the department of government mainly, if not solely, concerned exercised a minimum of control or influence on both home and overseas trade, its main function being the occasional negotiation of commercial treaties, it is now expected to deal actively with every aspect of trade and its concomitants. This includes distribution and general efficiency of industry, commercial relations and the promotion of exports. the administration of company law and that directed against monopolies and restrictive practices as inherent in modern business methods, a matter which received much attention in 1956 and resulted in the Restrictive Trade Practices act, 1956. In particular the board of trade had taken over the duties of the Import Duties Advisory committee established in 1932 to deal with the customs tariff, and was responsible for the participation of the United Kingdom in the proceedings of the General Agreement on Tariffs and Trade which represented the mid-century achievement of international solidarity in the matter of trade policy, the ultimate aim of which was embodied in the International Trade charter of 1948. This instrument, subscribed to by more than 50 states including both the United States and the United Kingdom. made provision for the International Trade organization to promote, among other things, the reduction of tariffs and other barriers to trade, and by these and other concerted measures to assure a balanced and expanding world economy. This step, however, had not been taken by 1956 owing to the failure of sufficient states to ratify the charter; *see* also COMMERCIAL TREATIES; FREE TRADE.

Commonwealth Associations.––After World War I, with a view to securing closer co-operation in matters of trade and communications between the several parts of the British Empire. new associations of imperial scope were created—the Imperial (later Commonwealth) Shipping committee (1920) and the Imperial (later Commonwealth) Economic committee (1925). These consist of official representatives of the United Kingdom and of the commonwealth countries supplemented in the case of the former committee by five persons experienced in shipping and commerce. The former deals with questions relating to ocean freights, facilities and conditions in the interimperial trade and reports severally to the governments concerned; it has thus dealt with such matters as terms of bills of lading, the deferred rebate system, certain harbours, rates of freight in particular trades and, in a long series of reports, with Hudson Bay insurance rates. The main function of the economic committee is to provide regular current information on the trade of the commonwealth in a wide range of raw materials and foodstuffs. Its considerable expenses are met largely by contributions from the several governments. It cooperates with the United Nations and its specialized agencies.

FRANCE

Chambers of Commerce.—From the time of their establishment. French chambers of commerce served as agencies of official administrative control and management of public commercial institutions, including inland waterways, ports, etc. In 1599 the city of Marseilles established the first *chambre de commerce* and empowered it to settle the merchant law and customs of the port, to appoint consuls and run the French consulates in the Levant, to equip expeditions against corsairs, to send embassies to the Barbaresque countries and to organize commercial missions. In 1700 Louis XIV, at the suggestion of Jean Colbert, caused an *arrêté* to be published ordering chambers of commerce to be created to nominate deputies to the royal council of commerce in Paris. Most large cities soon had them, including Lyons, Rouen, Bordeaux, Lille. Bayonne, La Rochelle, Toulouse and Amiens.

The French Revolution brought about a complete change in type of government control. Isaac Chapelier's law of 1791 forbade all types of economic association. Chambers of commerce, however, were soon legalized again. The chamber of commerce at

Rouen (which until the Revolution had been the chamber of commerce of Normandy) was officially re-established in 1802. By Napoleon's decree of 1804 (revised and codified in 1895 and 1908), chambers of commerce could be established, but only by a decree countersigned by the minister of commerce. upon the advice of the prospective municipal council. of the general council of the department, and of the existing chambers of commerce in the district. By the 1950s there was at least one chamber of commerce for each *département*. The members of these chambers, chosen from the commercial community, are appointed by official decree, there being not fewer than 12 nor more than 30, except for Paris which may have 48.

The chambers of commerce have acquired consultative as well as administrative functions. The government is bound to take their opinions regarding regulation of commercial practices, establishment of commercial exchanges and tribunals of commerce, improvement of transport and communications, application of local laws, sales prices of prison-made goods, and management of local public works together with the requisite special assessments, loans or taxes. In addition there is the usual wide range of legislative. tariff, freight rates and other matters upon which the chambers may make representations which may or may not be heeded.

The administrative functions of the French chambers of commerce are extensive. They may be authorized to establish and administer such institutions as bonded warehouses, public salesrooms, firearms testing establishments, and commercial, professional or technical schools. They may be granted concessions for public works and undertake the carrying out of public services, especially the management of ports, docks, canals and navigable rivers, under the supervision and control of the local state official. During World War I they, together with the municipalities, were even allowed to issue paper money and tokens to take the place of the fractional currency that had disappeared. Under the Stabilization law of 1928 these powers were ended.

Foreign Chambers of Conzmerce in France.—When British merchants in Paris in 1873 started what they called a chamber of commerce the French government was disturbed lest the public think that its powers were similar to those held by their own chambers. Soon. however, all the leading commercial countries of the world had chambers of commerce in Paris and elsewhere.

French Chambers of Commerce Abroad.—Beginning in 1883 the minister of commerce encouraged the establishment of French chambers abroad (which of course did not have the administrative powers they had at home). By the mid-1950s more than 50 had been founded in leading commercial centres all over the world, including several each in such countries as Spain and Belgium.

Trade Associations.—Although forbidden by the law of 1791, and not legalized until 1884, trade associations and trade unions, local, regional and national, existed in fact as early as 1821 though they were frequently disguised as friendly and benefit societies. In that year the first Federation of Industrial Associations was organized by the Carpentry association. In 1868 the National Union of Commerce and Industry was founded. It included 55 industrial associations representing industries other than the building trade. In 1896 there appeared the Commercial and Industrial alliance, in 1903 the Federation of French Manufacturers and Merchants, and in 1919 the *Confe'de'ration Générale de la Production Française* (C.G.P.F.), called into existence by Étienne Clémentel, minister of commerce, "to contribute to the development of the productive power and export trade of France, and to co-ordinate the activities of the syndicates and professional associations." The signing of the Matignon agreement of June 7, 1936, with the C.G.T. (*Confédération Générale du Travail,* national trade union organization) brought about a change in organization and leadership. The C.G.P.F. became the *Confe'de'ration Générale des Patronats Français* with a program similar to that of the N.A.M. in the United States and the F.B I. in Great Britain.

On the national level there developed four types of trade organizations. The *comptoirs* such as the *Comptoir Français des Produits Sidtrurgiques* were essentially cartels, regional, national or international in scope, usually centred about a single commodity or group of commodities. The *syndicats* such as the *Comitt des Forges* mere trade associations of specialized trades. The federations such as the *Union des Industries Chimiques* were groups formed out of syndicates and trade associations. The confederations such as the C.G.P.F. were combinations of closely allied federations and syndicates.

At the regional level there existed district associations for a wide variety of industries. In addition there existed regional federations of local associations such as the *Fédération Departmentale des Syndicats Patronauz du Bâtiment et des Travaux Publiques des Bouches du Rhône*. At the top were confederations of federations such as the *Comité d'Entente des Grands Groupements* at Marseilles. There were other groupings of specialized employer interests difficult to classify, such as the industrial societies in cities such as Nancy or Lille whose special aim was to increase efficiency.

After World War II, chambers of commerce and trade unions regained their prewar status but the powers of trade associations were drastically curtailed. The C.G.P F. was not revived; its place was taken by the *Conseil National du Patronat Français,* formed in 1946, a more comprehensive body including small, medium and large industrial and commercial enterprises in Paris and the provinces. It is regularly consulted by the government. The government itself, in response to postwar emergency problems, multiplied its controls over both foreign and domestic trade, nationalizing some industries and initiating even supranational cartelization measures in others. Thus the Schuman plan set up a high authority over production and sales of the combined coal and steel industries of France. Italy. west Germany, Belgium, the Netherlands and Luxembourg with power to allocate coal in times of shortage and to remove import quotas, tariffs, discriminatory pricing arrangements and freight rates.

GERMANY

The mediaeval merchant guilds of varied Iocal type and function were the colourful predecessors of the modern chambers of commerce and industry in Germany, The *Handelsvorstände* in Frankfurt-on-Main (1707), the *Handelszukunft* in Mannheim (1728), the *Kommerz-Deputation* in Hamburg (1765), the *Älteste der Kaufmannschaft zu Berlin* (1820) and the merchants' corporations in Stettin, Danzig and Magdeburg were typical of those that existed long before the rulers of the individual German states legalized and regulated them in the 1840s and 1850s.

In addition to voluntary duties of the usual type (*e.g.,* giving information on customs and trade, conducting commercial schools, administering exchanges. harbours, public and customs warehouses and operating arbitration courts), German chambers were required by state laws to draw up annual economic reports, nominate and swear in publicly appointed experts, weighers and assessors, and assist the courts in keeping the commercial register. To meet their expenses they were empowered in some states. such as Prussia and Bavaria, to levy a surtax on the regular income or profit taxes to which trade and industry were subject. They also obtained revenues from fees for certificates of origin, exchange and market fees, and receipts for rent of space in their buildings.

After the vicissitudes occasioned by World Wars I and II the organization of industry and commerce was fully re-established in the Federal Republic. There were in the mid-1950s about 80 chambers of commerce. and membership, where not compulsory, was very full. They were associated in the *Dcutsche Industrie und Handelstag* (first founded in 1861), at Bonn, which gave strong corporate effect to their views on all aspects of commerce. At the same time the extensive system of German chambers of commerce overseas was revived in a number of important countries though not by the mid-1950s including the United Kingdom.

Trade Associations.—Throughout German industrial history, the government has been instrumental' in promoting thorough organization and control; an outstanding example is the Potash law of 1910 which placed the industry under a cartel of the mine owners which fixed minimum export prices. During World War I such compulsory cartelization became the standard pattern. These centralizing tendencies took further shape in the *Reichsverband der Deutschen Industrie* (R.D.I.) embracing 445 national trade associations and 70 chambers of commerce and industry. The legitimate successor of this R.D.I. was the *Bundesverbund der Deutschen Industrie* (B.D.I.), established for western Germany in 1948, which became the recognized authority to speak for German industry; it embraces some 340 trade associations covering practically all German industry; among its numerous committees are those dealing with foreign trade, finance and international relations. Another important organ of German wholesale and export trade is the *Gesamtverband der Deutschen Gross und Aussen Handels.* Special aspects of commerce are dealt with by such bodies as the Association of Shipowners in Hamburg and the Insurance union in Cologne.

The interests of industrialists as employers of labour are served by the *Bundesvereinigung der Deutschen Arbeitgeberverband eintragener Verein* of Cologne, a confederation of employers' associations covering the whole field of German industry. With the B.D.I. it is a principal member of the supreme organization for the west German economy, the *Gemeinschaftsausschuss der Deutschen Gewerblichen Wirtschaft;* this body like its constituent parts is independent of the government but its influence is very great.

ITALY

The association in Italy of traders and artisans into trade guilds dates back to the middle ages. In modern times Law 680 of July 6, 1862, gave to these chambers of trades and arts, as they were then known, legal status and they became recognized as public bodies. Their functions were purely consultative. They were directed by boards whose members were freely elected by merchants and artisans, and numbered from 12 to 40 according to the importance of the locality concerned. Law 121 of March 20, 1910, more clearly defined their status and extended their functions, and the name was altered to Chamber of Commerce and Industry *(Camera di Commercio ed Industria)*; purely agricultural concerns were specifically excluded. The governing boards were still formed of 12 to 40 members, freely elected by any actively engaged in trade or industry and paying the weights and measures tax or the display window tax. The right to vote was extended to women, provided they owned or ran a business and paid the taxes named, and to commercial travellers and co-operative societies. The chambers continued to be mainly consultative but they were entrusted also with the registration of business concerns, keeping trade statistics, formulating trade usages and keeping registers of approved surveyors, receivers in bankruptcy, brokers and arbitrators. They kept lists of market prices of the principal commodities, issued certificates of value and origin for customs purposes and others in many business and official connections; provided facilities or premises for trade exchanges and museums and general information services for trade and industry. Association was voluntary and expenses were met from the fees charged for their services and a small tax levied on trade and industry. Foreigners were allowed to become full members, and to be elected to the boards, provided that they had been registered as resident traders for at least five years.

With the advent of fascism the old system of freely elected and voluntary chambers of commerce had to give way to a new regime of full government control instituted by Law 731 of April 18, 1926, and Law 1071 of June 16, 1927. These laws resulted in the setting up of provincial councils of economy (*Consigli Provinciali dell' Economia*), and of provincial offices of economy (*Uffici Provinciali di Economia*). The former councils each consisted of boards for agriculture, industry, commerce and labour (with social insurance) and where necessary a section for maritime trade; their primary function was to represent the trader, industrialist, farmer and worker. Each board had as ex-officio members a number of officials such as the district agricultural inspector, or district engineer for public works. Other members were selected by the minister for national economy from a list drawn up by trade associations. and the balance chosen by the same minister from a list of candidates nominated by the various trade and professional unions. The ministry fixed in each case the number of boards, the number of members for each board and the number of members of each category within the board and, notably, there ceased to be any form of free election. The councils continued to be consultative but became the official channel both for the representation to the government of the interests of their respective members and for the execution of government orders and enactments. They also continued all the other functions and services hitherto carried out by the chambers of commerce and industry which they replaced as stated above. The provincial offices of economy took over much of the executive work of the provincial councils of economy as agents for the government and for the economic development of each province. Under Law 875 of June 18, 1931, these councils and offices became the provincial councils or offices of corporative economy and the former in 1937 were renamed the provincial councils of the corporations.

After the fall of fascism Law No 315 of Sept. 15, 1944, finally abolished the fascist system and re-established the principle of boards chosen by free election, involving the restoration of the chambers of commerce, industry and agriculture, but retaining provincial offices of commerce and industry, the former becoming consultative organizations with certain public functions; and the latter being dependent on the ministry of commerce and industry and staffed by civil servants.

The president of the chamber of commerce is appointed by the minister and so replaces the prefect for all matters in the economic field connected with the working of the chamber. He is supported by four councillors, one each for trade, agriculture, industry and labour. The inclusion of a councillor for labour does not mean that the chambers concern themselves with questions directly related to labour but is a recognition of the importance acquired by workers in questions affecting the general economy. These councillors are assisted by consultative committees *(juntas)* formed of members chosen from the various sectors of economic activity in the province, which is the area within which the chamber also functions.

Trade Associations.— Trade associations in Italy draw their membership primarily from the handicraft trades and agriculture. They were profoundly influenced by the economic doctrines of Catholicism and consisted largely of employer and employee organizations. The first organization of national scope was the General Confederation of Agriculture, founded in 1911 with about 70,000 landed proprietors as members, dominated by the owners of the large estates in the Po valley. In 1919 the *Confederazione Generale dell' Industria Italiana (Cofindustria)* came into existence with about 100 member bodies. A third association of this kind, the *Confederazione Generale del Commercio,* was founded in 1946 and in 1954 *Cofindustria* initiated a movement to unite these three bodies into an "economic front" so as to use their considerable political influence to full advantage. In the 1950s *Cofindustria* was the most active and powerful of these employer organizations with a membership of 102 national trade associations and 114 regional associations; of the former the majority represented the food (21), engineering (19) and textile (18) industries, while the latter were naturally most numerous in the Northern Provinces, Lombardy (16), the three Venetias (15), Piedmont (13), while Tuscany (12) and Emilia (9) came next. The trade associations primarily function as employers in direct relations with the trade unions for questions of wages, hours and general conditions of employment but they also deal with production, prices, markets and the like on a national basis for their particular trade or industry.

U.S.S.R.

Trade organization in the U.S.S.R. is a matter of complete state control exercised in the main through the five-year plans which are settled, under the council of ministers as the supreme executive, by Gosplan (the state planning committee) which was established in 1921 and does its primary work through a system of subordinate planning offices. Thus the first of these plans after prolonged study and discussion was finally adopted in April 1929 for the period from Oct. 1, 1928, to Sept. 30, 1933, though eventually it was ended as completed by the end of 1932. Other such plans followed continuously until the outbreak of war in 1941 interrupted the series, which was resumed in 1946.

Gosplan is itself organized on the basis of a number of departments for each of the principal branches of industry plus one for internal and one for external trade together with a number of co-ordinating departments which have the duty of matching up production with demand, and controlling capital works and finance on a regional basis. In addition there are specialized divisions which deal with such economic factors as labour, transport and communications. Of prime importance is the Central Statistical administration. Once the plan is settled, its administration is the responsibility of the numerous ministers for the different branches of industry; there are some 30 of these covering such industries or groups as iron and steel, nonferrous metallurgy, oil, heavy and medium engineering, the chemical industry, manufactured consumer goods, also communications, railways, shipbuilding and, as indicated above, trade external and internal. Below these ministers in each case are the Glavki, or thief administrations, with control over industrial establishments producing a certain class of goods within a certain area. Under the Glavki are the trusts or combines each actually running a group of similar factories—though these may in important cases come directly under the minister. The control exercised by this official hierarchy necessarily includes not only meeting the specific requirements of the master plans as broken down for the several production units but the regulation of all matters incidental to that production such as, notably, labour training and recruitment, hours; pay and conditions, finance and office methods. Provision for the regulation of all these aspects oi the general economy is made at all levels. Because of this, the role of the trade unions in the U.S.S.R. is limited and very different irom that in countries with a free economy. *(See* TRADE (LABOUR) UNIONS.)

The foreign trade of the U.S.S.R. has of necessity to fall into line with the master plans for industry and so there is a complete state monopoly of all exports and imports. This was instituted by decree of April 22, 1918, and is vested in the ministry oi foreign trade (*Ministerstvo Vneshnyie Torgovlyi Soyuza S.S.R.)* It is administered through numerous ioreign trade corporations which deal severally with the export and import of certain groups of commodities or with trade with certain countries or with shipping (*Sovfrakht*). Contact with these bodies can be made by traders in other countries through the trade delegations of the U.S.S.R.

In view of this system it will be seen that there cannot be in the U.S.S.R. anything quite like the chamber of commerce which has become so well-established in western countries. There is however in London the Russo-British chamber of commerce, a joint Anglo-Soviet organization which was incorporated in 1916 and is affiliated to the Association of British Chambers of Commerce. It is active in the encouragement of trade between the British Commonwealth and the U.S.S R., and consists oi British firms interested in this trade. The president is British and the vice-president Soviet, whilst the executive council consists of equal numbers oi British and Soviet members.

(E. J. E.)

OTHER COUNTRIES

World War II and the resultant collapse of fascist totalitarianism brought about two major changes in trade organizations. It multiplied their number, especially in newly industrialized areas. It released them from domination by the state. In 1944 there began a restoration of freedom of association throughout the world. The emergence of free, self-governing business and labour organizations led to new legislation for trade organizations not only throughout Europe, but world-wide, as, for example, in the constitutions of Cuba (1940), Guatemala (1945), and Brazil (1946), in the labour codes oi Costa Rica (1943), and Nicaragua (1945), in the Bolivian decree of Feb. 7, 1944, in law VI of 1945 in Colombia, in the Egyptian Law of Dec. 6, 1942, in the labour codes of Iraq, Iran and Lebanon (1946), and in the Turkish law of Feb. 27, 1947.

Argentina. — At mid-20th century there were in Buenos Aires 21 merchants' and manufacturers' associations of major importance, mostly in the agricultural processing, and bullding-materials industries. They, together with similar organizations in Portugal, were the only ones that continued to be tightly supervised by government. Even *Confederacidn General del Trabajo,* including the powerful *Asociacidn Obreros y Empleados del Estado,* was not exempt.

Brazil. — At mid-20th century the *Associação Comerical de Rio de Janeiro* served as the official technical advisory board for the federal government. It published a weekly *Boletim* and a monthly *Revista do Comercio.* In addition there were 19 regional chambers of commerce and national syndicates ior 61 major industries and trades. There were five national organizations of trade unions, the largest being the *União Geral dos Trabalhadores do Brasil* with 112 member groups

Canada. — The postwar growth oi trade organizations in Canada was startling. In the early 1950s the Canadian department of trade and commerce listed 47 national agricultural and horticultural associations, 16 dairy and allied associations, 55 livestock and poultry, 24 building and construction, 14 national associations of co-operatives, 40 financial and insurance organizations, 18 national labour groups, 25 manufacturing associations in the field of food, feed and beverages, 13 for fish, 30 associations of manufacturers of textiles, clothing. and shoes, 22 of lumber and paper, 43 of miscellaneous products, 1j mining and oil, and 27 printing, publishing and advertising associations.

The Canadian Manufacturers' association had 6,400 members in 1947; The Canadian Chamber of Commerce Inc. had 400 boards of trade and chambers of commerce, 20 trade associations and approximately 1,200 business firms and corporations. The Trades and Labour congress of Canada had 400,000 members; the Canadian and Catholic Confederation of Labour had 325 unions with 80,000 members; the Canadian Congress of Labour had 28 international and national member unions with 1,039 units.

Egypt. — At mid-20th century there were 17 chambers of commerce, mostly *of* ioreign businessmen in Alexandria and Cairo. In addition there were 20 *Chambres d'Industrie,* for the most part founded during or after World War II, headed by the *Fdddration Egyptienne l'Industrie.*

India. — At mid-20th century the Federation of Indian Chambers of Commerce and Industry had 120 associations affiliated as members, including 18 regional chambers of commerce and 41 large national trade associations. The Jute Balers had more than 500 member firms; the East India Cotton Association, Ltd., 867.

In addition there were 63 important national trade unions, 27 affiliated with the Indian Federation of Labor, the remainder with the powerful All-India Trade Union congress. Among the former, the largest were the Textile Labour association with 85,000 members and the All-India Colliery Magdoor union with 48,300 members. The number of unions had grown from 29 in 1927–28 to 818 in 1943–44, and well over a thousand in 1950.

Japan.—Trade associations were founded in the 1880s, notably in the cotton spinners, textile, and silk-yarn industries. In 1931 the *Kanto Sangyo Dantai Rengokai* or National Confederation of Industrial Associations of Japan was founded with 39 member-associations. That year they became organs of the state in controlling prices, outputs, sales, capacity, exports, etc. By 1935 there were 662 such guilds covering 70 industries. In 1941 all firms and trade groups were centralized under "control associations" operated directly by the Imperial Rule Assistance association. On Nov. 3, 1946, in accordance with the policies, principles and standards laid down by the Far Eastern commission, freedom of association was declared a right in the constitution (chap. iii, paragraph 21).

By mid-20th century chambers of commerce and industry had resumed activity in Tokyo and other major cities. There also had grown up more than a dozen branches of the Japan Foreign Trade institute. But strong national trade associations except ior the *Zenkoku Kensetsugyo Kyokai* (All-Country Association of Construction Firms) had not yet emerged.

Trade unions, however, sprang up by the thousands with membership running into the millions. The top organization, the *Zen-koku Rodo Kumiai Rengo Kyogi-Kai* or National Council of Japanese Labour unions was founded in 1947. Largest of the constituent organizations, all iounded in 1946, were the *Nippon Rodo Kumiai Sodomei* with 2,892 unions and 1,247,868 members; the *Zen Nippon Sangyo-Betsu Rodo Kumiai Kaigi,* 18 unions and 1,173,782 members; and the *Nippon Nomon Kumiai* (farmers) with 4,741 unions and 906,151 members.

Mexico. — The Chambers of Commerce and Industry act of 1936 created as top organization *Confederacidn de Cdmaras Nacionales de Comercio e Industria.* Under it were organized more than zoo regional and national chambers of commerce. Every businessman and industrialist with a capital of joo or more pesos had to inscribe himself in the national register. At mid-20th century *Confederacidnde Cdmaras Industriales de los Estados Unidos Mexicanos* had 46 regional and national industry associations, the largest of them founded between 1941 and 1946. *The Cdmara* for manufactures had 10,500 members.

There were three major labour organizations. The largest, *Confederacidn de Trabajadores de México* (CTM) consisted of 13 *Sindicatos Nacionales de Industria* and 32 regional federations comprising 5,200 unions with roughly a million members. Next in size was *Confederacidn Regional Obrera Mexicana* (CROM) with 550 unions and 200,000 members.

New Zealand. — Chambers of commerce in 49 cities belonged in 1948 to the Associated Chambers of Commerce of New Zealand. Industrial Associations of Employers existed ior 22 industries, organized into iour regional manufacturers associations. That for Wellington had 670 member firms, Auckland 900, Canterhury 515, and Otiago and Southland 300. The New Zealand Federation of Labor had 34 Federations or Industrial Associations of Workers, including 53 unions each with more than 1,000 members.

South Africa. — At mid-20th century there were 20 major trade associations affiliated with the South African Chamber of Industries, the largest being the Master Printers with 455 members. There were 69 employers' associations of which only 27 were founded prior to 1941. The largest was the National Federation of Building Trade Employers with 2,195 members. In addition there were 410 registered co-operative societies with a total membership of 300,941. The South African Trades and Labour council consisted of 66 principal registered trade unions with 125,303 members, of whom roughly two-fifths belonged to the 7 Railways and Harbours unions. (T. J. K.)

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TRADE **ROUTES.** The great trade routes of the world are the accustomed paths, by land, sea or air, by which goods and mails pass in exchange between Europe and Asia, between Europe and America, between America and Asia. A trade route is something more than a dotted line on the map or chart. It is a road which has to be surveyed, charted, improved. patrolled, guarded and supplied. By land it may comprise railways, canals, metalled highways and telegraph wires. It may include bridges, viaducts, stations, repair sheds, reservoirs, fuel supplies, garages, hotels, traffic lights and signposts. By sea it will comprise charts, sailing directions, ports, lighthouses, pilot vessels, tugs, cables, pipelines, naval bases and warship patrols. By air it will include runways, repair facilities, meteorological stations and radar equipment.

The dotted line in the atlas may not exist except on paper but the way is flanked and marked by installations which are real, elaborate and costly. This has always been true, in some measure, since the first trade routes were opened.

Ancient Times.—Theoretically a man may trade with goods carried on his back, but in practice the traveller, able to carry little more than he needs to eat and wear, has always sought a means of conveyance. And trade begins virtually with the domestication of such animals as can carry a load. It is probable that long-distance trade, except along rivers, developed among nomadic peoples of the steppes. People whose livelihood depends upon cattle, sheep, asses and goats must in any case move between summer and winter pastures, and it is a natural urge to load the ass with goods found to be scarcer in one place than another. By 2000 B.C. the horse too was domesticated; wheeled vehicles, drawn by oxen, were also an early invention. Knowledge of these forms of transport spread to the middle east (brought by the nomads themselves) and was the means of founding one of the earliest trade routes, that connecting Babylonia and Egypt. This ran at first across the land bridge provided by Syria and Palestine, following the fertile ground. An alternative route developed, however, across the desert itself—shorter, but involving some of the problems of an ocean voyage. The traders followed known tracks between oases and wells; and cities. comparable in function to seaports, grew up at their points of departure and arrival. This trade, the importance of which may be measured by the size and wealth of these cities, caravan termini like Baghdad, Palmyra, Baalbek and Damascus, was limited in development because the natural products of Egypt and Babylonia were not markedly different from each other. Further eastward and westward lay regions more dissimilar, and it was to them that this Syrian trade route was extended. It could not, however, be extended by land. From the mouth of the Nile to the mouth of the Euphrates the trade could pass by camel or river craft. To extend farther in either direction, it would have to go by sea, this further development depending essentially upon the evolution of the river boat (or raft) into a seagoing sailing ship. This seems to have taken place upon the Nile, which rises in Africa but points toward Europe. Once seagoing vessels had come into use it was inevitable that trade bound from Babylonia to Europe should seek a shorter route to the sea, with a place of shipment at Tyre or Antioch. Moreover, the trade of the Nile delta would as inevitably seek a shorter route to the Indian ocean, either across the isthmus of Suez or up the Nile and so to a port farther down the Red sea. Farther northward, in the original home of the nomadic peoples, there was no necessity to use a sea route. There developed instead. overland, a caravan route which extended eventually from the Black sea to the north China coast. From these earliest beginnings there evolved the great trade routes between Europe and Asia.

Routes Between Europe and Asia.—The main centres of population in Europe and Asia are almost connected with each other by a line of high mountains. Trade must pass either to the north or south of them. On the northerly route the goods will go almost entirely by land. On the southerly route they must go by sea.

Carriage by sea tends to be less costly, but, apart from that, the southern route reaches China via India or Africa and, in either event, via southeast Asia, while the northern route passes through lands less populous and, to the merchant, less attractive. The southern route has for that reason normally had preference over the other. There exists, at least in theory, a more northerly route still, connecting China with Europe via the arctic circle, but the objections to this—ignoring the technical difficulties—are of the same kind. A route traversing such relatively uninhabited country could offer only the attraction of speed. and that has not hitherto been a paramount consideration in the transport of goods.

Trade passed at first over the more northerly route, overland, and was the means whereby the Romans obtained their supply of silk. Afterward this route was interrupted by hostile trihes, and it was not until 1245 that it regained its full importance. From then until 1345 the Mongols, holding sway between China and the Danube, encouraged the reopening of the silk route. along which Marco Polo and other European travellers made their way to the far east. For about a century trade passed freely and was then checked afresh by mainly Turkish intervention. But whether passing freely or restricted, this long-distance land route could serve only a limited purpose. No heavy or bulky goods could be worth the cost of transport on pack animals over such a distance. The silk route did more to create than to satisfy the demand for luxury goods, and it fell into relative disuse as the maritime routes developed. Its place was eventually taken by the Trans-Siberian railway, but this has never been an international trade route, serving as it does only the more local purposes of the U.S.S.R. After 1345 the vast bulk of the trade went by sea.

Of the alternative southern routes, the shortest is that via the

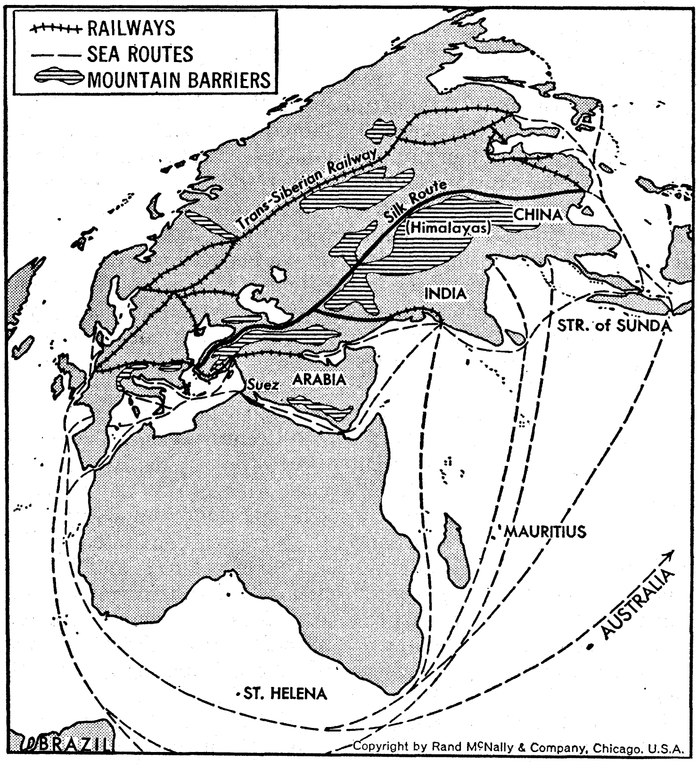

FIG. 1.—TRADE ROUTES BETWEEN EUROPE AND ASIA

isthmus of Suez, at which point the waters of the Red sea and Mediterranean are separated by barely 100 mi. of desert. In view of the cost of transshipment and the flat nature of the desert at that point, the idea of digging a canal to connect the two seas is an obvious one. Such a canal. dug by a pharaoh of Egypt, existed in 1380 B.C. Another was begun in 609 B.C.. and Darius later continued the work. If this was effectively in use it was between 285 B.C., when Ptolemy Philadelphus completed it, and 31 B.C., by which date it had ceased to be navigable. This canal connected the Red sea at Arsinoe, not nith the Mediterranean directly but with a branch of the Nile, and it was the dwindling of that branch which dried it up. The essential difficulty about this enterprise lay not so much in digging the canal as in navigating the Red sea. The project for a Suez canal was abandoned for the time being, and it is probably true to say that it was never really practicable before the introduction of the steamship.

On the other hand, there was considerable trade between Europe and Asia by other routes from about 130 B.C. This was the period during which the Persian empire stretched from the Mediterranean to the Indus and the Caspian sea, thus politically uniting much of the territory over which the trade would pass. The Persians were not themselves a seafaring people, and it had been left to the

Phoenicians, from 1500 B.C. or earlier, to extend the trade by sea from Sidon or Tyre to Carthage and Cadiz. They shipped westward the spices, silks and ivories of the east, and eastward the silver, copper and tin of the west. From the Persian gulf the trade was carried in Indian ships as far as Malabar. Goods were apparently transferred there to other Indian ships proceeding to Bengal or to the Straits of Malacca, where ships from China (as from about the 1st century B.C.) were contacted.

But this was not the only possible route. for goods could also still pass by the overland route! reaching the Black sea and so entering Europe via the Danube or the Adriatic. The wealth of Troy presumably depended upon this trade which led the Greeks and Trojans to quarrel over it. Between the Greeks (as, later, the Romans) and the Phoenicians was an essential rivalry, as between two alternative routes by which the same trade could pass. The struggle ended. for the time being, when Alexander the Great led his army to conquer Egypt and establish the new port of Alexandria with its famous lighthouse.

The Romans became heirs to this Hellenic empire and inherited from it a well-established trade with India and China. Mainly because of Parthian hostility, the Romans developed the sea route, whi'ch was notably improved by the discovery of how to sail direct from Egypt to India without following the coasts of Arabia and Baluchistan. This discovery, attributed to Hippalus, took place in about A.D. 50, leading to a vastly increased trade which did not decline until the time of Hadrian. This trade is described in detail by the author of the *Periplus of the Erythraean Sea*, written at Berenice in about A.D. 80–89, it dwindled only as the Roman empire itself declined. Direct trade by sea between the Roman empire and India almost ceased in the time of Caracalla. The foundation of Constantinople in A.D. 328 was the symptom of a revived interest in the land route via the Black sea, a route destined to be used throughout the middle ages.

The rise of Islam from A.D. 622 until about 800 marks a new phase in the history of trade between Europe and Asia. The Arabs, at the height of their success in the 8th century. controlled a territory stretching from Portugal to the Indus. This brought the whole of the southern route trade under Arab control and lessened the flow of what still passed through Trebizond and Byzantium. The Arab trade from the Atlantic to China was facilitated by the brotherhood of Islam but was based upon a Greek and Roman inheritance of knowledge, postal organization and commercial integrity. The trade of Christendom was largely confined to the northern side of the Mediterranean and led from Constantinople to Venice, Genoa or Marseilles with overland passage thence to Germany, Flanders and France.

Hostility between Christendom and Islam came to a head during the crusades (1100–1270) which temporarily recovered for the Christians the ports of the Levant and a share in the trade still passing through the Persian gulf to the Syrian coast. Concident with this was a period of Chinese enterprise in the Indian ocean, trade being active in the 10th–12th centuries. It was probably during this period that a number of important Chinese contributions to shipbuilding and navigation passed to Europe.

The chief profit from the crusades went to the Venetians who came to terms with Islam and secured a commercial supremacy in the Mediterranean which was not seriously shaken even when the Turks captured Constantinople in 1453. The commercial empire of Venice, based upon a chain of defended ports in the eastern Mediterranean, linked up with the land routes over the Alps into Germany. The German cities were connected in turn with the Netherlands, via the Rhine. and so joined up with the Hansa—an alliance of trading cities which extended from the Rhine delta up to the Baltic. England lay opposite the ports of Bruges and Antwerp but had little share, during the middle ages, in any long-distance trade. The Hansards controlled the more valuable imports and had their own establishment in London. English merchants were better able to compete on the western side of the British Isles. They could thus trade with Ireland, with Bordeaux and Portugal, making use of such ports as Bristol, Chester and Exeter. There was a change of pattern in the 13th century when the Venetians began to sail round from the Mediterranean and open trade directly at Southampton. Many of the essential techniques of modern commerce are derived from the Venetians and Hansards, although not necessarily invented by them. It was not until the 16th century that the English merchants began to be important even in northern Europe, nor until the 17th century that they began to trade as far afield as the Mediterranean.

As the European ports for eastern trade. Venice and the other Italian cities traded throughout most of the middle ages with lands under the rule of Islam. The Arabs of the Levant had proved tolerant of Christian merchants from the 12th century onward, partly because they depended upon them for arms. But long after the crusading spirit among the Italians had given place to commercial agreements with the infidel, the Spanish and Portuguese were waging bitter war to reconquer the Iberian peninsula for the Christian faith. During the period 1245–1345 Italian traders had travelled, under Mongol protection, as far as China. The Portuguese were absorbed, by contrast. in recovering Portugal, which they had no sooner done than they sought to outflank the Moors in Africa by circumnavigating that continent. It was the spirit of the crusade which led them to success in this enterprise in 1497—their actual route to the Cape being in the wake of Christopher Columbus' crossing of the Atlantic in 1492.

The new route between Europe and Asia via the Cape lasted from 1497 to 1869. Its immediate success was due less to its inherent advantages. considerable as these were. than to the vigour with which the Portuguese strangled every alternative. In a few years they built up a trade between Lisbon and Macao, with intermediate ports in east Africa, India, Ceylon and Malaya. But the Portuguese were unable to hold a monopoly for long against the stronger maritime peoples of western Europe — the Dutch. English and French. They soon lost their supremacy, the Dutch changing the route by sailing direct from the Cape to the Straits of Sunda, cutting out the ports of India when sailing to or from Java and the far east. The discovery of Australia was one by-product of this new route and the development of South Africa, in Dutch hands, was another.

During the 18th century the British established their sea power in the east, centred upon India. and built up a series of bases between Great Britain, India and China — St. Helena. Cape Town, Bombay, Madras. Calcutta and Penang. To these mere added Ceylon, Mauritius and Singapore early in the 19th century, Hong Kong in 1841, Labuan and North Borneo in about 1848. This represented the final achievement of the sailing-ship era. Already, however, from about 1840, there were signs of a revival of the older and shorter route. Napoleon had investigated its possibilities during his campaign in Egypt, being forced to realize in the end that the Red sea was no place for merchantmen under sail. New possibilities opened up, however, with the development of the steamship, and it was found possible to carry mails and passengers via Suez with a short overland journey (by rail from 1857) between one steamship and another. The logical sequel to this was to cut a ship canal across the isthmus, and this was finished in 1869 by an international company in which Great Britain acquired a controlling interest. Trade now reverted to the old route with British bases developed at Gibraltar, Malta, Cyprus, Alexandria and Aden. Cables were laid along the same route shortly afterward. For sea-borne trade this continued to be the normal communication between Europe and Asia, the longer sea route affording an alternative way of reaching Australia, via South Africa, more especially in time of war. The distance from London to Melbourne is 1,000 mi. less via Suez than the Cape but, because of canal dues and delays, there is little difference in either time or cost.

The air routes to the far east developed after 1945, being by the mid-1950s still used almost solely for passengers and mail. In general outline they duplicate the route by sea but take a shorter line over Arabia and India. British airlines use airfields at Rome and Zurich, Beirut. Cairo. Basra, Bahrein, Delhi. Calcutta. Bangkok. Singapore and Hong Kong. The airport at Bangkok has become important as the connecting link with the trans-Pacific seivices.

Routes between Europe and America. — Soon after the discovery of the new world in 1492 it was found that the wind system in the Atlantic favoured a clockwise movement of trade, the outward bound ships heading initially for South America—their course being the same as if bound for the east—and then sweeping northward through or near the West Indies, along the American coast and so homeward via the Newfoundland banks. There were modifications of this general movement, slave ships for example calling in west Africa on their outward passage, and some ships taking a more southerly route homeward. On the far side of the Atlantic the first point of commercial interest was the Spanish Main, leading to the isthmus of Panama. North of the isthmus lay Mexico, across it and southward lay Peru. These lands were conquered by the Spanish and remained a Spanish preserve until the 19th century, just as Brazil (on the route to the east) remained for long a preserve of the Portuguese. The Dutch and English. arriving later, secured footholds in the West Indies and passed on to the coasts of Virginia and New England, where the English soon predominated. The coasts on which they had settled were. from a long-term point of view, hemmed in by mountain ranges in the immediate hinterland. It was the French who outflanked that barrier by penetrating the St. Lawrence and gaining eventual access to the Great Lakes and the heart of North America.

Transatlantic trade based on Bristol and Liverpool increased

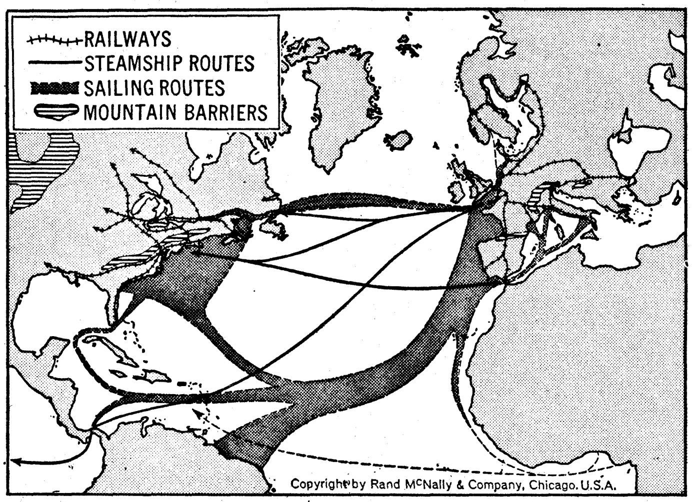

FIG. 2.— TRADE ROUTES BETWEEN EUROPE AND AMERICA

in the 17th and 18th centuries depending mainly on sugar, tobacco and slave trading. The French possessions on the St. Lawrence were conquered by Great Britain in the Seven Years' War and retained after the American colonies gained their independence in 1783. During these French Wars the trade routes in the North Atlantic were the scene of naval conflict, battles for the protection or interception of convoys taking place off the French coast, in the West Indies and near the American ports. These classic routes, upon which naval strategy was based, did not alter appreciably until the advent of the steamship. From about 1845 steamships began to prevail, soon becoming the normal means of transport for goods as well as for passengers. As they became more powerful, especially after 1870, they abandoned the more circuitous routes of the sailing ship. At the same time they had to plan their voyages in relation to fuel supply, the Atlantic crossing particularly favouring the steamship in having coal supplies at either end. As extensions of the Atlantic trade came the canals and then the railways, fanning out from the main European and American seaports. Perhaps the most important of the canals was on the American side and opened at a relatively early date. This was the Erie canal, in use from 1825 and connecting the Hudson river with the Great Lakes —a major factor in the rise to the greatness of New York as a trade centre of the world. The North Atlantic was crossed by telegraphic cables from 1866, supplementing the regular traffic of ships by the ready exchange of commercial and other news.

The paramount importance of the North Atlantic trade routes is due to the size and wealth of the centres of population which those routes connect. And, although the industries on either side of the Atlantic are partly the same, the natural products are markedly different. The vital character of this traffic is shown not only by statistics but by the elaborate and costly installations at termini such as Southampton, Liverpool, Hamburg, New York city and Montreal; as also by the vigour with which this route has been defended in time of war. During World Wars I and II attempts to intercept the trade were concentrated upon such vulnerable points as the Mersey estuary. The factors of distance and (at some periods) of neutrality averted any comparable attacks upon the U.S. end of this great trade route.

Perhaps the greatest volume of traffic in the world is that which passes through St. Mary's canal and the Great Lakes. There more than anywhere else the export traffic of a great continent is largely confined to a single outlet. Again the sea communications are largely duplicated by the air routes, which afford swift passage for mails and travellers between the great international airports of London and New York city. On the longer flights farther south from Lisbon. Port., use is made of intermediate airfields at the Azores and Bermuda.

Whereas the transatlantic trade was one in which British shipping predominated, the main interests of the United States began from an early period to turn toward the Caribbean. The first stage in this process had been the development of American trade with the Rest Indies, only slightly checked in 1783. The second stage was the Louisiana purchase of 1803 which made the Mississippi a main trade outlet instead of the western boundary of the United States. Thenceforward, as the middle west developed, its trade tended to follow the lines of least resistance, northward through the Great Lakes or southward to the Caribbean. It was the latter drive which gave the United States a growing commercial interest in Central and South America—a compensation for the extent to which the North Atlantic trade remained in European hands. As Mexico revolted against Spain in 1821, U.S. pressure south ard increased, leading to the independence of Texas in 1836 and its annexation to the U.S. in 1845. the establishment of commercial influence over Cuba and the rapid growth of the port of New Orleans, La. The Americans had great difficulty at first in breaking into the South American trade. All the historic connections of Brazil and the Argentine were with Europe, and New York is no nearer South America than is Liverpool or Hamburg.+

Where the U.S. was better placed was in relation to Peru and Chile. California had been seized from Mexico in 1846, preparing the way for the rise of San Francisco from 1849 and the first transcontinental railway of 1869. With the United States firmly established on the Pacific, the trade to the west side of South America was a legitimate field for U.S. enterprise. It was a coast well out of reach of European shipping, for the rounding of Cape Horn is a far more formidable feat than is the rounding of the Cape of Good Hope. But the pressure of exports seeking their market did not come from the narrow coastal plain of California. It came from the vast hinterland of New Orleans and pressed upon the slender barrier formed by the isthmus of Panama. There were the beginnings of a canal as early as 1880 but the French company went bankrupt and the aork was resumed by the United States in 1902. The technical and medical problems were immense, and the Panama canal was not completed until 1914.

With the opening of the Panama canal the full influence of eastern America could be brought to bear upon the west coast, not only of South America but of the United States itself. By 1930 the Panama canal had more traffic than the Suez canal. Long before that, the implications of the new route had become apparent. For nhile British traffic to Australia. Hong Kong. Manila or even Yokohama would still go via Suez—only New Zealand being nearer by Panamá—New York was now as near to Hong Kong or Manila by either route and nearer to Sydney by Panama. From the beginning the Americans were acutely aware of the need to protect the Panama canal by bases on the Atlantic side—Jamaica, for example, being potentially to the one canal what Malta is to the other. Part of the price of the U.S. intervention in World War I was the virtual British withdrawal from the Caribbean. This was a slow process, culminating in the lease of bases arranged during World War II. U.S. influence upon South America was further strengthened by the development of airlines, which shorten the distance, as for example between Belem and Rio de Janeiro, Braz.

Routes between America and Asia.—The United States has an interocean position, but with unequal opportunities as between the Atlantic and the Pacific. The Pacific has, to begin with, no potential trade comparable with that of the Atlantic. The ocean itself is wider but the lands which drain into it are less than half the area of those draining into the Atlantic. The rivers are short on the American side and those on the Asian side, if longer, are open to other objections, the Amur being frozen for half the year and the Hwang-ho changing its course too often. So the Pacific offers no limitless room for the expansion of trade. But, its potentialities had still to be fully explored by the second half of the 20th century, and some of the adjacent centres of population, in southeast Asia and Australia, for instance, were of growing importance.

The first trans-Pacific trade route was that established by the Spanish between Mexico and the Philippines. The United States, however, was the first world power to establish itself on the Pacific. This was the result, first of all, of the creation of a firm base extending from San Francisco to Alaska, acquired with the Aleutian Islands in 1867.

The next step was the acquisition of Pago-Pago in 1872, followed by the acquisition of the right to use Pearl Harbor in 1887. A growing interest in Hawaii, dating from before 1844 led to its annexation in 1898 and statehood in 1959.

At this point, United States interest in the Pacific trade routes fell very far short of control. Before the cutting of the Panama canal the eastern seaboard of North America was remote from the Pacific and the full American influence had therefore yet to develop. Nor was the United States the only power with interests in Pacific trade. The British empire straddled the Pacific with commercial bases at Vancouver (B.C.), Wellington (N.Z.) and Sydney (Austr.).

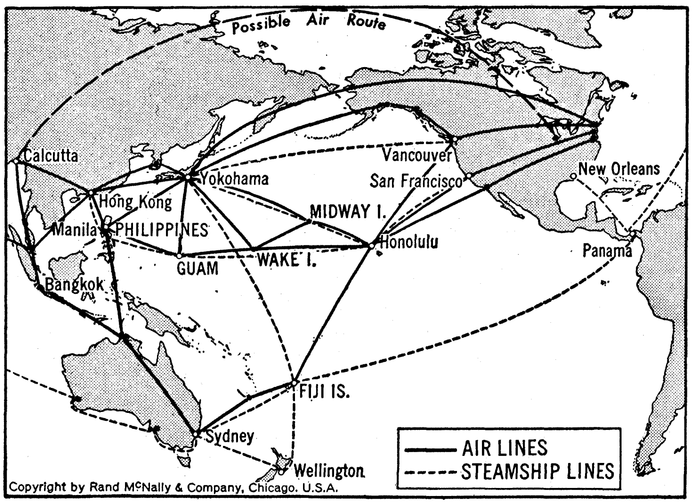

FIG. 3.— TRADE ROUTES BETWEEN AMERICA AND ASIA

The Germans, coming late on the scene, had interests in Samoa, which they showed themselves willing to defend in 1888, and Spain later sold to Germany the Carolines and the Marianas (Ladrones). But Germany was remote from the scene and far less directly interested than Russia. The completion of the Russian-leased Chinese Eastern railway and its connection with Vladivostok in 1897 had given the Russians a base in the north Pacific. The Russians' basic handicap lay, however, in the distance between their Baltic, Black sea and Pacific ports. Even the French in Indochina and the Dutch in Java were not wholly excluded. The question as to which power should succeed to this part of the Spanish empire had still to be decided.

The turning point was the Spanish-American War of 1898. A brief and unequal conflict gave the United States Puerto Rico and the entire Philippines. With a broad base on the U.S. coast, with Manila on the far side of the Pacific and with intermediate cable and coaling stations at Hawaii, Samoa, Midway and Guam, the United States was almost in a position to claim supremacy. It only remained to complete the Panama canal, the territory for which was obtained in 1903.

It was in 1903 that Pres. Theodore Roosevelt proclaimed at San Francisco that to the United States must belong the dominion of the Pacific.

Coincident, however, with the U.S. advance into the Pacific was the rise of Japan. The Japanese of the new Meiji era (1868–1912) quickly westernized their country and their forces, won victories over China in 1894 and 1895 and over Russia in 1905, acquiring Formosa, the Pescadores and (in 1910) Korea. This brought about a deterioration of U.S.-Japanese relationships, intensified during World War I when the Japanese used the occasion to capture from Germany the Marianas, Caroline and Marshall archipelagoes, simultaneously strengthening their hold over China. For a westernized Japan trade was vital, if only to dispose of the products of Japanese industry. With easier international relations, the Japanese might have secured a share, at least, of the trans-Pacific trade but the tariffs imposed during the slump of 1929–31 drove them to conquer Manchuria instead in 1931–32. This was only a partial solution to economic difficulties, and it became a Japanese ambition to open a new trade route, via Formosa and southeast Asia, to Australia. Squarely in the path of any such development stood the Philippine Islands, in U.S. hands, flanked by British Borneo, Malaya and New Guinea, and from about 1922 the British naval base of Singapore was developed with the object of preventang any such Japanese advance.

The fall of Singapore in 1942 represented a momentary triumph for the Japanese, but they held the area for only three years.

Decisively defeated in World War II, the Japanese could no longer suppose that their ambitions in this direction were practicable.

It remained true, nevertheless, that the route from Shanghai or Tokyo (or Vladivostok) to Manila and thence to Halmahera, Brisbane. Sydney, Melbourne and Hobart was still, potentially, one of the great trade routes of the world.

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TRADESCANT, JOHN (1608–1662), English traveler and gardener, was born at Meopham, Kent, on Aug. 4, 1608. He inherited the museum and physic garden that had been founded at South Lambeth by his father, John Tradescant (d. 1637?). In 1637 young Tradescant traveled to Virginia to collect specimens for the museum.

His *Musaeum Tradescantianum,* a catalogue of the museum and physic garden, was published in 1656. At that time, the museum was considered to be the most extensive one in Europe. A potpourri of rarities, it reflected the universal interests of scientific men of the period and was one of the precursors of modern museums of natural history and art. After Tradescant's death on April 22, 1662, the collections were eventually absorbed into the Ashmolean museum at Oxford.

See *Dictionary of National Biography* for a fuller account; A. W. Anderson, "John Tradescant," *Gardeners' Chronicle of America,* pp. 324–325 (Dec. 1947). (J. W. Tt.)

TRADES UNION CONGRESS, THE. The Trades Union congress of Great Britain was formed at a conference of trade union organizations in Manchester, Eng., in 1868 and has had a continuous existence as a permanent association of trade unions which each year send delegates to a congress to express trade union opinion on matters of common concern and to elect a general council to act as an executive body for the movement. During its rise to a position of national and international standing, the T.U.C. established its right to speak for the organized workers of Britain. At no time has there been any rival national organization to claim the allegiance of even a substantial minority. Unlike movements in some other countries the unity of the British trade union movement has never been broken by differences of religion, politics and theories of organization. In its early years the congress was concerned mainly with legislation affecting the status of the unions and the interests of their members, although from time to time it also considered political questions. In 1899 a resolution at congress called for a special conference representing the unions, the co-operative societies and the socialist organizations to devise means of increasing the number of Labour members of parliament (see LABOUR PARTY, THE [BRITISH]).

Increased trade union membership led to a growth in the influence of the T.U.C. which was enhanced during World War I by the decision to share in national consultation on matters of national importance. During World War II regular consultation between trade union leaders, employers and the government developed on a scale that embraced all ministerial moves, bills, regulations and other actions bearing on the interests of the workers. This practice continued after the war—a welcome change from the years when the unions could do little more than lobby ministers and M.P.'s when they wanted to make proposals to the government.

Some reference should also be made to the Trade Disputes and Trade Unions act of 1927 which was passed following the general strike in support of the miners in 1926. This act, which was repealed in 1946, banned general strikes and most sympathetic strikes and imposed restrictions on picketing. It also affected the political activities of the unions.

Membership. — Starting in 1868 with 118,367 members, the T.U.C. doubled that number in one year and by 1874 totalled more than 1,000,000 members in 150 unions. Membership subsequently fluctuated between 460,000 and 800,000 until 1890 when the million mark was again reached. At the beginning of World War I there were more than 2,000,000 members in about 200 unions, and by 1918 the total had risen to 4,500,000 in 262 organizations. The highest point in affiliated membership between World Wars I and II was 1920 when 215 unions affiliated 6,500,000 members. Then came a decline mainly as a result of the economic depression which beset the country particularly in the early 1930s. After 1934, when membership was 3,200,000, there was a steady increase and after 1952 the total affiliation was more than 8,000,000 in about 180 unions.

Unions in the T.U.C.—Unions affiliating to the T.U.C. pay an annual affiliation fee of 6d. on each of their members. Any trade union may affiliate providing it satisfies the general council of its bona *fides*. The repeal in 1946 of the 1927 Trade Unions and Trade Disputes act restored to unions in the civil service the opportunity of affiliation to the T.U.C.

Affiliated unions vary in size and character and in their views on organization. The biggest is the Transport and General Workers' union with about 1,250,000 members, and this organization, together with five others, makes up half the membership of congress. Nevertheless in 1955 there were three affiliated unions with less than 100 members and 37 with less than 1,000 members each. Generally, however, after 1920 the tendency was for unions to grow bigger and fewer, with amalgamation reducing the number of organizations in the same trade or industry. Such developments took place in unions organizing in coal mining, transport, engineering, distribution, building, foundries and the furniture trades.

Another move toward closer working among unions in the same trades and industries was the setting up of federations, usually for collective negotiation and other common action within an industry. The principal federations in 1955 were the Confederation of Shipbuilding and Engineering Unions, the National Federation of Building Trades Operatives and the Printing and Kindred Trades federation. There were also federations in cotton and woollen textiles. Since their constituent unions are affiliated direct to congress, none of the federations themselves affiliate though they keep close touch with the T.U.C.

Though some of the differences between craft, industrial and general unions have become less pronounced with technical change in industry, unions affiliated to congress usually so classify themselves, apart from those nonmanual and professional bodies which have grown in strength and numbers since the 1920s. Broadly speaking the craft union bases its organization on the tool operated, the industrial union organizes workers on the basis of the commodity they produce, while the general workers' unions having evolved from the organizing of the unskilled, include many workers of different industries and skills.

The aim of the trade union movement is to secure a 100% membership in every place of work with every worker belonging to the appropriate union. The term "closed shop" is often wrongly used in referring to this particular trade union aim and in 1946 the T.U.C. made it clear that the closed shop in the sense of an establishment in which only members of a particular union can be employed to the exclusion of members of other unions is alien to British trade union practice.

The Annual Congress.—Affiliated unions are entitled to send one delegate for every 5,000 members or part thereof to the annual congress which is presided over by the chairman of the general council for the previous year. All delegates must, when appointed, be working at their trade or be permanent paid officials of their union.

The annual congress has three main functions. It considers the detailed report of the work done by the general council during the previous year and if necessary makes recommendations for further action. It discusses and takes decisions on the motions forwarded for the agenda by affiliated unions. Finally it elects by ballot the general council for the coming year. Decisions are taken either by voice, show of hands (when each voter is counted as one) or, at the request of delegates or the discretion of the president, by a card vote, which can be called for on any issue. The card shows the number of trade union members represented by each delegation and enables each union to cast its full affiliated strength either for or against the issue.

The General Council. — In 1869 an elected parliamentary committee was appointed to carry out the decisions of congress. This committee did little more than keep an eye on legislation and interview ministers of the crown and members of parliament when the need arose. As World War I ended the demand grew that the movement should have a more effective centralized leadership, and in 1919 proposals for the setting up of an enlarged executive body were submitted to a special congress. This executive body, first elected in 1921, was the T.U.C. general council.

The 35 members of the modern T.U.C. general council lead the British trade union movement on broad national policy. They keep up relations with the government, with employers' organizations, and with a large number of advisory and consultative bodies concerned in particular with social and economic problems. Affiliated unions are divided into 18 trade groups and seats on the general council are allocated according to the size of the group. A 19th group ensures that two women trade unionists are always elected to the council.

Any union in a group may nominate to fill places in its group but all the unions in congress vote in the election. Similarly, only unions with women members may nominate for the women's group, but all unions cast their votes in the election. The effect of this system of voting is that members of the general council sit as representatives not of individual unions or groups of unions, but of congress as a whole. It also ensures that the members bring to their deliberations opinion and experience representative of the whole range of British industrial activity. The principal executive officer of congress, the general secretary, is elected by congress and is a member of the general council.

Once elected the council appoints its chairman for the year and, subject to the rules and standing orders of congress, acts as an executive body.

Neither congress nor the general council can override the autonomy of the affiliated unions, and none of their decisions are binding. However, the moral authority of the council is strong and since it interferes as little as possible in the domestic affairs of the unions, there is a readiness among affiliated organizations to accept its decisions.

Standing orders lay down specific duties for the council during strikes, in disputes between unions and on misconduct by unions. During a strike the council does not intervene unless it is asked to do so, or unless the interests of the movement as a whole are involved. Once, however, the council has intervened in a strike it is bound to seek a just settlement of the difference and to advise the unions involved. Should a union refuse this advice it is reported to congress. Similarly, if the general council is unable to get the necessary undertakings from a union which after full investigation is found to be behaving in a way detrimental to the interests of the trade union movement or contrary to the declared principles and policy of congress. the offending union is reported to congress. In the meantime the council may suspend the affiliation of the union.

When differences arise or threaten to arise between unions (for instance, on demarcation issues), the general council seeks a settlement through its disputes committee, which exercises a triple function as a fact-finding commission, as a conciliatory body and as a judicial tribunal. Unions are expected to abide by the council's decision, and in the event of serious disobedience the council may decide to suspend affiliation until the following congress, when the matter is raised. To help keep good relations inside the movement, congress agreed in 1939 on a set of guiding-principles — the Bridlington agreement — which though not a legal code aims to eliminate competition between unions organizing in the same field.

Besides a disputes committee there are a number of other committees through which the council operates. These committees and the council are served in detailed consideration of policy by a full-time staff at T.U.C. headquarters, organized on a departmental basis. The main departments are education, organization, research, international, production and social insurance, and their senior official acts as secretary to the appropriate committee. Other departments deal with press and public relations, publications and finance.

In addition to committees which are composed exclusively of general council members there are a number of joint committees which co-opt experts or representatives elected at special conferences. These committees deal with matters affecting trade councils, women workers, nonmanual workers, scientific development and the colonies.

Trades Councils and Regional Machinery. — Inside the movement the trades councils (local representative bodies of trade union branches) have long played an important part. First formed in the middle of the 19th century. trades councils were represented separately at congress until 1895. Then, after a period of uncertainty during which there was no formal association between the trades councils and the T.U.C., they were from 1924 brought more and more into the machinery of congress and became the local agents of the T.U.C., under a system of yearly registration.

The other part of the T.U.C.'s regional machinery is the regional advisory committees of which there are 16 in Great Britain. Made up of full-time officials of unions, these committees share with the trades councils the nomination of trade union representatives to many local bodies connected with industry and the social services, are responsible for keeping the T.U.C. informed about the situation in their regions, and co-operate with employers and government departments in advising ministers of the crown on industrial development.

External and Educational Activities. — Altogether the T.U.C. is represented on more than 100 government and other bodies whose activities affect the public interest. Among the most important outside committees with which the general council is associated are the National Joint Advisory Council to the Minister of Labour which deals with a wide range of employment problems and the National Production Advisory Council on Industry which concerns itself with factors affecting output.

As an autonomous industrial body the T.U.C. does not spend money on political action, nor does it have a political fund. The general council does, however, nominate representatives to the National Council of Labour, a nonpolicy-making consultative body which also includes the nominees of the Co-operative union, the executive committee of the parliamentary Labour party and of the Labour party national executive committee.

In 1949 the T.U.C. became affiliated to the International Confederation of Free Trade Unions which was founded in London in that year and has more than 54,000,000 members in 75 countries. The T.U.C. also has close contacts with trade unions in the colonies. Another international body receiving strong support is the International Labour organization (I.L.O.). Each year the British government invites the T.U.C. to nominate the British workers' delegate and his advisers to the annual conference of the I.L.O. The T.U.C., too, makes nominations for British workers' representatives to attend the specialist committees of the I.L.O.

Among the services of the T.U.C. which expanded steadily after World War II was the provision of training courses for trade unionists. By 1955 there were an annual summer school at Oxford; a trades council summer school at Oxford; weekend and day schools for Federations of Trade Councils on the basis of at least one a year for each federation; and a wide range of courses at the T.U.C. educational centre.

The T.U.C. also advises and assists unions preparing study courses and contributes to the Workers' Educational association and the National Council of Labour Colleges.

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TRADE (LABOUR) UNIONS. Trade unions are associations of employed persons for collective bargaining about their conditions of employment and also for the provision of benefits, legal defense and the promotion of their members' interests by bringing pressure to bear on governments and parliaments and, in certain cases, by political action. They undertake other functions besides these — for example, educational work and, in some cases, participation in the organization of industry through co-operative societies or by representation on control boards or in the management of productive operations; but their main work is in the field of collective bargaining, and in some countries the development of social security legislation has made their benefit activities less important than they formerly were.

The words "trade union" were originally used to mean a union of local trade clubs or societies to conduct a joint movement, the words "trade club" or "trade society" being used to describe the primary units of working class combination. Trades' union meant a combination of societies covering a number of different trades (for example, carpenters, bricklayers, etc., in a building trades' union). General combinations of societies in all trades were called trades unions or general unions. Later, as the local trade clubs amalgamated into larger bodies, the words "trade union" came to be used in their present sense, to cover any combination of workers for collective bargaining. The French equivalent is *syndicat ouvrier*, or simply *syndicat*, which still means mainly local trade union; the German word is *Gewerkschaft*, the Italian *sindacato;* Americans use mainly the term "labor union" or simply "union."

GREAT BRITAIN

No date can be assigned to the origin of trade unions; but in Great Britain they did not become numerous until the 18th century, mainly as local trade clubs of skilled workers in a particular town. There were occasional journeymen's combinations in the 16th and 17th centuries, to make demands on guild masters or other employers; but there is no basis for the attempt to treat trade unions as descendants either of the mediaeval guilds or of the bachelor or journeymen fraternities sometimes associated with them in a subordinate status.

The earliest trade societies arose among skilled workers, such as printers. tailors, saddlers, wool combers, brushmakers and weavers. They were usually small groups, often centred at a particular house of call, and they carried on friendly benefit activities as well as regulation of the conditions of employment, especially in relation to apprenticeship, hours of labour and standard wage rates.

These small trade clubs, until the 19th century, usually formed wider unions of delegates only on particular occasions, when they aished to put forward a common claim or to fight some concerted move of their employers. Such joint movements were most often limited to a single town or district and to a single industry; but in the case of weavers (and later miners) they sometimes covered considerable areas, for otherwise it was easy to defeat them by withholding work from a particular locality and transferring it elsewhere. This was especially the case in the textile trades, under the domestic system. That is why the weavers were the pioneers of trade unions covering a wide field; but their combinations of this type never lasted long and were usually broken up by the joint action of employers and the law. Spme trades, without permanent unions, had well-organized travelling arrangements whereby a journeyman seeking work outside his home district applied to the local house of call and was either found employment or helped on his way to another district (for example, wool combers, brushmakers. printers).

Mere local trade clubs were seldom interfered with by the law; but attempts to form wider unions soon brought the workers into conflict with municipal or national authority. In Great Britain, where the sections of the Elizabethan Statute of Artificers empowering the local justices to regulate wages and apprenticeship were not repealed until 1813–14, workers' combinations for the purpose of urging the justices to fix wages or to prevent the employment of illegal (that is, unapprenticed) men on skilled work were regarded as in themselves lawful up to the enactment oi the Combination acts (1799–1800) which definitely made all trade combinations unlawful.

But well before that the judges had come to regard as unla ful any combination which they regarded as being in unreasonable restraint of trade; and that was more and more held to cover all attempts to regulate wages or conditions of labour, as distinct from merely asking the justices to do so. Indeed, the Combination acts were passed less for the purpose of declaring trade unions to be criminal conspiracies — for in effect the courts had come so to regard them already — than for that of providing easier means of bringing minor offenders to book by empowering the justices to deal with cases of combination by summary jurisdiction, whereas previously such charges had involved procedure by indictment for conspiracy in a higher court. Formally, the Combination acts applied to employers' as well as to workers' combinations; but no employer was ever prosecuted under them.

In Great Britain, the name "trade union" still legally covers employers' associations, and a few such bodies are registered under the Trade Union acts. But in practice this wider sense of the term has little importance.

Early Legal Position. — Trade Unions were prohibited in France under the Le Chapelier Law of 1791, which outlawed all private associations; but in neither France nor England did the outla ry prevent their existence. though it rendered their leaders always liable to prosecution and their continuance precarious.

In Great Britain the Combination acts had been part of a series of laws passed to repress popular movements during the period of the revolutionary wars; and their enforcement was very uneven, being most severe in the mining and northern textile areas, where large numbers of potentially riotous persons were involved, and least so among the skilled urban craftsmen, whose small clubs were usually unmolested. The Combination acts were repealed, together with other acts against combinations in particular trades, in 1824, thanks mainly to the efforts of Joseph Hume and Francis Place; and the repealing act also removed the common law taint of illegality. It was replaced the next year by a much less generous government measure, which gave trade unions a bare legal right to exist, but imposed many restrictions on their actions. This act of 1825 remained in force till 1871. Other repressive statutes remained; in the famous case of the Dorchester labourers, or Tolpuddle martyrs, in 1834, the prosecution was not nominally for combining, but for "administering unlawful oaths," and the same charge figured in the indictment under Scots law of the Glasgow cotton spinners' leaders in 1837.

1825–1888.—British trade unionism after 1825 grew very fast and by 1830 attempts were being made to form a general trades union open to all kinds of workers. During these years the workers played their part in the reform agitation and, after the Reform Act of 1832 had left them voteless, turned to large-scale industrial action in the hope of improving their condition. Many unions passed under the influence of Robert Owen's ideas and launched ventures in co-operative production, including the Grand National Guild of Builders set up by the Builders' union in 1833 with the purpose of taking the entire building industry into its hands. Owen, taking the lead. tried to combine all the trade societies and unions into a Grand National Consolidated Trades' union which, after a year of bitter conflicts with the employers and the government, collapsed in 1834, its fall hastened by the sentence on the Dorchester labourers. From this point most trade unions and clubs abandoned the practice of administering oaths of secrecy to their members. The fall of the Grand National did not destroy the movement, but broke it up again into small independent local societies. with only a few unions (*e.g.,* the stonemasons) surviving as national bodies.

By 1845 recovery had gone far enough for a new central body—the National Association of United Trades for the Protection of Labour — to be set up. and for a revival of attempts at co-operative production under its auspices; but this body died away after a few years, and attention was given mainly to building up highly organized national or regional unions of skilled workers in particular trades — notably the Amalgamated Society of Engineers (1851) and the Amalgamated Society of Carpenters and Joiners (1861). The cotton operatives also reorganized strongly in local societies, federated for common action, and began to secure recognition and develop modern collective bargaining methods.

The miners, who had prematurely created a national union in the 1840s, only to have it destroyed by depression and conflict, built up a new nation-wide movement in the 1860s and began to press successfully for acts regulating safety conditions as well as for higher wages.

At this point the British unions became involved in a series of legal struggles which lasted from 1864 to 1875. Aided by the Reform Act of 1867, which enfranchised many urban workers, they not only repelled the attacks on the legality of trade unionism, but secured in the Trade Union Act of 1871 an assured legal status and, in the Master and Servant Act of 1867. the Employers and Workmen Act of 1875 and the Conspiracy and Protection of Property Act of 1875, great improvements in the workers' status at law and in the provisions regulating strikes and picketing. In 1869 the trade unions took part in forming a Labour Representation league to send workmen to parliament. and two miners mere elected M.P.s in 1874. There was a great growth of trade unionism in the late 1860s and early 1870s, including Joseph Arch's National Agricultural Labourers' union and other movements among the less skilled workers.

Many concessions were won. and many employers agreed to recognize and bargain with the unions now that their legal status had been made plain. But with the passing of the trade boom of the early 1870s and the onset of depression many of these gains were lost, and a period of stagnation followed and lasted through most of the 1880s.

New Unionism. — It was ended by the rise of the new unionism of 1888–89, largely a product oi socialist agitation during the preceding years and of disillusionment with the Liberal party after Joseph Chamberlain's secession.

The outstanding event of this period was the London dock strike of 1889, led by John Burns and Tom Mann, in which the dockers won an unexpected victory (the "docker's tanner"—6d. an hour). Workers, skilled and unskilled, flocked into the trade unions, and many new unions were formed with low contributions and few or no friendly benefits to bring in the lowest-paid workers (dockers, gas workers, workers' union, etc.). The peak reached in 1890–92 was not kept; but, after many members had been lost, the new unions established their position beside the old, which began to adopt less exclusive policies under the influence of the new ideas. The new unionists laid great stress on agitation for a legal minimum wage and eight-hour day, and on the right to work—that is, the obligation of the government to provide work or maintenance for the unemployed. These demands led straight to a revival of political action, which had languished after the movement of 1869–75. James Keir Hardie's Independent Labour party (1893) set to work to induce the trade unions to join forces with the Socialists in an independent political party; the Labour Representation committee was founded on this basis in 1900 and became the Labour party in 1906, when it won 30 seats in the general election that carried the Liberal party back to power.

Later Legal History.—Before this, the unions had become involved in a further contest with the law. In the case of the Taff Vale Railway company *v.* the Amalgamated Society of Railway Servants (1901) it was decided that a union could be sued for damages caused by its agents' actions during a strike. This decision, which threatened the right to strike, was reversed by the Trade Disputes Act of 1906—the Labour party's first important success.

Almost at once a new crisis arose. The house of lords decided in the case of W. V. Osborne *v.* the Amalgamated Society of Railway Servants that a trade union could not lawfully take political action, as unions had been doing unchallenged for many years. This decision too was reversed, by the Trade Union Act of 1913, which allowed political action by unions, on condition of a prior ballot vote in favour of an exemption ("contracting-out") for objectors. This act was temporarily altered, to substitute "contracting-in," by the act of 1927, passed after the general strike, but on the repeal of the 1927 act in 1946 the act of 1913 resumed its force.

1910–1950.—From 1910 to 1914 there was acute industrial unrest in Great Britain, signalized by many strikes, by the emergence of syndicalist and industrial unionist ideas derived from France and from the U.S., and by the creation of powerful new unions by amalgamations. This movement was cut off short by the outbreak of World War I in 1914 and the declaration of an industrial truce. During the war the unions continued to make large gains in membership, and, official trade union action being restricted under the Munitions of War Act of 1915, an unofficial leadership grew up in the shop stewards' movement, which became increasingly antiwar, especially after the Russian revolution of 1917. The shop stewards, who had previously been quite minor workshop representatives of the trade unions, where they existed at all, took up the demand for workers' control of industry voiced by syndicalists and guild socialists, but came later under the leadership of the elements which went in 1920 to the making of the Communist party.

The end of war in 1918 was followed by a further period of widespread strike action, interrupted by the depression and by the great defeat of the miners in 1921, but resumed in the general strike, called by the whole trade union movement (though not all trades were actually called out) in support of the miners in 1926. The defeat of this movement for a time seriously weakened the trade unions, which were further weakened by the depression of 1931–33, but thereafter rapidly regained strength, without resorting again to policies of mass action.

World War II brought, from 1940 onward, a further increase in membership and influence, with the unions taking a vital part in organizing the national productive effort. Trade union progress continued under the Labour government from 1945, with the unions securely entrenched on all manner of advisory and consultative bodies, both with the government departments and with the employers, and serving more and more as agencies for securing working-class compliance with the restraints rendered necessary by international economic difficulties, as well as representative bodies for forwarding working-class interests. By 1950 trade union membership (see Table I) had reached 9,235,000, organized in 704 unions, and including 1,405,000 women. (These figures excluded a few unions not making returns.) The membership was highly concentrated in a small number of larger trade unions (see Table II).

TABLE I.—*Trade Union Membership in the United Kingdom*

	Unions	Trades Union Congress		Unions	Trades Union Congress
1866	—	199,000	1925	5,522,000	4,366,000
1871	—	289,000	1930	4,839,000	3,719,000
	—	735,000	1933	4,392,000	3,295,000
1880	—	476,000	1939	6,244,000	4,867,000
1888	—	727,000	1945	7,803,000	6,671,000
		1,927,000	1948	9,301,000	7,937,000 (1949)
1892	1,501,000	1,155,000	1950	9,235,000	7,827,945
1895	1,407,000	1,000,000	1951	9,481,000	7,828,000
1900	1,972,000	1,250,000	1952	9,526,000	8,020,000
	2,565,000	1,662,000	1953	9,459,000	8,088,000
	4,145,000	2,682,000	1954	9,495,000	8,094,000
1918	6,533,000	5,284,000	1955	—	8,107,000
1920	8,334,000	6,418,000			

There were in 1955 another 14 unions with more than 50,000 members, including weavers (84), boot and shoe operatives (82), furniture workers (75), foundry workers (74), dyers, bleachers, etc. (73), locomotive engineers (69), painters (69), seamen (62), post office engineers (62), vehicle builders (57), draughtsmen (56), plumbers (56), cardroom operatives (51), typographers (51).

Negotiating functions are largely concentrated in the hands of the big unions, or in some cases of federations in which they are among the leading members—for example, National Federation of Building Trades Operatives, Confederation of Shipbuilding and Engineering Trade Unions, Printing and Kindred Trades federation, Northern Counties Textile Trades federation. In most industries national agreements have been concluded with employers' associations or federations, covering methods of negotiation, wages, hours and other conditions of labour.

Recognition of trade unions for collective bargaining has become almost universal, and in many cases trade union representatives are sitting with employers on government-sponsored control boards (*e.g.*, cotton) or development councils or voluntary joint bodies dealing with economic policy. Trade union accumulated funds amounted in 1954 to £74,000,000. In that year the income of 411 reporting unions, with 8,357,000 members, exceeded £20,000,000, and expenditure £17,750,000. The main items of expenditure were working expenses (£10,500,000), superannuation (£2,200,000), sick and accident benefit (£1,200,000). Dispute benefits cost only £483,000 and political fund expenditure was £394,000.

The British Trades Union Congress.—The central organization of the British trade unions, the Trades Union congress, was formed in 1868. It elects a general council of 3j members, representing occupational groups, to conduct its business between the annual meetings of delegates. Nearly all the big unions belong to it. For an account of the development, powers and administration of the British Trades Union congress, see the article TRADES UNION CONGRESS, THE.

The general council has no executive power to bind its affiliated unions or to engage in collective bargaining. (The general strike of 1926 was called, not by the general council or congress, but by a specially summoned conference of trade union executives.) The general council has, however, in practice great influence in formulating policy on behalf of the whole movement; its influence grew rapidly as more closely co-ordinated policies became needed. There is a separate Scottish T.U.C., made up mainly of districts of British unions but partly of separate Scottish unions; it has no great power, but is useful in airing Scottish opinion. Some British unions cover Northern Ireland, and a few extend to the Republic of Ireland; but the Republican Irish have their separate trade unions and congress as well.

Locally, trade union branches are federated in the numerous trades councils, but these have small funds and not much authority. They are mainly propagandist bodies. The general council co-ordinates their work through an annual Trades Councils' conference and a Trades Councils' Advisory committee.

(G. D. H. C.)

TABLE II.—*Great Britain: Largest Trade Unions, 1955*

Name of union	No. of members	Occupations of Members
Transport and General Workers	1,240,000	Dockers, vehicle workers, canal workers and general workers in many industries
Amalgamated Engineering union	823,000	Skilled and some unskilled throughout engineering trades
General and Municipal Workers	787,000	Municipal and public utility employees, engineering, shipyard and builders' labourers, general workers
National Union of Mineworkers	675,000	All grades of coal miners, except managerial
National Union of Railwaymen	372,000	Mainly traffic grades and less skilled shopmen
Union of Shop, Distributive and Allied Workers	344,000	Shop assistants and warehouse workers, and especially co-operative employees
National Association of Local Government Officers*	236,000	Clerical and administrative grades
Electrical Trades union	226,000	Skilled and less skilled
National Union of Teachers*	225,000	Mainly in state schools
Amalgamated Society of Woodworkers	196,000	Carpenters and joiners, cabinetmakers
National Union of Public Employees	175,000	Manual workers on road work, etc.
Union of Post Office Workers	161,000	Postmen, sorters, clerks, etc. (not engineering section)
Civil Service Clerical association	142,000	Middle and lower ranks of civil service
National Union of Printing, Bookbinding and Paper Workers	142,000	All grades in bookbinding and papermaking (*less* skilled grades in printing)
National Union of Agricultural Workers	135,000	England and Wales only
National Union of Tailors and Garment Workers	124,000	All grades
Iron and Steel Trades confederation	104,000	All grades, except blast-furnacemen and some craftsmen
Amalgamated Union of Building Trade Workers	94,000	Bricklayers, stonemasons and labourers
Transport Salaried Staffs association	90,000	Clerical and supervisory grades
United Boilermakers association	86,000	Mainly shipyard workers

*Not in Trades Union congress

UNITED STATES

Although U.S. unionism is almost as old as the nation itself, its rise to the position of a major factor in U.S. life came only mith the New Deal. It is thus proper to treat the year 1933 as the great dividing line in its development.

Early Unionism. — The first local unions, formed by craftsmen in such industries as carpentry, shoemaking and printing, were formed in the closing decades of the 18th century, when the bulk of the population was still engaged in agriculture. In the late 1820s the first labour movement on a scale larger than that of the individual craft local appeared on the American scene. The growing industrial and commercial towns along the Atlantic seaboard and also in the interior witnessed the formation of city-wide federations of local unions to discuss common problems, aid each other in strikes and organizing efforts, promote the sale of union-made goods, and represent the labour movement generally in its dealings with city authorities and the general public.

Almost immediately these local bodies turned to political action. creating local labour parties in a number of areas and urging workers to exercise their newly won franchise by voting for labour candidates. Though these parties did not federate, they advocated similar legislative proposals, including such measures as the 10-hour day, free public education, abolition of imprisonment for debt, regulation of child labour, and mechanics' liens to enforce payment of wages. The parties, though short-lived, enjoyed some degree of success, measured both by the number of candidates elected to officeand their influence in persuading the more conservative parties to champion some of their measures.

In 1834 an effort was made to form a national trade union centre by federating a number of the local central labour bodies. The National Trades' union achieved very little influence before it was wiped out, as was most of the existing labour movement, during the long depression period that followed the panic of 1837.

In the mid-19th century business expansion led to a revival of the union movement. Developing means of transportation and communication were enlarging the market and permitting the growth of enterprise on a larger scale, and these factors in turn stimulated the formation of national unions in a number of industries, beginning with the printers in 1850. Though the national union at the time mas little more than a paper organization, authority still being vested in the local unions. the growth of a national market in the decades following the Civil War was paralleled by the steady rise in power of the national union at the expense of its affiliated locals or regional councils.

The National Labor union, established in 1866, sought to unite the growing labour movement in the period that immediately followed the Civil War. The National Labor union campaigned energetically for the 8-hour day and promoted producers' co-operatives and labour political action. The political party which it sponsored in the 1872 election met with little response, and both the N.L.U. and its political arm failed to survive the year.

During the depression-ridden 1870s the unions could make little progress, though there was a series of important strikes. notably on the railroads in 1877, against wage reductions. In the anthracite coal areas of Pennsylvania a secret labour body knonn as the Molly Maguires carried on a terroristic campaign against the employers before it was broken up by the conviction of its leaders.

Knights of **Labor.**—As a continuous, more or less unified movement, with its peculiar philosophy and strategy. unionisrn in the United States cannot be said to have become established before 1880. By 1880 the Knights of Labor, organized as a secret group in 1869, had appeared in the open as a union of all workers, skilled and unskilled, manual. clerical and professional, and even of the small businessman. During the next ten years there was unfolded one of the most dramatic and significant episodes in the history of U.S. labour. Hardly known at the beginning of the period. the Knights achieved by 1886 a membership of close to 1,000,000 and an influence far transcending its size.

The Knights had set out first to organize all workers. For this slow and gigantic task, the organization had neither the financial resources nor an adequate staff of organizers. It depended on the spontaneous uprisings of men and women. Such uprisings occurred often in the few years from 1880 to 1886.

But when strikes ended in failure and strikers lost their jobs and when there was no place to turn for the sinews of war, it became more difficult to arouse enthusiasm and action. At the same time much of the attention and energy of the officers of the organization mas dissipated in carrying out the ambitious economic program of the Knights, which ran from simple trade union action over wages to vast co-operative schemes or plans for the reorganization of the currency and banking system of the country. To these sources of weakness was added the inevitable conflict for jurisdiction between the Knights and the established craft unions. The episode of the Haymarket bomb in 1886 at Chicago. Ill., brought the Knights of Labor undeservedly into disrepute and hastened its end.

Rise of the American Federation of Labor. — Even during the heyday of the Knights. a new central organization of U.S. labour was already forming under the leadership of Samuel Gompers and his associates. This organization, appearing in 1886 as the American Federation of Labor, had as its precursor the Federation of Organized Trades and Labor Unions. begun in 1881. The Knights sought to absorb the existing craft unions. to subject them to the loss of autonomy and to involve them in industrial disputes in which their own direct interests were apparently not at stake. Against this tendency craft unions revolted, organizing themselves in the loose federation which remained for a half-century the sole unifying agency of the American labour movement.

The principles on which the American Federation of Labor was founded originated in the practical experience of the leaders of this new movement and in their reaction against the practices of the times. They saw in craft unionism the solidarity and permanence which they found missing in the one big union, the Knights, and in the industrial unions, mixtures of skilled and unskilled, sponsored by the Knights.

They observed that the best chances of continuity and strength in a movement of organized labour lay in formulating narrow and attainable economic objectives instead of embracing a large and attractive program of economic reform which the trade unionists themselves had neither the interest nor the capacity to make effective. In view, finally, of the failures of past efforts to engage in independent political action, they abandoned attempts to form a labour party and sought to achieve political influence by other means.

In its beginnings, then, the American Federation of Labor was dedicated to the principles of craft unionism and autonomy, and of collective bargaining to win recognition of organized labour and advances in working conditions. To this plan the federation consistently adhered. It was a loose federation of about 100 national and international unions, each retaining full autonomy over its internal affairs. In return, each union received from the federation protection of its charter or of the workers and industrial territory over which it claimed jurisdiction. Out of this policy grew bitter jurisdictional disputes among unions affiliated with the federation.

Independent Unions. — The largest group of unions independent of the American Federation of Labor prior to the New Deal consisted mainly of the railroad brotherhoods, the unions of locomotive engineers, firemen, conductors and trainmen, with an aggregate membership of about 500,000. These railroad unions at no time affiliated with the federation. The Amalgamated Clothing Workers, for many years the most famous independent union, was admitted into the federation in 1933.

Analysis of Growth. — As an effective force in U.S. industry, organized labour hardly began to be felt before 1900. The period following the collapse of the Knights of Labor was devoted to building the foundations of the labour movement, to strengthening the few established organizations and to extending unionism into new fields. The decade 1890–1900 with its severe depression and general unemployment was not favourable to the growth of unions. With the recovery of business toward the end of the decade the growth of the labour movement began and continued with only slight recessions until 1920. From 1900 to 1914 the total membership of U.S. unions increased by nearly 2,000,000 (from 791,000 to 2,647,000) and unionism penetrated many unorganized industries, making its most notable advances in the coal industry. Among the manufacturing industries the progress of organization, while substantial. was slow.

This whole situation changed radically after the outbreak of World War I. The rapid improvement in business and rise in productive activity, the steady absorption of the unemployed in face of the cessation of immigration, the further stringency in the labour market after U.S. entry into the war, the rising levels of prices and of wages, were all factors contributing to the strength of organized labour. The membership of unions, consequently, nearly doubled from 1915 to 1920 (2,560,000 to 5,034,000), and unionism won a place for the first time in the textile industry, packing houses, machine shops, among the shop men and unskilled on the railroads, in the clothing industries and among many clerical occupations. In the iron and steel industry, however, the movement failed to make effective progress.

The war gains were not held. The liquidation of the war industries, the depression of 1921 and the revulsion in industry against organized labour caused the unions to lose 1,400,000 members by 1923. In spite of good business and employment, membership remained almost constant in the few years that followed. The severe depression following the stock market crash of 1929 further weakened the labour movement and left it in 1933 with fewer than 3,000,000 members.

With the coming of F. D. Roosevelt's New Deal administration, however, membership rose rapidly under the stimulus of legislation favourable to labour. The 1934 membership of 3,249,000 increased steadily until it reached approximately 16,000,000 at mid-century.

Handicaps to Growth Before the New Deal. — For generations U.S. industry drew a substantial part of its labour from the annual masses of immigrants from Europe. Although there was a drastic restriction of immigration after World War I, U.S. industry was still far from a condition of labour shortage. New sources of labour within the country were constantly being tapped, leading to an easy labour market:

All labour movements suffer from the internal dissension that arises out of clash of doctrine. Sooner or later the holding of a new view of the purposes of the labour movement grows into an attempt to capture the movement and to convert it to this view. Mild beginnings in this direction usually ended in bitter warfare and in the disruption of one or more unions. Such was the early history of the relations between the labour movement and the socialists; after 1905 between the Industrial Workers of the World (I.W.W.) and the American Federation of Labor; and after 1918 between the Communist movement and the established unions. In the clothing industry, for instance, the struggle for control in the years following World War I between the Communist Workers' party and the administration of several of the unions in this industry resulted in nearly destroying organizations that only a few years before were among the most effective in the country.

Before 1933 U.S. unions were handicapped by their uncertain and unfavourable legal status. The free use of injunctions in disputes, prohibitions against interference with interstate commerce and the "yellow-dog" contract were the devices which hindered union expansion, although the Norris-LaGuardia act of 1932 was a major improvement antedating the New Deal. Virtually all of the remaining legal disabilities were swept away by the legislation supported by the Roosevelt administration.

Organized labour in the United States was also handicapped by "welfare capitalism." Many industrial leaders abandoned repressive measures to engage in competition with labour unions for the loyalty of their employees. In place of the national trade unions with members recruited throughout the whole of an industry, regardless of geographical location or ownership of the business, industry created company or plant unions. These organizations, sometimes described as employee representation plans or works councils, were limited either to a single plant or to several plants under common ownership. Their number grew rapidly during the decade following World War I.

The most fundamental of the union's problems is that of adjusting its policies to changing economic conditions. Often, before World War I as well as after, strong and established unions were reduced in size and strength because they failed to gauge the probable inroads of machinery and business depression.

Sometimes the struggle betueen a union and machinery would last for a generation, but in the end the union was beaten. This was largely the history of the cigar makers' union. In general, also, nearly all of the organized industries in the United States remained partly nonunion. Unless the union is able to organize the nonunion area, or so to protect the competitive position of the union area that the nonunion firms do not grow, the union will find business being diverted to the unorganized area and control slipping from its hands. The failure of the United Mine Workers to organize the nonunion coal fields of West Virginia and at the same time to strengthen the competitive position of the union operators in Illinois. Pennsylvania and elsewhere led to temporary disruption of the union in the years after 1925.

The New Deal and the Revival of Unionism. — The 1920s were the first period of economic prosperity which did not witness an expansion of unionism. During the depression which followed the stock market collapse of 1929 and assumed catastrophic proportions in 1932 and early in 1933, labour was too benumbed to do more than engage in a few desultory desperate strikes, mostly under Communist leadership.

With the new administration of Franklin D. Roosevelt came a new dawn for labour. Now government stepped in not only to restore the most seriously deteriorated standards of employment but to pave the way directly for unionism.

New Deal labour legislation originated in the National Industrial Recovery act (NIRA) passed in June 1933. Its labour provisions included both protective labour legislation (child labour was regulated; minimum wages and maximum hours of work were to be set for each industry operating under an approved code) and labour relations legislation.

Section 7(a) of the NIRA gave employees the "right to organize and bargain collectively through representatives of their own choosing" and to be "free from the interference, restraint, or coercion of employers of labor" in their organizing and bargaining activities. Through the decisions of the National Labor board and the first National Labor Relations board interpreting section 7(a), a solid beginning was made toward a common lam of collective bargaining. The legal protection afforded by Section 7(a) and the desire by masses of workers for union representation gave U.S. unions the most favourable organizing opportunity in their history. In the period 1933–35, the United Mine Workers, the International Ladies' Garment Workers' union and the Amalgamated Clothing Workers made the most vigorous comebacks.

Prior to 1933 there was only a handful of permanent union members in the mass production industries. This can be attributed to several factors: the determined opposition of large manufacturers to unionism, the heterogeneity of the labour force, ineffectual organizing tactics and the dominance of the craft philosophy.

The new political climate, with its ascendancy of government over business and the former's patronage of unionism as a major stabilizer of the economy, gave the U.S. labour movement unprecedented opportunities to expand its numbers. To facilitate this, the A.F. of L. chartered federal (plant-wide) locals. Yet this new opportunity soon brought a characteristic difficulty. The initial organization of these previously unorganizable workers raised two crucial policy questions. How vigorously should organizing work be carried on in the mass production industries? What should be done with these newly chartered federal labour unions?

A federation minority, with the support of most of these new federal locals, demanded an aggressive organizing drive and the chartering of industrial unions in the mass production industries. The craft unionists, representing a majority of the federation's membership. argued for a more cautious policy and for the preservation of established jurisdictional rights. These "old" unionists tended to look upon industrial unions in the mass production industries as dual unions and hence disruptive of the labour movement. They held this view because the craft unions theoretically had the right to organize certain workers in these industries.

The issue came to a head in the 1935 convention of the American Federation of Labor. The industrial unionist resolution stated that "in the great mass production industries . . . industrial organization is the only solution." It was at this convention that the "older" elements in the A.F. of L. showed a lack of statesmanship.

As a result of the convention's defeat of the industrial union resolution, representatives of eight international unions announced on Nov. 9. 1935, the formation of the Committee for Industrial Organization. Its purpose was "to encourage and promote (industrial union) organizations of the workers in the mass-production industries of the nation, and affiliation with the American Federation of Labor."

Still refusing to compromise, the executive council of the A.F. of L. in Jan. 1936, ordered the immediate dissolution of the C.I.O. movement as a dual unionism move. When the C.I.O. unions refused to dissolve their organization, the council in Aug. 1936 suspended ten of them. The Tampa. Fla.. convention (1936) approved this action. In March 1937, the council ordered all city centrals and state federations of labour to expel all delegates from the ten suspended unions.

While the split stemmed originally from the conservatism of a few key A.F. of L. leaders. it was perpetuated by John L. Lewis in his capacity as head of the C.I.O. In late 1937 a tentative agreement was reached between A F. of L. and C.I.O. peace-making committees, but at the last minute Lewis rejected the plan which would have granted industrial jurisdictions to the original C.I.O. unions, with negotiations to proceed between the new "dual" unions and the A.F. of L. unions concerned, but all the C.I.O. to re-enter the portals of the A.F. of L. en bloc. After 1937 numerous attempts were made to bring the A.F. of L. and the C.I.O. together, but all failed.

In May 1938 the C.I.O. was transformed into an independent federation to be known as the Congress of Industrial Organizations.

Great Upheaval of the 1930s.—The federation's outlawing of the C.I.O. in 1936 as a dual union was overshadowed by a series of sensational victories under the latter's banner. The C.I.O., in February–March 1936, came to the aid of the rubber workers. who were on strike; the financial support. encouragement and technical advice given the strikers represented the C.I.O.'s debut as the leader and inspirer of the mass production workers.

The first concerted C.I.O organizing campaign was undertaken in the steel industry—citadel of the open shop. The chief product of the NIRA period in the steel industry was a growth of employer-sponsored organizations. The C I.O. placed $500,000 at the disposal of the Steel Workers' Organizing committee, which pursued a two-pronged attack. It not only attacked the fortress frontally but it also Infiltrated the company unions to promote independent unionism.

On Feb. 28, 1937, it was announced that the U.S. Steel corporation's chief subsidiary, the Carnegie-Illinois Steel corporation, would sign a contract with the S W.O.C. Within three months of the signing, the S lV.O.C. had reached agreements, practically without resort to strikes, with approximately 140 companies. including 14 U.S. Steel subsidiaries and the Jones and Laughlin Steel corporation. However, against "little steel" the S.W.O.C. campaign was less successful. Following the signing of the agreements with U.S. Steel's subsidiaries, the S.W.O.C. called strikes against four of the largest independents. Aided by police, national guardsmen and "citizens' committees" in the communities where strikes were called, "little steel" defeated the S.W.O.C. and succeeded in avoiding unionism and collective bargaining until 1941.

The tactics accompanying the drive in the auto industry differed appreciably from those in the steel industry. Where the S W.O.C. organizing campaign was carefully planned and centrally organized, the rank and file in the auto industry often initiated strikes in spite of the restraining influence of the union leadership.

On Dec. 28. 1936. 8,000 workers in the Cleveland Fisher Body plant of the General Motors corporation walked out, and during January sit-down strikes spread through the General Motors network of plants. Court orders to eject the strikers from the plants were issued, but the fear of serious bloodshed influenced Gov. Frank Murphy of Michigan to order the sheriff not to serve them. On Feb. 11, 1937, unionism attained its first real victory in the auto industry when the General Motors corporation signed with John L. Lewis as the spokesman of the United Automobile Workers. The signing of this agreement was followed by a sit-down strike of Chrysler employees. which mas ended on April 6, 1937 when that corporation recognized the union. Ford succeeded in holding out until the summer of 1941.

The United Electrical. Radio and Machine Workers of America was formed in March 1936 out of an amalgamation of rebelling A.F. of L. federal unions and a loosely tied group of independent local unions.

To organize the textile industry the C.I.O. created the Textile Workers Organizing committee staffed by Amalgamated Clothing R'orkers officials. Betneen 1937 and 1941 the C.I.O. was also able to make inroads in meat packing. shipbuilding, oil, metal mining and numerous other industries.

While the organizational efforts nhich made the newspaper headlines were those of the C I.O., the importance of the campaigns carried on by affiliates of the A.F. of L. and those directly under federation auspices should not be minimized. The formation of the C.I.O shook the A F. of L. internally. The original issue of craft *v.* industrial (or "horizontal" *v.* "vertical") unionism found itself blanketed by this larger issue of unionizing rivalry. To support a federation-directed organizing campaign as well as to combat the C.I.O., an assessment of one cent per member a month was voted.

The A.F. of L. international unions vigorously seconded the efforts of their parent body and the total membership of the federation increased from 3,000,000 in 1935 to approximately

7,000,000 at mid-century. In absolute numbers the following showed the greatest growth: teamsters, ladies' garment workers, carpenters. electrical workers and hod carriers. Other A.F. of L. unions such as the hotel and restaurant employees. retail clerks, meat cutters and butcher workmen and building service employees had a large percentage rate of growth. During this same period the A.F. of L. chartered many new onions.

While there was a tremendous increase in union membership during this period. to a total of about 16,000,000, it still remained true that the bulk of union members mere concentrated in a few large organizations at mid-century. About a dozen unions, each with 250,000 or more members, contained almost half of the total union membership. These giants, plus 15 or 20 medium-sized unions, formed the main body of U.S. unionism.

What factors help to explain this rapid growth in union membership after 1933? Undoubtedly the existence of a favourable governmental climate comes first, especially after the re-election of Roosevelt in 1936. With the C.I.O. a new generation of leaders and organizers entered the lists. Its campaigns were aggressive, well financed and led by capable tacticians. Probably a major factor was the air of victory radiating from the C.I.O.'s leader, John L. Lewis.

The A.F. of L.'s rejuvenation under the spur of rivalry belied the forecasts of doom by its detractors. The early strategic victories in the campaign over General Motors and U.S. Steel created the conviction of the "C.I.O. march to victory." The extended period of full employment during and after World War II enabled the new unions to become fully entrenched in their respective industries.

The La Follette investigating committee of the late 1930s brought to light the mechanism whereby employers prevented the spread of unionism prior to the New Deal. The investigation covered a variety of industries throughout the country and disclosed the existence of a widely practiced industrial militarism—arsenals, "standing armies" and espionage. These disclosures came at a time when the favourable climate of the New Deal had already been giving way to the more normal suspiciousness of unionism's intentions always present in the minds of U.S. middle groups, and thus delayed an out-and-out swing in public opinion.

National Labor Relations Act.—The upheaval derived its impulse more from the general political climate than from the specific enactment to give unions greater rights—namely, the National Labor Relations (Wagner) act of 1935, to take the place of section 7(a) of the National Industrial Recovery act which had been declared unconstitutional. Employers as a rule were convinced that it would meet with the fate of its predecessor, and the act was held in virtual suspension. Its constitutional validity rested on the authority of congress to prevent industrial strife which impeded interstate commerce. The act itself cited as its justification the objective to minimize industrial conflict through the equalization of the bargaining power of the employees and management.

The employees could achieve something nearer equality in bargaining power only if they could organize and bargain collectively without fear of employer reprisals. The promotion of collective bargaining meant that an agency—the union—had to be stimulated so that it could represent the workers in negotiations with management.

The Wagner act declared that "employees shall have the right to self organization, to form, join, or assist labor organizations, to bargain collectively through representatives of their own choosing, and to engage in concerted activities, for the purpose of collective bargaining or other mutual aid or protection."

The act stipulated two methods of protecting these rights. First, it included a list of unfair labour practices which employers must not commit. The National Labor Relations board was made responsible for the prosecution and adjudication of all unfair labour practice charges. One of the forbidden practices, employer domination of employee organization, forecast the doom of company unions. Second, the board certified the union authorized to represent the employees and could hold elections among the workers to that end. The union selected by a majority of the employees voting was the exclusive bargaining agent for the entire unit. The board also determined the election unit, whether the plant, craft or industry.

The NLRB was in no way concerned with the contents of the collective bargaining agreement nor with efforts to interpret or enforce it. In brief the settlement of disputes over the terms and conditions of employment were outside the board's province. The board intervened only to create the foundation of the collective bargaining structure and to keep it from being undermined by employer animosity.

The unexpected validation of the NLRA in the spring of 1937 nas a turning point in U S. constitutional development—a change amounting to a peaceful revolution. The U.S. Supreme Court held that congress could regulate the labour practices of employers whose operations affected interstate commerce.

Because it could be shown that most manufacturing industries substantially affect interstate commerce, the significance of these and subsequent decisions was to widen vastly the prerogative of congress over the whole field of labour problems.

Even with this broad interpretation the act did not apply to all industry. It was estimated that about 13,000,000 people, or about 40% of all nonagricultural workers in the country by mid-20th century, were subject primarily to state regulation. The bulk of these were employed in retail trade, building construction, utilities, amusements and recreation. hotels, garages, insurance and real estate, laundering and dry cleaning and miscellaneous personal services. To give to these workers Wagner act rights, several states enacted state labour relations acts.

Protective Labor Legislation.—The peaceful constitutional revolution in 1937 also made possible the Fair Labor Standards act of 1938. It established basic minimum wages and overtime payment requirements for employees engaged in interstate commerce or in the production of goods moving in interstate commerce. (The minimum straight time hourly rate was increased to 75 cents an hour in 1950 and to one dollar an hour in 19j6.) The act stipulated that one and a half times the norker's regular hourly rate of pay be paid for all hours worked over 40 a week. The act also placed restrictions on child labour by prohibiting the shipment of goods in interstate commerce if produced in any establishment employing oppressive child labour.

More stringent minimum wage and overtime pay requirements were written into the Davis-Bacon act (1931) and the Walsh-Healey Public Contracts act (1936). In combination these tno acts provided that the secretary of labour set minimum wage rates on work done under contract for the federal government. The latter act also provided for overtime payments after eight hours work a day.

The Social Security act of 1935 provided for two nationwide systems of social insurance to protect nage earners and their families against loss of income from unemployment, old age and death. First, the old age and survivors insurance program was an all-federal system operated through the Social Security administration. Covered wage earners and their employers shared equally in the cost of the program. Second, unemployment insurance was a federal-state plan under which each state would set up its own law and state administrative agency, with the federal government paying all operating costs. It was financed by a 3% federal tax levied on the payroll of employers. Prior to 1932 organized labour was hostile to compulsory unemployment insurance—an opposition founded on the basic A.F. of L. suspicion of government. The extent and duration of the 1929–33 depression, however, caused the A.F. of L. in 1932 to support unemployment compensation legislation. Like the NLRA, the Social Security act was validated in a decision in 1937.

To protect workers in industries exempt from federal regulation, many states passed minimum wage and maximum hour laws applicable to them. Nonetheless, the chief form of state protective labour legislation, mostly antedating the New Deal period, dealt with industrial injuries and accidents under workmen's compensation, with the later addition of unemployment compensation. Other state protective legislation included child labour regulations, industrial safety and sanitation codes, apprenticeship regulations, equal pay laws, fair employment practices and sickness disability compensation. The trend was toward a gradual levelling of standards in all states.

Labour Relations in World War II.—Shortly after the start of the national defense program in June 1940, the number of U.S. strikes began to increase rapidly, coinciding with a sharp rise in employment. To avoid lost production President Roosevelt on March 19, 1941, created the National Defense Mediation board. It was given jurisdiction over all labour disputes certified by the secretary of labour as threatening "to burden or obstruct the production or transportation of equipment or materials essential to national defense." The NDMB was a tripartite board composed of labour, industry and public members appointed by the president.

The NDMB endeavoured to conduct three-party collective bargaining in cases where labour and management could not work out a solution to their differences. However, the board was also authorized to institute fact-finding procedures to investigate the causes of differences between employers and employees with public recommendations for equitable settlements. The board, however, lacked any enforcement authority, and to achieve compliance with its recommendations it had to appeal to the president. The NDMB was abolished in Jan. 1942 after its C.I.O. members had earlier withdrawn as a result of the board's refusal to accept the union-shop principle for the captive coal mines.

In late Dec. 1941, after U.S. entry into World War II, an industry-labour conference was convened in Washington, D.C., to formulate a policy of wartime industrial relations. Union heads had given a no-strike pledge following the Japanese attack. The conference participants were in agreement that all industrial disputes should be settled by methods which would not hamper war production, but they could not agree on the union security question. As an outgrowth of this conference the president on Jan. 12, 1942, established the National War Labor board. It was empowered to deal with every type of dispute that "might interrupt work that contributes to the effective prosecution of the war." The NWLB was also a tripartite board whose members were appointed by the president. If the board could not gain a voluntary settlement it would act as a compulsory arbitration panel.

As a result of an executive order issued Oct. 3, 1942, the NWLB was charged with the administration of another vital wartime measure—stabilization of wages as part of the administration's anti-inflation program. Wage increases that required price rises needed the further approval of the director of economic stabilization. To cope with its great volume of work the board decentralized, setting up 12 regions, each under a regional war labour board, to handle cases arising in its area. The War Labor Disputes (Smith-Connally) act adopted in June 1943 gave statutory authority to the War Labor Board.

The Smith-Connally act also gave the president power to seize privately owned war plants and to operate them under government control, where an actual or threatened strike or lockout involved interference with war production. It forced union officials to notify the appropriate federal agencies of the existence of a labour dispute affecting war production. For 30 days thereafter, no strike could be called in such private plants. On the 30th day, the NLRB was to conduct an election among the employees directly involved, to determine whether they wished to strike.

Failure of the industry-labour conference to agree on the union security question tossed it into the lap of the NWLB. In solving this problem the board often granted both "maintenance of membership" and the checkoff. Under this type of union security, union membership was not compulsory but anyone who was a member of the union after the brief escape period had expired had to remain in the union or be discharged.

In an attempt to stabilize the general wage level the NWLB developed the "little steel" formula. Announced on July 16, 1942, it stated that wage rate increases, made because of increases in the cost of living, would be limited to 15% of the existing rate on Jan. 1, 1941. While prohibiting general wage rate increases above those set by the "little steel" formula the NWLB did sanction: (1) wage increases clearly necessary to correct substandards of living; (2) intraplant wage adjustments to create a balanced wage rate structure; (3) increases to adjust interplant wage inequalities; and (4) fringe wage issues. The latter referred to paid vacations, paid holidays, preparation time, shift differentials, sick-leave pay, dismissal or severance pay, etc.

In more than 300 cases the board directed managements and unions to negotiate the elimination of intraplant wage inequities—different rates of pay for jobs entailing the same skill and experience. To accomplish this goal the parties were required to analyze the content and character of each job in the plant, assess each job's relative standing in the production scheme and set the appropriate rate for each job classification. The board thus stimulated a rationalization of the wage rate structure.

Restrictive Labour Legislation.—The end of hostilities terminated the no-strike pledge, and the years 1946, 1947 and 1949 saw numerous large-scale strikes. The unions, especially in the newly unionized industries, still had to convince employers that they had taken root and proved it by successfully standing guard over the real wages and job control acquisitions in the collective agreements. To the latter it added a new device of "social security by contract" in the shape of pensions and other social insurance protections obtained by collective bargaining. But with these determined stands in the economic arena unionism suffered a serious loss in its legal status. The 80th congress under Republican control enacted in 1947 the restrictive labour law popularly known as the Taft-Hartley law.

As a prelude to the passage of the Labor-Management Relations act of 1947, numerous states had enacted one or more union control laws. As early as 1939 Pennsylvania had amended its state labour relations act, and Wisconsin repealed its act and passed a new one. Between 1939 and 1947, five states passed new labour relations acts of a restrictive nature. These laws dealt, among other things, with mass picketing, jurisdictional strikes, sympathetic strikes, primary and secondary boycotts, refusal to handle nonunion materials, prohibition of the closed shop and the checkoff, registration and submission of information by the unions to the state government, filing of financial statements and regulation of strikes in public employment and public utilities.

There were at least three major factors contributing to passage of the Taft-Hartley act. Employers, while no longer opposing the collective bargaining objective of the NLRA, saw themselves pilloried in the one-sided recital of "unfair practices." The public was concerned with the strike wave which followed World War II, especially the perennial coal strike threats. Lastly, the conservative middle class groups, with their suspicion of unionism on so many scores, added their influences in congress.

The Taft-Hartley act retained the Wagner act's stipulation of the rights of employees and the means for their protection, but placed a host of union activities under government surveillance. Foremost of these was the definition of certain union activities as unfair labour practices. The NLRB was to prevent their occurrence, and injunctions were relied on for enforcement.

Certain restrictions were placed on the internal administration of unions. Under a union shop contract men could be discharged only for cause or for failure to pay their union dues and initiation fees. Furthermore, the NLRB was charged with determining whether these dues and fees were excessive. In order to be able to use the services of the NLRB, unions had to file extensive information with federal authorities. Union officers had to file affidavits of nonmembership in the Communist party.

The act also defined the procedures to be followed in attempting to write a new collective agreement and in dealing with strikes or lockouts which threatened the national health or safety, giving the president the power to exact a cooling-off period of 80 days enforceable by court injunction in which an ad *hoc* board probed the dispute. The Taft-Hartley act stated that certain provisions could not be included in a collective bargaining agreement even though both parties might want them. The chief outlawed provision was the closed shop. Also prohibited were the compulsory checkoff, payment by an employer for services not performed, inclusion of plant protection workers in a bargaining unit with production workers and a one-sided union administration of health and welfare funds to which employers agreed to contribute.

Unions could be sued in the federal district courts for violation of contract. Employees of the federal government were prohibited from striking. the penalty being immediate discharge, forfeiture of civil service status and denial of re-employment for three years. Before a union could negotiate for a union shop a majority of the eligible employees in the unit had to approve it in a special election. Statutory rules were established for the NLRB to follow in defining the bargaining unit.

There was a separation of the judicial and prosecuting functions previously performed by NLRB employees. The general counsel was now given a status independent of the board and was charged with the responsibility of prosecuting all unfair labour practice charges. Another major provision of the Taft-Hartley act established the Federal Mediation and Conciliation service as an independent agency. The act further provided that union shop agreements could not be entered into in states in which they were prohibited by state law. This provision touched off a series of bitter fights over the enactment of such measures in a large number of states. By 1956 "right-to-work" laws, as they became known, had been enacted in 18 states! most of them in predominantly agricultural areas that were seeking to attract industry. Passage of the Taft-Hartley act and of "right-to-work" legislation slowed down the unionization of the south. Approximately 14,800,000 workers, or 48% of the workers in occupations in which unions had sought agreements. were employed under collective bargaining agreements in 1949, contrasting with 4,000,000 in 1935. In manufacturing industries, 7,900,000 workers. or 69% of those employed, were covered and in nonmanufacturing industries 6,900,000 workers, or 35% of those employed.

Merger of the A.F. of L. and C.I.O.—The deaths in Nov. 1952, of both William Green, long-time president of the A.F. of L., and Philip Murray, who had succeeded John L. Lewis as head of the C.I.O. in 1940, helped set the stage for the merger of the rival federations. By this time the A.F. of L. had far outstripped the younger federation. having achieved a membership of over 10,000,000. more than double that of its rival. The death of Murray, depriving the C.I.O. unions of the one leader whom all could accept willingly, led to a struggle for power between rival blocs led by the two most powerful unions, the United Automobile Workers and the United Steelworkers. Though Walter P. Reuther of the U.A.W. won the C.I.O. presidency by a close vote, he succeeded to the leadership of a divided movement which faced the danger of defections unless labour unity was achieved promptly.

By this time, moreover, the issues which earlier had divided the two federations had largely disappeared. The issue of craft as against industrial unionism no longer was a major stumbling block, since the A.F. of L. itself was organizing workers in such industries as aircraft on an industrial basis. The C.I.O. had purged itself of Communist influence, and the two federations had co-operated in fighting Communism, both on the home front and in the international field. The A.F. of L., for its part, had moved more vigorously against corruption than in the past, expelling one of its affiliates. the International Longshoremen's Association, in 1953, for failure to rid itself of racketeers. In political action, in their criticism of the Eisenhower administration, and in their general outlook on domestic and foreign issues the two federations had been moving closer together. Raids by unions upon one another's membership remained the greatest stumbling block in the path of unity.

In 1953 the federations negotiated a no-raiding agreement, which was signed in June 1954, by 65 A.F. of L. and 29 C.I.O. unions! with a combined membership of over 10,000,000. The agreement, however. was not binding on non-signers. In addition the A.F. of L. established an internal no-raiding pact, also on a voluntary basis. The C.I.O. had earlier established comparable internal machinery, so that three pacts now existed to prevent raiding and settle jurisdictional disputes.

On Feb. 9. 1955, a merger agreement was reached. All affiliates of either federation automatically became members of the combined body without change in jurisdiction. Competing unions were to be encouraged, but not forced, to merge. All workers were guaranteed rights to full union benefits, without regard to race, creed, colour or national origin. Free and democratic unionism was to be ensured, with protection from corrupt elements as well as from Communists and others opposed to democracy. The A.F. of L., by far the larger of the two bodies, was given a proportionate share of the offices. Industrial unions were to have a department of their own within the merged organization, and state and city central bodies were to merge within tao years after the merger of the federations. The names of the two bodies were combined to form the name of the new federation. The merger officially took place on Dec. j, 195j, bringing approximately 15,000,000 unionists together.

The merged labour movement, breaking sharply with the A.F. of L. tradition on national union autonomy, issued a series of ethical practices codes to govern the behaviour of officers of affiliated unions in financial and other matters; it likewise created enforcement machinery. with expulsion the ultimate penalty for unions that failed to conform. Nevertheless the entire labour movement found itself on the defensive, with the disclosure of serious financial irregularities in certain unions, notably the powerful Teamsters. The A.F. of L. also continued to be plagued nith jurisdictional disputes. the most troublesome of which concerned the conflicting claims of the building trades and some of the large industrial unions. Jurisdictional disputes and an unfavourable climate of public opinion delayed the launching of large-scale organizing drives. in the white-collar field and in the south, that had been planned to follow the merger.

Labour and Political **Action.**—With the New Deal, organized political action became an important activity of the U.S. labour movement. Politics was no new experience to the American Federation of Labor. As early as 1906 the pattern was established: "reward your friends and punish your enemies." The early investments in political action, however, were meagre. The X.F. of L.'s traditional non-partisan political policy was modified somewhat by its support of Robert La Follette's independent candidacy in 1924. Between 1924 and 1936 labour was relatively inactive politically. In 1936, however, the C.I.O. engaged in a strenuous campaign to help re-elect Roosevelt, launching Labor's Non-Partisan League for that purpose. In 1943, alarmed at the growth of conservative influence in Congress, the C.I.O. created its Political Action Committee under the able leadership of Sidney Hillman.

The A.F. of L., far less active politically until the passage of the Taft-Hartley act. thereupon established Labor's League for Political Education as its political instrument. The railroad brotherhoods also set up similar machinery. These labour political agencies co-operated to support candidates friendly to labour. for the most part working closely with the liberal wing of the Democratic party. With the merger of the A.F. of L. and the C I.O. in Dec. 1955, their political arms were combined into a Committee on Political Education; which like its predecessors was to operate within the framework of the two-party political structure.

Communism and International Labour **Relations.**—U.S. labour became concerned with Communist infiltration into positions of command as early as the 1920s. Fired by a sense of mission as the vanguard of the proletarian revolution, the Communists had sought to assume leadership over the labour movement and use it for political purposes.

Even before the passage of the Taft-Hartley act, U.S. labour mas ejecting leaders who had subordinated the interests of the trade unions to those of the Communist party. The act with its compulsory anti-Communist affidavit for union officers gave greater sweep to a spontaneous trend Communists had played a vital role in the early stages of the C.I.O mass production unions because of their indefatigable zeal as organizers. However, during 1949 and 1950 the C I.O. expelled 11 unions found to be Communist-dominated. and amended its constitution to bar Communists or their consistent followers from membership on the executive board. Prior to this drastic purge the Communists had been defeated after several years struggle in the C.I.O.'s biggest affiliate. the United Automobile Workers By the latter 1950s Communist influence in the labour movement was at its lowest point in more than 20 years, and dwindling rapidly.

While U.S. labour acted to solve this crucial internal trade union problem, it also showed novel activity on the international scene. It vigorously backed up the administration's program of rebuilding western Europe and containing Communism. A new term came into use—"labour diplomats." These "diplomats" set out to win the confidence of the non-Communist unions in western Europe and to encourage them to resist Communist encroachment. The culmination was the International Confederation of Free Trade Unions formed in Dec. 1949, to ensure "collaboration between the free and democratic trade union movements throughout the world." The World Federation of Trade Cnions set up in 1945 as labour's counterpart of the policy of continuing the "grand wartime alliance" had quickly become a soviet tool. The A.F. of L. had never joined it, but the C.I.O. did, together with the unions of Britain and western Europe. In the new trade union international (I.C.F.T.U.) the A.F. of L. and C.I.O. appeared for the first time as co-operating and equal members. U.S. labour imposed its stamp upon the new international when the traditional commitment to socialism was omitted from its platform in order to avoid raising an issue which might divide labour on opposite sides of the Atlantic ocean. *(See* also AMERICAN FEDERATION OF LABOR—CONGRESS OF INDUSTRIAL ORGANIZATIONS; CLOSED SHOP; LABOUR LAW; STRIKES AND LOCKOUTS.)

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CONTINENTAL EUROPE

France.—In France trade unions became active in Paris and Lyons in the 1820s and 1830s, but had no legal recognition until 1864, when a regime of toleration began, and no assured legal position until 1884. The right of combination was still refused after this to public employees. The federation of *syndicats* formed under the act of 1884 came at the outset mainly under Socialist party (Marxist) influence: but did not make much progress until in 1894 it was absorbed into the *Fédération des Bourses du Travail,* which had been formed the previous year by the *bourses du travail* (a mixture of trades councils and local labour exchanges). The combined body came under the influence of Fernand Pelloutier, an anarchist-syndicalist, who stood for a revolution based on local working-class solidarity rather than on national organization. It opposed parliamentary action, favouring direct action by strikes to coerce both the employers and the government. In 1895 a *Confédération Générale du Travail* was founded, but was amalgamated with the F.B.T. in 1902, and passed under syndicalist leadership. The new C.G.T. remained aloof from the socialists, who were divided into a number of rival parties. Under Pelloutier's leadership it developed the theory and policy of revolutionary syndicalism—no agreements with employers, sudden strikes, sympathetic strikes, sabotage and antimilitarism—with a social general strike in the future as the means of ushering in the new era of workers' control. To Pelloutier's doctrines Georges Sorel added the notion of the general strike as an inspiring social myth and of the practice of aggressive direct action as a training in revolutionary techniques. The C.G.T., which had its period of maximum activity between 1902 and 1914, thus grew up wholly apart from French socialism, though of course many trade unionists belonged individually to socialist bodies. The C.G.T.'s policy was laid down in the Amiens Charter of 1906, which had considerable international influence on trade union developments during the following years.

The majority of the C.G.T., despite its antimilitarist philosophy, supported the war effort in 1914, and the consequent dissensions led, after the Russian revolution, to a split. The C.G.T. formulated in 1919 its doctrine of a *nationalisation industrialisée,* based on workers' participation in the control of industry, but took a nonrevolutionary line. The Communists founded in 1921–22 a rival body, the C.G.T.U. *(Unitaire),* and up to 1935 the French trade unions remained divided into hostile factions, which greatly reduced their power.

In that year, under pressure of the crisis of 1934, the two main bodies united in a new C.G.T. This was a leading element in the popular front movement, which was victorious in the general election of 1936; and the trade unions remained united, largely under Communist leadership, until 1948, when a section headed by Léon Jouhaux, long the leader of the French trade union movement, broke away to form a C.G.T.—*Force Ouvrière,* in fairly close association with the Socialist party, but up to 1957 F.O. had remained unable to shake the Communist control over the main body of manual workers, the elements supporting it being largely white-collar workers. The Catholic trade unionists (*Confédération Française des Travailleurs Chrétiens*), who had always formed a distinct element in French trade unionism, had little strength outside the textile industries and certain white-collar groups.

Germany.—In Germany workmen's associations first came to the front in the 1840s, mainly on a political basis; and the movement was renewed in the 1860s under the leadership of Ferdinand Lassalle. The Marxists also became active; but these new movements were also mainly political, and there was no considerable growth of trade unions until the 1870s. From 1878 to 1890 trade unions, as well as socialist bodies, came under the ban of Bismarck's antisocialist laws.

On their repeal the movement developed rapidly, the largest section being closely associated with the Social Democrats, though nominally independent of them. The *Freie Gewerkschaften,* organized under a *Generalkommission der Gewerkschaften Deutschlands,* had reached by 1914 a membership of 2,000,000; and there were two smaller movements, the more important under Catholic and the lesser under liberal auspices. These bodies remained separate under the Weimar republic, with the *Allgemeiner Deutscher Gewerkschaftsbund* (successor to the general commission) by far the preponderant element.

The severe depression of the 1920s hit trade unionism hard; and it was also rent asunder by dissensions between Social Democrats and Communists. The Communists formed some separatist bodies, but tried in the main to work through and capture the free trade unions, which were largely paralyzed by political dissensions until the whole movement was destroyed and transferred to a nazi-controlled *Arbeitsfront,* governed from the top, after the nazi accession to political power in 1933.

After 1945 trade unionism was gradually revived, but separately in eastern and western Germany. In 1957 there were two separate trade union movements, one associated with the Unified Socialist (Communist) party in eastern Germany and the other in western Germany, including both Christians and Social Democrats.

Western European Countries.—Rival Christian and mainly socialist free trade union movements existed in Italy, Belgium, the Netherlands and a few other countries, and the former were linked both between World Wars I and II and in 1957 in an International Federation of Christian Trade Unions. Trade unionism was strong in the Scandinavian countries, in Finland, and fairly strong in Switzerland.

In Austria it was suppressed under the nazis, but revived, especially in Vienna, after 1945. In Spain it perished after the Civil War of 1936–39; previously it had been long divided between the predominantly anarchist-syndicalist National Confederation of Labour (C.N.T.), strongest in Catalonia, and the mainly socialist

General Union of Workers (U.G.T.), strongest in central and northern Spain.

In Italy too there was a long history of dissensions between syndicalists and socialists, until the whole movement mas suppressed and replaced by *sindacati* under fascist control in the 1920s. The fascist unions, based on compulsory workers' contributions and conducted under strong party control, had no independent role, though much was made-of them as a façade under the fascist regime. After the liberation of 1944, trade unionism re-emerged, passing mainly under the control of the Communists and left-wing socialists, until in 1948–49 various groups split away to form separate federations, one under Catholic and the other under moderate socialist auspices. As in France, up to 1957 the main body (*Confederazione Generale Italiana del Lavoro*) remained predominantly under Communist influence.

Soviet Union and Eastern Europe. — In Russia trade unions first appeared on a considerable scale in the revolution of 1905, but were thereafter crushed out. They reappeared in the 1917 revolution, and speedily became highly organized in a national movement under Communist control. The Soviet trade unions were used as agents of the state in the execution of social policies, and were given a large share in the control of the commissariat of labour. When, however. they threatened in the late 1920s and early 1930s to assert their independence of Communist party control, their leadership was promptly purged, and they became more and more welfare agencies and subordinate instruments of state policy. As welfare agencies they retained very important functions in the organization of social services for their members; but industrially they became mainly instruments for helping in the drive for higher production and for Communist propaganda abroad as well as at home.

The *Vsesoyuzny Tsentralny Soviet Professionalnykh Soyuzov,* or All-Cnion Central Council of Trade Unions. took a leading part in forming the World Federation of Trade Unions in 1945, and gave particular attention to efforts to foster trade unions under Communist or near-Communist leadership in colonial countries and in the far and middle east. and also to building up their influence over the trade union movements in eastern Europe and in France and Italy. Of the countries under Soviet domination, Czechoslovakia had the most strongly organized trade union movement; but growth had been rapid elsetvhere, especially in Poland and Hungary.

OTHER COUNTRIES

Australia and New Zealand. — Outside Europe and the Americas, the strongest trade union movements are in Australia and New Zealand. These have a long history, having been started mainly by settlers from Great Britain, including, in Australia, Chartists and others transported for political offenses. The Anstralian and New Zealand unions fought their earliest battles for the eight-hour day. and subsequently for the minimum wage, and were the creators of the Labour parties nhich rose later to political power. The systems of arbitration built up in both countries at first favoured union claims. but later, when a living wage had been secured, offered fewer advantages so that strong left-wing opposition developed, accompanied by many strikes. Industrial unionist ideas. derived from the United States, became influential in the period before 1914, and retained some hold, especially among miners and dock workers, who were influenced also by Communism. The main body of trade unionists. however, supports the Labour party and works under the arbitration system.

India. — In India trade unions did not become important until the 20th century, and have been rent by many divisions. Between World Wars I and II there existed rival central bodies, the Indian Trades Union congress and the more moderate Indian Federation of Labour, besides many independent bodies, such as the Railwaymen's federation and the Gandhist Ahmedabad Labour union.

Communists made many attempts to capture control of the unions, with some success; and there were also rivalries between the Socialist party and the Indian Congress party leadership, to which the main body of the Socialists remained attached up to 1947. The split between the Socialist and the Congress parties led to new rivalries; and the position remained unsettled at the mid-1950s.

China and Japan. — In China trade unionism has been a battleground of rival political tendencies ever since its emergence as a defined movement in the 1920s. Trade unionism of a sort, in the form of guilds and clubs of workers in the same trade, has a very long history, and the basis of modern trade unionism is still in working groups of this type or in factory councils. More formally organized trade unions came into existence during the period after World War I, with Communists playing a leading part. After Chiang Kai-shek's coup of 1927, unions under Communist influence were suppressed, and the movement was driven largely underground. Later. the Kuomintang leaders began to organize government-sponsored unions under approved leadership, and the Communists in addition to carrying on their own "red" unions, adopted a policy of infiltration into these "yellow" unions and of fomenting mass strikes wherever opportunity arose—as it continually did because of the vast inflationary rise in prices. The struggle for the control of the unions was resumed after 1945; and the Communists, whenever they established control of an area, set up or consolidated unions under their own control and gave them large authority in relation to privately owned undertakings. Strikes multiplied in the areas still under Nationalist control, and the Communists were able, despite repression, greatly to increase their hold on the workers throughout the country, and thus to prepare the way for their victories of 1949.

Trade unionism in Japan, after developing fairly rapidly in the 1920s, was for the most part suppressed in the 1930s, except for benefit societies under official surveillance. It emerged again after 194j and became a point of contention between left-wing and moderate tendencies.

Malaya. — In parts of Malaya and in Hong Kong, Chinese labour organizations at mid-20th century were strong and largely under Communist influence. In Malaya Chinese guilds and associations of the traditional type were numerous: and on them were superimposed societies and clubs, largely of friendly society type, formed under the Societies Ordinances of 1889 and 1895, and on these again regular trade unions under the Trade Union ordinances which came into operation in 1946. Meanwhile the Malayan Communist party, founded in 1928, set up cells among the workers; and after 1945 these were expanded into trade unions nominally covering most industrial groups and federated into a General Labour union, which m s later divided into separate bodies for Singapore and for the rest of Malaya.

Colonial Trade **Unionism.**—Trade union movements at mid-20th century had begun to develop in other colonial areas, particularly in the British West Indies and in west Africa. They were in most cases closely connected with political movements, but had an economic basis in the low standards of living and in the conditions of mining and plantation economies in backward areas. There had been extensive strike movements in Trinidad, Jamaica and other parts of the West Indies, in Mauritius and in Nigeria and other parts of west Africa.

The policy of the British government was to recognize colonial trade unionism and to endeavour to guide it as far as possible into nonpolitical channels. As against this, the World Federation of Trade Unions, especially after it had come entirely under Communist control. tried to develop colonial trade unionism as an auxiliary to the anti-imperialist movement of the coloured peoples and to influence it toward mass strike action whenever opportunity occurred. In Jamaica William Bustamante rose to power in the 1940s mainly by organizing mass trade unions among the plantation workers and other discontented groups, though after his accession to office his policy became very different. The rival movement led by N. W. Manley had greater strength among the more skilled workers. Jamaica has its own Trade Union congress, which forms a sector of the Caribbean Labour congress, with similar bodies throughout the British West Indies.

INTERNATIONAL ORGANIZATIONS

Internationally, world trade unionism was split after 1949 between two rival organizations — the Communist-controlled World

Federation of Trade Unions, set up in 1945 on a wider basis, and the International Confederation of Free Trade Unions, founded late in 1949 mainly by the national bodies which had seceded from the W.F.T.U. in protest against its Communist direction. Trade union organization began with the International Federation of Trade Unions, set up in 1901, and centred in Germany up to 1914. The I.F.T.U. was reconstituted in 1919, with headquarters in Amsterdam. Neth.; and the Russians soon set up a rival Red International of Labour Unions as an auxiliary to the political Communist (third) international.

The contest between these bodies continued up to 1939; but after 1941 there were close contacts between the British and Soviet trade unions, and in 1945 an attempt was made to set up an inclusive international. The W.F.T.U. was intended to reconcile differences; the British T.U.C. and the U.S. Congress of Industrial Organizations, as well as the Soviet V.Ts.S.P.S. took part in its foundation, only the American Federation of Labor reiusing to join. The rift came with the strong opposition organized by the Communists against the Marshall plan. The headquarters of the W.F.T.U., under French leadership. joined in this opposition. and, after vain attempts to check this. the British T.U.C. and the C.I.O. left the organization and proceeded. with the A.F. of L. and the Dutch. Scandinavian. Belgian and other national groups. to establish a rival federation, including minority groups in France, Italy and various other countries. The bodies attending the inaugural conference of the I.C.F.T.U. included the French Christian Trade Union federation, but not the'distinctively Christian movements from other countries, to whose presence the free trade union movements of the Netherlands. Belgium, etc.. objected. During the conference it was decided to invite all the Christian federations to join, subject to their dissolving their separate international federation; this they refused, and the separation still existed in 1957, the Christian unions—chiefly, but not exclusively Roman Catholic—being organized in an International Federation of Christian Trade unions (I.F.C.T.U.) extending to Latin America as well as Europe.

While the western trade unions were forming their new international in London, the W.F.T.U. was holding a conference of trade union movements in Asia and Oceania at Peking. China. attended by delegates from China. Malaya, Burma, India. Ceylon. Indonesia. Indochina. Thailand and other areas: to draw up a common program for Communist trade union action. The two internationals were also contending for control of the international trade secretariats of trade unions in particular industries (transport workers, miners, railwaymen, metal workers. textile workers, etc.). These bodies, many dating back to the period before 1914, had refused to merge themselves in the W.F.T.U. before the split; and after the split a number of them formed a joint committee which co-operated independently in preparing for the foundation of the I.C.F.T.U.. to which they would become attached. but in such a way as to keep their independence. Other secretariats remained attached to the W.F.T.U., which regarded them as subordinate departments and set to work to form new ones in rivalry with those which rejected its control.

The W.F.T.U. claimed in 1945 to represent 67,000,000 trade unionists. including 30,000,000 members of Soviet *profsoyuzy;* the I.C.F.T.C. in 1949 claimed 48,000,000 participating in its inaugural conference and another 2,000,000 expected to join. There has been keen rivalry between the I.C.F.T.U. and the W.F.T.U. in stimulating the growth of union in the less developed countries. The I.C.F.T.U. has been particularly active in India and West Airica. and has been engaged in substantial educational and training projects in these and other areas. All these international federations are recognized by UNESCO. and there is close cooperation between UNESCO and the I.C.F.T.U. in the field of workers' education. (See also INDUSTRIAL RELATIONS.)

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TRADE WIND, the name given to the regular northeasterly and southeasterly winds which blow from the subtropical belts of high pressure toward the equatorial belt of low pressure. Their regularity, especially over the oceans, explains their name, the term "trade" being used in the otherwise obsolete sense of "course" (*cf.* "tread").

The trades. broadly, extend from latitude 30° N. to 30° S. and thus cover about half of the earth's surface. They are best developed over the oceans, with the exception of the north Indian ocean where they are replaced by the monsoon. The great variety of climates included in the trade-wind belt ranges from extreme aridity with fog at the eastern margins of the oceans to copious rainfall with tropical storms along their western edges. ***See*** also CLIMATE AND CLIMATOLOGY.

See H. Riehl, *Tropical Meteorology,* ch. ii (1954). (H. RL.)

TRADING POSTS flourished in North America from earliest colonial days until late in the 19th century as places of exchange of goods and currency between Indians and the settlers and traders. In 1565 the explorer Pedro Mendenez wrote to Philip II of Spain mentioning the existence of trading areas along the Gulf of St. Lawrence to which Indians brought bison skins for trade to the French.

The first English trading post was established at the Jamestown colony in Virginia. Corn and pelts were the chief articles of exchange until beads, or wampum (*q.v.*), were established as currency.

In 1668 two French traders, Sieur des Groseilliers and Sieur de Radisson, opened a post on the shore of Hudson bay which eventually was chartered by Great Britain as the Hudson's Bay company (*q.v.*). Throughout the period of colonial expansion, the principal mother countries—Great Britain. France and Spain—set up strategic trading posts which supplied the Indians with guns and ammunition and, later, liquor. After the Revolutionary War, in an effort to control the liquor problem and to establish a fair standard of trade, a law was passed authorizing government trading posts controlled directly by the president. All border forts became trading posts.

In 1806 an office of Indian trade was created. By 1810 posts had opened in Ohio, Georgia and in the Louisiana, Indiana, Michigan, Mississippi and Orleans territories.

The government measures did not solve the problem, however, as British trading posts, handling illegal liquor and supplying the Indians with war materiel, continued to operate in the Ohio and Mississippi river areas until after 1814. Furthermore, the government posts were bitterly opposed by private traders. In 1822 the posts were abolished.

In 1811 John Jacob Astor (*q.v.*) set up a post on the Columbia river which became one of the largest fur centres in the nation. Another famous post was the one near Gardner, Kan., the town marking the beginning of the Oregon trail west. By the 1840s trading posts had been established throughout the southwest and the Pacific coast. Many of the original sites have since become large cities—Kansas City, Boise, Spokane, Winnipeg, and Vancouver among them.

The physical structure of a trading post is described by the Smithsonian Bureau of American Ethnology (*Handbook of American Indians,* 1910) as "a large square inclosed by a stockade ... within the stockade were storehouses, quarters for the men, and a room for general trade."

TRAFALGAR, THE BATTLE OF. The British naval victory over the French and Spanish fleets off Cape Trafalgar, on Oct. 21, 1805, was a sequel to the breakdown of Napoleon's scheme for invading England.

An account of the movements leading up to it, known as the Trafalgar campaign, will be found under the heading NAPOLEONIC CAMPAIGNS.

Admiral Villeneuve, returning from the West Indies, succeeded in making the port of Ferrol; thence he should have sailed for the Channel and effected a junction with the Brest fleet, but, judging that Napoleon's schemes were already defeated, he made for Cadiz instead. Nelson, after his arrival at Gibraltar from the West Indies, had fallen back on the English Channel fleet, but Collingwood was watching Cadiz with three ships. On Villeneuve's arrival, he retreated slowly towards the Straits, and the French pursued him; but they had no wish to be drawn into the Mediterranean, and after a time retreated to Cadiz, and Collingwood was able to resume his station; he was joined at the end of August by reinforcements amounting to 22 ships. The importance of defeating or effectively blockading this allied force which now numbered 33—15 of them Spaniards—was fully realised by the Admiralty, and in September they decided to send Nelson to take command of the blockading force.

Nelson in Command at Cadiz.—Nelson left Portsmouth on Sept. 15 with three sail of the line, arriving off Cadiz on the 29th of the same month—his forty-seventh birthday. He had sent ahead a frigate to forbid any hoisting of colours or firing of guns, in order not to draw the attention of the Allies to the arrival of British reinforcements. But the unofficial welcome he received was such as to put heart into any commander of a fleet. During the first fortnight of October he was reinforced by a further six ships, so that his strength was at one time 34, but at the time the battle was actually fought he had only 27 ships at his disposal; six had been sent to Gibraltar to revictual, and Admiral Calder, who was going home to face court-martial for his unsatisfactory action off Finisterre, was magnanimously allowed to return in his flagship. Nelson did not keep the bulk of his fleet close to Cadiz; only the frigates were inshore, most of the ships being some 30 to 40 miles to sea, connection being maintained by a line of signal ships.

Villeneuve Ordered to Mediterranean.—Nelson's first task was to induce Villeneuve to put to sea, and this was performed for him by Napoleon himself. A new coalition of European powers had just been formed against Imperial France, and Napoleon, unable to use his troops against England owing to the breakdown of his schemes, had marched them against Austria. He thus required naval support in the Mediterranean, and Villeneuve was ordered to leave Cadiz and enter that sea; furthermore, should he encounter an enemy fleet to which he was not inferior, he was not to hesitate to attack them. These commands reached the French Admiral at the end of September. He knew, however, that they could never be acted on successfully, and a council of war held at the beginning of October decided that, though a sortie might be possible, to give battle to the British fleet would be suicidal. At this time, too, it appears that the Allies were under-estimating the strength of the British. Later in the month Villeneuve heard that Napoleon was sending Admiral Rosily to supersede him. This he regarded as a reflection on his honour, and he decided to put to sea before his successor arrived. He did not intend to give battle to Nelson if he could get into the Mediterranean without doing so, but he fully realised that he would probably be forced into action; and he thought that, in such a case, Nelson's probable plan would be to obtain local superiority over part of his fleet. To guard against this he formed a reserve squadron of 12 ships under the Spanish Admiral Gravina, which was to keep to windward of the rest of the fleet, and thus be able to come to the assistance of any part of it that was in difficulties.

Nelson's Battle Orders.—Nelson had also drawn up orders for the guidance of his officers, and had explained to them how he intended to fight the battle. His instructions are embodied in the "Nelson Memorandum," which was drawn up at a time when he expected to have a larger force than 27. None the less the principles it contained are applicable with equal force to a smaller fleet. They were that the attack was to be made in two bodies; the larger, under Collingwood, was to obtain local superiority over the enemy's rear, while Nelson, with the smaller body, was to preserve him from the interference of the van and centre, should they attempt to go about to the assistance of the rear, as they normally would. On the day of battle Collingwood's squadron consisted of 15 ships and Nelson's of 12.

Villeneuve Puts to Sea.—It was on Saturday, Oct. 19, that the first of the Allies got to sea. Nelson knew of their movements immediately, and made sail for the south-east so as to cut them off from passing through the Straits. Only part of the allied fleet got to sea on the Saturday, and on Sunday the 20th the weather was so bad that they returned to the neighbourhood of Cadiz. Nelson, throughout, kept his main fleet out of sight, but followed them, move for move, receiving. all the information on which he based his decisions from his frigates. Monday the 21st was a fine day; the wind was light and blowing from the north-west, and at dawn the two fleets were in sight of one another. The Allies were sailing south, making for the Straits again, and the British were some 12 miles to the west of them. Nelson at once ordered his fleet to form two lines of sailing, in accordance with his plan outlined above. His own squadron was the more northerly of the two, and each admiral was leading his own squadron, Nelson in the *Victory*, and Collingwood in the *Royal Sovereign*. In this formation, they approached the allied fleet, and as they came more clearly into view, Villeneuve, for the first time, saw that he had underestimated their strength. He at once sacrificed the originality of his dispositions by ordering Gravina, with the reserve squadron, to come into the line; and, shortly afterwards, partly with a view to keeping Cadiz open as a refuge on his lee, and partly to counter what he thought was designed as an attack on his rear as he was sailing south, he ordered his whole fleet to wear and sail roughly north.

Collingwood's Attack.—Villeneuve's order to his fleet to wear was made about 8 o'clock, and it was not properly finished when Collingwood, who was to initiate the attack, ordered his squadron to change its formation from an irregular line ahead to an irregular line of bearing. This was about 8·50, some two hours after Nelson had first ordered the advance. Collingwood's object was to bring his force into a line as nearly parallel as possible with the part of the enemy line that he was to engage, and the concavity in their line was such that this manoeuvre would virtually produce that result. Nelson had given his second-in-command a free hand in deciding how to carry his line into battle, so that the credit for this movement, admirably suited as it was to the circumstances and designed to enable the British ships to use their broadsides as they got into action, must be given to Collingwood. For the rest, he carried out brilliantly the part assigned to him—namely to break through the enemy and engage the rear 12 ships. His own vessel, the *Royal Sovereign*, being a very fast sailer, was in close action just after 12 o'clock, and to her fell the duty of selecting the gap which would enable him to cut off 12 ships. Actually he cut off 15 and became engaged with 16.

Nelson's Attack.—It now remains to consider the movements of Nelson's line. The commander-in-chief it will be remembered had kept for himself the duty of preserving Collingwood from any interference from the allied centre or van. For this purpose he continued his advance in the order he had first assumed, that is to say, irregular line ahead. With the object he had before him, he naturally wished to disguise the point at which his attack was finally to be directed, and line ahead was the most flexible and easily-managed formation he could adopt. It had the drawback of exposing the head of the line, as it approached, to the concentrated fire of the enemy, but Nelson was prepared to regard this as a justifiable risk in view of the advantage of flexibility which the formation conferred, and which was peculiarly valuable in the particular circumstances. The event proved him right. He began by aiming at the van rather than the centre of the allies, whose leading ships, nervous of having their T crossed, crowded on sail to prevent this manoeuvre being executed, thus taking themselves further from that part of their line which was now being attacked by Collingwood, and which Nelson did not intend should be assisted by them. Indeed, the whole of the allied van and centre, mystified by Nelson's movements and uncertain of his aims, could do nothing but wait for him to declare his intentions, while they left the rear to look after itself. Nelson was himself leading his line, and as the "Victory" approached the allied van he turned to starboard, followed in succession by the ships in his squadron, and sailed down the allied line, looking for a suitable place at which to break through. This turn enabled him to open fire, but he preferred to hold it. Finally he found a gap astern of the "Bucentaure," 12th ship in the line and Villeneuve's flagship, and, passing through, he opened fire, raking the ships on either side with terrible effect. The majority of his line deployed to starboard and broke through the allies at various places between the points pierced by Nelson and Collingwood; but two more ships ahead of the "Bucentaure" were engaged, the Ieading ten ships finally being left without attention. Six of these, under Dumanoir, at length made some attempt to go about to the help of those behind them, but their arrival was too late to be of any use, and they made off; for, in the meantime, Nelson's 12 had been matched with 7, with the inevitable result. By this time, too, victory had declared itself for Collingwood, who had been left without interference, as Nelson had designed, to complete the destruction of the rear.

Completeness of the Victory.—In all, 20 prizes were taken —about 60% of the allied fleet. A larger percentage was taken or destroyed at the Nile, but the comparison is not a sound one, for at the latter battle the enemy was caught in a confined space. At Trafalgar they had plenty of room to manoeuvre and a friendly port on their lee; yet they could not escape. such was the paralyzing effect of Nelson's tactics—an inspired mixture of the traditional and original. Nelson had solved a problem that had puzzled British admirals for a century—namely, how to prevent the French making off while most of their fleet was still more or less intact. For this reason Trafalgar is regarded as the greatest of naval battles and Nelson as the greatest of admirals. *See* also NAPOLEONIC CAMPAIGNS.

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TRAFFIC REGULATION. Prior to the end of the 19th century there was little need for traffic regulation on roads and streets. Travel was slow and road congestion did not often occur. A few basic rules of the road, such as keeping to the right (or left), were time-honoured traditions rather than regulations and were adequate for the times.

The mechanization of highway traffic greatly increased the number. size and speed of road vehicles. This revolution in the highway transportation of civilized countries produced many social and economic benefits to the public but traffic congestion and casualties became extremely critical problems. Coincident with the increase in the seriousness and scope of these problems, more rigid regulation of road traffic was demanded. Thus from an antecedent of customs and conveniences modern traffic regulations became extremely numerous and complex.

Traffic regulation includes the use of traffic controis and traffic-control devices in addition to laws. Traffic controls are applied at specific locations where their need is warranted; they consist of one-way streets. control of parking. speed limits and intersection controls. Traffic-control devices are the means by which road users are advised. directed and warned concerning the traffic controls which apply at specific places and times; they consist of traffic signs. signals and pavement markings. For the most part traffic controls and traffic-control devices are legally defined and are made enforceable by specific traffic laws. However, some traffic-control devices may be advisory or informational only, such as route markers or town destination signs.

The extensive use of the motor vehicle and its wide range of travel have placed emphasis on the need for uniformity in traffic regulations, and great progress has been made toward the unification and reciprocity of traffic regulations among the free nations of the world and their political subdivisions.

HISTQRY OF TRAFFIC LAWS

The evolution of traffic law reflects the changes in highway transportation and in public opinion throughout the years. When the motor vehicle was first introduced traffic laws favoured the horse and required motorists, when meeting a horse-drawn vehicle, to stop and lead the animal past the frightening machine. In present-day traffic horse-drawn vehicles are prohibited on some highways.

The role played by the motor vehicle in modern society is so important that nearly every aspect of highway traffic must be regulated. Modern traffic laws apply: (1) to the vehicle, as to registration, mechanical fitness, equipment, size and weight; (2) to the driver, as to age, ability to drive and financial responsibility; and (3) to the safe and expeditious use of public roads.

The authority to enact traffic laws varies considerably among different countries. In some the highest governmental authority may enact traffic legislation (such as parliament in Great Britain); in others traffic laws are enacted at lower governmental levels (such as the various states in the U.S.). In almost all countries municipal authorities have the power to establish local traffic controls (or ordinances) when enabling legislation has been provided. Where enabling legislation is not available many traffic rules are enforced under the authority of broad police powers designed to protect the safety and welfare of the public. Early traffic rules were enforced by this method.

Before 1899 no effective attempts were made to control traffic anywhere except in Great Britain, where the Highway act of 1835 provides that carriages and animals shall be driven on the left. or near, side of the road. Prior to this act the rule in Great Britain and Ireland that vehicles should keep to the left was a custom which the police enforced as a matter of common law. The act of 1835 was followed by the Town Police Clauses act of 1847, which requires the driver of a carriage meeting another to keep to the left, and when overtaking another to keep to the right except in cases of "actual necessity" or some sufficient reason for deviation. (The table lists the countries and regions where road traffic is required to keep to the left or to the right.)

Rule of the Road

Rsep to the Right	
Algeria	Iraq
Austria	Israel
Belgium	Italy
Belgian Congo	Luxembourg
Canada	Mexico
*Central America	Monaco
Cuba	Morocco
Denmark	Norway
Dominican Republic	Pakistan
Egypt	Philippines
Finland	Portugal
France	Puerto Rico
French Community	†South America
Germany	Spain
Gibraltar	Switzerland
Greece	Tunisia
Haiti	Turkey
Holland	United States
Iran	U.S.S.R.
	Yugoslavia
Keep to the Left	
Australia	Ireland
Ceylon	Japan
Cyprus	Malta (and Gozo)
Great Britain (including Northern Ireland and Isle of Man)	New Zealand
Hong Kong	Sweden
Iceland	Virgin Islands
India	West Indies, The

*Except British Honduras, left.
†Except British Guiana, left.
Source: Courtesy American Automobile Association.

The Road Traffic acts of parliament of 1930 and 1934 formed the basis of most of the traffic regulations in force in Great Britain. The act of 1930 also provided for the publication of a highway code of road manners as official advice but not a part of the traffic law. The ministry of transport and civil aviation (organized in 1919 as the ministry of transport) was empowered to make detailed regulations covered broadly by the Road Traffic acts. Under this enabling legislation local authorities in Great Britain have power to make certain traffic regulations subject to approval by the minister of transport.

In the U.S. in 1899 William Phelps Eno, organizer of the Eno Foundation for Highway Traffic Control, compiled a traffic code for New York city. He had observed that traffic in British cities operated efficiently because drivers and pedestrians obeyed without question the time-honoured rules of the road handed down through generations and that the police enforced these common-law rules. At that time in U.S. cities there were few rules for driving recognized by the public or the police and vehicles were driven in a chaotic manner. Although the automobile industry was in its infancy and motor-vehicle registrations were below 10,000, Eno envisioned the vast increase in motor-vehicle use and reasoned that the American public should be quickly educated relative to traffic rules through the issuance of a traffic code. His code was proposed ior New York city in 1900 but was not adopted until 1903. It was subsequently adopted by a number of other cities in the U.S. and by Paris in 1912. The code was revised and reissued at least five times prior to 1918. In 1919 it was again revised and adopted by the highways transport committee of the U.S. Council of National Defense.

In 1924 the National Conference on Street and Highway Safety (N.C.S.H.S.) recognized the sovereign power of individual states to regulate and control traffic. This conierence was a co-operative activity, with Herbert Hoover. then U.S. secretary of commerce, as chairman. Its membership consisted of a number of national organizations concerned with rapidly increasing traffic casualties and the need for uniiormity of traffic laws among the various states. At the first general session of the conference it was obvious that uniformity in traffic laws among the states could only be achieved through the drafting of model legislation, and a committee on uniformity of laws and regulations was created to draft the models. This committee, combined with another committee created for the same purpose by the National Conierence of Commissioners on Uniform State Laws, produced its first draft of the uniform motor-vehicle code in time for review by the second general session of the N.C.S.H.S. in 1926. At this conference the first uniform motor-vehicle code in the U.S. was adopted and recommended to state legislatures for enactment. The first model traffic ordinance recommended to cities for enactment was drafted by the committee in 1928 and reviewed by the third conference in 1930. This ordinance was designed to conform with state statutes provided through the uniform motor-vehicle code. At the next three conferences, held in 1934, 1938 and 1944, the code and ordinance were reviewed and revised.

In 1947 the N.C.S.H.S. was dissolved but the work of revising the model code and ordinance to keep them up-to-date was taken over by the National Committee on Uniiorm Traffic Laws and Ordinances (N.C.U.T.L.O.). The membership of this committee consisted of representatives of over 50 national agencies, and at least one formal meeting of the group was held each year.

Uniform Motor-Vehicle Code of the **U.S.**—The widespread ownership of motor vehicles in the U.S. placed critical emphasis on the development of sound traffic laws. Legal processes, public-road administration and traffic problems vary among different countries, but the uniform motor-vehicle code developed in the U.S. is typical of the modern traffic laws required, with modifications to meet local conditions, throughout the world. The essence of the model code, revised in 1956 by the N.C.U.T.L.O., is briefly summarized under the headings of its principal subdivisions.

The Department of *Motor* Vehicles.—This section provides for a separate motor-vehicle department in the state government, having a division of registration, a division of drivers' licences and a division of highway safety and patrol. Details pertaining to the authority to grant, refuse, revoke, cancel or suspend vehicle registration, certificate of title or drivers' licences, and to the enforcement of traffic regulations are also covered.

Certificate of Title and Registration of Vehicles.—Provisions are set forth governing issuance and renewal of a certificate of title of vehicle ownership, the validity and recording of liens or other financial encumbrances on the vehicle, vehicle-registration procedures and special registration requirements for dealers, manufacturers and transporters.

Antitheft Law.—This section deals with methods of receiving or disposing of a vehicle; penalties for unauthorized use of and tampering with a vehicle; and offenses related to title and registration.

Dealers, Wreckers and *Rebuilders*.—Requirements are established for licensing these agents, and their obligations are specified with respect to title and registration of vehicles.

Operators' and Chauffeurs' Licences.—This section includes provisions for the issuance of licences, examination of applicants and suspension or revocation of drivers' licences.

Financial Responsibility.—Legal provisions require deposit of security following an accident serious enough to be legally reportable, and specify conditions and methods under which proof of financial responsibility must be provided for future accidents.

Owners of Vehicles for Hire.—Special provisions are made for this class of owner—concerning financial responsibility, liabilities and methods of renting motor vehicles—to conform with motor-vehicle department requirements.

Civil Liability.—This section covers liability of government agencies arising from the operation of a publicly owned vehicle; liability with respect to gratuitous guest passengers in a motor vehicle; and liability imputed to the vehicle owner for negligence or willful misconduct of operator.

Accidents *and* Accident Reports.—Included are the requirements for reporting accidents; duties of persons involved in a motor-vehicle accident; responsibility of coroners and garages to report evidence of an accident; and public uses of accident reports.

Equipment of Vehicles.—Minimum requirements for vehicle equipment are specified, including lights, brakes, horns, mufflers, tires, air conditioning, safety glass and the display of flares and other warning devices when certain vehicles are disabled.

Inspection of Vehicles.—This section authorizes properly designated officials to inspect any vehicle that is believed to be unsafe or not properly equipped, and requires inspection for operating deficiencies of every motor vehicle at least once a year at either state-operated inspection stations or by officially designated inspectors.

Size, Weight and Load.—The maximum legal sizes and weights of motor vehicles are specified; official enforcement of weight limits is authorized; and provision is made for special permits ior oversize and overweight vehicles.

Powers of State *and* Local Authorities.—This section provides for co-ordination and uniformity in the enactment and enforcement of traffic laws on both state and municipal levels; requires the state highway department to adopt a manual and specifications for a uniform system of traffic-control devices consistent with national standards; requires local authorities to conform with the state manual and specifications; and authorizes education officials to adopt and enforce certain regulations governing the design and operation of school buses.

Records and Reports of Convictions.—Every magistrate or judge of a court is required to maintain records of traffic complaints and citations and to make suitable reports of these records to the motor-vehicle department.

Parties and Procedures Upon Arrest.—This section defines parties in violation of the code; establishes procedures upon arrest; and requires use of quadruplicate traffic-arrest forms in a manner designed to avoid cancellation or solicitation for cancellation of a traffic citation.

Rules of the Road.—This section pertains particularly to the operation of traffic on public highways, including regulations for driving on right side of road, overtaking and passing, right-of-way at intersections, restricted access, turning and speed change, general speed restrictions, reckless driving and driving under influence of alcohol or drugs, parking, pedestrian rights and duties and obedience to traffic laws and traffic-control devices.

Traffic Laws in the United States.—The provisions in the uniform motor-vehicle code have been adopted by most of the states in the U.S., either entirely or in part.

Driving Licences and Tests.—All states require drivers' licences and. in this connection, written and oral examinations are given on knowledge of lams, traffic-control devices, liability and driving courtesy. It is common practice to require tests of eyesight, literacy and driving skill. Drivers' licences are usually obtained through local branches or agents of the motor-vehicle department and must be renewed at intervals of from one to three years.

Registration. — Vehicles must be registered annually in all states. It is general practice to permit nonresident drivers to operate for a certain period of time without registration in a given state, Proof of vehicle ownership is required although some states do not require certificates of title; however, change of vehicle ownership must be reported in all states.

Insurance.—Three types of liability laws are in force in the U.S.: the security type, under which, following the report of an accident, the drivers (or owners) involved must show ability to pay damages; the future-proof laws, under which a similar showing of financial ability must be made after certain traffic offenses or failure to pay damage claims; and compulsory insurance laws, under nhich motorists must file proof of financial responsibility as a condition of vehicle registration.

Vehicles and Equipment. — Each state has its own size and weight regulations, and changes in these occur during state legislative sessions each year. Although there is wide variation among the states, the tendency has been toward adoption of the size and weight limitations of the uniform motor-vehicle code. Few states require official vehicle inspection.

Accident Reporting. — State laws generally require reporting of accidents by motorists. Accidents involving injury or death must usually be reported immediately to local or state police. Most states also require that these accidents, and those involving property damage over a given amount. be reported to a central state agency on forms provided for the purpose.

Additional *Regulations.*—More than half the states adopted the "Rules of the Road" recommended by the uniform motor-vehicle code or a similar set of rules.

The President's Highway Safety conference, following its inception in 1946, urged each state to compare its motor vehicle laws with the uniform motor-vehicle code and, as increasing traffic problems caused this to be done. essential conformance with the code was expected throughout the country.

Traffic Laws in Great Britain. — The traffic laws in Great Britain differ in detail from those of the uniform motor-vehicle code developed in the U.S., although in purport they are much the same. Some of the principal British traffic regulations for motor vehicles are described below.

Driving Licences and Tests. — Application for a driving licence must be made to the council of the county or county borough, and the form of application incorporates a declaration of fitness to drive. Driving licences can be endorsed by the courts for violations of lams for moving traffic (not for parking violations). Driving tests were introduced in 1935 and are conducted by examiners appointed by the ministry of transport.

Registration. — All vehicles, except those of the sovereign, must be registered with a county, county borough or burgh council, which issues a registration book. The book must be returned to the council when the licence is renewed, when the vehicle is altered. sold, destroyed or taken permanently out of the country or when the person in whose name the vehicle is registered changes his address. This person need not be the legal owner.

Insurance.—No mechanically propelled vehicle may be used on a public highway unless it is covered by insurance or a suitable security against claims arising from injury or death. A certificate of insurance must accompany each application for vehicle registration.

Vehicles and *Equipment.*—Vehicles must conform to regulations as to size and weight and must be properly equipped with respect to brakes. lights, safety glass, etc. 'The vehicle must be so maintained that no danger is likely to be caused.

Accident Reporting. — Accidents must be reported to the police as soon as practicable and within 24 hours if name, address and certificate of insurance are not made available to any person having legal reasons for requesting them.

Additional *Regulations.*—Numerous laws prohibiting certain acts when driving and when the vehicle is parked are generally similar to those of other countries.

TRAFFIC CONTROLS

Traffic controls are the means employed to insure orderly movement of vehicles and to achieve the highest practicable efficiency in using streets and roads for both travel and parking. However, such controls should be applied only when engineering studies or accident records show a need for them; overzealous use of controls may result in needless delays. with consequent impatience on the part of motorists giving rise to further hazards.

One-Way Streets. — These may be of three general types: (1) operation in the same direction at all times; (2) operations reversed in direction at different times to accommodate the predominant`flow during peak traffic hours; and (3) operations one-way and two-nay during peak and off-peak hours respectively. One-way operation increases the capacity of a street. increases speed nith safety and reduces traffic delays.

Curb Parking Controls. — Parking regulations apply to both time and space factors. Parking time limits are used to reduce the length of time a vehicle may be left at the curb. They may also be used to prohibit curb parking during peak traffic hours. Space controls of parking may prohibit curb parking at certain places at all times or they may reserve parking spaces for commercial loading zones, buses or taxis. Parking time controls increase the turnover of curb-space use and discourage illegal parking practices. Curb-parking prohibitions along sections of a street, on either or both sides, increase street capacity for moving vehicles and eliminate hazards and interference saused by parking maneuvers. Parking is generally prohibited near intersections, at entrances to public meeting places and at fire hydrants.

Speed Controls. — The common speed regulations consist of (1) the basic rule requiring motorists to travel at reasonable and prudent speeds; (2) maximum numerical limits imposed throughout a region, such as a state or urban area; and (3) speed zones suited to environmental and traffic conditions at certain locations and, occasionally, at certain times. While the severity of accidents obviously increases nith increased speed there is much controversy concerning the influence of speed on the incidence. or frequency, of accidents. Some authorities object to the inflexibility of numerical speed limits because such limits take no account of the continuously changing traffic environment. Numerical speed limits are of two types: the absolute limit. which when exceeded requires no further evidence for arrest; and the prima-facie limit. which places the burden of proof of safe driving upon the driver if he exceeds the numerical limit.

In the United States, revision of the uniform motor-vehicle code discarded prima-facie limits in favour of absolute limits of 30 m p h. in any urban district, and 60 and 55 m.p h. in other locations during day and night respectively. The code also provided for speed zoning and for altering maximum limits for certain vehicles.

In Great Britain the general speed limit was established at 20 m p.h. in 1903. During subsequent years this limit was violated so frequently and became so controversial that the general limit for passenger vehicles was abolished completely in 1930. Finally in 1934 parliament imposed a limit of 30 m.p.h. on passenger vehicles in built-up areas; lower limits for commercial vehicles were continued in all areas.

Intersection Controls. — Traffic is controlled at intersections by the establishment of "through" or "stop" streets and the prohibition of turning movements. Stop regulations are often required when minor roads intersect with major roads and automatic traffic signals are not warranted. In customary American and British practices, automatic traffic signals are warranted only (1) where the average hourly number of vehicles and pedestrians entering the intersection exceeds a specified volume; (2) where traffic hazards cannot effectively be reduced by other methods; or (3) to promote continuous flow at a given speed through a coordinated system of signals.

TRAFFIC-CONTROL DEVICES

The safety and efficiency of movement of highway traffic depend upon the drivers' immediate recognition and understanding of standardized traffic-control devices. Some semblance of uniformity in traffic-control devices in European countries was achieved at the 1926 International Convention on Motor Traffic and the European conference in 1931, although there still remained many local variations. In the U.S., need for uniformity in the design and application of traffic-control devices was first met when the secretary of agriculture, at the request of the American Association of State Highway Officials (A.A.S.H.O.), named a joint board to designate the major route systems of the country and to develop a uniform method of marking them. In 1927 the board published its manual and specifications for the manufacture, display and erection of U.S. standard road markers and signs. In 1930 the N.C.S.H.S. approved, for city use, the report of the committee of the American Engineering council on street traffic signs, signals and markings. The conflicts in these two documents were reconciled when a joint committee on uniform traffic control devices, composed of representatives of both the A.A.S.H.O and the N.C.S.H.S., was appointed in 1931, This joint committee developed and published the first *Manual on Uniform Trafic Control Devices for Streets and Highways* in 1935. In 1942 representatives of the Institute of Traffic Engineers were appointed to the joint committee, and subsequent revisions of the manual were sponsored by all three agencies.

Unfortunately the American and European traffic-sign systems have little in common. The European system utilizes distinctive symbols (pictorial or abstract) as compared with the use of word messages and few symbols in the American system. North Africa and the Middle East use the European system; Asia and the Far East (with language problems) use symbols similar to the European system; British signs combine both systems, with a symbol plate and a word-message plate on most signs; Japan uses signs from both systems; and North, Central and South America use the American sign system.

INTERNATIONAL UNIFORMITY IN TRAFFIC LAWS

With the increase in international travel, great need developed for formal agreements among nations with respect to such matters as reciprocal recognition of drivers' licences and vehicle registrations, universal vehicle-size and equipment requirements, uniform traffic laws and standardized control devices. Uniformity in the western hemisphere was initiated in 1943 by a convention held in Washington, D.C., on the regulation of inter-American automotive traffic. This convention established reciprocal agreements on motor-vehicle customs, registration, sizes, weights, equipment ownership and drivers' licences. Ho ever, no such steps were taken on a world-wide basis until the United Nations Conference on Road and Motor Transport was held in Geneva in 1949. The objects of this world-wide convention were to review all previous conventions related to road traffic, to establish broad reciprocal agreements as to traffic regulations applicable to international traffic and to develop a protocol on uniform traffic signs and controls.

The principal provisions of the 1949 United Nations conference may be summarized as follows:

1. General provisions were included to preserve the authority of the individual nations to regulate traffic but each nation agreed to admit international traffic under provisions of the convention. Individual vehicles or drivers were to be admitted for a maximum period of one year.

2. Rules of the road were provided to cover basic regulations of universal application designed to promote safety and the orderly flow of traffic. These consist of certain fundamentals found in traffic laws of many countries, such as safe and prudent operation to avoid accidents and obstruction of the way, special precautions in passing other vehicles, keeping on the proper side of the road and display of proper lights at night.

3. Provisions were made for uniform design and use of traffic signs and signals.

4. The domestic registration certificate must be recognized by all countries when the vehicle carries a registration plate and separate sign indicating country of registration (for example. "USA," United States; "GB," United Kingdom; "F," France); vehicles were required to be in safe mechanical condition; and the authority of each country to control vehicle sizes and weights was recognized.

5. Reciprocal recognition of the driving licence was authorized but any country might require an international drivers' licence; withdrawal of driving licence after certain offenses is permitted. The conference recognized the validity of provisions of the international convention (1926) and the inter-American convention (1943).

The conference, through the Transport and Communications Commission of the UN, appointed a group consisting of a traffic expert from each of the six continental areas of the world to recommend a uniform system of road signs and signals. This group met in 1950, 1951 and 1952 and submitted recommendations which were presented to the various nations of the conference for ratification.

The new traffic-sign system recommended by the UN is patterned more closely after the European system than the American. Although the United States ratified the 1949 convention with respect to traffic regulations, it did not immediately accept the protocol for unified signs and signals recommended by the UN conference.

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TRAHERNE, THOMAS (1637–1674). English poet and clergyman, was the ardent exponent in prose and verse of the way of life he called "felicity." He was the son of a shoemaker at Hereford. He entered Brasenose college, Oxford, in 1653 (B.A., 1656; M.A., 1661; B.D., 1669) and was presented to the living of Credenhill, near Hereford, in 1657, but almost certainly did not hold it. He was episcopally ordained in 1660 and in 1661 was again presented to the living which he held till 1674. From 1669 to 1674 he lived in London and Teddington, Middlesex, serving as chaplain to Sir Orlando Bridgeman, who was lord keeper from 1667 to 1672. He was unmarried. He died at Teddington in 1674.

Traherne published *Roman Forgeries* (1673) and prepared *Christian Ethicks* (1675) for the press. His *Thanksgivings* in rhythmical prose were published anonymously as *A Serious and Patheticall Contemplation of the Mercies of God* (1699). Other *Meditations and Devotions* were published or republished anonymously in 1717. The chance discovery in a London street, identification by Bertram Dobell and publication by him from manuscript of the *Poetical Works* (1903) and *Centuries of Meditations* (1908) was a literary sensation. The manuscript *Poems of Felicity* were then found to have been in the British museum, London, since 1818 and were edited and published by H. I. Bell (1910). Later discoveries were a manuscript volume of meditations, etc., on occasions of the church's year, and a notebook containing early poems.

Traherne is a religious poet of great intensity and individuality. His background is Christian theology, the Bible (particularly its poetry), Renaissance Platonism and his own early ecstasies described in the third *Century* and in some of the poems. He was probably influenced to some extent by Henry Vaughan. He is not of the metaphysical school, however, though he has his own philosophy. He anticipates Wordsworth and also, though deficient in imagery, William Blake; Wordsworth especially because of the gleam irradiating his memory of childhood, Blake because of his boldness and imaginative insight. He aimed at giving an unvarnished account of mental experience, but the purity and vividness of this experience produce a poetry worthy of them. His nature was both intensely sensuous and intensely spiritual, and his greatness often consists in the fusion of these two elements. He is a conscious artist who never uses the same stanza form in two poems, and who excels in fine openings.

Poems of Felicity was prepared for the press (but not published) by his brother Philip (d. 1723). A third of its contents are also in Poetical Works (1903), but Philip made many changes in the text, some for stylistic reasons, others because he could not follow Thomas's imaginative flights or was shocked at their daring. It is therefore certain that poems known only in Philip's transcript are not all exactly as Thomas wrote them.

The Centuries, prose sections numbered in hundreds (Centuries *of* Meditations is not Traherne's title and is misleading), were written in London for Mrs. Susanna Hopton of Kington, Herefordshire, who was the centre of a small religious society. In them Traherne instructs her in the way of "felicity." Every man is "Heir of the World," to whom it is given as his paradise. He must be conscious of his happiness and must be aware that this phenomenal world is not all. Primary and infinite is Spirit, that is, God. The third Century is largely autobiographical and contains several poems, including "On News." In the fourth Century Traherne expounds the principles of "felicity," which he certainly attained himself. His childhood experience did not last, but he regained "felicity" at Credenhill, enriched by thought and fortified by a living and permanent awareness of Spirit. It was probably at Credenhill that he wrote most of the poems.

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TRAILING ARBUTUS: see ARBUTUS, TRAILING.

TRAIN BANDS, a term often applied to the English militia and especially to the London militia in the 17th century. (See MILITIA.)

TRAINING, MILITARY. Military training consists of systematic. progressive education and instruction of individual soldiers and military units in the efficient performance of specific warlike duties. It is concerned basically with the inculcation of discipline, leadership, morale, initiative, teamwork, physical conditioning, and the understanding of weapon functioning and personal protective measures. including first aid and hygiene. Advanced individual training teaches the basically trained soldier to function effectively as a member of a military team. Combined training includes the employment of the weapons, tactics and teamwork between combined arms. Training for higher command includes study in strategy, tactics, staff procedures, administration, logistics (supply), personnel and industrial management.

In ancient Greece, the Spartan system of military training began with the removal of the boy from his family to the military barracks when he was seven years of age. Weapon skill and iron discipline were stressed. For the Roman, military training included marching (4 mi. an hour), leaping and running, swimming, sword practice, special drill, use of the bow, sling and javelin, vaulting and burden carrying (60 lb., less arms).

In 18th-century Europe, Frederick the Great of Prussia (see FREDERICK II) developed a method of military training based upon rigid discipline and sustained delivery of musket fire at a more rapid rate than any contemporary army. His instructions to his generals were an early effort to train individuals for high command and staff duties. Prussian discipline was predicated upon instantaneous, automatic obedience to orders. The basic concept of Prussian military training was introduced into the United States by Baron von Steuben. As inspector general and drillmaster of Washington's troops at Valley Forge; he wrote Regulations for the Order and Discipline *of* the Troops of the *U.S.*

Prior to the American Revolution. military training in the American colonies consisted of an annual muster day when able-bodied male citizens turned out on the village common and drilled under local militia officers (see MILITIA; NATIONAL GUARD). The men so trained were skilled in hunting and repelling Indian attacks but lacked formal military training and discipline, though generally they were expert marksmen. The French and Indian War trained such officers as Col. George Washington and others to lead troops. A limited number of Revolutionary War leaders were former British officers, such as Horatio Gates and Charles Lee. President Washington after the Revolution urged the establishment of a military academy. This was done in 1802 at West Point, N.Y. The naval academy was established at Annapolis, Md.. in 1845. Private schools and institutions such as the Virginia Military institute, The Citadel in South Carolina, and Norwich in Vermont were military training schools with academic instruction.

The American Civil War (1861–65) was fought initially by untrained troops. Units of volunteers (*q.v.*), under inexperienced officers, trained as they marched to the battle front. The final phase of training was received in battle.

OFFICERS' TRAINING CORPS

U.S. Reserve Officers' Training Corps.—The origin of federally sponsored military training in civil educational institutions in the U.S. rests in the Morrill act of 1862, which required that colleges and universities receiving grants of public land include in their curricula certain elementary military instruction under supervision of the secretary of war. The need for this form of instruction was emphasized by World War I, and an attempt was made to meet it in the National Defense act of 1916, wherein a Reserve Officers' Training corps (R.O.T.C.) was authorized to extend to a wider range of institutions than land grant colleges. The corps was scarcely organized before the U.S. was compelled in 1917 to supplement its work by training camps.

The R.O.T.C. as an effective force in civilian institutions for military education dates from the National Defense act of 1920. The army R.O.T.C. consisted of a senior and a junior division. The former, established at colleges, universities and selected military schools, and divided into units corresponding to the principal combat arms and specialist services, included a four-year course averaging about four hours per week and one summer camp of six weeks The junior division, established in selected high schools and equivalent institutions and including only infantry units, was confined to boys over 14 years of age. It provided a three-year course of three hours per week and was practically the equivalent of the basic infantry course in the senior division. A naval R.O.T.C. program, established in 1926 to train reserve officers for the navy, was organized along similar lines.

The term National Defense Cadet Corps schools was adopted in 1957 to designate those high schools offering military training under the National Defense act, section 55–*C*. This program required that a school have a minimum of 100 boys, 14 years of age or older and permitted the school to employ a military instructor while the government furnished the necessary equipment, not including uniforms.

Upon gaining separate and independent status under the National Security act of 1947, the air force continued the operation at 78 institutions of its R.O.T.C. units, which had been established in 1946 under the army air forces. In the mid-1950s the enrolment in air force R.O.T.C. at more than 180 institutions approximated 120,000 students annually. Enrolment in the first two years of the A.F.R.O T.C. was open to all students who met certain physical and other requirements. However, for enrolment in the last two years and appointment in the grade of second lieutenant from this program, primary emphasis was placed on those students who desired and qualified for flying training upon graduation.

The U.S air force academy was established on a temporary basis at Lowry Air Force base. Denver. Colo.. in 1955. The permanent school at Colorado Springs offers cadets a four-year academic course nith a commission, upon graduation, as second lieutenant in the regular air force.

Training Camps.—In 1916, over 12,000 men attended military instruction camps patterned after the young businessmen's military training camp held in Plattsburg. N.Y., in 1915. At these camps, used for officer training in 1917–18, thousands of civilians were trained (in 90 days) to lead troops. The introduction of such complex equipment as radio, the telephone. aircraft and motorized transport in World War I required the soldier to be trained in technical as well as conventional military subjects. Further, tactical training had to be readjusted to include the stabilized trench warfare concept. Basic or recruit training and specialist training taught basic proficiencies and skills in the operation of technical military equipment. Advanced unit training followed, or was conducted concurrently with, basic and specialist instruction. During this phase, units were taught to function as integral parts of a larger organization, or as self-sufficient, separate units. Approximately one year was required to train an infantry combat division, from the arrival of new recruits until the completion of individual basic, specialist and unit training. Manoeuvres and tactical problems designed to test co-operation between the component units and staff sections occupied the training periods prior to movement to the port of embarkation.

From 1921 to 1940 part-time military training with the U.S. army was offered to young men aged 17 to 27. Initially, the program consisted of one month's annual training without pay on a volunteer basis for three years. Later, an additional year was added.

The successful graduates of the Citizens' Military Training camps were tendered commissions as second lieutenants in the Officers' Reserve corps (now U.S. army reserve).

By World War II, military training had become even more complex. Technical skills and capabilities far removed from the earlier requirements of the battlefield had to be developed and taught. The concept was to give to each soldier basic and advanced combat training regardless of his assignment. Tests to determine the aptitude of the soldier and to determine his military occupational specialty were part of the program. Those who passed the tests were given a classification number and performed military duty in that occupational specialty. Replacement training consisted of from 13 to 17 weeks of basic combat instruction. On completion, soldiers went to advanced or specialist training or to combat divisions as individual replacements. On arrival at a replacement depot, further classification mas carried out before the replacement joined his new unit at the front. Where the combat situation permitted, he was given further training in the rear area before beginning front-line duty. Schools of the arms and services (*i.e.*, infantry, artillery, ordnance. signal. quartermaster, chemical, etc.) conducted specialized training, including the operation of schools where officer candidates, after 13 to 17 weeks training. were graduated as second lieutenants. Tactical unit training was conducted to include, generally, the regiment, division and army. Specialized area training included amphibious, desert. jungle, arctic and mountain warfare indoctrination courses for units scheduled to face combat under these climatic and geographical conditions.

During World War II, battle indoctrination courses were designed to subject the recruit to every sight, sound and sensation of battle and to train him to act calmly with sound judgment regardless of noise. confusion and surprise. Physical and mental toughness was achieved in the training cycle by the operation of strength and confidence courses. Completion of obstacle courses and the traversing of infiltration courses covered with live machine-gun fire was required of each infantry soldier before he completed basic training.

After the outbreak of the Korean war, the Universal Military Training and Service act was passed by the congress of the U.S. in 1951, but its military training provisions were implemented only on an experimental, voluntary basis. Though a model training centre for the program was organized and conducted by the U.S army at Fort Knox, Ky., certain features of the plan, especially those requiring compulsory training, met with an unfavourable public response.

The Armed Forces Reserve act of 1952, as amended by the Reserve Forces act of 1955, provided a voluntary military training program for young men between the ages of 17 and 18½ years, the period of enlistment being for eight years. Six months of active training were required on graduation from high school. While in high school the reservist under this program was deferred from active duty until he graduated or attained the age of 20 years. Upon completion of the six-months training, the individual returned to his home where he was required to participate for 3 years in weekly reserve drills and annually two-weeks camp training with pay. By fulfilling this obligation in performing his reserve duty, the reservist was granted deferment from Selective Service.

Other military training programs were offered to young men 17 to 26 years of age by the reserve; *i.e.*, a six-year enlistment with two years active duty, or with no active duty until called for service. No deferment from Selective Service was granted in connection with the six-year enlistment. Critical specialists, aged 18 to 26 years, who were engaged in critical industry or skills and classified as 1A also had the option of six-months active duty for training. Under this program the remaining 7½ years of the eight-year enlistment were spent in the reserve in a draft-deferred status.

The training of armed forces reserve units is accomplished by lectures, attendance at service schools, field training or sea training duty exercises, and unit training camps, extension courses and on-the-job training at reserve training centres. The courses parallel those given in the resident courses at service schools so far as this instruction is applicable to the wartime duties of the reserve, and is adaptable to instruction by extension course methods. With their consent, reserve personnel may be ordered to active duty in peacetime for periods in excess of 15 days during which time they are paid in the same manner as personnel of the regular establishments.

Courses are available to members of the army reserve in all army schools up to and including the National War college and the Industrial college of the armed forces. Often there is a choice for the applicant of taking either the regular course in a particular school and subject, or a shorter associate course designed especially for the civilian components. Reserve personnel may also serve on short active-duty periods in regular army units, replacement training centres, army schools, R.O.T.C. staffs and in higher headquarters. including the general staff of the department of the army. The above cited conditions obtain generally in the training of reservists of the armed services.

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GREAT BRITAIN

Britain's fighting services after World War II aimed at a very high standard of training in order to compensate for lack of numbers—a factor likely to be even more evident in the future than in the past. This high standard is difficult to attain owing to the complexity of modern weapons and equipment and the advent of the short-service national serviceman. To meet these conditions, greatly improved methods of instruction have been developed.

Higher Training. — The highest level of individual instruction is given at the Imperial Defence college in London, where senior officers of all fighting services and representatives from other commonwealth countries, the civil service and industry study the higher direction of war. At a lower level instruction is given at the Joint Services Staff college at Latimer, Chesham, Bucks., and at the separate staff colleges maintained by each service. Because of world-wide dispersion of units, very large-scale exercises are rarely possible in peacetime, except in the North Atlantic Treaty organization command. Instruction in the handling of large forces — often involving combined operations by sea, land and air — is usually given at theoretical exercises in which the commanders and staffs, but not the troops. take part.

Signal exercises — in which headquarters of units and formations. and their signal communications participate — are held at lower levels, especially to practise junior staff officers.

Training of Junior Leaders. — The standard of its young officers and its noncommissioned officers is the measure of a fighting unit's efficiency, and British defense services place great emphasis on the training of junior leaders.

Potential regular officers are trained as cadets at the service colleges at Dartmouth (navy), Sandhurst, Surrey (army) and Cranwell, Lincs. (air force) usually, but not invariably, after a short period in the ranks.

The policy governing the training of the individual is based on the service schools of instruction. Taking the army as an example, the schools of infantry at Warminster, Wilts., artillery at Larkhill. Wilts., signals at Catterick, Yorks., and many others, exist to teach officers and N.C.O.'s to become instructors who, on completion of their courses, return to their units to train other officers, N.C.O.'s and men.

These schools are directly under the war office, which is thus able to control training policy throughout the army. The system is similar in the other two services.

Training in Units and Formations. — Recruits, regular and national service, on joining the services receive their first few weeks basic training at their corps or regimental depot, or its naval or air force equivalent, before being drafted to units as primarily trained men. The basis of a good unit — naval ship, army unit or air force squadron — is the individual skill of its personnel in handling their weapons, or other equipment, and performing their particular duties. In addition training in teamwork is necessary, as only by combined effort can a fleet, army or air formation fight efficiently. Training in teamwork is known as "collective training."

Also taking the army as an example, individual training is carried out in the winter and collective training in spring, summer and autumn (in the tropics this order is reversed). Collective training begins with subunit (troop and platoon) training and progresses through various stages to large-scale exercises. embracing all arms. For units stationed in Germany after World War II the climax is reached with land and air exercises on a very big scale, and in some overseas commands, such as Hong Kong, the royal navy also participates.

Nonregular Personnel Training. — Territorial army training is supervised by a small cadre of regular officers and senior N.C.O.'s in every unit. The training of territorials (volunteers and national servicemen who have completed their full-time service) is on a part-time basis in drill halls during the evenings, at week-end camps and exercises and at an annual camp which usually lasts two weeks. Its scope varies in different types of unit and is subject to modification to meet local conditions.

Regular reservists of all services are called up occasionally for short periods, mainly to train them to handle new types of equipment.

Army Emergency Reserve Personnel, consisting mostly of men whose duties in war and civil life are similar, are called up for training infrequently and for short periods only.

The Combined Cadet Force — comprising Sea Cadet corps, Junior Training corps (formerly the Officers' Training corps), Army Cadet force and Air Training corps — trains boys up to the age of 17. first basically and then for the particular branch of service which they will join as national servicemen. The purpose of this training is to develop self-reliance and powers of leadership.

(*C*. N. B.)

TRAINING, TRANSFER OF, is the exerting by one habit of some influence upon the learning of, or the memory for, another habit. In some cases one habit may influence another by making the second easier to learn or to remember; this is positive transfer of training. In other cases one habit tends to interfere mith the learning of a second; this is negative transfer of training. Negative transfer of training is one of the important causes of forgetting.

One of the simplest forms of transfer is so obvious that it is likely to escape attention: habits are not entirely specific to the environmental or stimulating conditions that pertain at the time of training. Thus a person who has learned to drive an automobile under one set of environmental circumstances may be expected to drive in a satisfactory manner under many other conditions of traffic and terrain.

Similarly, the golfer who has learned to play on one golf course can transfer his skill to other links. In such cases the change of environment is apt to produce a small loss of efficiency but if the change is not too radical, efficiency will quickly return to its accustomed level.

The fact that habits are not bound to the specific circumstances of the training situation underlies much educational theory and practice. It is not desirable to teach children habits that will operate only in school; it is expected that the habits learned will transfer to life situations that differ markedly from the classroom environment.

While transfer from school situations to subsequent life situations does occur, it would be a mistake to assume that the transfer takes place in an entirely general and comprehensive manner. This view, once widely held and usually referred to as the doctrine of formal discipline, is based upon the theory that mind can be divided into a number of relatively independent faculties or powers. The doctrine of formal discipline held that it was possible to strengthen these various powers of mind by employing relatively formal exercises, much as it is possible to strengthen the muscles of the arm by exercising mith bar bells, and school curricula were designed to provide such mental exercises rather than to teach specific factual content. At the turn of the 20th century. however. an investigation by E. L. Thorndike and R. S. Woodworth cast grave doubt on the plausibility of the theory. Subsequently Thorndike advanced the theory that transfer of training takes place in terms of identical elements existing in two training situations. According to this view the study of mathematics should transfer positively to the later learning of engineering not because the study of mathematics strengthens the analytical powers of the mind but because mathematics is used in and is a part of the latter discipline. In the same way the learning of spelling and grammar should help the student in his subsequent study of English composition.

Identical elements between two learning situations can cause negative transfer as well as positive transfer if the identical elements lead the person to make incorrect responses in the second situation. There are many identical elements involved in driving an automobile in England and in the United States, but in one respect these may cause the driver who moves from one of these countries to the other to make an incorrect response: he may find himself driving on the wrong side of the road. Negative transfer often operates to hinder new learning. For example, if a child is required to learn two equally difficult poems in succession, more effort is required to memorize the second poem than the first; this is because the material that has already been learned tends to become confused with the material being learned in the second poem. This is an example of negative transfer and is sometimes given the name of proactive inhibition. Negative transfer also can produce forgetting. In the example used above it may be shown not only that the second poem is more difficult to memorize but also that. once learned, the new habit tends to interfere with the child's memory for the first poem. This type of memory interference is known as retroactive inhibition and it is believed that a great amount of everyday forgetting may be attributed to this cause.

The theory of identical elements is capable of being refined further. This is because habits themselves are capable of being analyzed into two components: stimuli and responses. While this division is not apparent in complex habits, it is abundantly clear in simple ones. In teaching a dog to come when a whistle is blown, the whistle is the stimulus for the dog and approach is his response, If the dog has been trained to approach at the sound of a particular whistle, it should not be difficult for it to learn a second habit: approaching when a slightly different nhistle is blown. The more similar the new whistle is to the old one, the easier it will be for the dog to transfer its previous training to the new situation. If a very different whistle is used, however, the second habit will be more difficult to establish. On the other hand if the dog is to be taught a different response — to run away, for example — it would be well to use a very different type of stimulus for training the second habit. If the same or a similar whistle is used to stimulate the dog to perform in the second situation, the old habit will interfere with the new response and negative transfer will result Again the similarity between the stimuli is the important factor in determining how much transfer in this case negative, will occur

Two principles governing the amount and direction of transfer from one training situation to a second can be stated.

1. Amount of transfer of training, without regard to whether it is positive or negative, will depend upon the degree of similarity between the stimuli evoking the responses in the two training situations. The more similar the stimuli the greater will be the amount of transfer.

2. Whether transfer will be positive or negative depends upon whether or not the responses learned in the first training situation are appropriate in the second If the first learned responses are appropriate to the second training situation, transfer, if it occurs at all, will be positive; if the responses are inappropriate, transfer will be negative. See also HABIT; LEARNING.

See J. A. McGeoch, *The Psychology of Human Learning*, rev. ed. by A. L. Irion, ch. 9 (1952); C. E. Osgood, *Method and Theory in Experimental Psychology*, ch. 12 (1953). (A. L. I.)

TRAJAN (MARCUS ULPIUS TRAIANUS; A.D. 53–117), Roman emperor, was born at Italica, near Seville. His family was Spanish, possibly with some Italian blood, but his father had had a distinguished career under Vespasian, earning a consulship, patrician rank and ornamenta *triumphalia*. The son served ten years as a military tribune, partly under his father's command in Syria. In 88/89 he was commanding a legion in Spain when it was summoned to the Rhine by Domitian against Antonius Saturninus. He obeyed orders promptly and was given an eponymous consulship in 91, but Domitian did not, apparently, employ him again. On Nerva's accession he was appointed governor of Upper Germany, with three legions. About Oct. 27, 97, Nerva, faced by a mutiny of the praetorian guard in Rome and by the possibility of military uprisings elsewhere, publicly adopted Trajan as his successor; the mutineers were punished and all trouble ceased.

The nearest army commander was an effective choice in the circumstances, but Nerva had himself put Trajan in this key position, presumably with an eye to his record and character, and on all counts Trajan quickly justified his selection. It was always difficult to find a man who could fill equally well the roles of imperator for the provinces and of princeps (not *dominus*) in Rome. When Nerva died (c. Jan. 27, 98), Trajan bore out his military reputation by remaining for several months on a tour of inspection of the Rhine and Danube frontiers. But he at once swore an oath never to execute a senator, and when he returned to Rome in 99 to hold his third consulship in 100, he took care, even in the smallest details of ceremony and behaviour, to show himself a loyal servant of the constitution, at once respectful toward the senate and indulgent toward the people.

Throughout his reign relations between senate and princeps remained excellent. All important decisions were in fact still taken by the emperor, but the senate's opinion was politely consulted, and its interminable debates, often ending with a supine reference to the emperor, were a prerequisite to any action within its traditional spheres of competence. The reward of Trajan's patience and understanding was the loyal co-operation of all members of the senatorial class, and he knew how to get the best out of all types of public servant. It was this aspect of his rule that won him the title *Optimus* (with the implication that he ruled not by right of inheritance but as the best man available), though characteristically he did not accept this title officially until 114.

In Rome Trajan was particularly noted for his magnificent games and buildings. He did much for Italy, reclaiming wasteland and building roads, aqueducts and new harbours at Ostia, Centumcellae and Ancona. He tried to arrest the decline of Italian agriculture and manpower by extending the *alimenta* system of Nerva, by making senators invest in real estate in Italy and possibly by forbidding emigration. His record of provincial administration is less easy to assess. In generai it was efficient, combining firmness with humanity—witness his treatment of the Christians: they remained an illegal sect, liable to punishment; but there must be no organized persecution. Yet we hear from Pliny of several senatorial proconsuls' being tried for misgovernment (possibly a sign that Trajan's lenience toward this class was abused) and of special imperial officials' correcting irresponsible local government in provincial towns (this form of paternalism was to have a paralyzing effect later). It is also possible that his wars overstrained the manpower and economic strength of the empire, particularly of the eastern provinces.

Trajan's reign saw the last major extensions by conquest of the Roman frontiers. The Dacian Wars (101/102 and 105/106) converted an aggressive mountain kingdom into a bastion of the empire. The acquisition of Arabia Petraea (105–106) was a logical consequence of Vespasian's tidying up of the Syrian frontier. It is also arguable that Trajan's main object in going to war with Parthia in 113 was to establish a workable eastern frontier all the way from the Red sea to the Caucasus. But the evidence for all these campaigns is extremely inadequate. especially for topography. It seems likely that the First Dacian War was designed merely to bring Decebalus to heel as a controlled client king; when he surrendered he was left with a diminished kingdom and with a Roman garrison in his capital, Sarmizegethusa. Apollodorus' bridge across the Danube was thus to serve the garrisons north of the river. On Decebalus' revolt in 105, Trajan drove the Dacian raiders out of Moesia and besieged and captured Sarmizegethusa; and the war ended with Decebalus' suicide and the rounding off of Dacia, including its gold mines, as a Roman province. Further east the Tropaeum Traiani at Adamklissi indicates similar effective measures against the Bastarnae and Rhoxolani, who helped Decebalus in 101/102 and had caused continual trouble for some time. Colonies, roads, camps and patrolling river fleets now linked' the whole northern frontier from the English channel to the Black sea into one economical defensive system.

The Eastern War (113–117) started when Chosroes of Parthia violated the Neronian settlement by supplanting a Roman nominee by one of his own on the throne of Armenia. Trajan's reply was unexpectedly energetic for a man of 60 years. He rapidly overran Armenia and northern Mesopotamia, which became for a while Roman provinces. Then, either lured by these successes or seeking a decisive encounter with the Parthians, he went on to capture Ctesiphon and sailed down the Tigris to the Persian gulf, where he sighed for the youth of Alexander. At this point the Parthians counterattacked and all the newly occupied territory rose behind him. Trajan was caught with his forces hopelessly deployed, but by the end of 116 he had recovered some of the lost ground, and he fully intended to resume the struggle next year. Then he fell dangerously ill. Reluctantly he started back for Rome, presumably meaning to arrange with the senate the delicate question of his successor—delicate because the "best man" seemed to be Hadrian, a relation. But he died on the journey, at Selinus in Cilicia, c. Aug 8, 117. He would never have left Hadrian in charge of the army in Syria if he had not now decided to adopt him. But the genuineness of the deathbed adoption was doubted, Hadrian wished to be free to secure his own position, and a peace was hastily made with Parthia under which all Trajan's recent conquests were abandoned.

See R. Paribeni, *Optimus Princeps*, 2 vol. (Messina, 1926–27); B. W. Henderson, *Five Roman Emperors* (London, New York, 1927). (F. A. LR.)

TRAJECTORY. In mechanics the term trajectory denotes the path described by an object which is moving under the influence of a system of forces. For example, a projectile leaving the muzzle of a gun moves through the air under the influence of two forces. namely, gravity and air resistance; the path or curve that the projectile describes in space is termed its trajectory (see BALLISTICS). Likewise in astronomy, the trajectory of a celestial body is its path in space determined by the gravitational forces. A kno ledge of the forces acting on an object makes it possible, through Newton's second law, to compute the trajectory of the object; *i.e.*, the curve described and the object's position on that curve at any given instant.

In meteorology the term is applied to the path followed by an air particle through the atmosphere. Here the motion is determined by the pressure, Coriolis and frictional forces (see METEOROLOGY).

Since the motion of the air at all levels in the atmosphere is a prime factor in determining weather change. the meteorologist attempts to determine and predict air trajectories, Direct experimental evidence on air trajectories can be obtained by tracking gas-filled balloons: set to float at a given pressure level in the atmosphere.

A broader use of the term trajectory is found in mathematics. In addition, a trajectory may be defined as (1) a curve or a surface drawn through a set of points and (2) a curve or surface which intersects a family of curves or surfaces at a constant angle. In the latter case, if the angle of intersection is a right angle, the trajectory is called an orthogonal trajectory. (J. M. AN.)

TRALEE (*Traigh-li,* "the strand or shore of the Lee"), a seaport and the county town and administrative capital of County Kerry. Ire., lies 20 mi. N.N.W. of Killarney. 64 mi. S.W. of Limerick and 74 mi. W.N.W. of Cork by road. Pop. (1961) 10,714. It is well served with road and rail conveyances to the numerous watering places along the coast. It is connected n·ith the port of Fenit, 7 mi. W., by road and rail. Large vessels discharge at Fenit where the viaduct has been reconstructed and where coal: iron and timber are imported.

The Geraldines. who came in the Norman invasion, fortified the town and founded in it a Dominican abhey in 1243, and from this event Tralee's recorded history began. The ruins of this abhey contain the remains of many of the earls of Desmond. Tralee was incorporated by James I. (C. T. K.)

TRALLES (mod. GUZEL **HISSAR**), an ancient town of Caria, Asia Minor, situated on the Eudon, a tributary of the Maeander. It was reputedly an Argive and Thracian colony, and was long under Persian rule, of which we hear in the history of Dercyllidas' raid from Ephesus in 397 B.C. Fortified and increased by the Seleucids and Pergamenians, who renamed it successively Seleucia and Antiochia, it passed to Rome in 133. Rebuilt by Andronicus II about 1280. it was superseded a few years later, after the Seljuk conquest, by a new town. founded by the amir Aidin in a lower situation. *See* AYDIN.

TRAMWAY: see ELECTRIC TRACTION.

TRANENT, a small burgh of East Lothian, Scot.. 8 mi. E. of Edinburgh by road. Pop. (1961) 6,317. The town possesses the oldest coal-mining charter (1202–18) in Great Britain, and the mines in the neighbourhood provide the staple industry, though there is a great deal of arable farming on the very fertile soil. In 1954 the New Ross high school was opened.

In the neighbouring village of Ormiston, 2 mi. S. on the Tyne Water (pop., 1951, 1,914), Robert Moffat (1795–1883), the South African missionary and father-in-law of David Livingstone, was born.

TRANG, a *changwat* in southern Thailand on the west coast of the Malay peninsula facing the Bay of Bengal. Area, 1,909 sq.mi.; pop. (1960), 240,463; including significant minorities of Chinese and Malays. Major products are tin and rubber, both developed initially by Chinese immigrants and still produced in large part by their descendants. Trang town, pop. (1960) 17,158, the provincial capital, is a crossroads of major highways and lies on the rail spur whose southern terminus is Kantang, a small port near the mouth of the Trang river 12 mi. to the south. (G. W. SK.)

TRANI, a seaport and episcopal see of Puglia. It.. on the Adriatic. in the province of Bari and 26 mi. by rail W.N.W. of that town, 23 ft. above sea level. Pop. (1957 est.) 37.501 (commune). The cathedral (dedicated to St. Nicholas the Pilgrim. a Greek who died in 1094 and was canonized by Urban II), on an open site near the sea. was consecrated, before its completion, in 1143; it is a basilica with three apses, a large crypt and a lofty tower, the latter erected in 1230–39 by the architect whose name appears on the ambo in the cathedral of Bitonto, Nicolaus Sacerdos. It has an arch under it, being supported partly on the side wall of the church and partly on a massive pillar. The arches of the Romanesque façade are ornamented; the bronze doors, executed by Barisanus of Trani in 1175, rank among the best of their period in southern Italy. The capitals of the pillars in the crypt are fine examples of the Romanesque. The interior of the cathedral has been barbarously modernized, but the crypt is fine. Near the harbour is the Gothic palace of the doges of Venice, which is now used as a seminary. S. Giacomo and S. Francesco also have Romanesque facades, and the latter and S. Andrea have domes. The fine castle was begun by Frederick II (1233) and enlarged in the 15th and 16th centuries. The Palazzo Caccetta (1458) is a fine Gothic building. Trani produces wine (Moscato di Trani). Trani is the *Turenum* of the itineraries. It first became a flourishing place under the Normans and during the crusades, but attained the acme of its prosperity as a seat of trade with the east under the Angevin princes. Its code of maritime law (the *ordinamenta maris*) is the first of medieval codes (1063).

TRANQUILIZING DRUGS are a group of drugs that are useful in the treatment of mental disease, their chief characteristic being that they have a calming effect on disturbed patients, making those patients more accessible to psychotherapy. The tranquilizers fall into at least two different groups on the basis of their pharmacologic action, and into four different chemical classes: (1) alkaloids, of which the best known is reserpine; (2) phenothiazines, with chlorpromazine the oldest and best-known representative; (3) diphenylmethanes. including benactyzine; and (4) propanediols, typified by meprobamate.

Drugs that act on the nervous system have long been known and used, as the depressants (anesthetics and sedatives) and stimulants (convulsants). Even drugs that alter mood and behaviour more subtly. as alcohol and caffeine, are hardly new. Yet the exploitation in modern psychiatry of agents that produce or relieve hallucinations or anxiety or other attributes of mental experience had an explosive effect on many aspects of life.

Psychoactive drugs—that is. drugs that affect mental life or behaviour—may be divided into two groups: (1) those that produce symptoms seen in the mentally ill, the psychosomimetics, and (2) those that relieve these symptoms, known by the not too satisfactory name of tranquilizers. A number of tranquilizing (also called ataraxic) substances are prescribed by physicians, and several times this number are being prepared and tested. Some of these drugs have been purified from nature, as the snakeroot or *Rauwolfia* alkaloids; most have been synthesized in the laboratory, as chlorpromazine and meprobamate.

The exact locus and manner of action has not been established for any of these agents. All but the meprobamatelike group act upon the autonomic (visceral) nervous system to cause changes in heart action, blood pressure, intestinal movements, skin colour, pupil size, etc., but these actions are not essential for the action on mental condition. Reserpine liberates a substance from the brain, the amine serotonin, which has a number of physiological effects on nerve and muscle cells. Chlorpromazine, which acts much like reserpine clinically, does not release serotonin, though it does decrease the action of the related epinephrine. Bromlysergic acid, which does release the amine, is hardly active pharmacologically. Both reserpine and chlorpromazine are tranquilizers, yet they render animals more sensitive to convulsions produced by strychnine or electric shock and can even initiate "convulsive" activity in certain deep portions of the brain.

Tranquilizers, in addition to their differences in mechanism, also act differently on mood and behaviour. Reserpine and chlorpromazine render monkeys "tranquil" to handling, inactive and unresponsive to a signal of an impending shock; meprobamate does not eliminate the conditioned responses or decrease their activity but has some taming action. In man, also, chlorpromazine and reserpine quiet disturbed psychotic patients. while meprobamate has little effect; conversely, meprobamate seems more effective in relaxing neurotic tension. anxiety and muscle spasm.

Although the effective tranquilizers give relief from certain psychotic and neurotic symptoms. there is no evidence that they produce cures, and there is reason to suspect that chronic use may lead to occasional addiction. toxicity or other untoward effects. Changing disturbed mental patients to undisturbed ones, however, has made psychiatric wards more peaceful, and the use of these drugs seems to be related to a decrease in hospital population. The wide and sometimes indiscriminate use of certain tranquilizers to relieve strain and worry by persons who are not mental patients is even harder to evaluate. The effective therapeutic action and the price that must be paid in terms of dulling of drive or attention remain to be established. *See* also NEUROPHARMACOLOGY AND PSYCHOPHARMACOLOGY; PSYCHIATRY. (*R.W.* G.)

TRANSCAUCASIA. From March 12, 1922, until Dec. 5, 1936, the republics of Armenia, Georgia and Azerbaijan were combined to form the Transcaucasian Soviet Federated Socialist Republic, which on Dec. 30, 1922, became a constituent part of the Union of Soviet Socialist Republics. With the adoption of the so-called Stalin constitution, the republic was dissolved. For the geography of this region *see* CAUCASUS; for history, *see* ARMENIA, AZERBAIJAN and GEORGIA.

TRANSCENDENTALISM. "Transcendentalism" is an expression originally used to designate the philosophy of Immanuel Kant (*q.v.*), who spoke of his *Critique of Pure Reason* as laying down the plan for a complete "transcendental philosophy"; its use was later extended, perhaps because of the title of F. W. J. von Schelling's *System of Transcendental Idealism* (1800) and the influence of S. T. Coleridge, to cover the thought of the German idealists generally. In the United States the term was at one time predominantly understood as referring to the tenets of the members of the Transcendental club, founded in Boston in 1836. These "Transcendentalists," among whom *R.* W. Emerson (*q.v.*) is much the best-known, professed a form of romantic idealism whose main driving force was an antipathy to the philosophical outlook of the Enlightenment. They constitute the American equivalent of Coleridge and of Thomas Carlyle, both of whom had some influence on them.

Kant gave a special meaning of his own to the term "transcendental," but he did not coin the word. Medieval philosophers grouped together under the title *transcendentia* or *transcendentalia* those concepts, such as "being," "unity" and "goodness," which cut across the Aristotelian division of categories, in the sense of not being predicable under any single category; Aristotle himself (cf. *Metaphysics* Γ, 2; *Nicomachean Ethics,* i, *6)* had recognized their special characteristics without giving them a special name. The doctrine of transcendentals is already present in Albertus Magnus, author of the dictum *quodlibet ens est unum, verum, bonum,* and in St. Thomas Aquinas; but it was left to Duns Scotus to work it out in detail. Besides being (the most general of all concepts), Duns in his *Opus Oxoniense,* book i, distinction 8, question 3, recognizes two important classes of transcendental attributes: those, such as "one," "true," "good," which are simple, coextensive with being *(passiones convertibiles)*; and those, such as "contingent" and "necessary," "actual" and "potential," which are disjunctive *(disjunctae)*. *(See* A. B. Wolter, *The Transcendentals and their Function in the Metaphysics* of *Duns Scotus,* Washington, 1946.)

Although Kant mentions the "transcendental philosophy of the ancients" in one passage in the *Critique of Pure Reason* (2nd ed., p. 113, 1787), his own understanding of the term seems, on the surface at least, to have little to do with the doctrines just mentioned. Transcendental philosophy, for him, comprises first an inquiry into the nature and extent of the a *priori* elements in knowledge and second a complete enumeration of those elements, together with analyses of the concepts involved and a full review of what can be deduced from them *(ibid.,* p. 27). Behind this program, which Kant did not claim to be carrying out in full but for whose execution he thought his own work provided a firm foundation, lay Kant's own special philosophical conceptions. The first task of philosophy, in Kant's view, was to conduct a critique or critical examination of the powers of speculative reason. The extent of these powers had, he believed, been much exaggerated by earlier philosophers when they claimed to be able to arrive on the basis of pure reason at conclusions about the fundamental nature of things. Metaphysicians had thought it possible to begin from premises which were alleged to be self-evident and from them to deduce what looked like important truths of fact (*e.g.,* that God exists and that the human soul is immortal); and though no one of these "proofs" had escaped criticism, attempts to construct them continued. It was Kant's aim at once to explain these metaphysical pretensions and to show them to be baseless. To explain why they were made we must take account of what for Kant was a fact, namely that pure reason has some knowledge of its own, or, in his own language, that there are some valid synthetic *a priori* judgments. But an examination of the logical status of these judgments and of the conditions under which they were possible showed that their existence afforded no real encouragement to metaphysicians. for they turned out to be not so much material truths as propositions concerning the form of experience. Their function was to express the necessary conditions of experience as such. and they were accordingly empty in themselves, gaining significance only when brought to bear on concrete data. Thus the principle that every event has a cause. to take Kant's best-known example of a synthetic *a priori* truth, may be treated as an injunction to seek causal connections throughout experience; in this sense it may be said to prescribe the form of possible experience. But it is an empty truth except when used in conjunction with empirical data; in advance of experience we can say on the strength of it only that an event will have some cause or other, not what its cause must be. It follow-ed that the kind of use of the causal principle which metaphysicians had attempted to make (*e.g.,* in the "First Cause" argument for God's existence) was illegitimate, since in passing beyond the bounds of the experienceable they automatically deprived themselves of the data without which pure concepts of the understanding were so much idle machinery.

This general sketch should serve to throw light on Kant's peculiar definition of "transcendental" and his distinction between "transcendental" and "transcendent." "I entitle *transcendental,"* he writes, "all knowledge which is occupied not so much with objects as with the mode of our knowledge of ohjects'in so far as this mode of knowledge is to be possible *a priori" (op. cit.,* p. 25). The term "transcendental." that is to say, is in place only when epistemological questions are being asked, and then only when the hypothesis that some of our knowledge is *a priori* is being considered. Thus the "Transcendental Aesthetic," the first main division of the *Critique,* is an examination of whether there are any *a priori* elements in human sensibility and an attempt to establish that the ideas of space and time answer this description; while the celebrated "Transcendental Deduction of the Categories," which constitutes the centre of Kant's whole argument, seeks to show both that there are concepts of this nature *(a priori* concepts) and what their role in knowledge is. Similarly the "transcendental idealism" to which Kant commits himself gets its name from his belief that what we know is conditioned by factors in our cognitive apparatus. To have drawn attention to these factors was, in Kant's own view, among his main philosophical achievements. But he was equally insistent that to show that a concept or principle functions *transcendentally* will not justify our making a *transcendent* use of it. We attempt such a use when we seek to apply an *a priori* concept such as cause or substance, not to the ordinary objects of experience, which Kant called "appearances," but to "things in themselves," which by definition lie beyond the sphere of experience. It was characteristic of philosophical dogmatism, Kant thought, to make such attempts; why he believed they must fail has already been indicated.

In later philosophical terminology, Kant's principal merit in this part of his work may be said to be his having initiated an inquiry into the precise status and nature of principles which function as ultimate presuppositions. He saw that a dictum such as "every event has a cause" neither expresses a truth of reason in the Leibnizian sense (since it is not analytically true), nor yet is a simple truth of fact, as empiricists had supposed; and he realized that the establishing of presuppositions of this kind constitutes a special problem, since neither deduction from the self-evident nor induction from experience can form their basis. His appeal to the argument "from the possibility of experience." sometimes known as "transcendental proof," was his own way of solving this problem. But the careful limitations that he sought to place on the powers of pure reason had little appeal to his immediate successors. The "transcendental idealism" of Schelling is entirely different from the "transcendental idealism" of Kant, in so far as it seeks to establish truths about the reality which lies behind the phenomena of nature and mind; *i.e.,* just such a thesis as Kant had argued to be inadmissible. It was because of its use by Schelling and others like him that "transcendentalism" acquired the pejorative overtones which it retains in many philosophical circles.

(W. H. W.)

TRANSCRIPTION, in music, is the arrangement of a composition written for one instrument (or group of instruments) for performance by one of another kind. as of an organ work for the piano, of an orchestral work for the organ and so on.

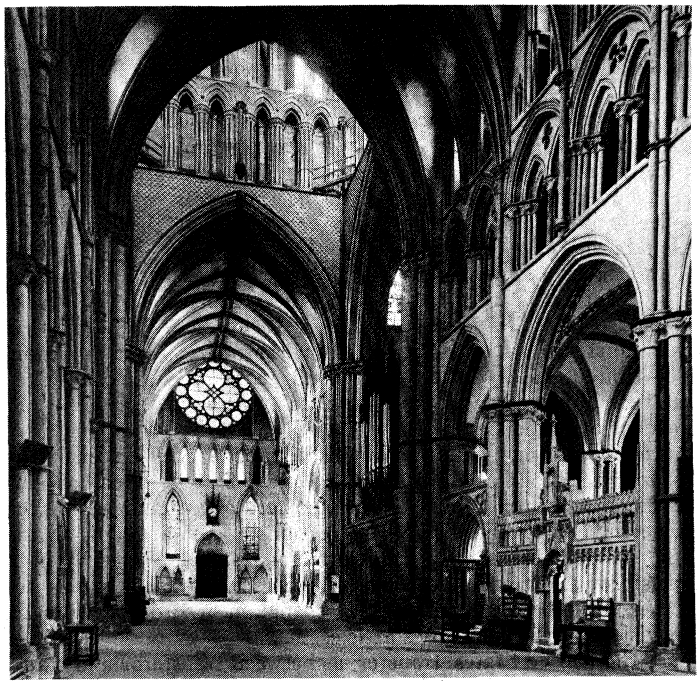
TRANSEPT, in architecture, is a transverse section or portion of a hall or building, of considerable relative size. whose main dimension is at right angles to the long dimension of the building proper. thus developing a plan of either cruciform or T shape. In ecclesiastical architecture, it is the arms of the church, at right angles to the nave.· At least two early Christian basilicas in Rome, St. Peter's and St. Paul's, were from the beginning provided'with transepts, each taking the shape of a long, unbroken transverse hall whose length was equal to or extended beyond the combined width of nave and aisles and was separated from the nave by a great arch known as the triumphal arch. In the opposite wall an arch of similar size led into the apse.

The transept, however, constitutes no essential part of the architecture of the basilica (*q.v.*); it never occurred in the civil basilicas of ancient Rome. Though hardly a Christian invention, its origin and original purpose remain conjectural. Conceived as an extension of the sanctuary proper, rather than of the nave and aisles where the congregation assembled, the transept may have been adopted in order to accommodate a large number of clergy or in order to provide space for the tables on which the faithful deposited their offerings. A more plausible interpretation is suggested by the early use and conspicuous development of transepts in the ecclesiastical architecture of the Christian east.

In Palestine, Asia Minor, Egypt and Greece the transept was either combined with basilical structures or incorporated in churches of central plan, forming two arms of an equilateral cross. Invariably these eastern transept churches were dedicated to a martyr who was buried there (St. John's, Ephesus; the Menas basilica in Egypt; St. Demetrius' at Salonika) or to the memory of a sacred event believed to have occurred at the place where the sanctuary was built (Church of the Multiplication of Loaves, Palestine). The transept facilitated the circulation of large numbers of pilgrims past or around the place of worship. The connection of the transept with the cult of the Christian dead is all the more noteworthy because of antecedents of transept architecture that occur in funerary structures of Greek and Roman antiquity.

Eastern influences or the cult of relics may account for the reintroductioq of the transeptal basilica in the west during and since the 8th century (St. Praxedis at Rome; St. Denis, near Paris; abbey at Centula [St. Riquier]). The great development of the transept began in the 11th century. Among the great basilical churches of the Romanesque period there is hardly one without a transept. Liturgical requirements of the Benedictine order and the increasing number of clergy that had to officiate in monastic and cathedral churches account for this development. In the churches of the congregations of Cluny and Citeaux additional altars were placed along the eastern walls of the transepts or in chapels opening out of these walls. In the abbey of Cluny (begun 1089) there even were two transepts in the eastern part of the basilica.

German Romanesque basilicas, which were often provided with t o apses, one at each end of the nave, occasionally also have two transepts inserted between nave and apses, as in St. Michael's at Hildesheim. In this church each transept arm terminated in two superimposed galleries dedicated to the cult of the angels. Romanesque transepts tend to be large and are frequently designed like the naves, with triforia, clerestories and even side aisles. In several churches (St. Maria im Kapitol, Cologne; St. Lucien at Beauvais) transept arms ended hemispherically like the main apse and thus described a trefoil ground plan. This pattern, derived from Christian antiquity (6th-century additions to the Nativity basilica at Bethlehem), was adopted once more in the early Gothic cathedrals of Tournai, Noyon and Soissons. (See ROMANESQUE ARCHITECTURE.)



A F. KERSTING

NORTH TRANSEPT OF LINCOLN CATHEDRAL. ENGLAND

The transept loses its importance in Frehch Gothic architecture, which provided space for subsidiary altars in chapels radiating from the ambulatory. In the cathedrals of Paris and Bourges the transept does not project at all beyond the outer walls of the church; in Chartres, Reims and Amiens it extends beyond the nave but merges with the contour of ambulatory and chapels.

In England, where even the cathedral clergy often lived under the Benedictine rule, large churches continued to be provided, even in Gothic times, with large transepts, often with two of them. In Durham the Nine Altars transept was added in the 13th century. These English transepts tend to be large, the west transept of Lincoln (c. 1200) being almost 225 ft. long, the transepts of York (c. 1216–56) about 220 ft. and .those of Lichfield (1220–40) about 145 ft. The most beautiful of all are the double transepts of Salisbury (begun 1220). (See GOTHIC ARCHITECTURE.)

In Renaissance architecture and baroque architecture (*qq.v.*), transepts, often with hemispherical endings, continue to be frequent. Bramante planned St. Peter's at Rome as an equilateral cross. each arm of which was to be apse ended. In modern church architecture the transept seems to be less common.

In the U.S., transept cathedrals have for the most part followed European precedents. The Cathedral of St. John the Divine in New York city was designed in the Gothic style. with a transept 320 ft. long; the Cathedral of St. Peter and St. Paul in Washington, D.C., with a transept 135 ft. long, was patterned after English Gothic cathedrals.

Attempts to interpret cruciform churches symbolically and to see in the arms of the transept the arms of the cross or crucifix appeared at an early date and continued through the middle ages and even the Renaissance. Such interpretations, however, do not indicate the source of transeptal architecture but rather were inspired by it.

See also RELIGIOUS ARCHITECTURE; BYZANTINE ARCHITECTURE.

(O V. S.; X.)

TRANSFER, in law, means the extinguishing of an interest in an object of property in one person and the creation of such interest in another person. For the form or method by which a transfer of land is effectedsee LAWS OF REAL PROPERTY AND CONVEYANCING; for personal property generally see PERSONAL PROPERTY.

This article describes the procedure for transfer of securities that are called in the U S stocks and bonds and for which the corresponding terms in England are shares and stocks or debentures. Stocks (U.S.) or shares (Eng.) define the extent of an investor's holding in the capital of a company or corporation. Bonds (U.S.) and stocks or debentures (Eng.) represent the investor's holdings or participation in a loan to a company, municipality or government (see STOCK). In the transfer of these securities three persons are concerned: the transferee, who may be a buyer or recipient of a gift; the transferor, who may be a seller or donor; and the company or other body that has issued the security.

In English and commonwealth law shares are regarded as essentially contractual relations between the company and the stockholder so that the power to transfer, if any, and the form that the transfer must take are based on the articles of association. The United States, on the other hand, tends to look upon shares of stock as property so that power to transfer is regarded as an incident of property.

An outward manifestation of this difference may be seen in the form of the stock certificate in the United States, which contains on its back a form for endorsing transfers or assignments by the owner named on the face of the certificate. In England, on the other hand, there is a separate form for transfer, signed by both transferor and transferee, which is then sent to the company together with the old certificate for change in accordance with the provisions of the company's articles.

In the United States, transfer, as between transferor and transferee, is effected by delivery to the transferee of the stock certificate properly endorsed or assigned on the back. If the endorsement or assignment omits the name of any transferee, any person possessing the certificate, even wrongfully, may claim it as his own and further transfer it to innocent persons. The Uniform Stock Transfer act in force in most states tends to make a stock certificate a negotiable instrument.

As betneen owner of the stock and the company, however, transfer is not complete by delivery of the certificate from transferor to transferee but only on change of registration on the books of the company, usually kept by a professional transfer agent or registrar. In England the transfer agent is entitled to treat the registered owner as absolute owner and has no duty to inquire as to his power to transfer. In the United States transfer agents have considerable responsibilities to see that wrongful transfers do not occur. It is for this reason that they refuse to register stocks in the name of children and, more importantly, require that the signature of the owner endorsing a transfer be guaranteed by a bank or person known to the transfer agent. If the stock is owned by an executor or trustee even more onerous duties are imposed on transfer agents. To avoid these complications many trustees and large traders keep their securities registered in the names of nominees, that is, individuals whose names and signatures are on file with the transfer agent.

Bonds or debentures are usually negotiable securities that may be issued in registered form (*e.g.*, U.S. savings bonds) or bearer form. Where transfer is permitted, as it usually is, it too is effected by delivery or delivery and endorsement.

In England and some states of-the U.S. there is a tax imposed on the transfer of securities based on the market or sometimes par value of the security. (A. DM.)

TRANSFORMATION GROUPS: see GROUPS.

TRANSFORMER, an electric device for stepping up or stepping down voltage, depending on which is desired. Transformers are employed for widely varied purposes; *e.g.*, to operate toy electric trains, increase the effectiveness of telephone transmitters and transmit electric power at high voltages for long distances. Transformers change voltage through electromagnetic induction and without any continuously moving parts. As they change voltage transformers also change current, although the frequency of the current is unchanged. In a step-up transformer the voltage delivered is greater than the voltage received and the current is less. In a step-down transformer the voltage delivered is less than the voltage received and the current is greater.

General Principles of Operation.—In the simple transformer shown in fig. 1 two windings of insulated wire surround the central portion of a magnetic core that consists of thin sections, or laminations, of steel stacked side by side. A lamination thickness of .014 in. is common for transformers that operate at 60 cycles (cy.) per second. The core represented may consist of E- and I-shaped laminations stamped from steel sheets having the desired thickness and magnetic properties. The sheets are usually given a heat treatment known as annealing to improve their magnetic properties. An oxide that forms on the lamination surfaces during the annealing process is a poor electrical conductor and provides some insulation between adjacent laminations. If more insulation is necessary the laminations may be dipped in an enamel that yields a hard finish when baked.

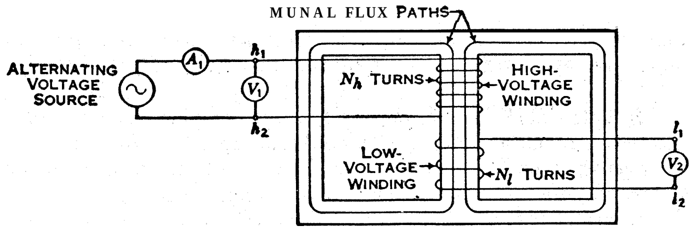


FIG. 1.—WINDINGS AND CONNECTIONS OF A SIMPLE TRANSFORMER

In fig. 1 an alternating voltage source is connected between the terminals h_1 and h_2 of a high-voltage winding having N_h turns. This causes the winding to become a primary. A voltmeter V_1 connected between h_1 and h_2 registers the effective voltage. A graphical representation of the time variations of the voltage is the voltage wave form. With what is known as a sine wave form the maximum instantaneous voltage is 1.41 times as great as the reading on V_1.

The application of voltage to the high-voltage winding establishes an alternating current. The current in the N_h turns causes an alternating magnetomotive force that in turn establishes alternating magnetic flux in the core. In fig. 1 two flux paths are represented. Since the flux passes through both windings, it is common to them and is called the mutual flux. Usually either air, an insulating vapour or oil surround the windings and the core. These materials are poor magnetic conductors compared with the core and so most, but not all, of the flux is confined to the core. For the present, assume that all the flux is in the core. The alternating flux induces an electromotive force of self-induction in the high-voltage winding nearly equal at every instant to the voltage applied to the winding. This electromotive force acts as a throttle or choke and causes the current to be much less than if the winding had resistance only and no self-inductance. The current drawn is called the exciting current. Its effective value is registered on the ammeter A_1 in fig. *1.* The value of the exciting current drawn by a winding with a given number of turns when operated at a given voltage and frequency depends upon the cross section of the core normal to the flux and the magnetic properties of the steel. Because of surface irregularities the contact of an E lamination with an I lamination is never complete. As a result the exciting current is greater than it would have been with no separation between laminations.

With a sine wave form of voltage the voltage equation of a transformer is

$$V = 4.44 N f B_m A \times 10^{-8}$$

where V root-mean-square (effective) volts (v.) are applied to the N turns of a winding, f cy. per second is the frequency, B_m lines, or maxwells, per square inch is the maximum instantaneous flux density in the core of A sq. in. cross section. For transformer steel a typical value for B_m is 70,000, a value that may be used in the above equation to design a winding for use at a given voltage and frequency on a given core.

In fig. 1 the mutual flux set up by the exciting current in the high-voltage winding induces an electromotive force of mutual induction in the low-voltage winding. Assuming that all the flux is confined to the core, the voltage induced in each turn of the low-voltage winding is equal to that in each turn of the high-voltage winding. As a result the voltage across the high-voltage winding as registered on voltmeter V_1 is to the voltage across the low-voltage winding as registered on voltmeter V_2 as the number of turns N, is to the number of turns N_l. The transformer is operating to step down the voltage since N_l is less than N_h.

If a load such as a lamp is connected between terminals l_1 and l_2 in fig. 1, an alternating current flows in it. One action of this current is to reduce the amount of mutual flux. This action in turn causes a proportional reduction in the electromotive force induced in the high-voltage winding and permits more current to flow in that winding A component of current appears in the high-voltage winding that is equal to the current in the low-voltage winding divided by the inverse ratio of turns. That is, if a transformer has $N_h = 1{,}000$ and $N_l = 100$, the ratio of turns is $1{,}000 \div 100 = 10$. If the low-voltage winding is delivering 20 amp., a component of $20 \div 10 = 2$ amp. appears in the high-voltage ninding. In general, the reading on the ammeter A_1 would not increase exactly two amperes since the two-ampere component would add vectorially and not numerically to the current that existed in the high-voltage winding with no current drawn from the low-voltage winding.

The flow of current through the winding resistances causes a heat loss that raises the winding temperature. The rated. or full-load, current of a ninding is the value which, when carried continuously, causes the specified temperature rise. The design of 60-cycle transformers is such that the exciting current is likely to be 5% of the rated current.

If the rated current of the low-voltage winding of a 10-to-1 ratio step-down transformer is 20 amp. then, when the low-voltage winding is delivering 20 amp., a component of 2 amp. is required in the high-voltage winding. If the load were disconnected from the low-voltage winding the current in the high-voltage winding would drop to the exciting value, or about 5% of 2 amp., which is .1 amp. The vectorial addition of 2-amp. and .1-amp. components could not be more than 2.1 amp. and would have that value only nhen the nature of the load is such that the components are in time phase. Usually the resultant current is just over 2 amp. Hence when the windings are carrying their rated currents the ratio of the currents is very nearly equal to the inverse ratio of turns. The cross section of the wire required in the high-voltage winding would be about one-tenth that in the low-voltage winding. The volume of copper in the high-voltage winding is roughly equal to that in the low-voltage winding, since the winding with the greater number of turns has the wire of smaller cross section.

Assume that 1,000 v. at rated frequency are applied to the high-voltage winding of a transformer that has a turn ratio of 10 to 1. With no load connected to the low-voltage winding the voltage across it is 100 v. Further assume that the exciting current is .1 amp. Now assume that when enough lamps are connected across the low-voltage winding to cause it to deliver its rated current of 20 amp., the current in the high-voltage winding increases to 2.01 amp. The voltage delivered will decrease. usually by a small percentage. Assume that the decrease here is from 100 to 98 v.

Part of the decrease occurs because of resistance in the windings. The remainder occurs because of what are called the leakage reactances of the windings. Flux that links one winding and not the other is called the leakage flux of the winding that it links. The voltage induced in a winding by its leakage flux divided by the minding current is the leakage reactance of the winding. The leakage reactances depend upon the distance between the windings. With a core such as in fig. 1 it is common to have one minding completely surround the centre portion and the second winding surround the first.

The capacity of a transformer is specified in volt-amperes (va.) or kilovolt-amperes (kva.). If a winding is rated at 100 v. and 20 amp., the transformer capacity is 100 v. $\times$ 20 amp. = 2.000 va. or 2 kva. In the example considered above the transformer was delivering 98 v. $\times$ 20 amp. = 1,960 va. with an input of 1,000 v. $\times$ 2.01 amp. = 2.010 va. Hence the volt-ampere input and output are nearly equal.

The steel in a transformer core is an electric as well as a magnetic conductor. The alternating flux induces electromotive forces in the steel. These produce eddy currents in the steel, which in turn produce heat, known as the eddy current loss. For frequencies up to a few thousand cycles per second the eddy current loss can be kept to a value that can be tolerated by building the core of laminations rather than using a core of solid steel. Just how thin the lamination should be for a given frequency is determined by economic considerations. As laminations are made thinner the eddy current loss is reduced, but the cost of making and handling a greater number of laminations is increased. The thickness of the insulation needed is the same on thin as on thick laminations. As a result, with extremely thin laminations the insulation occupies an objectionably large percentage of the gross cross section of a core.

Hysteresis (*q.v.*) loss also takes place in the steel of a transformer core, occurring when the steel is carried through magnetic cycles represented by the alternating flux. This loss is not reduced by laminating the core. The hysteresis loss at a given frequency and flux density can be reduced only by improving the magnetic properties of the steel.

The sum of the eddy current loss and the hysteresis loss is called the iron or core loss.

Another loss occurs in the solid material that insulates the windings from each other and from the core. The alternating electric field in the solid material causes what is known as a dielectric loss.

Performance Characteristics. — The core loss and dielectric loss of a given transformer depend upon the voltage and frequency. For power circuit transformers that operate at nearly constant voltage and frequency, these losses are nearly constant regardless of the value of current being delivered. The loss in the windings, known as the copper loss, varies in proportion to the square of the current. When no current is being delivered there is no loss in the secondary winding but there is a loss in the primary winding caused by the exciting current there. This loss is usually insignificant compared with the core loss and the dielectric loss. Hence, when rated voltage at rated frequency is applied to one minding and the other winding is open-circuited, the power input to the transformer is considered equal to the core loss plus the dielectric loss. The combination of the core loss and the dielectric loss in kilowatts in commercial 60-cycle transformers is likely to be from .25% to 1% of the kva. rating of the transformer.

The resistances of the windings of a transformer can be measured with direct current when no alternating voltage is being applied. Then in normal operation the copper loss in a winding is equal approximately to the resistance times the square of the alternating current. The losses in both windings are added to obtain the total copper loss. Actually, because of what is called skin effect, the resistance of a winding for an alternating current is greater than that for a direct current having an equal effective value. The copper loss in kilowatts with rated current in each winding of a commercial 60-cycle transformer is likely to be from .5% to 3% of the transformer kva. rating.

The losses in a transformer depend only upon the voltages across and the currents in the windings. The power output of a transformer depends not only upon the voltage output and the current output but also upon the load power factor, which may range from zero to one. If a transformer is delivering rated current at rated voltage to a load whose power factor is one, its efficiency is likely to be from 96% to 99%.

The losses in a transformer appear as heat which should be removed as rapidly as it is produced after the winding temperature has reached the highest permissible value. Dry-type transformers are cooled by the natural movement of air or by air blown by fans through ducts near the windings. Transformers that are insulated by oil or a synthetic liquid may be water-cooled, in which case cool water is circulated in sealed tubes immersed in the liquid, or they may be cooled by pumping the hot liquid out of the transformer case into radiators where it is cooled and then returned to the case.

With rated voltage at rated frequency maintained across the primary winding. the change in voltage across the secondary winding that occurs as the output current is changed from rated value to zero is a measure of what is called the voltage regulation of the transformer. If 120 v. are delivered with rated current and 123 v. when no current is delivered, the voltage change is 3 v. The voltage regulation is the percentage change in terms of the voltage at rated current, or $(3 \div 120) \times 100 = 2.5\%$. The voltage regulation of a given transformer depends upon the load power factor. Usually, load power factors are such that the output voltage increases when the load is removed. However, with a load of leading power factor it may be that the voltage will decrease or perhaps not change.

Power transformers with ratings as large as 360.000 kva, have been built. Large transformers are often constructed as three-phase units in which the magnetic and electric circuits of three phases are combined. For a given kva. rating the weight and volume of a three-phase transformer are less than would be the combined total for three single-phase transformers each having one-third that kva. rating. A three-phase transformer is shown in fig. 2. Here the three high-voltage bushings through which the currents flow to and from the transformer windings are prominent in the upper centre portion of the figure. On each side of the transformer may be seen a radiator through which cooling oil circulates.

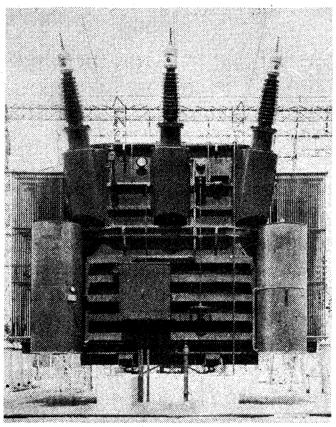


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FIG. 2.— THREE-PHASE TRANSFORMER RATED 25,000 KVA. AT 132,000 TO 34,500 V. AND 60 CY.

In a communication circuit a transformer may be used for what is called impedance transformation. Assume that a 1.000-ohm resistor, a transformer having 200 turns in one winding and 100 turns in the other, and a source of 10 v. at 1,000 cy. per second are available. If the 100-turn winding is connected to the source and the resistor connected across the 200-turn winding, there will be approximately 20 v. across the resistor. The resistor will draw 20 v. $\div$ 1,000 ohms = .02 amp. The transformer will be delivering 20 v. $\times$ .02 amp. = .4 va. Since the input volt-amperes to the transformer will equal approximately the output, the transformer will draw .4 va. $\div$ 10 v. = .04 amp. from the source, a value equal to that which would be drann by a resistor of 10 v. $\div$ .04 amp = 250 ohms connected directly to the source. Hence the combination of the 1.000-ohm resistor and the transformer is equivalent to a 250-ohm resistor.

By a similar analysis it can be shown that if the 200-turn winding were connected to the source and the resistor were connected across the 100-turn minding, the volt-amperes drawn from the source would be equal to that drawn by a 4,000-ohm resistor connected directly.

Audio transformers, intended for use in circuits in which the frequencies are in the audible range, have a core of steel or other magnetic material. Very thin laminations or powdered materials are sometimes required to limit the eddy current loss to a tolerable value.

Radio-frequency transformers for use in circuits in which the frequencies are above the audible range consist of coils supported near each other by insulating material. If metallic cores were used the eddy current loss in them would be objectionably great.

Transformers may have the same number of turns in each winding. These are used to isolate electrically one circuit from another. Some transformers have two or more coils on either or both sides. The coils may be connected in series for operation at one voltage or in parallel for another.

History of **the** Transformer.— The principles of electromagnetic induction were discovered in 1831 at the Royal Institution in London by Michael Faraday (*q.v.*), an English chemist and physicist. Utilizing these principles various experimenters built induction coils consisting of two coils of wire close to but insulated from each other. When a battery is connected to one coil the current in that coil soon attains a value fixed by the coil resistance. Then if the circuit is interrupted the sudden decrease in current induces an electromotive force of self-induction in that coil and one of mutual induction in the other. By using more turns in the second coil than in the first, the momentary surge of electromotive force in the second coil can be made to be much greater than the battery electromotive force.

An early demonstration of the use of an induction coil to step donn voltage and increase current was made by Elihu Thomson (*q.v.*) at a Franklin institute lecture in 1879. He used two pairs of induction coils with their primary nindings in parallel. The secondary windings in parallel supplied current to a small arc lamp. Apparently this was the first recorded case in which induction coil windings were used in parallel. These coils had a closed magnetic circuit of steel instead of the more common one containing a large proportion of air.

In 1883 Lucien Gaulard, a Frenchman, and John Dixon Gibbs, an Englishman, developed an induction coil system using primary windings in series. In 1885 George Westinghouse secured options on the Gaulard and Gibbs system patents and in 1886 purchased the patent rights for use in the United States. William Stanley, a young inventor employed by Westinghouse, was assigned the project of improving the transformer and developing the alternating current system for distributing electrical energy. Stanley discarded the Gaulard and Gibbs plan of operating primary windings in series and connected them in parallel to a constant voltage supply. He was convinced that it was permissible to connect a coil of only a few ohms resistance across several thousand volts if a good magnetic circuit was provided so that only a small current was required to produce a self-induced electromotive force equal to the applied voltage.

In the Gaulard and Gibbs transformer the core was composed of iron wires. Sometimes these were straight and did not form a complete ring. Stanley made some cores with the iron wires formed into a ring and others with continuous and laminated cores. At first iron plates about $\frac{1}{8}$ in. thick were tried. Later the iron plates then used by photographers were found to be even better. The plates were separated by thin sheets of paper. One improved method of construction suggested by Westinghouse was to wind the coils about the middle section of a stack of H-shaped punchings. Then the magnetic circuit was closed by placing two stacks of I-shaped punchings across the open ends of the H stack.

In 1885 Stanley established a laboratory in Great Barrington, Mass., and by March 1886 had in operation a system that supplied current directly from a 500-v. generator to customers 4.000 ft. distant. Transformers stepped down the voltage to 100 v. for lighting at the customers' premises.

The first plant for distributing alternating current energy in the United States was built by Westinghouse in Buffalo, N.Y.. and put in operation on Nov. 30. 1886. It was supplied from 133-cycle, 1,000-v. generators. *See* ELECTRICITY: *Transformers and Alternating Currents;* ELECTRIC POWER; *see* also references under "Transformer" in the Index volume.

BIBLIOGRAPHY.—S. A. Stigant and H. M. Lacey, *The J. & P. Transformer Book* (1928); G. V. Mueller, *Alternating-Current Machines* (1952); R. R. Lawrence, *Principles of Alternating-Current Machinery* (1954). (G. V. M.)

TRANSISTOR, a device able to amplify electrical signals by the action of electronic charge carriers within a semiconducting crystalline solid. Since transistors can be made very small, long-lived and efficient, they are finding extensive use in electronic systems for such purposes as communication, automatic control and high-speed computation.

One form of transistor (the point-contact type) was invented by John Bardeen and Walter Brattain in the course of a research program at the Bell Telephone laboratories, Murray Hill, N.J., initiated after radar experience in World War II showed a need for better understanding of semiconductor devices. The program was directed by William Shockley, who as theorist, device analyst and inventor made outstanding contributions to the field of semiconductor electronics. In the first five years after its announcement in 1948, the transistor was shown to be useful for many communications functions in radio and television receivers, sound and high-frequency amplifiers, electronic computers, control systems, etc. It is a device comparable in flexibility with the thermionic electron tube. Its range of application supplements that of tubes by making feasible operation of electronic equipment in smaller sizes, consuming less power and with improved reliability, especially under conditions of high vibration or shock.

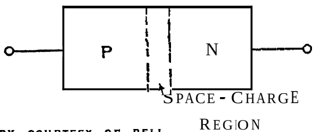

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FIG. 1.—P-N JUNCTION DIODE

DEVICE STRUCTURE AND BEHAVIOUR; CHARGE CARRIERS

In describing how amplification takes place by means of these devices, it is useful first to explain that for both tubes and transistors it is essential to generate and control a stream of electric charge carriers. Under suitable conditions, it is then possible to derive from the stream a greater amount of power than was expended in controlling it. As a result, weak control signals can be amplified through successive stages to produce useful output.

The basic stream of charge carriers may be produced in a variety of ways. In a typical vacuum tube, a stream of electrons released from a source (cathode) is controlled by a small input signal applied betneen cathode and control grid. These controlled electrons are then accelerated and collected by a positively charged electrode (anode). The energy gained from the anode appears as a larger power facsimile of the input signal in the output load.

Transistors, on the other hand, achieve their amplification functions by controlling the flow of electrons within specially treated solid materials called semiconductors. In a typical transistor, described below, the charge carriers are released from a source (emitter) and controlled by a signal between the emitter and a control electrode (base). The controlled stream is then accelerated and collected by a relatively high-potential electrode (collector), and, again, the energy gained from the collector appears as an amplified replica of the input signal in the output load.

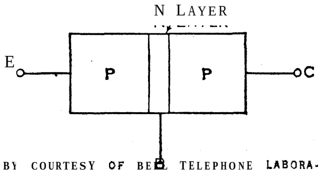

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FIG. 2.—P-N-P JUNCTION TRIODE

Operation of usual transistors depends on the fact that semiconductors, such as germanium or silicon, can conduct electricity by the motion of either or both of two kinds of charge carriers. One kind. which carries a negative charge, is called a "conduction electron"; it is an electron of such an energy that it can wander through the crystal with relative freedom. The other kind, which carries a positive charge, is called a "hole," because it is actually a deficiency of one electron in the valence bond structure of the crystal. Under proper conditions, this deficiency may be filled from another valence bond by an electron which. in doing so, leaves another deficiency behind; thus in effect the hole moves through the crystal, carrying a positive charge. By incorporating in the crystal appropriate chemical impurities or other deviations from lattice perfection, either type of charge carrier can be caused to predominate, with the other type being in the minority. Thus, according to whether the negative or positive carriers are in the majority. a specimen of semiconductor is classified as N type or P type.

Most transistors are constructed by juxtaposing regions of different conductivity types within a single crystal of semiconductor, so as to produce the useful controlled current of charge carriers. The following broad descriptions of some of the principal structures is based on Shockley's classic paper on P-N junction published in 1949 (see Bibliography).

P-N Junction Diode.—This simple semiconductor structure is of interest not only because it is a useful device in itself but also because it can be regarded as a building block with which to construct other semiconductor devices. When suitable regions of P- and N-type conductivity adjoin in the same semiconductor, as in fig. 1, the magnitude of current flow depends markedly on the direction of the potential applied. For example, if the P region is made positive, then some of the positive charges (holes) it contains are impelled across the P-N boundary into the negatively polarized N region. Concurrently, some negatively charged conduction electrons from the N region are attracted across the boundary into the P region. In general, both flows of holes and of electrons may contribute appreciably to the electric current which flows in this direction of applied potential, called "forward bias." On the other hand, if the applied potential is reversed, then both types of majority carriers—both holes in the P side and electrons in the N side—are repelled from the boundary. Only the minority carriers, both electrons in the P side and holes in the N side, are attracted across the boundary; since normally these minority carriers are very small in number, the junction draws comparatively little current under reverse bias conditions.

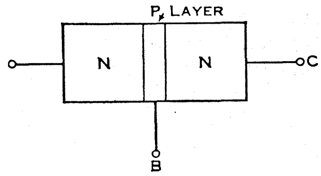

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FIG. 3.—N-P-N JUNCTION TRIODE

Because of these properties, the P-N iunction diode is widely used as a rectifier; *i.e.,* a device which permits current to flow essentially in one direction only when alternating voltage' is applied. In connection with ordinary radio receivers, for example, rectification is used in developing direct power supply voltage from the alternating current supply mains. Other rectifiers (detectors) recover the sound signal from an amplitude-modulated radio broadcast wave, while still others (mixers) are used to shift the frequency of the radio wave to a value desired for amplification purposes.

The P-N junction is also an important feature of the action of many transistors in that the junction can act as a source or as a collector of charge carriers. Under forward bias, the current which flows consists of the injection or emission of minority carriers, both holes into the N region and electrons into the P region. The concentration of minority carriers can thus be greatly increased over what is normally present in the material. Moreover, if the semiconductor is a nearly perfect single crystal, the injected minority carriers may remain above the normal concentration an appreciable length of time; lifetimes of 100 microseconds or more are commonly used in transistor material. However, if too long a time elapses, the minority carriers will each "recombine" with a majority carrier, thus tending to reduce the minority carrier concentration toward its equilibrium value.

Similarly, the P-N junction under reverse bias acts as a collector of minority carriers, since any which may arrive at the junction are attracted across it. Under normal diode conditions this reverse current of collected minority carriers is low, reflecting the low equilibrium concentration of such carriers. However, if the minority carrier concentration is increased through the action of a nearby emitter, the collector current correspondingly increases.

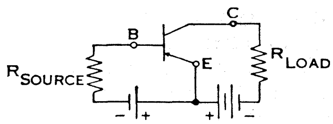

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FIG. 4.— BASIC AMPLIFIER CIRCUIT

A P-N junction also contains a layer of space charge whose magnitude depends upon the voltage drop across the junction. The need to charge and discharge this layer limits the speed with which the junction potential can change.

P-N-P Junction Triode.—By combining an emitting junction and a collecting junction in the same unit, it is possible to cause a controlled stream of minority charge carriers to flow from one to the other, as diagrammed in the P-N-P junction transistor of fig. 2. In normal operation, the emitter junction E is biased in the forward direction (emitter positive) so that it injects minority carriers (holes) into the base region. When the base region is thin and its crystal perfection is good enough to provide an adequately large lifetime for the minority carriers, nearly all of them live long enough to flow to the collector junction. The latter is normally biased in the reverse direction (collector negative), so that it collects the minority carriers which the emitter has injected, together with a small number which may also be present from other sources.

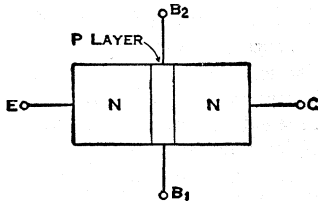

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FIG. 5.—TETRODE

The triode amplifying properties derive from the fact that the collector current depends mainly on the small control voltage between emitter and base. Since the collector current, in flowing through an external load, can develop much more power output than is required to control the base-to-emitter voltage, the device can be built into a circuit which amplifies. A basic circuit is shown in fig. 4. In practical cases, the gain. or ratio of power at the output to power at the input, sometimes can be as much as 10,000 times (40 decibels).

Amplifying devices are widely used in electrical communications wherever it is desired to bring weak signals up to higher power levels. In addition, they can be used to generate alternating currents, or to act as very fast electronic switches or electronic computing devices.

N-P-N Junction Triode.—By arranging two N-P diodes as diagrammed in fig. 3, it is possible to make an N-P-N junction transistor. Its action is analogous to that of the P-N-P junction unit described above. However, since in the N-P-N the stream of minority carriers which is emitted, controlled and collected is composed of negative electrons rather than positive holes, it follows that in normal operation the electrode potentials are all opposite in polarity to the P-N-P. The availability of similar devices with opposite polarities makes possible certain symmetrical amplifiers and specially efficient low-frequency amplifiers which have no counterpart in the electron tube art.

Extension of Performance to Very High Frequencies.—With the structures just described in principle, it is feasible with available semiconductors such as germanium to build amplifiers for frequencies up to a few score megacycles per second; that is, somewhat beyond the commercial broadcast range but rather short of such uses as walkie-talkies, mobile radio or the frequency modulation band. Attempts to extend the range to encompass these additional uses encounter both fundamental and practical difficulties, which make necessary resort to new principles of operation.

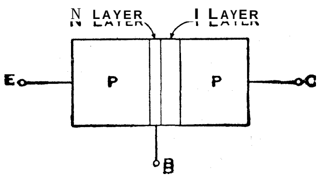

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FIG. 6.—INTRINSIC BARRIER TRANSISTOR

Two phenomena conspire to limit the range of the simple triodes. The first is connected with the time taken for the charge carriers to travel from emitter to collector across the base layer of thickness w. Even though the input current pulse at the emitter might be infinitely sharp, by the time it has reached the collector the pulse has spread out by diffusion; *i.e.*, because of random motion of the individual charge carriers within the semiconductor crystal. This effect therefore limits the speed with which the transistor can respond to fast signals or to high frequencies. The effect is measured in terms of the current amplification factor, alpha, which is the ratio of A.C. collector current to A.C. emitter current under constant collector voltage. The speed of response then depends upon the "alpha cutoff frequency," f_α, which is that frequency where α^2 is down to one-half its low-frequency value. For transistors in which the carriers travel entirely by diffusion, this frequency depends on their diffusion constant D in the material and on the inverse square of the base thickness w: $f_\alpha = 0.8\ D/w^2$. With a base layer $\frac{1}{1{,}000}$ in thick, for electrons in germanium this frequency is about five megacycles; in silicon, with a smaller electron mobility, it is about two megacycles.

The other factor limiting speed or frequency of operation is the time taken to charge the junctions, mainly the collector junction. There is present at each P-N junction a layer of electrical charge whose magnitude varies with the applied potentiai. Consequently, the junction has an electrical capacitance C_c. When the potential changes, the charge distribution can respond at only a finite rate because the current to the junction capacitance must flow in through the effective resistance r_b' of the base layer. This charging rate corresponds to a second characteristic frequency of the transistor; namely, $f_o = \frac{1}{2} r_b' C_c$.

A useful measure. or figure of merit, showing frequency capability is the frequency at which the gain has fallen to unity. It is closely related to the maximum frequency at which the device can generate electrical oscillations of alternating current, and is given approximately by one-half the geometric mean of the two limiting frequencies above; namely,

$$f_{\max} = \frac{\sqrt{f_\alpha f_o}}{2} = \left(\frac{f_\alpha}{8\pi r_b' C_o}\right)^{\frac{1}{2}}.$$

If an attempt is made to improve frequency response by decreasing the base layer width w, the base resistance r_b' also increases. If an attempt is made to decrease r_b' by reducing the base laver resistivity, the maximum voltage $V_{\max}$ at which the collector can operate is reduced. Thus in an optimally designed triode there is a minimum base width below which it is not profitable to go without further modifications of the structure. In germanium. at base widths of the order of 0.0005 in., maximum frequencies of the order of 150 megacycles result, but at the cost of greatly reduced area, lower maximum voltage and therefore lower power output.

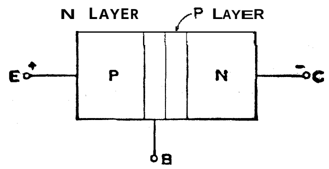

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FIG. 7.—CONJUGATE-EMITTER STRUCTURE

Tetrode.—One means for overcoming this speed limitation of conventional junction triodes is the tetrode structure invented by R. L. Wallace and diagrammed in fig. 5. A second base connection is made to the opposite side of the triode base layer of fig. 3. In operation, with the second base B_2 biased more negatively than the eniitter, charge carriers can be injected only very close to the first base connection. Consequently, the base resistance r_b' between the electron stream and B_1 is reduced to very low values even for base widths w as small as 0.0001 in., and it becomes advantageous to further increase the speed of current response f, by reducing w and to further decrease junction capacity by reducing area. In the laboratory such microtetrodes were pushed to maximum oscillation frequencies above 1,500 megacycles.

Intrinsic-Barrier Triode.—Another structure for improving frequency performance of transistors, which also improves the power-handling capability, is the four-conductivity-zone structure invented by J. M. Early, of which a particular version is diagrammed in fig. 6. By inserting between the collector and the base a layer of semiconductor of comparatively high purity ("intrinsic" or I type), the space-charge layer of the base-collector junction is greatly thickened, with a corresponding reduction of collector capacitance C_c by a factor which may be as large as 50 or more. Since the rise in voltage between collector and base is thus distributed over a longer distance, there is also a corresponding increase in the maximum collector voltage, $V_{\max}$. Further, the base layer resistivity can be greatly reduced without increasing C_c or reducing $V_{\max}$, since these are now controlled principally

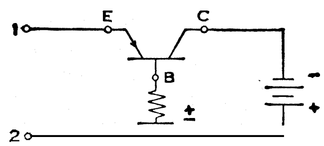

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FIG. 8.—NEGATIVE-RESISTANCE CIRCUIT USING A TRANSISTOR WITH MULTIPLYING COLLECTOR

by the thickness of the intrinsic barrier region. The combination of all these features means that the time needed to charge the collector junction is greatly reduced.

The structure also promotes high speed of collector current response, since the base layer can be made very thin to keep down the diffusion time taken by carriers crossing the base region. The time taken for carriers to be collected across the intrinsic layer is also very short, since the layer is pervaded by the high electric field of the collector-base junction.

In summary, the intrinsic barrier principle favours the characteristic frequencies f_0 and f_α of the transistor so much as to increase frequency response by a factor of 30 or more over what is feasible with a conventional triode.

Even though by the mid-1950s this structure was relatively new, experimental models oscillated above 600 megacycles. Furthermore, the maximum power was about 100 times greater than the capabilities of the older structures.

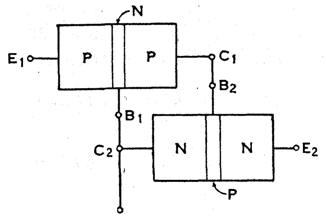

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FIG 9.—PAIR OF TRIODES NEARLY EQUIVALENT TO THE CONJUGATE-EMITTER STRUCTURE OF FIG.

Current-Multiplying Triodes.—In all the junction triodes and tetrodes mentioned up to this point, the collector does not collect more current than the emitter emits; or, in transistor terminology, the current amplification factor alpha is limited to unity. However, one of the useful properties of some types of transistors is their ability to have alphas greater than unity, of the order of two to five. For pulse-type circuitry such as is widely used in electronic computers, such high alpha can lead to a negative-resistance property which permits considerable circuit simplification and reduction of the number of transistors needed.

Conjugate Emitter *Structure—Shockley's "P-N* Hook."—One way in which current amplification factors greater than unity can be obtained is by means of the four-conductivity-zone structure of fig 7. Here the emitter and base are a conventional P-N structure, but the collector is a compound structure consisting of a thin P layer backed up by an N-type region to which the collector contact is made. As will be explained, such a compound collector can do more than collect minority carriers which have come from the emitter; under the influence of the minority carriers, the compound collector may also release majority carriers, so that the total collector current becomes greater than the incident minority carrier current.

In normal operation, the biases of the P-N-P-N structure of fig. 7 are like the P-N-P triode of fig 2, and the emission of holes into the base region under the control of the emitter-to-base potential is as before. Likewise, the collection of holes into the second P region across the reverse-biased N-P junction is similar. However, the final P-N junction is designed to be a good emitter of electrons from the N region into the P region, and it may be noted that with the biases as given this final junction is biased in the forward direction. Consequently, any current which flows across it must be, in major part, electrons flowing into the second P region. Alternatively, it may be said that under the influence of the primary current of holes, the compound collector not only collects the holes but also emits a secondary current of electrons which can be much larger than the hole current. By suitable design, current gains as large as 50 can be obtained.

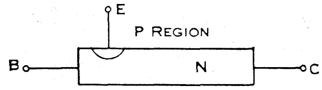

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FIG. 10.— FILAMENTARY TRANSISTOR

If the two-terminal characteristics of such a transistor, for example in the schematic circuit of fig. 8, are examined, it is found that in regions where, because alpha is greater than unity, the collector current increment is large enough to override the emitter current increment, the device exhibits a negative resistance; *i.e.*, the incremental current which flows at terminals 1–2 is opposite in direction to the incremental voltage applied. Such negative resistance circuits are often useful, as in computer service.

The name "conjugate emitter" comes from the fact that the final P-N junction emits carriers of opposite sign to those supplied by the emitter. The entire composite P-N collector is also often called a "P-N hook" from the appearance of the electron energy diagrams.

An effect almost exactly equivalent to the P-N-P-N conjugate emitter triode can be obtained by the use of a conjugate pair of triodes, one P-N-P, one N-P-N, connected as in fig. 9. The leads E_1, B_1 and E_2, when biased in the same way as the emitter, base and collector of fig. 7, behave in very nearly the same way, although the "conjugate" emitter E_2 and the flow of electrons are in a separate transistor unit.

Filamentary Transistor; Conductivity Modulation.—Another way of obtaining collector multiplication is illustrated by the filamentary transistor of fig. 10. So-called because of its shape, the filamentary transistor consists of a thin rod of semiconductor with an emitter attached on one side. In normal operation, when the rod is biased by a potential applied between B and C, any minority carriers injected by the emitter are swept down the rod. The end toward which the minority carriers are swept is the collector, the other end the base. Since the current of minority carriers is electrically charged, it attracts an equal charge of majority carriers from the collector in order to leave the filament electrically neutral. Consequently, the conductivity of the filament has been increased, an effect entitled "conductivity modulation." The total collector current is greater than the current of minority carriers. A somewhat different version of this transistor in which the emitter junction is near the centre can be regarded as an emitter diode in which alternatively either end of the rod can be used as a base; consequently, it is also called the double-base diode. These units as usually built have much lower gains than the junction triodes previously described, but have utility in negative-resistance circuits.

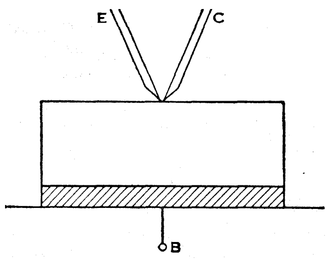

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FIG. 11.—POINT-CONTACT TRANSISTOR

Point-Contact Transistor.—The form of transistor invented by Bardeen and Brattain, the point-contact type, also exhibits collector multiplication as a major feature. Here the emitter and collector are made by pointed wires close together on the surface of the semiconductor, while the base contact is a large-area low-resistance contact to the semiconductor (fig. 11). The mechanism of operation is similar to that of the other units; the emitter under forward bias injects minority carriers into the body of the semiconductor (base). These minority carriers are collected by the collector, with multiplication; *i.e.*, the collector also releases majority carriers. Just how the collector multiplication works is obscure and somewhat controversial; it appears probable that in some versions of the point-contact transistor the collector acts like a conjugate emitter, while in other versions probably the mechanism is conductivity modulation as in the filamentary transistor.

For most amplification purposes the point-contact transistor has been superseded by the junction units, because rectifying junctions made by placing points on a semiconductor surface are inferior to those called "junctions" made by other methods, described below. However, for some purposes the point-contact unit is still useful. Since a negative resistance is simply and economically obtainable, it finds employment in pulse-type computer circuitry. Since the unit has very small area and therefore very low collector capacitance, it is fast and especially useful for high-speed computers.

Besides the three structures just described, there are also other ways of obtaining the effect of a multiplying collector, and it is possible that some of these may become important.

Majority Carrier Transistors.— To this point the discussion has concerned transistors which operate by injecting, controlling and collecting a stream of minority charge carriers within a semiconductor. However, it is also possible to obtain useful effects with a stream of majority carriers. In order to avoid confusion, a different terminology is used. The stream of majority carriers comes from an electrode called the "source," is controlled by a "gate" and terminated in a "drain." These electrodes have functions analogous to those of the emitter, base and collector of the minority carrier transistors; the functions are also analogous to those of the cathode, control grid and anode of an electron tube.

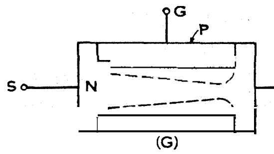

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FIG. 12.— FIELD-EFFECT TRANSISTOR

In normal operation the space-charge region, between the gate G and the dotted lines, is swept almost free of holes and electrons

Field-Effect Transistor. — The structure diagrammed in fig. 12 represents a particular version, due to Shockley, of the field-effect transistor. A rod of N-type semiconductor has nonrectifying contacts S and D at the two ends. Circumferentially disposed around the middle is a P-type region to which the gate contact G is made. In normal operation, the drain D is positively biased with respect to the source S, so that a current of electrons (*i.e.*, majority carriers in the N-type material) tends to flow from S to D. The gate G is negatively biased; since this is the reverse direction of the P-N junction, little current flows to the gate. Ho ever, as in any P-N junction, there is a space-charge region between the P- and N-type materials; when the reverse bias is large enough, this space charge region has the effect for a finite distance beyond the junction of repelling or "sweeping out" the conduction electrons which would normally be present in the N-type material. Depending upon the numbers of carriers present (*i.e.*, upon the electrical conductivity of the N-type material), such a reverse-biased junction may be capable of sweeping out carriers for a distance of as much as several thousandths of an inch.

With the normal carriers thus swept away, the conductivity of the rod between source and drain and consequently the drain current is reduced. As the reverse bias of the gate is further increased, the space-charge region increases in extent until at a particular point the entire cross-sectional area of the rod is swept clean of carriers, an effect known as "pinch-off." Further increase of gate voltage thenceforth has little effect on the drain current. Since the control of the drain current by the gate voltage requires very little power, the replica of the gate signal, obtained by passing the drain current through an external load resistor, has been amplified. Furthermore, the control electrode (gate) draws very little current, an advantage which the field-effect transistor shares with the vacuum tube.

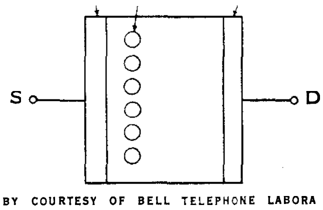

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FIG. 13.—ANALOG TRANSISTOR. THE GATE CONNECTION IS MADE TO THE ROW OF RODS

W

Enough field-effect transistors have been made to show that the action is well understood. However, for many specific purposes their over-all performance appears to be less attractive than that of the minority carrier transistors.

"Analog" Transistor. — In fig. 13 is diagrammed the cross section of a planar version of a device whose structure and method of operation is so analogous to a vacuum tube that it has been called the analog transistor by its inventor, William Shockley. Here the source S and drain D of the charge carrier stream are area contacts on opposite faces of a slab of low-conductivity semiconductor, while the control electrode (grid) consists of a set of rod-shaped inclusions which have conductivity type opposite to the source and drain. Like the anode of a triode vacuum tube, the drain D is biased so as to attract majority charge carriers from the source, while the control electrode, like the grid of the tube, is biased in the reverse direction. Under these conditions, if the drain voltage is sufficiently large it will draw a current from the source which can be controlled by the grid voltage. At the same time, very little power is required for the grid since the current'is small.

Summary of Transistor Structures. — By the use of the basic prototypes just described, a large number of useful devices can be constructed. In each case, for a particular purpose the design variables, such as resistivity, geometry, etc., can be varied to produce the best practical result. Furthermore, the possibility of still other principles of operation, leading to additional prototypes, cannot be excluded. In the face of such a large number of possibilities, this article will not attempt to catalogue exhaustively the properties of all possible transistors. Rather, the rest of the article will describe some semiconductor materials usable for transistors, and some fabrication techniques.

MATERIALS FOR TRANSISTORS

In order to support a useful, controlled flow of minority charge carriers in the structures covered in the preceding section, a semiconductor material -must meet a number of requirements: (1) It must support the two kinds of charge carriers; (2) when minority carriers have been injected. they must have a lifetime long enough to enable them to reach their destination; (3) for the device to operate with a desired speed, the carriers must reach their destination with a corresponding speed (*i.e.*, they must have an adequate mobility); (4) the desired stream must not be obscured by undesired carriers arising from other causes, especially from the thermal energy uhich the material always has because of its temperature; (5) the number of carriers must be suitably controllable to make the material N or P type in the necessary amount.

Crystal Structure. — A crystalline solid consists of an ordered array of atoms. Each atomic nucleus, positively charged, is surrounded by the number of electrons corresponding to its atomic number, or position in the periodic table of the elements. The electrons, negatively charged. move in orbits which are arranged in groups or "shells" around the nuclei. The innermost shells of electrons are so tightly bound to their own nucleus that they do not interact with neighbouring nuclei; they can be torn loose only by relatively large amounts of energy such as are associated with X-rays, alpha particles or other nuclear radiations. However, the outermost electrons are more loosely bound and do interact with their neighbours; that is, they travel back and forth in the lattice. These interactions result in the binding forces which hold the crystal together. It is these same outer electrons, acting in the same way, which also create the binding forces which hold together ordinary chemical compounds and which are responsible for the chemical valences of the elements; for this reason, the outermost electrons which bind the crystal together are called valence electrons (see VALENCE).

Electrical Conduction by Charge Carriers. — A perfect crystal in equilibrium at absolute zero temperature is an insulator[1]. There can be no net flow of electric current, because for each electron travelling in a certain direction through the valence structure, there is a symmetrically placed electron travelling in the opposite direction. For each electron travelling back, another travels forth. In order for a current to flow, there must be some unpaired electrons. These electrons can appear in several ways. In particular, when the material is heated or illuminated, some electrons can acquire energy and be broken loose from the valence bonds. For every valence bond broken, there result two units of electronic charge which can contribute to the electrical conductivity when an electric field is applied. First, the free electron, because of its negative charge, experiences a force which causes it to drift through the lattice, thus carrying a current. Second, after the electron has left, the formerly neutral region where there is now a "hole" in the valence structure has a net positive charge because one electron is missing. Under the influence of the field, another valence electron can move into the hole in the same direction as the free electron; of course, this event leaves a hole where the second electron came from, into which still another valence electron can move, and so on. It may be said, therefore, that the hole

[1] statement assumes the crystal is a nonmetal in which the energy bands and do not overlap. *See* C. Kittel, *Introduction to Solid State Physics*, p. 261 (New York, 1953).

has moved in the direction opposite to the free electron.

The two kinds of charge carriers needed for minority carrier transistors are thus supplied by the negatively charged electrons and the positively charged holes.

Just as two charge carriers are created when an electron leaves a valence bond, so also the opposite process can occur; a free electron can drop into a valence bond, thus destroying two charge carriers. Consequently, the minority carriers are said to have a lifetime, which is the average length of time before the minority carrier is lost by recombination with one of the majority carriers.

For moderate applied electric fields, both electrons and holes move with velocity proportional to the field. However, in general, holes are a little harder to move than electrons. The holes are said to have a lower mobility, the mobility being the average velocity imparted by a unit electric field (one volt per centimetre).

Control of Conductivity and Carrier Lifetime.—To have adequate mobility and minority carrier lifetime for transistors, the semiconductor usually must be a carefully prepared single crystal. Any defects in the crystal contribute to the recombination rate, thus impairing the lifetime. If the crystal is polycrystalline (*i.e.*, consists of a number of small single crystal grains), the measured mobility may also be greatly lowered because the material in the boundaries between the grains may have a greatly disordered crystal lattice which interferes with the orderly motion of the charge carriers. The grain boundaries may also have different properties because they tend to contain more chemical impurities than the rest of the crystal. Because these requirements are so stringent, it is a long and difficult task to give an adequate and fair evaluation of even a single material for transistor purposes.

To control the majority carrier concentration, chemical impurities are included in the semiconductor crystal lattice. For example, to produce N-type conductivity in germanium, arsenic is often added as an impurity. Germanium, a member of Group IV of the periodic table, has four valence electrons. When arsenic, which has five valence electrons, is substituted into the germanium lattice, four of the electrons play the role of their germanium counterparts. The extra fifth electron is not needed to complete the lattice and is very loosely bound to the arsenic atom, so that only very little energy is required to activate it as a conduction electron. Consequently, germanium, when "doped" with a small amount of arsenic as an impurity, acquires (at room temperature) approximately one conduction electron per arsenic atom and becomes N-type.

Similarly, to produce P-type conductivity in germanium, gallium may be added. Since gallium has only three valence electrons, the valence structure is one electron short in the neighbourhood of each gallium atom. It is said that each gallium atom has added a hole to the valence structure. This hole also is very loosely bound to the gallium impurity which caused it, and accordingly very little energy is required to activate it and cause it to move through the lattice as a positively charged hole. Consequently, germanium doped with a small amount of gallium as an impurity becomes a P-type or hole conductor, with (at room temperature) approximately one hole present for each atom of the Group III chemical impurity. This type of conduction is called extrinsic because it depends on the impurities, to contrast it with the intrinsic conductivity which exists in the pure material.

The properties of transistors, as described above, depend on the extrinsic conductivity of the semiconductor. Accordingly, the intrinsic conductivity, which arises in the following way, must be relatively small. Because of the heat energy which the crystal possesses by virtue of its temperature, the atoms of the lattice are in continual vibration; and as the temperature increases, these thermal vibrations also increase, tending more and more to excite valence electrons into conduction electrons, and thus to produce intrinsic conductivity which is characteristic of the pure crystal itself. This intrinsic conductivity tends to be inhibited when a large amount of energy is required to activate a valence electron into the conduction band. Consequently, to keep down the number of undesired charge carriers from sources other than the controlled stream, the semiconductor should have an adequately large energy gap between the band of energies corresponding to the valence electrons and the band of the free conduction electrons. Even so, the intrinsic conductivity increases sharply (exponentially) with temperature, and eventually produces so many carriers that the transistor effects are swamped. The larger the energy gap, the higher the temperature at which the transistor will still work.

It is basically for this reason that a metal cannot be used as a vehicle for a controlled stream of minority carriers in the transistor sense; for in a metal, where there is no energy gap above the valence band, the valence electrons are too easily lured from their bonds.

To obtain the needed extrinsic conductivity, ordinarily the number of impurities used is extremely small—perhaps 1 part in 1,000,000, or even 1 part in 10,000,000. By ordinary standards transistor materials are extremely pure, yet their electrical properties depend on the accurately controlled residual impurity. Totally new levels of purity and control were made available through the brilliantly simple zone-melting processes invented by W. G. Pfann. By this means, germanium was prepared in which impurities constituted less than 1 part in 10^{10}—probably the purest substance known.

Impurity atoms of the type which contribute conduction electrons to the lattice are for that reason called donor atoms, like the Group V elements phosphorus, arsenic and antimony in germanium. Impurities of the other type, which accept valence electrons from the lattice and thereby produce hole conduction, are called acceptor atoms, like the Group III elements boron, aluminum, gallium and indium in germanium.

Other effects can also result from impurities. Some impurities degrade the minority carrier lifetime? acting as centres for generation or for recombination of charge carriers. Others may produce "traps" which can hold a charge carrier temporarily and release it at a later time.

FABRICATION TECHNIQUES

Various mechanical, electrical, chemical and metallurgical techniques have been used to make transistors and other semiconductor devices. Some of the principal ones are listed here. By combining these or other suitable techniques as building blocks in various ways, the transistor structures may be made. Since in each of these structures the dimensions and the semiconductor may be varied, the number of possible combinations is legion.

P-N Junctions.—One basic problem common to many of the structures is the fabrication of a P-N junction, which may be made by various methods as outlined below.

Point Contact.—The mere placing of a clean metal point in contact with etched N-type germanium, for example, gives the effect of a P-N junction inside the semiconductor. Why this junction should occur was for a long time a mystery; its explanation by John Bardeen in terms of surface energy states was an important step on the road to understanding transistors. On etched P-type germanium a rectifying point contact may be made if the point is of a particular material (*e.g.*, phosphor bronze, which contains the donor impurity phosphorus) and if the point is momentarily heated by passage of a pulse of current, a process known as forming. Such point contacts are relatively simple to fabricate, but their properties are, of course, sensitive to the surface condition of both point and semiconductor. Moreover, much better rectifiers can be made by some of the other methods.

Grown P-N Junction.—This is so-called because it is made by controlling the impurity concentration in a single crystal while it is being grown from a melt. A seed crystal is dipped into the molten semiconductor and then withdrawn, being gradually cooled so that it serves as a nucleus upon which additional material crystallizes. The impurity concentration and hence the conductivity is controllable either by adding impurities to the melt while the growing proceeds or by varying the rate of growth of the crystal.

Alloy P-N Junction.—This is so-called because it is made by melting together (*i.e.*, alloying) the semiconductor with a desired impurity. For example, a small button of indium may be heated in contact with N-type germanium until the indium melts and dissolves a portion of the semiconductor. On cooling, the germanium which recrystallizes or regrows from the melt is, of course, P type (because contaminated with indium, an acceptor impurity): so that a P-N junction has been formed. Two such junctions, which may be formed simultaneously on opposite sides of a thin wafer, compose a P-N-P alloy junction transistor, sketched in principle in fig. 14. An N-P-N alloy junction transistor can be made by the analogous method of melting suitable N-type buttons into a P-type semiconductor. The alloy junction is also sometimes called a fused or bonded junction.

Diffused P-N Junction.—This is so-called because it is made by diffusing a suitable impurity into the semiconductor. For example, when N-type silicon is exposed to boron chloride at a high temperature, some of the boron diffuses in and converts the silicon surface to P type. Although some slight diffusion also occurs during the alloying process, it seems better terminology to reserve the term "diffused" for those cases in which the dominant process does not involve melting of the semiconductor.

Surface Barrier Junction.—This may be made and contacted by an ingenious chemical process of etching and plating. The surface of the semiconductor is first etched electrolytically, with the etching electrolyte being a fine jet directed at the surface; consequently, the area etched may be very small. Second, by reversing the polarity of the current flow while the jet is still present, a metallic electrode is plated onto the freshly etched surface. The surface barrier is a rectifier, evidently for the same reason as a point contact; namely, because of the charge in the surface energy states. A particular advantage of the jet-etch-plating technique is the possibility it affords of making high-frequency transistors. Etching simultaneously on both sides of a wafer can be precisely controlled to give a very thin web (0.0002 in.), consequently a very small distance between the emitter and collector junctions. The consequent high alpha cutoff frequency, coupled with the low capacitance of the small junctions, can result in a frequency response up to 300 megacycles or more.

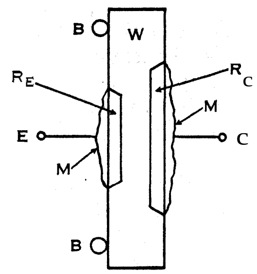

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FIG. 14 —P-N-P ALLOY GERMANIUM JUNCTION TRIODE:

(B) Base contact ring; (C) collector contact; (E) emitter contact: (R_E) regrown emitter region, P-type; (R_c) regrown collector region, P-type; (M) solidified indium-germanium mixture; (W) germanium water

Ohmic Contacts.—In contrast with the fabrication of a P-N junction, another generic problem is the fabrication of a low-resistance ohmic contact. In this case it is desired to get rid of all traces of rectifying action at the contact, a matter which is not always simple but which may be done in a number of ways.

Alloying.—The process is similar to the making of an alloy P-N junction except that the type of impurity used is the same as the substrate rather than opposite; so that instead of a rectifying junction, a low-resistance contact results.

Plating a Metal Onto an Abraded or Sand-Blasted Semiconductor Surface.—Here the mechanical working of the material so reduces the minority carrier lifetime that rectification is destroyed.

Welding, Bonding or Soldering.—Since these methods involve formation of a liquid phase during the process, they are closely related to alloying.

Point Contact to an Abraded Surface.—This method is often unsatisfactory because the resistance is too high. However, if the current is kept small, a point contact may be used for test purposes even on etched surfaces.

Surfaces.—A third general problem is the preparation of a suitable surface. The action of the various structures was described above in terms of bulk properties inside the semiconductor, such as lifetime, conductivity, etc. However, an unsuitable surface may impair or destroy the desired action. For instance, commonly the surface, even when carefully prepared, has such a high tendency to recombine carriers that it may seriously interfere with the number which succeed in reaching the collector. When the surface is abraded or sand-blasted, it may cause the complete disappearance of minority carriers, rectifying or injection action.

To obtain a surface with adequately high lifetime, it is conventional to etch in order to remove material whose crystal structure may have been impaired by previous mechanical treatment, such as sawing, grinding or lapping to make a flat surface. The etching may be by chemical or by electrochemical means. Even after a high-quality surface has been obtained, if stable and reliable properties lasting many years are desired, the maintenance of the surface in a good condition is a serious problem. Extremely minute quantities of contaminants, such as water or oxygen, amounting to far less than a single layer of atoms, may cause appreciable changes; even in a high vacuum the avoidance of such small quantities is difficult. In the mid-1950s it was possible to make transistors that were probably satisfactorily stable for periods of the order of about ten years, if their temperature was not allowed to rise much above room temperature. The stability obtained was comparable with the best obtainable with electronic equipment.

USEFUL RANGE OF TRANSISTORS

By combinations of these fabrication techniques and others not mentioned, it is possible to make a great variety of semiconductor devices, including all those mentioned in the first section of this article. Among these possibilities are low-level amplifiers suitable for receiving weak signals up to several hundreds of millions of cycles per second; oscillators up to more than 1,000,000,000 cycles per second; and detectors up to the highest radio frequencies now usable, about 100,000,000,000 cycles per second. Power in the range of 1 to 50 w., sufficient to drive electromechanical devices such as relays, loud-speakers and small motors, can be obtained. With such devices it is possible to build an enormous variety of communication and control equipment, such as voice-frequency systems, telephone amplifiers, radio receivers, data transmitters, automatic control systems and complex, high-speed electronic switching and mathematical computing equipment. Such apparatus features miniature size, portability, minimum power requirements, ruggedness and long life. While a number of such applications had .already been carried through by the 1950s, a much greater number remained to be developed in the future.

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TRANSIT CIRCLE (*MERIDIAN CIRCLE*), a telescope for measuring the time when a star passes across the meridian and at the same time measuring its altitude. These two measurements determine respectively the right ascension and the declination (*qq.v.*), hence the place of the star on the celestial sphere. Because of its fundamental importance in positional astronomy, and as the source of standard time furnished to the community, the transit circle is traditionally regarded as the leading instrument, at least in the great national observatories; but in modern times important observatories have grown up whose work lies wholly in other directions. The transit circle looks rather like a big gun on a gun carriage, and to the stranger the surprising thing about this kind of telescope is that it cannot be turned to all parts of the sky; it only moves up and down in the north and south line. looking out through a slit in the walls and roof. Nor can it be used for prolonged study; the observation is a snapshot as the object passes rapidly across the field of view.

Suppose that the exact position of some star is to be remeasured. From the catalogues a star is chosen that is due to pass across the north-south line in a minute or so; and by means of a setting circle the telescope is elevated to the proper angle to catch it. The aperture of the object glass is probably eight or nine inches, and it mill easily show stars to the ninth magnitude. While waiting, the field of view can be examined. A faint artificial illumination shows stretched across the field a number of wires that are actually made of spiderweb; there is one horizontal wire which can be moved up or down by turning a micrometer screw, and a considerable number of vertical wires (perhaps ten). The star now enters the field—at the extreme right since the telescope inverts—and is seen traveling rapidly toward the left. The telescope is shifted slightly so as to bring the star almost onto the horizontal wire and then the instrument is clamped at that altitude. Now the star is approaching the series of vertical wires; as it passes each, the pressing of a key records the instant on a chronograph on which the standard sidereal clock is recording the seconds.

Near the centre of the field there is an intermission which gives a few moments for making the altitude observation. Turning the micrometer screw, the horizontal wire is made to bisect the star, an action repeated two or three times to reduce accidental errors. There is no time for the micrometer head to be read, but it is furnished with some printing or recording device which keeps a record of settings. Tapping off the passage over the vertical wires is now finished, and the star disappears from view. Next, at the side of the instrument four long microscopes are read which are viewing a graduated circle attached to the telescope. Their combined reading will ultimately tell at what elevation the telescope was clamped; to that must be added the reading of the micrometer head so as to include the extra displacement given to the wire to bring it onto the star.

The whole observation takes two minutes or less, but there is a great deal of work in store for the computer. He must sort out the taps on the chronograph belonging to this star and also the records of the micrometer head. The error and rate of the standard clock must be worked up from the clock stars observed during the night. The large correction for refraction must be computed and applied to the altitude. Various observations for adjustment will have been taken, and from these the collimation, azimuth, level and zenith point corrections must be deduced and applied. There will be further corrections, not specially connected with the instrument, to be included before the final place of the star is obtained in the form of mean right ascension and declination. This typical procedure may be varied somewhat. The most importaht modification is the use of the traveling-wire micrometer (see MICROMETER), which is generally employed in first-rate work. Attempts have been made to substitute some photographic or photoelectric method for visual observation.

Formerly the altitude observation and the time observation were made with different instruments, called, respectively, the mural circle and the transit instrument. The mural circle is obsolete, but the transit instrument survives as a small portable instrument used for determining longitudes and for the most accurate determinations of time. The transit instrument is virtually a transit circle shorn of its graduated circles and microscopes.

The transit circle is used for determining the positions day by day of the sun, moon and planets. For stellar work its scope is limited to the brighter stars, roughly those brighter than magnitude 9 (there are more than 100,000 of these). There is no advantage in observing fainter stars with it, since the work can be done more speedily and accurately by photography; but photographic measures are relative, and the positions can be made absolute only if the photograph contains some reference stars whose absolute positions are already known from meridian work. Thus transit-circle observation is extended only so far as to provide accurate positions of a reasonable number of reference stars on all photographs.

TRANSKEI, THE, the name given to the part of Cape province, U. of S. Af., lying between the Kei river and Natal, excluding Elliot and Maclean. It covers Tembuland, Griqualand East and Pondoland. Area 16,329 sq.mi. Pop. (1951) 1,300,920, including 18,481 Europeans. These territories form mainly a native reserve, although there are many European farms in Mt. Currie and Matatiele.

The undulating country is fertile and well watered and the climate is healthful. Wool is produced and there are small deposits of iron

TRANSMITTER: see MICROPHONE.

TRANSMUTATION OF THE ELEMENTS. The transmutation of one metallic element into another was one of the chief objects of the earliest chemists, or alchemists, and was notably unsuccessful. Today, under the influence of modern views on the constitution of matter, transmutation into nearby elements in the periodic table has been successfully accomplished with respect to practically every one of the chemical elements.

See ALCHEMY; ACCELERATORS, PARTICLE; NUCLEUS; RADIOACTIVITY, ARTIFICIAL; RADIOACTIVITY; NATURAL.

TRANSPLANTS, TISSUE AND ORGAN. Transplants (grafts) are classified as autotransplants, homotransplants or heterotransplants, according as the tissue is obtained from the recipient himself, from another member of the same species or from a member of another species.

The fate of a living autotransplant depends on whether its nutritional requirements are adequately met and thus, with most tissues, on the early re-establishment of a blood supply. Pieces of skin (either whole thickness or partial thickness) or small pieces of other tissues may be transplanted freely to suitable sites and soon become permeated by new vessels. Autotransplants of skin and subcutaneous tissue are left connected by a pedicle containing blood vessels, at least until they acquire a new blood supply, and transplants of organs are made similarly or by vascular anastomosis; *i.e.,* by connecting the artery and vein to suitable vessels in the new site.

Homotransplants, as a rule, evoke a state of immunity in the recipient and in consequence are destroyed after a few days or weeks. The immunological nature of the process was suggested by the discovery that a second transplant from the same donor is destroyed more quickly than the first, and was confirmed by the subsequent discovery that increased resistance to a transplant could be transferred to an animal of the same inbred strain as the recipient by transplanting cells from the lymph nodes draining the region in which the transplant was located. The antigens concerned are located in the cell nuclei, are genetically determined and appear to be common to all the nucleated cells of an individual. There is evidence that they are complex mucopolysaccharides. Antibodies can sometimes be demonstrated in the recipient's serum, but those concerned in the destruction of homotransplants appear to be transported by cells (probably lymphocytes) (see IMMUNITY). The survival of homotransplants may be prolonged temporarily by experimental and therapeutic procedures; *e.g.,* administration of cortisone.

Exceptionally, homotransplants may survive permanently, notably (1) when the donor and recipient are identical twins or animals of a closely inbred strain; (2) when the tissue, such as cornea and cartilage, is devoid of blood vessels; (3) when the recipient before birth (or in some species soon after birth) has been injected with living cells from the prospective transplant donor and has in consequence become specifically tolerant of his tissues; (4) when the recipient has been exposed to whole body irradiation; and (5) when the transplant is isolated by a porous membrane which allows the passage of fluids and nutritive substances but not cells. Homotransplants between nonidentical twins normally survive only temporarily. In cattle, however! and very occasionally in man, nonidentical twins may exchange blood-forming tissue during intrauterine life, following which the blood of each contains red cells of two different blood groups, and homotransplants interchanged between them survive permanently.

Homotransplantation of adult blood-forming tissue to an immature recipient may cause runt disease, characterized by retardation of growth, diarrhea and sometimes death; a similar condition, termed secondary disease, may develop after transplantation to an irradiated adult. Both conditions appear to be due to an immunological action of some of the transplanted cells against the recipient.

Heterotransplants are normally rapidly destroyed. They too evoke a state of immunity, and cytotoxic antibodies usually can be demonstrated in the recipient's serum. Tumour heterotransplants may survive, however, in certain special sites.

In surgery, free autotransplants of skin, bone and cartilage are used extensively. Skin transplants are of special importance in the treatment of deep burns. They usually consist of only part of the thickness of the skin. and in this event the donor site will heal spontaneously. Free nerve transplants also are used, sometimes in the form of multistrand or cable grafts made from small sensory nerves which can conveniently be sacrificed. Attempts have been made to increase the permissible dose of radiation in cancer patients by removing bone marrow before treatment and replacing it afterward as an autotransplant. Pedicled autotransplants of stomach or bowel are used in reconstruction of the alimentary tract after resection for cancer and other disorders, and pedicled transplants of bowel are used also in reconstruction of the urinary tract.

Homotransplants of cornea are used to restore sight in patients with corneal opacities and conical cornea. They may be partial or full thickness and will remain clear provided that blood vessels do not enter them. Homotransplants of skin survive for only a few weeks but may be lifesaving in patients with extensive burns. They are replaced by autotransplants when the patient's general condition is satisfactory. Homotransplants of bone are used in orthopedic surgery. They are often dead and, even if living, do not survive permanently, but they provide a scaffolding which facilitates repair by the recipient's own tissue. Homotransplants of arteries are used in vascular surgery, and they too act as scaffolding for regenerating recipient tissue, but the tendency is to prefer substitutes of woven synthetic materials. Homotransplantation of a whole kidney is unjustified unless an identical twin is available as donor, because the transplant is unlikely to function for more than a few weeks and a patient can be maintained on an artificial kidney for this period. Several instances of successful transplantation of a kidney from an identical twin, however, have been reported. Homotransplantation of blood-forming tissue has been tried in conjunction with X-ray therapy in leukemia and cancer, but by the early 1960s had succeeded only in experimental animals.

For storage, transplants of blood and bone blood vessels, which need not remain alive, are frozen, freeze-dried or kept in antiseptics. Skin transplants survive for a few weeks at 4° C. and for months after being soaked in glycerol and frozen to −79" C.. but the problem of storing whole organs by freezing or by continuous perfusion remains unsolved. *See* also PLASTIC SURGERY.

See M. F. A. Woodruff, *The* Transplantation *of* Tissues and Organs (1960). (M. F. A. W.)

TRANSPORT. For separate articles dealing with this subject, *see:* for land transport: AUTOMOBILE; ELECTRIC TRACTION; MOTOR TRANSPORT. COMMERCIAL; RAILWAY; ROADS AND STREETS; SUBWAY (UNDERGROUND RAILWAY); TRAFFIC REGULATION; TUNNEL. The following articles cover transport at sea: SHIP; SHIPBUILDING (MERCHANT AND NAVAL); SHIPPING, HISTORY OF; SHIPPING INDUSTRY. Inland waterways are dealt with in BARGES AND CANAL CRAFT; WATERWAYS, INLAND; INLAND WATER TRANSPORT; LOCK: RIVER AND RIVER ENGINEERING; WEIR. *See* also PANAMA CANAL; SUEZ CANAL. Subjects connected with coast and port protection are treated under BREAKWATER; BUOY; DOCK; HARBOURS; JETTY; LIGHTHOUSES; PIER; PORT OPERATION. For air transport, *see* AERONAUTICS and AVIATION, CIVIL.

General Characteristics. — This article deals with the history and organization of the chief forms of transport. Transport is a personal activity, a social service and an industry. There are two sharply defined stages: the period up to the Industrial Revolution, before which only the power of human porters, draft animals and the winds could be used; the period beginning with the Industrial Revolution, which brought steam, electricity and internal combustion as prime movers.

Basic conditions have greatly influenced both the techniques used and the forms of organization and ownership; *e.g.*, inland transport always involves both a vehicle and a specialized way, whether road, railway or waterway. A road is a much less specialized way than a railway, being used by many kinds of traffic; and the community has thus generally accepted the responsibility for providing the roads. The construction of railways has generally been undertaken by private capital, except where it has been necessary, for political or economic reasons, for the state to take the initiative. On roads there is usually no connection between the provision of the track and the ownership of vehicles. On railways, though, it was early recognized that the provision of the track should be under the same control as the provision and operation of the trains.

Sea and air transport are fundamentally different. Nature provides the track, and conducting transport is confined to the provision and operation of the vehicles and of the terminal facilities. Ships are generally privately owned; docks and harbours are owned by local authorities, public corporations and private companies.

Inland transport by water is an intermediate case. Where rivers are used, operations are similar to sea transport. Where an artificial waterway has been made, it is like both road and rail. Canal boats may be owned by the authority owning and maintaining the canal, or by common carriers or private traders. The canal may be provided by the state or be privately owned with tolls charged for passage.

Air transport differs economically from both land and water. Airline operation needs first to expend power and money merely to keep the vehicle air-borne. The cost of operation is very high. Terminal facilities are generally provided by the state, while operation is by corporations owned either privately or by the state.

LAND TRANSPORT

Pack Animals. — Women were the first porters and remain so in primitive societies. The use of animals for transport — dog, ox, horse, reindeer, camel and elephant — marked a great advance.

The dog was possibly the earliest animal to be used in transport. Because of its small size and limited strength, it was trained only when no better animal was available. Throughout the arctic and in parts of the old world the dog is still used.

The ox was the most widely distributed of all transport animals, species existing in a wild state in North America, Africa, Europe and Asia. The domestic ox was common in Europe and Asia in the Stone Age. The ox wagon was common transport in Mesopotamia and Egypt in early times; it is still seen round the Mediterranean, and has spread to South Africa and South America.

The domestic horse, presumably derived from the wild horse of the central Asian plains, seems to have been the earliest domesticated animal in Japan, though used for riding, not for draft. Its westward spread altered the history of Europe. Stray horses running wild over the plains and horses deliberately let loose in America soon produced wild herds in both North and South America. These wild horses profoundly influenced the life of the Indians. The horse is rarely used by African natives, except those in close contact with the Arabs. Human carriers (men, not women) are the usual means of transport in Africa south of the equator as far as the cattle areas, where oxen are used.

The reindeer provides not only transport but milk, flesh and skins. A herd of them constitutes wealth in Siberia and among the Lapps of northwestern Europe.

The camel, with its thirst-defying stomach, its capacity for thriving on desert herbage and its flat feet, which spread out instead of sinking into the soft sand, has made life and wealth possible in the Sahara. The camel rivals the horse in the drier districts of Asia from the near east to China, and has been invaluable in the exploration of the deserts of Australia. A good riding camel will cover 150 mi. in a day, and the Bactrian or two-humped baggage camel can carry more than 1,000 lb.

The domestication of the African elephant came late, but the Indian elephant was early trained for transport. Its great strength and intelligence can be used in pathless jungle and for road and bridge building, but because of its enormous appetite, which must be satisfied off vegetation where it works, and its delicate constitution, compared with other animals, its usefulness is definitely and narrowly limited.

Draft. — Man can drag more than he can carry on his back. Where the surface of the country is suitable some contrivance is made for hauling. The American Indians developed a type of sledge and also dragged skins sewn into bags along the frozen ground. Though over the whole of the arctic packs are carried on the back (human and canine), as the ground hardens sledges are made, on which far heavier loads can be transported. South of the frozen land, the toboggan takes the place of the sledge, and farther south a special method of packing led to the travois, a V-shaped framework formed by tent poles with a skin tent cover tied on and household goods piled on the top, the whole being dragged by dog or, later, horse. Such primitive constructions preceded the wheel cart, and survive in farm sleds, the sledge on runners and slide car. The wheel is not a primitive invention; though wheeled vehicles were familiar in early time in Assyria and Egypt, there was no wheeled vehicle in the Americas before Columbus.

Early Roads. — Porterage by human beings or pack animals needs only rough tracks trodden down by traffic. The first step toward more efficient overland transport of heavy loads was the use of tree trunks as rollers placed under the load to move it for a short distance. With the transformation of the roller into a wheel, a specialized track and vehicle were needed. Efficient transport over long distances was possible. The Romans, invading Britain in the 1st century B.C., found war chariots in use; doubtless some primitive carts were then also employed. The invading Romans built a network of paved roads constructed on sound engineering principles which, while primarily intended to provide for the rapid movement of troops, could also be used for wheeled traffic. There is evidence of the use of chariots and carts in other early civilizations.

Evidence of the existence of roads in the ancient world is generally evidence of a strong central government interested in military transport. Even as late as the 19th century the most spectacular road developments were in France under Napoleon, and in the 20th century under the fascist government in Italy and under the Nazi regime in Germany.

With the breakup of the Roman empire, the road system of Europe declined. The free movement of persons and goods was restricted, and travel was virtually confined to knights, nobles, priests and a few itinerant merchants.

The medieval monarchy recognized no special responsibilities for road construction and maintenance, but the church here and there attempted to fill the gap, assuming responsibility for the provision of bridges or certain stretches of road.

The first tentative move toward a modern road system began with the Tudor period and the beginnings of a system of local government based on the parish. Road maintenance became a duty of each parish under an act of 1555, and highway surveyors were appointed under an act of 1662 to levy rates for road upkeep. This system persisted, with modifications, until modern times. It has always led to disputes as to how far the roads are used by local people (and are thus a proper charge to the local community) and how far they are used by through traffic and should be charged to the nation or to the users of the roads.

Road Building in the **17th** and 18th Centuries. — France led among European countries in developing a modern inland transport system. Near the end of the 16th century the duc de Sully started creating a national system of roads surfaced with broken stones. The great road builder of France, however, was Jean Baptiste Colbert, who became comptroller in 1665. By enforcing the feudal system of compulsory labour, he brought about the surfacing of 15,000 mi. of road. In 1775 P. Tresaguet, by making provision for drainage of the roadway, began the construction of better roads and substituted a continuing force of paid workers for the earlier system. Two Scotsmen, however, Thomas Telford (1757–1834) and John Loudon McAdam (1756–1836), first built roads according to scientific methods. Telford laid a base of large stone on which smaller stones were placed, the surface being of finely broken rock. McAdam omitted the foundation of large stone and laid crushed rock for a few inches. The McAdam road was lighter and cheaper to build than Telford's. The McAdam foundation, with a binding of cement and a surface of asphalt or concrete, continued in use into the 20th century.

Roads in the Modern World. — Great Britain. — Both the technical knowledge and the forms of organization needed for a modern system of roads came into being in the 18th century. The principle that the parish should pay for the roads was largely replaced by one that the roads should be paid for on the basis of use. Though the first recorded levy of road tolls was in 1346, no real progress on these lines was made until early in the 18th century. Then the turnpike system began to be widely adopted. Sections of main roads were turned over to turnpike trusts, usually made up of local landowners. The trusts raised loans for road building and improvements and met costs of upkeep and charges for interest and repayment of capital out of tolls collected. Although some turnpike trusts actually did the work, many farmed out both the work and the collection of tolls to contractors.

With the development of fast stage coaches, the turnpike system reached its peak — just before railway competition began, about 1830. The turnpike trusts were not always efficient, nor had they the foresight to encourage steam power by road. Their levying of prohibitive tolls on the early experimental steam carriages, such as Gurney's, virtually ensured the future of steam traction on the railways. As the railway steadily superseded the roads for through traffic in the second quarter of the 19th century, the revenues of turnpike trusts declined and the system fell into desuetude.

Toward the end of the century, also, the growth of a modern system of local government made it easier to lay upon it the duties of a highway authority.

This system survived into the 20th century, though the growth of motor transport and the return of traffic to the roads began to raise the expenditures on roads and the question of national versus local responsibility. A road fund was established in 1909, with all proceeds of motor taxation to go for road expenditures. This system broke down because successive chancellors of the exchequer could not resist drawing upon the road fund for general government purposes.

The permanent principle that road maintenance, while being carried out mainly by local authorities, should be financially assisted by grants from the central government was, however, firmly established.

At mid-20th century there were about 8,000 mi. of trunk roads financially charged to the minister of transport, though the highway authorities maintained them as his agents and at his cost. The remaining roads were "classified" and "unclassified," the former comprising about 86,000 mi., or slightly less than the total road mileage in Great Britain in 1955. The unclassified roads were considered of purely local importance and were unsupported by grants

Other Countries. — The movement for good public roads began in western Europe 11 years before it started in the U.S. There the early and widespread development of railways, in a country sparsely populated, provided facilities for other than local transport that were fairly adequate until near the end of the 19th century. It then became manifest in the more thickly populated northeastern states that improved county and state roads were necessary. New Jersey acted in 1890, and Massachusetts, New Tork and other states soon followed.

In certain countries the growth of motor traffic caused a reversion to the turnpike system. In the 1920s Italy constructed *autostrade,* motor roads for high-speed traffic only between important centres, free from sharp curves. junctions and steep gradients. In the 1930s Germany also built Autobahnen, partly for military reasons. to provide an alternative to railways. Perhaps the widest development of the turnpike system took place in the U.S. where, especially after World War II, turnpikes provided unrivalled facilities for high-speed motor traffic. (See ROADS AND STREETS.)

Organization of Passenger Road Transport. — Road passenger transport has developed in three main forms — private, hackney and stage carriages. Use of private carriages presupposed the existence of a wealthy class and a reasonably good road system. By the 17th century not merely the aristocracy but also officials (such as the diarist Samuel Pepys) and merchants of the new middle classes began to own their own carriages in London. But for long journeys horseback remained the commonest form of travel until in the late 18th and early 19th century main roads were provided upon which a carriage could maintain a good average speed.

From the private carriage it was an easy transition to the hackney coach. The hackney was a device for sharing the overhead costs of a carriage among a number of persons, each of whom was prepared to pay part of the running costs and a contribution toward the overhead costs in return for the exclusive use of the vehick for a limited time. In London and in Paris the hackney vehicle appeared in the 17th century, and as soon as it had become common in London it began to compete with a much older form of public transport, the boats of the Thames watermen.

The stage carriage was later in appearing on a large scale, and its full development had to await the construction of a modern road network. It carried the principle of sharing expenses a good deal farther than the hackney, since the running and overhead costs of the vehicle were shared among a number of passengers simultaneously.

Whereas in the 17th century it was still an adventure to travel, most journeys being made on horseback, by the end of the 18th century stage coaches covered the country with a network of services that on the whole were well maintained. The mail coaches operated under contract with the postmaster general and kept to strict timetables, under penalty. By 1836 there were more than 3,000 coaches on the road; from one London tavern alone no fewer than 80 coaches departed every day. But this rapid development was followed by an even more rapid decline; as the railways came into operation, the coaches disappeared from one main road after another.

One of the institutions that also vanished was the posting house, the office, often also an inn, at which horses could be hired for a stage of a journey to draw the traveller's own chaise, or at which both a chaise and horses could be hired for the journey to the next posting house. Costs were high, and after the rise of railways a reserved railway coach or compartment met the needs of the wealthy traveller better.

The carrier's cart was a recognized institution in country districts for many years. It survived the arrival of the railway in many country districts as a purely local facility, until the advent of motor transport. In fact, while long-distance services by road vanished, a new network of road services connecting with railway stations appeared.

Street tramways were pioneered by the American George Francis Train, who introduced short lines of horse tramway in both the United States and Great Britain in the middle of the 19th century. These lines had, however, no statutory authority and in Great Britain lasted only a short time, large-scale development having to wait until the passing of the Tramways act of 1870. Between 1870 and the end of the century numerous horse tramways were laid down. In many cases, upon the expiry of the initial concession, the local authorities exercised their rights of purchase and a second stage of development followed which coincided with the general application of electricity to tramways.

The electrified tramways were extended for considerably longer distances than the old horse tramways, and generally proved successful competitors of the railways for suburban traffic. In some cases they were extended outside the city boundary to run over reserved tracks apart from the road. The end of the tramway era came in sight when the growth of motor traffic had increased street congestion to such a point that the presence of rail-bound vehicles could no longer be tolerated in the busiest streets. Many tramways were converted to trolley buses (electrically propelled, steerable vehicles on rubber tires, designed like omnibuses, which draw their power from overhead wires). The general trend however was toward the replacement of tramways by motorbuses, in view of their greater flexibility.

The horse bus started in London with George Shillibeer's pioneer service from Paddington to the City in 1829. Throughout the 19th century horse buses were increasingly used in the principal cities, but their development was checked for a time when electric trams took the lead. Soon afterward, however, the internal-combustion engine proved that it could provide a reliable and satisfactory form of motive power for the omnibus, and by World War I the horse bus had been generally superseded by the motorbus. This developed steadily; the modern vehicle differs from its predecessors principally in burning diesel oil instead of gasoline.

The growth of the motor-coach lines connecting important towns and holiday resorts stemmed from the old horse-drawn wagonette or charabanc. In the early 20th century the first motor charabanc was designed; from providing occasional joy rides it developed steadily into a nation-wide network of passenger coach services, in many cases highly competitive with the railways.

The Railway: Its Economic Significance.—The technical aspects of railways are fully covered in other articles. Attention is drawn here to the place of the railway in general economic history.

In the first quarter of the 19th century the flanged wheel on the iron rail offered the most promising scope for the application of steam power, because of the limitations of the then-existing road system, the absence of efficient vehicle suspension systems and of pneumatic tires, and the excessive tolls imposed by the turnpike trusts on steam road carriages. The engineer who made the greatest single contribution to steam locomotive design, George Stephenson, happened also to be a great designer of railway systems. A powerful advocate of the steam locomotive, he was commissioned to lay out lines of railway upon which the locomotive could show to the best advantage its capacity for both heavy haulage and high speed.

At the same time as Stephenson and other engineers were demonstrating the technical abilities of the new form of transport, the growing industrial wealth of Great Britain was making available the flood of new capital required for the construction of a vast network of railways. This was accomplished, in the main, over a period of no more than 40 years, from 1830 to 1870.

The revolution achieved by the railway in the economic condition of many countries during the 19th century was paralleled only by the further revolution wrought during the 20th century by the advent of motor transport. For the first time cheap and rapid travel to all parts of a country became widely available; the markets for raw materials and manufactured goods widened enormously, and costs of production fell as output increased.

Before the nationalization of railways in 1948 (Transport act, 1947), the state took no part in railway construction in Great Britain; government intervention was directed almost exclusively at the protection of the public safety, at the control of rates and fares and at ensuring the control of monopoly in the public interest. The fierce intercompany competition of the mid-19th century tended. however, constantly to dwindle by voluntary amalgamations, agreements for pooling schemes and agreements on rates and fares. Finally, after World War I, the British government by the Railways act of 1921 amalgamated all the principal railways into four groups, which in turn were unified under public ownership under the Transport act of 1947.

In the United States, also, private enterprise of a competitive character was the mainspring of railway development, and well into the 20th century it continued its traditional role. In most continental European countries, however, the state had early accepted the duty not merely of regulating but of participating in railway construction-especially in the economically less advanced countries, where private capital was not sufficiently abundant or sufficiently enterprising to cover the needs for railway construction. Development of transcontinental railways also demanded state action, and in some cases also became a measure of political expansion and influence, as, for example, the development of the Baghdad railway (*q.v.*) and the Trans-Siberian railway, which led to the further opening up of the vast resources of Siberia and closer relations between Russia and China. In Europe, especially, the need to use railways for the'movements of troops led to the development of strong state control.

Both in Great Britain and in the United States railways during the 19th century were not subject to the stimulus of much external competition from other forms of transport. Consequently, when road motor competition arose in the first quarter of the 20th century the railways were often slow at first to meet the challenge and adjust their traditional ways of doing business. A consequence was that while the railways continued to carry something like the same volume of traffic as 50 years previously, this represented a greatly reduced proportion of a greatly increased total volume of traffic offering. The ever-increasing balance of traffic was mainly carried by road. The problem of road-rail competition is further discussed in the following section.

The most effective technical answer by the railways to road competition was the abandonment of steam traction and the adoption of either electric or diesel power. Electrification proved indispensable for handling dense volumes of passenger traffic, as in suburban services; while by the middle of the century diesel traction was ousting steam rapidly in North America and many other parts of the world.

Organization of Freight Road Transport. — It was during World War I that the potentialities of road motor transport as a serious commercial rival to the railways were first demonstrated. The production of motor vehicles on a large scale for military purposes was combined with their use for the conveyance of men and supplies in various theatres of war, including the mobilization of the Paris taxicabs to rush troops to the battle of the Marne and the dispatch to the front of large numbers of London buses.

During the first quarter of the 20th century the railways had already experienced successful competition from electric trams and motorbuses for short-distance passenger traffic, which in most cases they had not attempted to meet. The rapid growth in the use of private cars, however, made inroads upon the previous railway monopoly of long-distance passenger traffic, and a third party to the competition entered when motor-coach lines were opened on roads which covered the same ground as the railways. So far as passenger traffic was concerned the competition was of a straightforward character, and in certain cases the railways found it possible to make concessions in their fares which enabled them to retain a substantial volume of traffic. As regards freight traffic, however, the problem was complicated by the existence of different systems of charging.

After World War I, large numbers of army surplus trucks (lorries) were offered for sale and many demobilized men invested their war gratuities in the purchase of vehicles. A period of rapid development and keen competition in road haulage followed, during which serious inroads were made into many railway traffics. Road transport generally concentrated upon those traffics which were highly rated under the railway classification and for which it was therefore easy for the road operators to offer lower rates.

The railways, in the days when they held a virtual monopoly of inland transport, had evolved a system of differential charges based mainly upon the assumed liability of different types of goods to bear different levels of transport costs. Thus coal and minerals, being relatively cheap in relation to their weight, were charged a much lower rate per mile than manufactured articles, textiles, etc. The theory was that, "taking the rough with the smooth," this system would encourage the maximum volume of traffic to pass, even though it might involve some element of subsidy as between the consignors of different types of goods. The road haulage operators, however, charged more or less uniform scales irrespective of the nature of the articles carried. Their charges were designed simply to cover the costs of operating the vehicle, with a margin of profit. The railways claimed that this competition was unfair in the sense that their road competitors were only carrying the "cream" of the traffic and were leaving them with the relatively unprofitable parts, which nevertheless in the national interest must continue to be transported and which could not bear a higher charge.

Between World Wars I and II this transport problem arose in practically every highly industrialized nation. The attitude of governments was generally that they desired to keep the railways in being and efficient, since they remained essential for heavy industrial traffic and would also be vital in time of war. At the same time, they did not wish to strangle or restrict unduly the development of a new and progressive service, which in many respects had advantages over the railways since it could give door-to-door deliveries without intermediate handling and for certain forms of transport was also cheaper.

In most countries a partial solution was found through some form of licensing of road vehicles. In Great Britain licensing of passenger services began with the Road Traffic act of 1930 and of goods vehicles with the Road and Rail Traffic act of 1933. In the United States the principal statute was the Motor Carrier act of 1935. These measures introduced a licensing system for vehicles. Existing operators were generally entitled to licences in respect of their existing services, but were obliged to submit proof of need for extensions. In Great Britain proof of need applied merely to the acquisition of further vehicles, but in the United States it also applied to the routes to be served.

In Great Britain the Labour government of 1945–51 decided that this system had failed to produce adequate co-ordination of transport facilities, and it nationalized long-distance road haulage under the Transport act of 1947; the subsequent Conservative government repealed these provisions and embarked upon denationalization. In the United States competition continued to be regarded as the best safeguard of efficiency, subject only to the principles of licensing and public control laid down in the Motor Carrier act. It became clear, however, that the Motor Carrier act had not operated to prevent the expansion of motor-truck lines, which took place on a spectacular scale after the end of World War II.

WATER TRANSPORT

Primitive Boats. — Water transport usually requires less effort than transport by land, and is often more highly developed among primitive peoples. The earliest type of boat is the raft, made of grass, logs of wood, bundles of reeds or other light materials tied together, on which man can float. Such was the raft of the Tasmanians, made of eucalyptus bark tied in cigar-shaped bundles nine or ten feet long, thinning at either end. Similar floating rafts of varying materials were used by early Egyptians on the Nile and by the Incas on Lake Titicaca. Inflated skins are used among the pastoral people of western Asia and North Africa, and inverted pots are used to support rafts for ferrying across the Nile river. The coracles of the ancient Britons, described by Pliny and still used in modern times in Wales and round the coasts of Ireland, the skin-covered canoes used by hunters in British Columbia and the bullskin boats in the western states of the Cnited States are varying developments of the same type.

The finest examples of skin boats are the Eskimo umiak and kayak. The umiak is the boat commonly used for hunting large game. The kayak is seldom used for transport but is essentially hunting and fishing equipment. Skin boats are mostly fitted for temporary use; great care has to be taken in beaching them, while, if they are left in the water, the skins soon rot. Both kayak and umiak, though still important, were less widely used than formerly in the 20th century.

FROM WISSLER, "THE AMERICAN INDIAN" (OXFORD UNIVERSITY PRESS)

ESKIMO KAYAK, MADE OF SKIN STRETCHED OVER A TIGHT FRAME. WORK WITH A HOLE FITTING THE HUNTER'S WAIST

Where suitable trees of good size are found, a simple type of boat is made of a sheet of bark. The Lillooet canoes of British Columbia were formerly always of bark, poplar, cottonwood, spruce, cedar or birch. In the spring two rings were cut around the tree trunk, with a line connecting them, and the bark was pried off in one piece. This was fixed to a wooden framework by sewing with root fibres, and all the crevices were caulked with moss and gum. The Australian bark canoes are of eucalyptus. A large sheet is peeled off, the ends are turned up and either tied or sewed, and the joints are caulked with resin.

The boat made out of a solid tree trunk has many advantages. Ancient dugout canoes, sometimes 50 to 60 ft. long, are found in British peat bogs, but it is not possible to date them with any precision.

The finest and most varied boats are found among the islands of Polynesia. where there are relics of primitive types, rafts of poles lashed together or bundles of bulrushes. The Moriori of the Chatham Islands used to venture out to sea, 60 at a time, on a raft of flax flower stems (Phormium *tenax*) floating on sea kelp bladders. Beautifully balanced dugout canoes, with or without outriggers, and carvel-built plank boats ingeniously lashed together with cord are universal. and in these long voyages of hundreds of miles from island to island are undertaken.

Early Ocean Shipping.—The Phoenicians, Greeks and Romans were able to navigate the ocean in vessels equipped with sails and with one to three banks of oars, and it was by means of these craft that they established and maintained their colonies. The Roman armies and their equipment and supplies were transported to Carthage and Gaul in these boats. The early civilizations developed in river regions, with special opportunities of production and transport, and about the Mediterranean, an inland sea providing a navigable highway.

The mariner's compass, though the properties of the lodestone were known in China and India long before they were in Europe, did not have much influence in the east because the orientals were not maritime people; but in Europe, from the 14th century on, mariners could sail by the compass whither they uould. and by the end of the 1jth century the sailing vessel had carried men to America and around Africa to India.

Shipping From the Middle Ages Onward.—The principal shipping routes were concentrated in the Mediterranean until trade developed with the new world, with West and South Africa and the far east. Genoa and Venice were the most important trading powers in the Mediterranean. The Mediterranean ships were of two distinct types, the sailing vessel and the galley. The sailing vessel had a considerable beam in relation to its length, and consequently a good cargo-carrying capacity. The galley was narrow and built for speed; a vessel of war: it could also carry a limited amount of cargo, generally articles of high value, and it was the principal means of communication between Venice and its trading outposts.

The galley was unsuited for the great oceans, where the sailing ship pioneered the main trading routes. But the broad distinction between the wide-beamed cargo vessel and the narrow, faster galley was repeated in later centuries when British trade was largely carried on by two types of ships, the East Indiaman and the free trader. The East Indiaman was the large sea transport, up to 1,500 tons, belonging to the East India company; it was armed to repel attacks by pirates and operated a "liner" type of service. The free trader on the other hand was a lighter, faster vessel which was developed in the West India trade but which eventually penetrated wherever a profitable cargo could be found. It was the forerunner of the cargo tramp of today.

As late as the 17th and 18th centuries it was common for a merchant engaged in overseas trade to own his own ships. A voyage was a single trading venture. The amount of capital required for such ventures was of course considerable; but, until it became legally possible to set up limited liability companies, the risks could be shared only by taking in partners. It became customary for the ownership of a vessel and its cargo to be divided into 64 shares, of which the various partners took up as many as they could afford.

With the growth of specialization that followed the Industrial Revolution. and the increasing supply of capital for investment, it became less common for a merchant also to be a shipowner. Shipping services then developed in two main directions—the establishment of liner services giving regular sailings and carrying both goods and passengers at fixed charges, and the provision of tramps which had no fixed itinerary and would sail to any port in the world if a profitable cargo could be obtained.

The differences in organization between liner and tramp services were reflected in different systems of charging. The liner companies organized themselves in shipping conferences, which agreed on the rates to be charged and published schedules of fares and rates to which all the member companies adhered. Traders were induced to leave their traffic with the conference lines by the offering of rebates, which were forfeited if a trader employed other shipping lines. Tramp steamers, on the other hand, were frequently owned by small companies, and their rates fluctuated in accordance with the world demand for shipping.

The wooden sailing vessel gradually gave way to the steel steamship during the first three-quarters of the 19th century. Robert Fulton's "Clermont" inaugurated steamboat navigation on inland waterways in 1807; the "Savannah" made an early transatlantic crossing with steam power in 1819; the screw propeller was invented in 1836; and the iron hull dated from about 1840. The Inman line adopted the propeller in 1850 and the Cunard line did so in 1862. The "Great Eastern," the giant of its time (floated 1858). had not only a screw propeller but also paddle wheels and six masts for sails. Twin screws were first used on warships in 1880 and came into use on merchant vessels in 1881. Steel began to replace iron in hull construction about 1880.

The relatively slow technical development of the ocean vessel was largely the result of the limitations of the marine engine. Engines with low steam pressure and consequently long, slow piston stroke could be used to drive paddle wheels by direct crankshaft action, uhereas gearing and loss of power were involved in giving the propeller the requisite speed. While direct-acting engines were used to drive propellers as early as 1854, it was not until after 1870 that the compound steam engine came to be exclusively used; then the ocean vessel developed rapidly in speed, size and economy of service.

The turbine. which had been invented in 1884, was introduced in warships and large, high-speed ocean vessels about 1900; but while the turbine uas superior to the reciprocating engine for some purposes, its use did not involve a fundamental change such as accompanied the introduction of the internal-combustion engine named after its inventor. Rudolf Diesel. The diesel engine did away with boilers and furnaces, it occupied less space than steam equipment and thus added to available cargo capacity. It consumed much less fuel, gave a vessel a much greater sailing range and was more economical to operate. For these reasons it was largely adopted for vessels of moderate size and speeds. One check upon the general dieselization of shipping was the higher cost of installation and the weight of the diesel engine and its auxiliaries, but these handicaps have been largely overcome.

During the 19th century the Cnited Kingdom had slightly more than 50% of the world's shipping tonnage. During World War I a large part of this was sunk and the United States appeared as a large-scale operator of shipping. Between World Wars I and II the British share declined to less than one-third of the total, and after World War II it was between one-fifth and one-quarter.

Air competition after World War II seriously affected the volume of high-class passenger traffic upon the main ocean routes; but its effect was masked for a time by the shortage of shipping that prevailed immediately after the war and the consequent pressure upon shipping space. Air transport did not, however, generally affect the demand for freight except in the case of articles of high value in relation to weight, especially perishables. There seemed a good prospect that a reasonable equilibrium would in fact be achieved between air and shipping services. under which each could play its proper part.

Canals and Inland Waterways.—The first modern British canal was promoted by the duke of Bridgewater to connect Worsley, and thus Liverpool, with Manchester. It was opened in 1761.

On the continent of Europe and in North America, inland water communication generally developed through the improvement of existing natural waterways, with the addition of some artificial waterways—often built and owned by the state; but in Great Britain the canals were generally built by private enterprise. The distances to be covered were not great but, because of the undulating countryside. the canals suffered from the drawback of frequent changes of level and consequent interruption of traffic at locks. They were also generally constructed to a narrow gauge, and even this was not standard throughout the country. Most of the canals could accommodate only the "narrow boat" of seven-foot beam. The wider canals could generally accommodate barges of broader beam, but on some wide canals the locks were too short for the narrow boat. Thus, while Great Britain was foremost in the development of a network of canals, through working was difficult and the system was less well-equipped to survive railway competition than were other systems elsewhere.

The long inland waterways of the continent, such as the Rhine and the Danube, and in America the Mississippi, on the other hand, continued despite the rise of railways to play an important part in the life of the communities they serve. A special place in world transport is also held by ship canals, which, like the Riel canal connecting the North sea with the Baltic, may also have considerable strategic value in time of war. The Suez and Panama canals are equally of great international importance, and free passage through them is safeguarded by international agreements.

The original conception of canals in Great Britain was that the canal company would merely provide a track open to all comers on payment of the appropriate tolls. Canal boats or barges, serving as common carriers, were operated in some cases by boatmen who owned a single vessel, in others by companies that maintained fleets of boats. Traders with premises adjacent to the canals often provided boats for the carriage of their own goods. Lastly, in some cases the canal company operated boats or barges itself, through a subsidiary company.

In Great Britain during the 19th century many canals were bought up by the railways in order to eliminate their actual or potential opposition to the parliamentary powers which the railways were seeking. Some canals, however, such as the Aire and Calder Navigation, which connects an important coal field with a port, continued to play a useful part and remained financially solvent. But despite various attempts to rehabilitate the canal system, no substantial capital investment could be attracted for this purpose. Eventually the Transport act of 1947 brought practically all the canals in Great Britain under state ownership, their management being entrusted to the British Transport commission. The commission undertook a careful survey of the whole of the canal system and reached the conclusion that. out of a total of 2,101 route-mi., only 336 route-mi. offered prospects of a satisfactory return from substantial improvements. while 994 route-mi. should be maintained without substantial expenditure's being justified, and 771 route-mi. should be abandoned as soon as opportunity offered. An important exception to the general nationalization of the canals was the Manchester Ship canal (*q.v.*).

AIR TRANSPORT

General Characteristics. — The economics of commercial air transport are dominated by the need to expend considerable energy merely to keep the vehicle on its "track"—in other words, airborne. Fuel consumption must therefore always be high in transporting a given load from place to place. Another feature of air transport is the high cost of safety precautions. On the other hand, the high speeds achieved mean that a regular and frequent service can be maintained over long distances with a small number of operating units.

Like shipping, air transport undertakings do not generally own the terminals from which they operate; most are publicly owned. Dues are charged to air-line operators for the services provided.

Between World Wars I and II commercial air transport generally required to be subsidized. This was done either by direct payments from the state, as in the case of the subsidy which the United Kingdom government paid to Imperial Airways Limited, or through the placing of mail contracts on a subsidy basis, as in the case of the United States air lines. Private flying developed more sloivly than was at one time expected. Charter transport, providing a taxi service of the air, steadily developed, however, and had become an important factor at peak holiday periods in carrying the overflow from the regular air lines.

In Great Britain the first civil air lines started, financed by private capital, shortly after World War I. They led a precarious existence. and eventually the four principal operators were amalgamated in 1924, under government pressure, to constitute Imperial Airways Limited. The government held some shares in this company and appointed two directors to the board, undertaking to give it a decreasing annual subsidy for a period of years. The main task of the new company was to develop a system of air communications throughout the British empire, in addition to maintaining the services to the continent and the Channel Isles that had been provided by its predecessors. The air service from Cairo to Basra, Iraq, was opened in 1927, and the first through service between England and India started in 1929. This was extended to Singapore in 1933, and the first London-to-Australia through service opened in 1935. Air routes reached Cape Town in 1932.

Shortly before the outbreak of war. under an act passed in 1939, Imperial Airways was amalgamated with British Airways, an organization formed in 1935 which operated various continental routes, to form the British Overseas Airways corporation (B.O.A.C.). This was a nationalized public corporation, whose board was appointed by the government and whose general policy was subject to government approval. After the war, British European Airways (B.E.A.) was set up to take over the services between Great Britain and the continent, so that B.O.A.C. serves the long-distance ocean routes while B.E.A. links Great Britain with the European continent. The two public corporations are complementary to each other and do not compete.

For a full account of the development of passenger travel by air, see the article AVIATION, CIVIL.

Cargo Transport by Air.—The first notable event in the evolution of the air cargo carrier was the Zeppelin airship launched in Germany in 1900. Although passenger business was paramount, valuable papers and small packages of relatively large unit value were also transported—essentially the beginning of air express. The Hamburg-American line, acting as agents for the German Zeppelin company, announced in 1932 the first regular transoceanic sailing schedule for the "Graf Zeppelin." The service was expanded later to include both North Atlantic and South Atlantic crossings, until World War II forced its abandonment.

While interest in lighter-than-air vehicles grew apace in Europe, the United States turned its attention to the possibilities of heavier-than-air craft. World War I created a great demand among European nations for aeroplanes and stimulated C.S. manufacturers to focus more of their energies upon their development. By the end of the war sufficient progress had been made to bring about the establishment of the first regular airmail service. A line began operation May 15, 1918, between New York city and Washington, D.C., and gradually the service mas extended until July 1, 1924, when the transcontinental mail service was formally inaugurated. While this activity was in progress, the Universal Postal union was alert to international airmail possibilities. As early as 1920 at the congress of the Universal Postal union at Madrid an international airmail service was discussed! and in 1924 such service was made the subject of official regulation.

Ocean steamship lines sought permission to operate air-cargo services. Although they were not given this privilege, some lines held financial interests in air lines and also entered into special contracts with air-line companies for cargo services between stipulated ports.

During World War II the great possibilities of the plane for transporting heavy loads were first realized. However, such use of the plane was not commercial. The post-World War II years marked the beginning of a rapid growth in scheduled freight and express services and in the use of planes exclusively for such purposes. The Railway Express agency handled nearly all the cargo hauled by the air lines. This was a matter of convenience, because the air lines had not developed a transportation service between the airports and the points of origin or destination of their cargo.

Another aerial device tested as a carrier as early as 1939 was the helicopter, employed for short-haul duty, particularly the carriage of mail. It has also been widely utilized for rescue work at sea and on land. involving the dropping of foodstuffs and other emergency supplies as well as the transference of persons from hazardous locations to places of safety.

TRANSPORT AND THE STATE

Public and Private Ownership and Forms **of** Organization — In 1955 there was a large variety in the forms of organization and ownership in transport, extending from the British Transport commission with nearly 900,000 employees to one-man businesses operating a single motor truck or bus. Both private capital and the state provide important transport services.

Individuals, through their ownership of private cars, possess a degree of mobility unknown in any previous age. Trading firms can provide motor vehicles to carry their own goods with, in most countries, a wide degree of freedom. They also sometimes operate canal barges for the same purpose; and some large corporations even own oceangoing steamers, particularly for the carriage of oil, iron ore and fruit. Traders also in many countries own specialized railway cars (*e.g.*, refrigerator cars) for the transport of their own goods, although in such cases they do not of course perform the haulage.

Public transport services are provided on the roads and on canals by large and small firms and by individuals. The character of railway operation however requires investment of large amounts of capital, and railway ownership is therefore confined to corporations, either privately or publicly owned, or to the state.

Air lines are generally operated by companies or corporations, which may be either privately or publicly owned. The operation of urban passenger transport, whether trams, trolley buses or motorbuses, is divided between privately owned companies, public corporations and municipalities. Shipping is generally carried on by private capital, though in some cases the state has itself entered this field, generally setting up a publicly owned corporation for the purpose rather than entrusting the management to a department of state. The director-general of the French National Railway company has pointed out that two main trends can be discerned in transport organization. The first is the tendency toward consolidation and centralization.

The 19th century was the steam age. Steam was the chief source of power both for manufacturing and for transport. In factories, central enginehouses provided, by means of shafting and belts, the power for large numbers of machines. Centralization of the power supply was accompanied by a trend toward consolidation and enlargement of individual business firms. This trend was particularly marked in railways, where amalgamation tended to produce a continually larger scale of operation. At sea the same tendency was apparent; shipping companies consolidated and grew in size, just as the size of their vessels increased.

The culminating point of this process of consolidation was probably reached in Great Britain when the Transport act of 1947 amalgamated the four railway companies into a single state-owned system and brought under the same control the canals, a large part of the docks system of the country, the London passenger transport services and also long-distance road haulage. Although a subsequent government enacted that road haulage should to a large extent be returned to private ownership, the British Transport commission remained probably the largest transport undertaking in the world, apart, possibly, from the Russian state railway system. Its railway system is approached in magnitude by the state railways of various European countries; but it is unique as a single public body providing so many diverse forms of transport.

A contrary tendency, however, began with the advent of the internal-combustion engine and electric power. The main effect of using these prime movers is greatly to reduce the scale upon which power can be economically applied to particular tasks. Instead of a steam locomotive hauling a railway train weighing several hundred tons, a truck or lorry will carry anything from half a ton to 20 tons of goods directly to any point to which the road system penetrates. Equally, in factories, small electric motors can be employed to give power to each individual machine.

Accordingly, it is now much easier both for the individual to have unlimited rapid personal transport and for the trader to meet his own transport requirements through the employment of trucks. There has thus been remarked on the one hand a tendency for public transport to grow in size and (since competition within the industry always tends to become less effective) for the state to step in to protect the interests of the public. On the other hand, transport of the most flexible kind has become increasingly available in private hands, and represents probably the most effective safeguard of the consumer. The main clash in fact is not, as in the 19th century, between rival common carriers, operating different forms of public transport, but between public transport and private transport.

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TRANSPORT, MILITARY. This is a broad term that includes all forms of ground, water and air transport employed in preparing for or prosecuting war. Most of it is conventional transportation put to military use but some is specially designed to meet peculiar military requirements. So basic is military transport in the conduct of war that without it the organization and utilization of large bodies of men as armies would be impossible. It is transportation that makes it possible for military units of size to take to the field, to maneuver over wide areas, to wage wars in distant lands. In the absence of transport, warfare would be primitive indeed, confined to short raids by small groups armed only with light, simple weapons.

This article is organized according to the following outline:

I. CLASSIFICATION OF VEHICLES

A. GROUND TRANSPORT

Ground transport, the most varied and important item in military transport, ranges from the individual porter. equipped with gear devised to assist him in carrying burdens, to vehicles mounted on wheels, tracks, runners, rollers or combinations thereof and propelled by animals or self-contained power units. It includes the one-man cart, the animal-drawn wagon, the railroad locomotive and car and innumerable types of motor vehicles and trailers designed to roll over highways or operate across country. In the military forces of the western nations the motor vehicle became, during the first half of the 20th century, the dominant form of ground transport in the field. Military vehicles can be distinguished from each other in a number of ways. Usually they are classified according to assignment. use and purpose.

1. Organic and **Nonorganic.**—When classified on the basis of assignment they are listed as organic and nonorganic vehicles. The first are those assigned to military units according to their tables of organization and equipment; nonorganic vehicles are not assigned to specific units but may be temporarily attached to them.

2. Administrative and Tactical. — When classified according to use, the general terms that apply to military vehicles are administrative and tactical. Administrative vehicles are normally commercial-type vehicles suitable for routine military transportation not directly related to combat operations. Tactical vehicles are those employed in the field in connection with combat and tactical movements. Since many vehicles in this category also meet the requirements for routine operations, they are often employed as substitutes in administrative service. When this is done they are classified as administrative vehicles.

3. General and Special Purpose. — General-purpose vehicles are conventional types modified to meet a variety of military transportation needs. Included in this group are trucks, trailers, semitrailers, special-equipment vehicles mounted on a standard chassis, passenger cars and buses. The term special-purpose vehicle embraces all those built to meet requirements which cannot be met by modifying the chassis of a general-purpose vehicle. It comprises fire trucks, tractors, amphibious trucks and combat vehicles. The latter is by far the largest category, including such types as armoured cars, artillery carriages and tanks. Combat vehicles are not usually considered military transports since movement of men and supplies is not their main purpose. How effective they can be in emergencies as cargo carriers, however, has been demonstrated in warfare many times. A classic instance was the use that Field Marshal Erwin Rommel made of tanks in towing trucks and trailers when faced with a shortage of fuel during his long retreat across the Libyan desert following the battle of El Alamein in World War II.

B. Water Transport

Water transport used for military purposes includes all types of floating equipment ranging from barges, lighters and small craft to huge ocean-going freighters and passenger liners converted to troop carriers. Since most of the vessels employed for military purposes are taken from the carrying trade, their military classification follows that of the shipping industry. In general they are grouped as harbour craft, passenger. combination passenger and cargo, cargo and special-purpose vessels.

1. Main Types.—Harbour craft include all floating equipment such as tugs, lighters, barges and boats normally used in ports to handle ships or move men and things from ship to shore or from shore to ships at anchorage.

Passenger ships are personnel carriers ranging from small coastwise vessels to huge ocean liners like the "Queen Mary" and "Queen Elizabeth." Although designed to transport people they can carry some light, compact freight.

Combination passenger and cargo vessels can lift both men and freight. Normally they ply their trade between ports where full-fledged passenger service would be unprofitable.

Cargo vessels are designed to lift freight of every description. To get the most economical use out of them requires careful prestowage, loading and discharge planning. They are fitted with large hatches and booms that enable some to handle weights up to 60 tons. Known in the trade as freighters, they usually contain a few spaces for passengers.

The special-purpose class comprises a variety of ships designed to carry special types of cargo. On the whole they are unsuited for transporting general cargo but often they can lift cargo similar to that for which they were built. In this group are tankers, colliers and seatrains. Tankers are used primarily for transporting bulk petroleum products, colliers for coal and ore and seatrains for railroad rolling stock. Easily loaded and discharged, the latter proved invaluable during World War II in speeding tanks, vehicles and locomotives to overseas theatres of operation.

2. Landing Craft and Ships.—Because the assumption of the offensive in World War II required the western Allies to undertake amphibious operations, the world witnessed the appearance of a host of novel vessels for military transport. The development of some, mainly small boats and craft for ship-to-shore operations, antedated the war. Among them the Higgins boat, a craft of shallow draft that could be beached and retracted easily, was the most promising. Tested by the U.S. marine corps in 1941 in maneuvers, it proved satisfactory in moving men, tanks and artillery ashore.

After the entrance of the United States into World War II, the emphasis in both that country and Great Britain switched to the design and production of landing craft and ships needed for the extensive amphibious operations that the U.S. and British military leaders agreed would have to be undertaken if victory over the Axis powers was to be won. Only with thousands of craft and vessels, capable of landing large bodies of men quickly and sustaining them by over-the-beach supply operations until ports could be acquired and worked, could Germany and Japan be dislodged from the areas they had overrun. Because the amphibious landings often involved long voyages and prolonged operations, some of the types of vessels in the building program had to be entirely seaworthy. In the development and production of many types the Americans and British participated jointly.

Since the vessels were designed to meet peculiar military needs, they can be placed in the special-purpose class. Most important among them were the landing craft, infantry (LCI), the landing ship, tank (LST), the landing ship, medium (LSM), the landing ship, dock (LSD), the landing craft, medium (LCM), the landing craft. tank (LCT) and the landing craft, vehicle, personnel (LCVP). The majority of these ships and craft were shallow-draft roll-on, roll-off vessels that could be beached under favourable hydrographic conditions. This enabled them to discharge their loads quickly without first transferring them to small boats, lighters and craft, thus reducing the hazards of transfer at sea and the turnaround time.

Chief among the personnel carriers in this group was the LCI. It was powered by a diesel engine and had accommodations for 200 men plus space for 30 tons of cargo. The ship was equipped with twin ladders on both sides of the bow and troops could be disembarked into shallow water or directly onto beaches. Among the vehicle carriers developed during World War II were the LST and the LSM. Both had ramps built into their bows and flat bottoms that permitted them to disgorge vehicles directly to docks or beachheads. When track was installed on the LST's and rail ramps were erected on the beach to bridge the water gap between shore and ship, they could handle railroad rolling stock equally well. Completely seaworthy, the LST and LSM could navigate oceans with sufficient speed to permit them to sail in slow convoys.

The LSD was similar to the LST but larger. Its main purpose was to carry amphibious vehicles long distances over rough waters. The effectiveness of the ship was demonstrated in the Pacific campaigns of World War II and during 1958 in the resupply of the Chinese Nationalist garrisons on Quemoy.

The LCT and the LCM were smaller in size than the LSM. Built to carry a few tanks or motor trucks, they could operate efficiently in calm seas over short distances. The LCVP was both a vehicle- and a personnel-carrying craft. Its normal use was in ship-to-shore operations.

Although all the above vessels were designed to serve as assault shipping they could be used equally well in resupply operations. Produced by the hundreds during World War II in U.S. and British shipyards, they accounted for much of the success attained in amphibious operations. If one type were to be picked above the others for effectiveness, the laurels would probably go to the LST, a vessel first developed by Great Britain and later modified by the United States. Without doubt it was one of the best of the vessels originally designed for beach landing. So valuable was it that after World War II both the U.S. army and the U.S. navy encouraged the shipping industry to build similar but larger and faster models for commercial use in order to establish a pool of roll-on, roll-off vessels on which they could draw in an emergency.

C. Air Transport

Air transport is the most recent addition to military transport. Used but slightly in World War I, it underwent a rapid development between World Wars I and II in all western nations. From small planes capable of lifting only a few hundred pounds of mail, aircraft reached the stage where they could carry tons of cargo and scores of passengers. Startling progress in increasing capacity and speed was made during World War II and equally startling advances were made in the postwar years. Because of the growth of commercial air transportation their exists a vast pool of aircraft in most modern nations that could be converted to military use in time of war. In addition, most nations and particularly the U.S. and the U.S.S.R. have developed both planes and helicopters primarily to lift troops and supplies. Some of the new types are capable of lifting over 100 men and many tons of supply and equipment. Among those specifically designed by the United States to carry troops or cargo, the C-119 (Boxcar), the C-123 (Provider), the C-124 (Globemaster) and the C-130 (Hercules) are the most important.

Known carriers produced by the U.S.S.R. after World War II were the 11-14 ("Crate"), the "Camp," the Ukrainia ("Cat") and the Tu-104A ("Camel"). One large plane, the Tu-114 (Rossiya), had a double-deck fuselage. It was capable of flying between 170 and 180 passengers from Moscow to Peking or Vladivostok at a speed of 570 m.p.h.

II. HISTORICAL DEVELOPMENT

Throughout history, military men have been dependent on some form of transport to enable them to carry the supplies and equipment needed to sustain their operations, More often than not the transport they employed was conventional, typical of the period and region in which they fought. As society developed and the conduct of war became more complicated, the need for transport to fit special military requirements grew. To a large extent it was met by modifying existing transport; in most of man's long history the differences between conventional and military transport have been few. It is only in recent times that military and commercial transports have tended to diverge more sharply, but even so few basic differences exist and the great mass of military transport is still conventional transport adapted to military purposes.

Before the dawn of civilization, primitive man in making war on land carried his supplies and equipment strapped on his back or loaded them on beasts of burden. When traveling over water he used a raft, canoe or crude boat. The invention of the wheel revolutionized land transportation. It brought first the two-wheeled cart and then the four-wheeled wagon into existence. When new sources of power were discovered it made possible the railroad, the steamboat, the motor vehicle and the land-based airplane.

Second only to the wheel in its effect on society was the invention of the sail, which enabled man to harness the power of the wind to propel craft over water. From the days of the Phoenicians, who were among the earliest peoples to equip ships with sails, until the mid-19th century the sailing vessel was the dominant form of water transport. Supplemented at first by man-powered oars, it permitted easy and rapid movement to distant lands. Without it none of the vast overseas colonial empires of the ancient and modern world could have been established and maintained.

A. Men and Animals

Until the early 19th century land transport was simple, and not until the U.S. Civil War, when the railroad was used, was there any great change in military transport. What equipment and supplies man did not carry on his person or load on an animal, he moved in one-man carts or animal-drawn wagons. As military transport, the use of men, animals and animal-drawn vehicles had both advantages and drawbacks. Men, being more agile and intelligent, could operate as porters in rougher terrain and with less care and direction than animals. Horses, camels, donkeys and elephants could carry far heavier and bulkier loads, but they could not operate in all the areas where men could. When harnessed to vehicles, as many were after the wheel was invented, the weight and bulk of the load they moved were greatly increased, but their ability to move over difficult terrain declined.

Which animal was first used to haul carts will probably never be known. It may have been the ox. Slower but stronger and tougher than horses, oxen yoked in pairs could haul much heavier burdens over more primitive roads than could an equal number of horses. It is not surprising, therefore, that for centuries the ox was a leading beast of burden in both military and commercial transportation. Only with the improvement of roads did he give ground to the horse and mule. His decline in military transport was gradual and it varied in time and location. In the United States, for example, ox-drawn vehicles were used by the army until late in the 19th century, long after they had been discarded by the armies of western Europe. The reason was that western Europe had better roads than did the American frontier where most of the U.S. army was stationed. In parts of Asia and Africa carts drawn by oxen and water buffalo served as military transport in the 20th century. Both the Boers and the British used oxen in the South African War and the water buffalo was widely used in the Pacific theatre during World War II.

The use of men and animals as carriers of military supplies is still important despite the development of vehicles driven by steam and internal-combustion engines. That they will continue to be employed for some time to come is probable because they can operate in areas where mechanized vehicles cannot, and because they do not break down or run out of fuel as do machines.

The importance of manpower and animal power in military transportation in the future will, of course, vary greatly with conditions. In Asia, for example, where manpower is abundant and cheap, it is reasonable to believe that porters will continue to be employed. How effective man can be as a carrier was demonstrated in the Korean conflict where, with the aid of an A frame on his back, he probably carried more tonnage than was moved by vehicles. The individual soldier is unlikely ever to escape from being a transporter for the simple reason that he must carry on his person not only weapons and equipment but enough food, water and ammunition to sustain himself in the field for a short time. His burden may be reduced but it cannot be eliminated entirely. Animals, on the other hand, will probably continue to give way gradually to machines in western nations, but it is impossible to predict when they will disappear entirely. Under certain conditions there is still no substitute for them. Even modern armies like those of the United States and England, which had given up their use before World War II, were forced to procure mules and horses during the war to supply forces moving over the rough and difficult mountain areas of north Africa, Sicily and Italy. In Burma the British employed water buffaloes and elephants in addition to mules and horses; in the Philippines the Americans, Filipinos and Japanese frequently resorted to the use of water buffaloes in flooded areas. Water buffaloes will doubtless still be required to haul military supplies through the rice paddies of southeast Asia in time of war, for enough roads to permit resupply by other methods of laqd transport do not exist.

The trend in modern armies after World War II was to lighten the load placed on the soldier and to decrease the time he must carry it so that he could enter battle stripped of nonessentials and untired by grueling approach marches under heavy pack. The American and European infantryman formerly carried between 70 and 80 lb. on his person and often more; the modem soldier usually carries about 40 lb. This reduction in the soldier's burden was bought at the expense of self-containment, though the loss was partially offset by a cut in the weight of certain items of equipment and by improvement in the means of regular resupply. The latter was largely the result of the greater flexibility that came from newly developed motor vehicles and aircraft, the increase in the numbers of both, better communications and improved control of transportation.

B. The Rise of Steam Transport

With the invention of the steam engine in the late 18th century, man for the first time had at his disposal a form of power other than animal and wind that he could apply to transport. By attaching the steam engine to wheels that could run on track, he produced the railroad; by putting it in the hull of a ship and harnessing it to a water wheel he produced the steamboat.

Before the advent of the railroad, which brought new velocity to land transport, wind-propelled sea transport could often outrace animal-drawn vehicles in long-distance movements. Napoleon recognized this fact but could do little about it, for the British navy controlled the seas and could halt the growth of a rival merchant marine at will. With the extensive building of railroads in Europe during the 19th century, making movement by land easy and rapid, the advantage in transportation for waging war passed temporarily to the continental powers. Had it not been for the fact that sailing ships gave way to steamboats about the same time that railroads came into being, the balance in transportation would have swung more sharply than it did in favour of nations that could utilize railways most effectively to move armies to distant points.

By mid-19th century enough railroads had been built in Europe and America to warrant the keen interest taken by strategic planners in their use for military movements. It was not long after that governments, with strategic purposes in mind, began to encourage railroad construction. While more emphasis was placed on this factor by European nations, it was considered by others as well. The role the U.S. war department played in surveying routes for transcontinental railroads is evidence of its existence in the United States.

The first major conflict in which both railroads and steamboats were used extensively was the U.S. Civil War. The supremacy of the North in both, many historians maintain, was a determining factor in the outcome. Because the North had more rail capacity in strategic areas the Federal government was able to move men, equipment and supplies quickly from one front to another. Because it could outproduce the Confederacy in ironclad river boats propelled by steam, it was able to break through the defense barriers along the Tennessee and Mississippi rivers and strike at the heart of the South.

In Europe the first impressive use of rail transport was made by Prussia in mobilizing for war against Austria in 1866. A few years later, in the Franco-German War, railroads proved to be even more effective in moving military forces. The next extensive use of the railroad was during the Russo-Japanese War (1904–05). To sustain their armies in Manchuria, the Russians moved equipment, supplies and reinforcements thousands of miles over their broad-gauged Trans-Siberian railroad. The Japanese, in turn, depended on the South Manchuria railroad to move men and supplies from Port Arthur to Mukden, where the final battle was fought. The Russo-Japanese War was the first war in history in which railroads clearly played a decisive role, although before the end of the 19th century they had been accepted by military leaders as the main means for handling large-scale movements in areas where they existed.

The rise of railroads affected army organization as well as strategic planning in all western nations. So completely did railroads dominate military thinking that few leaders would have disagreed with the head of the French bureau of transportation, when he stated on the eve of World War I that it would be impossible to move an army corps by any other means. Though true at the time, the validity of the concept was soon challenged by highway transportation. Yet it remains a fact that railroads played a dominant role in land transportation throughout World War I and remained the best means for moving large forces in rear areas.

The steamboat gained recognition as a means of military transport somewhat later than the railroad, primarily because of the nature of the major wars fought in the 19th century. Although steamboats were used in the Crimean War by the British and French, it was not until the end of the century, during the Spanish-American and the South African wars, that their effectiveness was fully demonstrated. By this time the steamboat had supplanted the sailing vessel as thoroughly as the railroad had supplanted the wagon train.

C. Ships in Modern Wars

After 1898 the United States, Great Britain, Japan and, to a lesser extent, France all required sea transport in their wars. Endowed in its early history with a strong merchant marine, the United States, when it became a world power, was woefully lacking in ships that could serve as military transports. The famous clipper ships of the pre-Civil War era had long since relinquished their supremacy as fast cargo carriers to steamboats. With their decline went American interest in merchant shipping. By 1870, despite the growth of external trade, most American exports and imports were being carried in foreign bottoms, mainly British. A short-lived revival of interest in shipping around 1880 faded quickly. When the nation went to war with Spain it could barely scrape together enough vessels to transport its armies to the areas of conflict in Cuba, Puerto Rico and the Philippines. During the same period Great Britain, because of its dominant merchant marine, was never at a loss for ships to move troops and supplies to overseas garrisons. Although the lessons of the Spanish-American War were immediately recognized, the United States made no progress in rebuilding a merchant fleet until World War I. It entered that war without a merchant marine worthy of the name. Britain, Germany, France, Japan and even small countries such as Norway and the Netherlands had more vessels flying their flags than did the United States. Strenuous efforts were made to build a merchant fleet during the war, but they came too late to make the United States fully self-sufficient in water transport. Without ships flying foreign flags, and the German and neutral ships seized while interned in U.S. ports, the United States could not have transported and maintained its expeditionary force in France. Notable among the German liners appropriated and converted to transport duty was the "Vaterland," the largest vessel of its day. As the "Leviathan," it carried about 12,000 men each trip.

The cargo-ship construction program inaugurated during World War I would in time have produced enough bottoms to meet the military requirements of the United States. Houever, with the end of the war in 1918 the program was abandoned and with its passing went the plans to make the United States self-sufficient in merchant ships. What vessels had been built were in large part tied up and, years later, sold as scrap. As a result the United States entered World War II little better endowed with a merchant marine than it had been in 1917. As in World War I it leaned heavily at first on foreign vessels, mostly British, Norwegian and Dutch. Fortunately, during World War I U.S. industry had mastered many of the problems of producing ships rapidly; the country also had a ship-construction program set up under the Marine act of 1936 which called for the building of 500 vessels within ten years. This program was quite inadequate to meet the full needs of global war, but it served to pave the way for the mass production of ships.

By concentrating on standard designs, the United States was able to produce vessels quickly on an unprecedented scale. The two chief types became known as the Liberty and Victory ships. Over 2,600 Liberties were built, enough to earn them the reputation of being the leading carriers of World War II. Their main drawback was their slow speed of 11 knots. In this respect, the Victory with its 17-knot speed was far superior to the Liberty and therefore tended to replace it as the standard U.S. ship. Between 1943, when the first Victory slid down the ways, and the end of the war a total of 531 were built. Like the Liberty, the Victory was primarily a cargo vessel, but many were converted to other purposes from time to time as the need arose, particularly to troopships and aircraft carriers.

Great Britain, too, went into a heavy ship-construction program during World War II. In addition, it took over and operated many of the cargo and passenger ships flying the flags of countries overrun by the Germans. Among them were the French liners "Ile de France" and "Pasteur" and the Dutch "Nieuw Amsterdam." To get the greatest possible military use out of the tonnage produced, the shipbuilding program in both the United States and Britain was accompanied by the development and production of new cargo-handling equipment such as fork lifts and heavy cranes. Also stressed was the enlargement of port facilities and the building of harbour craft. One tremendous project, undertaken to facilitate the handling of ships and cargo for the 1944 cross-channel invasion, was the construction in England of two huge artificial ports known as Mulberry A and B. When towed to the far shore in sections shortly after D-day by ocean-going tugs and then assembled, they served to relieve the strain on the Normandy beaches over which the bulk of men and supplies were being moved.

The belligerents constructed thousands of craft and lighters to meet the needs of greatly increased port, offshore and inland waterway activities during World War II. These vessels ranged in size from small launches to huge seagoing tugs, barges and ferries. As water transport they deserve to rank in significance with ocean-going cargo and passenger ships. Among the new types of craft produced were the sea mule, a powerful little harbour craft used to push lighters and small barges short distances; the rhino ferry, a self-propelled barge developed by the British for use off the

Normandy beaches and in navigating inland waterways; and the ocean-going tug. Only three of the latter were built, but they rendered remarkable service, first in towing strings of barges across the Atlantic and later in moving ponderous components of the artificial ports from England to the Normandy beaches. Among the most used transports were the steel and wooden lighters and barges built for port, river and canal operations. Hundreds were shipped in parts to the British Isles from the United States and Canada. After the Korean conflict a unique craft called the beach lighter was developed in the United States. Married to a large vessel of the roll-on, roll-off type, it can take on vehicles at sea and move them from ship to shore.

When World War II ended, many of the vessels produced by the United States during the emergency were placed in the reserve fleet. Some were sold to shipping companies; some were turned over to other countries. During the Korean crisis, many ships in the reserve fleet, mostly of the Victory class, were temporarily restored to service. Meanwhile the shipbuilding program did not stand still as it had after World War I. New types of vessels, similar in design to the Liberty and Victory ships but considerably improved, were constructed. Known as the C types, they developed speeds of from 11 to 20 knots and had gross tonnages varying from 5,100 to 13,000 tons. Construction of a type called the Mariner was begun in 1951. By mid-1958, 35 had been completed. Although built to carry vehicles and cargo, these vessels could quickly be converted to troop transports or hospital ships.

D. The Rise of Motor Transport

Following the railroad and the steamship, the next type of transport to appear was the automobile. It was made possible by the invention of the internal-combustion engine and the pneumatic rubber tire. First designed to carry passengers, it was soon adapted to cargo as well. In the early part of the 20th century the motor vehicle was added to the list of military transports in most western nations. From shaky beginnings in Great Britain, Germany and France, it became the major means for moving modern armies on land. With its capacity to travel quickly on ordinary roads for short distances, it soon challenged the supremacy of animal-drawn wagons as military transport for short hauls. Before World War II it had practically replaced animal transport in several modern armies and was in a position to compete with railroads in long hauls. That it could do this successfully was conclusively proved during that conflict.

The transition from animal-drawn to motorized vehicles in the United States can be said to have begun in 1904 when a few trucks were tested at the United States Military academy. This experiment and a subsequent one a few years later failed to attract favourable attention and by 1914, when World War I broke out, whatever plans the army may have had to supplement animal-drawn with motor vehicles had been abandoned. The western European countries, particularly England, France and Germany, were not so easily discouraged and all three of these powers overcame early obstacles and entered World War I equipped with motor vehicles that soon proved their value.

1. Mexican Expedition. — Profiting by the successful use the belligerents were making of motor transport, the U.S. war department immediately enlisted the co-operation of the Society of Automotive Engineers in designing a $1\frac{1}{2}$-ton and a 3-ton truck suitable for military use. By 1916 enough were available to permit Brig. Gen. John J. Pershing to employ them, with civilian drivers, on his expedition into Mexico in pursuit of Pancho Villa. This marked the first effective use of motor trucks in a military operation by a U.S. force.

By the time the troops were withdrawn from the border, the army had acquired about 2,000 motor vehicles, most of which were commercial types. Their various sizes and makes gave the army its first introduction to the perplexing problem of maintaining and repairing mechanized transport in the field. So serious was this problem that a strong demand arose for standard models that would meet military requirements and simplify the replacement of worn-out parts.

2. World War I.—As a result, two types of trucks, one with a capacity of from $1\frac{1}{2}$ to 2 tons, the other capable of carrying from 3 to 5 tons, were designed. These vehicles differed from earlier military and commercial models in that they had greater ground clearance, larger engines, radiators and gasoline tanks, four-speed transmission and demountable rims. With the entry of the United States into the mar, the quartermaster general, who had responsibility for design and procurement, sought to develop an all-purpose truck that would meet various military requirements and reduce the difficulties of maintenance and repair. But since the need for large numbers of motor vehicles was immediate, the war department, unable to await their production, bought whatever usable trucks it could locate at home and abroad. The result was that the American expeditionary force in France was saddled with 216 makes requiring 445,000 parts of which only 20% were interchangeable. Thus the maintenance and repair problem, first encountered on the Mexican border, continued to plague the army with confusion and delay.

To solve the parts problem, a standardization board, composed of representatives from the main procuring and using agencies, was set up early in 1918. About the same time the war department organized the transportation service under the direction of the quartermaster general and made it responsible for procurement.

Out of the standardization board's deliberations came a decision to concentrate on a four-wheel-drive chassis designated the TT and several other chassis upon which different types of bodies could be mounted. With this accomplished, procurement and production were on a sounder basis. The military services did not obtain all the motor transport they wanted, but the progress made in motorizing ground military transport in the United States during World War I was astounding. The vehicle strength rose from about 4,000 in April 1917 to 129,154 by the end of the war, an expansion of more than 30-fold.

The rapid increase in motor vehicles was bound to affect the army profoundly. From an organizational standpoint, the most significant result was the establishment of centralized control over motor transport. This was done gradually and was not fully accomplished until Aug. 15, 1918, when the motor transport corps was created. Although abandoned after the war, it was a forerunner of the army transportation corps established early in World War II.

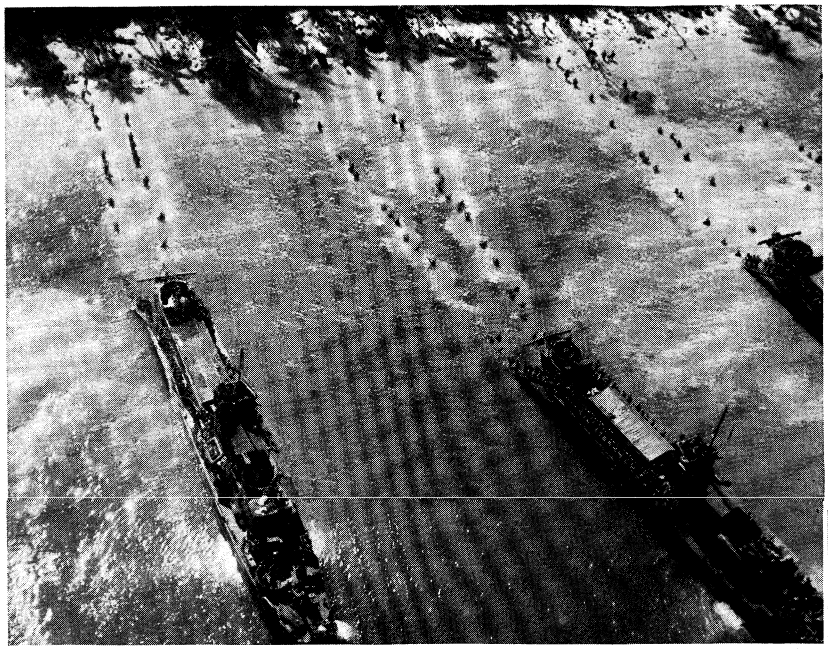
Although motor transport did not play a decisive role in World War I, it was always important and was at times critical. One instance occurred early in the struggle when the French army, in order to check the rapid advance of the Germans toward Paris, commandeered all the motor vehicles it could find in the metropolitan area to rush reserves into the fight. While the railroads moved more men into the battle on this occasion, motor vehicles, in shuttling Gen. Joseph Gallieni's so-called taxicab army to the front, were an important if not decisive factor in checking the enemy's advance.

Another instance occurred during the long, desperate Verdun campaign in 1916 when the Germans again seemed to have victory in their grasp. Their railroads in the forward area destroyed by enemy artillery, the French managed to move an entire corps in ten hours by motor trucks over a road net from Bar-le-Duc to the front which had been earmarked by Gen. Henri Pétain solely for military traffic.

Although World War I decisively proved that motor vehicles were practical in short hauls from railheads forward, it did not thoroughly test their suitability for long-distance moves. In such operations rail transport remained dominant. It was not until World War II that the motor vehicle rose to first rank in theatres of operation.

3. World War 11.—By the outbreak of World War II in 1939, trucks had all but replaced animal-drawn vehicles in the armies of France, Great Britain and the United States. In part, this rise of motor transport is attributable to the great progress made by the automotive industry in the two decades following World War I. Mass production, greater power, improved design and highway construction in this period settled whatever doubts remained that the motor vehicle could replace the horse and mule

MILITARY TRANSPORT VEHICLES OF WORLD WAR II

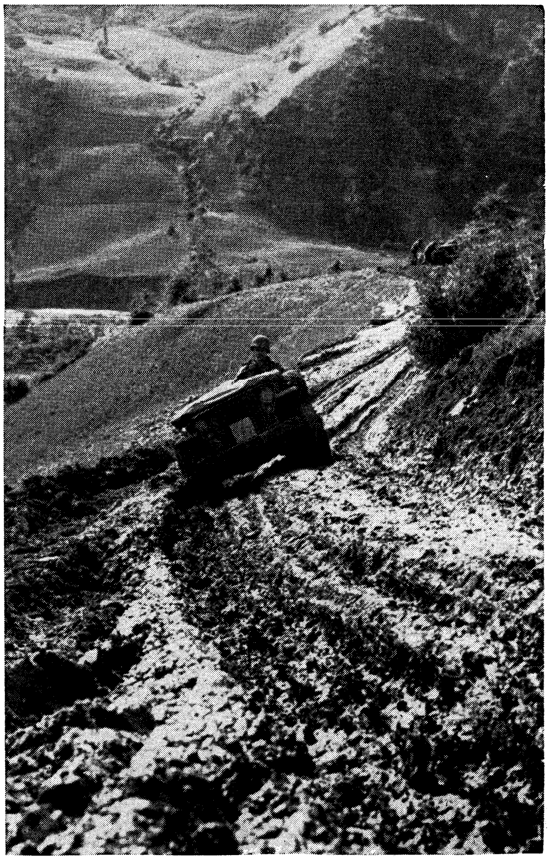


Left: LCI's (landing craft, infantry) unloading on the shore of Morotai island, southwest Pacific, in 1944. The LCI was the principal vessel used for personnel in beach landings. It held 200 men, 30 tons of cargo

Below: M29 cargo carrier, called the "Weasel," a small, tracked vehicle which was particularly effective on snow and ice. It is shown here being used to evacuate the wounded in the European theatre in 1945

Below: Unloading railway equipment from a seatrain at Cherbourg, Fr. Ships brought the equipment from England to France where it was placed directly on rails ashore, ready to operate

Below: The jeep, possibly the most famous vehicle of the war. Ruggedly constructed, with four-wheel drive, the jeep could operate on unimproved roads and trails and could ford streams 18 in. deep when fully loaded. Photograph was taken along a muddy supply road in the Apennine mountains, Italy

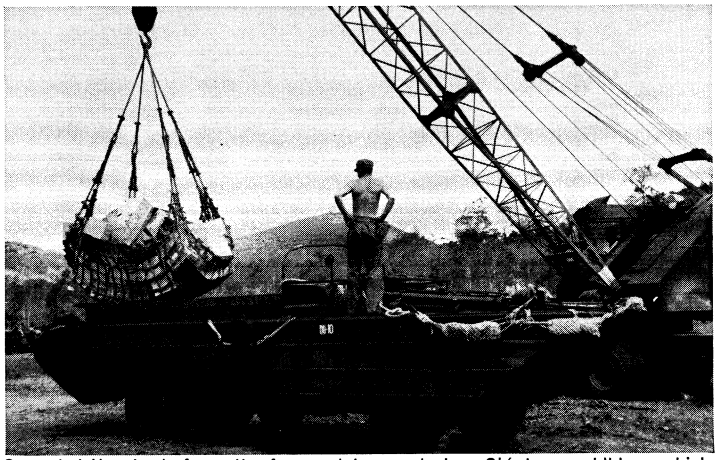


Below: Infantry crossing the Moselle river, Fr., in an assault boat, used frequently in Europe for river crossings where bridges had been blown up or where gasoline was not available to power larger landing craft

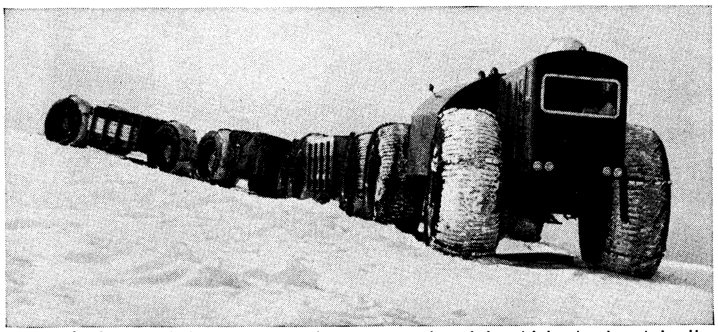
BY COURTESY OF DEPT. OF DEFENSE, PHOTOS (ALL EXCEPT TOP) U.S. ARMY, (TOP) U.S. NAVY

The pack mule. Although almost completely replaced by motor vehicles, mules and other draft animals were used during World War II in mountainous areas

Human carriers were still used in World War II where trails were too steep for mules or motor vehicles. This picture was taken near Futa pass in the Apennine mountains, Italy

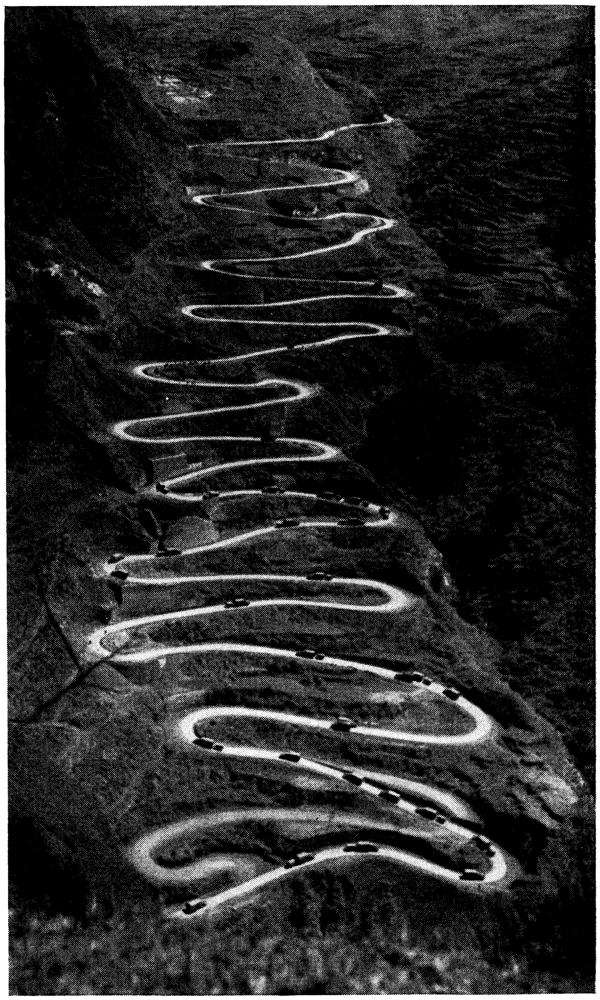


Crane hoisting load of supplies from a dukw, or duck, a 2½-ton amphibious vehicle equipped with an engine which could drive its wheels on land or propellers in the water. The dukw was used as a shuttle craft between supply ships and cargo dumps ashore during World War II in all theatres of operation



"Sno-train," or logistical cargo carrier, an experimental vehicle developed in the 1950s. Tires are four ft. wide and ten ft. high, enabling the train to travel over all types of snow and mud conditions. The vehicle was also being prepared for possible nuclear propulsion

Transferring cargo between helicopter and truck. During the Korean war the helicopter proved to be an efficient carrier into otherwise inaccessible mountainous regions



Hairpin turns along a mountain road in China near Kweiyang, south of Chungking. Motor convoys, such as that shown, were a principal mode of supply in the China-Burma-India theatre in World War II

TYPES OF MILITARY TRANSPORT

BY COURTESY OF (ALL EXCEPT THIRD FROM TOP, LEFT) DEPT OF DEFENSE, U S ARMY PHOTOS (THIRD FROM TOP, LEFT) R G. LETOURNEAU, INC.

in the field and challenge the railroad in long-distance hauling, Among the highways built partly, if not solely, for military purposes just before World War II were the *Autobahnen* in Germany. Like the military roads of the Roman empire, they made possible the swift movement of troops to frontiers.

Tests conducted by the U.S. army in the years immediately following World War I proved that motor vehicles were practical for long as well as short hauls. Progress in solving the problem of hundreds of different types and thousands of parts was also made. By 1932 the U.S. army had designed a standardized fleet of 25 truck types mountable on five different multiwheeled chassis. This simplified maintenance and reduced the cost of spare parts to from 25% to 10% of that of the vehicle. This economy was facilitated by co-operation between the army and the automotive industry, with the latter more often than not taking the lead in developing and standardizing vehicles and pushing their use. Economy and standardization in the automotive industry were enhanced by the concentration of production in fewer and larger companies and by the tremendous development of mass-production techniques, made possible by the phenomenal growth of the industry after World War I. In 1918 the total number of automobiles and trucks on the roads of the United States amounted to 6,000,000; in 1941 it was around 32,000,000, more than in all the rest of the world.

Similar although less spectacular was the rise of the automotive industry abroad. In developing motor transport for military use the Germans stressed the half-track type in the belief that it would be more reliable in field operations than all-wheel vehicles. The Polish campaign in Sept. 1939 confirmed this and by 1940 most of German military motor vehicles were half-tracks. The British, on the other hand, clung to the wheeled vehicle while the French went in for all types, full track, half-track and wheel.

The U.S. army concentrated first on its five multiwheel-drive types. Out of this came the $\frac{1}{2}$-ton weapons carrier, the $1\frac{1}{2}$-ton cargo truck and troop carrier, the 24-ton cargo truck, forerunner of the famous 6×6 all-purpose vehicle, the 4-ton prime mover for light artillery and the 6-ton truck and prime mover. Later the ordnance department, which took over responsibility for development and procurement from the quartermaster corps in 1942, designed several other types for special purposes. The United States produced about 3,600,000 military vehicles during World War II. Of this total, 1,440,540 were light and medium trucks, 816,807 were light-heavy trucks, 155,146 were heavy trucks and 1,221,922 were trailers and miscellaneous vehicles. Most of the trucks used gasoline for fuel but some, especially prime movers, ran on diesel oil. The huge U.S. output resulted in a ratio of one vehicle to every four men in France in 1945 as compared with a 1 to 40 ratio in 1918. The ratio in the army as a whole in World War II was 1 to 5. Of the total U.S. truck production, 750,000 were sent to Allied nations under lend-lease agreements. Among them were the ubiquitous jeep, a $\frac{1}{4}$-ton, four-wheel-drive truck and the 24-ton amphibian dukw (or duck). The jeep was similar to a vehicle the Germans had developed just before the war and used with considerable success in the Balkans. Both it and the jeep could negotiate terrain that was impassable to other wheeled vehicles.

The dukw was both a boat and a 2%-ton truck, constructed so that its engine could apply power to propellers when in water and to four wheels on land. Equipped with high-flotation tires that could be inflated or deflated by the driver when traveling over submerged sand bars or beaches, the amphibian was the best vehicle yet produced to carry cargo from ship to supply dumps behind the shore line. Used in every major Allied amphibious operation from the beginning of the Sicilian campaign until the end of the war, it rendered such valuable service that it is often listed as one of the several inventions that made the Allied victory in World War II possible. Toward the close of that war its effectiveness in river crossings was demonstrated in western Europe and in the U.S.S.R. So highly regarded was the dukw that all nations, including the U.S.S.R., equipped their armies with it or with models similar to it. The United States after World War II produced a family of amphibians patterned after the dukw. The largest was the barc, a huge amphibian capable of carrying the heaviest tanks and equipment or 100 tons of cargo.

The degree to which armies had come to depend on motor vehicles for transportation during World War II can be seen in the use to which such vehicles were put after the landings in Normandy. In the late summer and fall of 1944, when the railroads were unable to handle the forward movement of supplies from beaches and ports to distant points in the amount expected of them, highway express systems for long hauls were set up. The best known of these, although not the most efficient, was the Red Ball express, organized in Aug. 1944 and operated until mid-Nov. 1944. In around-the-clock operations, it moved cargo from Cherbourg and the Normandy beaches to armies hundreds of miles distant. At its height approximately 5,400 trucks were assigned to the operation and 8,209 tons of supplies per day were moved into army areas. Other express systems organized to support the advancing armies were Red Lion, White Ball, Green Diamond, ABC and XYZ. The XYZ, organized to support the Allied drive across the Rhine into Germany in early March 1945, was operated until V-E day. Its daily average delivery to the armies was about 13,000 tons.

The experiences of World War II proved that the confidence in motor transportation was justified. In every theatre of operation trucks dominated transportation; in the interior zones they challenged the railroad even in the field of long hauls. Only in areas where adequate roads did not exist or could not be built quickly were the belligerents forced to rely on other means. The Allies in western Europe normally supplemented motor transport with rail, inland waterway and air transport. The Germans used all these and wagons as well.

4. Limitations of Motor Transport. — This heavy commitment to motor vehicles had its drawbacks, not the least of which was that it made military forces dependent on hard-surfaced roads. It meant that much energy and a tremendous amount of equipment and material had to be devoted to road construction and maintenance. Among the great road-building projects undertaken during the war, the best known were the Ledo and Burma roads in southeast Asia and the Alaska highway in Canada. So heavily did their construction draw on U.S. resources that many have questioned whether in the final analysis their building hastened or delayed victory. They certainly contributed far less than the many projects undertaken in the Persian gulf, Mediterranean, European and Pacific theatres. But whatever the final verdict of history, there can be no doubt that they widened the area of operations for motor transport.

A second drawback of motor transport is its dependence on fuel and spare parts to keep it operational. The need for fuel is so great in modern military forces that without it operations cannot be conducted. Figuratively, it is correct to label gasoline *le sang de guerre.* To provide a steady flow of this "blood of war" requires special land, sea and air transport, hence the demand for pipelines, gasoline trucks, rail tank cars, seagoing tankers, fuel resupply aircraft, storage tanks and gasoline containers. Animal-drawn vehicles to be sure also require fuel in the form of forage, but its temporary absence does not bring movement to an immediate and complete halt. Except for harnesses, horseshoes and a few wagon parts, most of which can be locally procured or met by improvisation, animal transport offers no serious maintenance and repair problems.

Largely because of this problem and climatic and highway difficulties in areas where they expected to operate, the Germans did not drop horse-drawn vehicles from their tables of organization and equipment for field units. Forward of army railheads in Poland and the U.S.S.R. they used mostly horse-drawn wagons for resupply. In the desert country of north Africa where forage was scarce, they equipped their troops entirely with motor vehicles.

The reliance of the Russians and Poles on horse-drawn vehicles was in part dictated by the same considerations, but much of it can be attributed to their industrial backwardness. Other illustrations of the extent to which fuel requirements, terrain, climatic factors and other local conditions can determine the type of transport used are to be found in Tunisia, Sicily, Italy, the Pacific islands, Norway, Finland and Greenland. Forces in the first three areas were driven to the use of horses and mules as pack animals in mountainous country. In Papua both pack animals and native porters were used. In Norway and Finland, where snow, ice, cold weather and lack of roads impeded vehicular traffic, the Germans resorted to pack animals, aerial cable tramways and sledges drawn by reindeer. On the icecap of Greenland the Americans used dog sleds.

5. Korean War.—During the Korean war, United Nations forces discovered that the native porter enabled the North Korean and Chinese armies to forward enough supplies to launch highly effective if not long-sustained offensives. Roadbound and railbound by their complete commitment to motor vehicles and railroads, the UN forces found themselves at a distinct disadvantage in coping with an enemy who could operate in terrain considered too rough and inaccessible to permit large-scale movement. Until UN troops organized their own porters to supplement conventional transport they faced constant infiltration of their lines and loss of territory. Reliable statistics on the amount of supplies carried by porters in the North Korean and Chinese armies are difficult to obtain. Some estimates place it higher than that carried by all other means. Whatever it was, it affords a striking example of how troops whose transport is adapted to local conditions can win victories over those wedded almost completely to mechanical transport. Whether or not adverse conditions will remain equalizing factors in the future depends in large part on the progress made in developing new machines to overcome them.

III. PREPARATION FOR FUTURE WARS

In planning for future wars, nations must consider the kinds of conflict in which they may become involved. The spectrum of possibilities includes cold war, limited nonnuclear war, limited nuclear war, general conventional war and general nuclear war. Because these types of war differ radically, the design and support of military structures to meet them must also vary. The conflicting demands of each raise the question as to where emphasis in preparation should be placed, Probably in no area does this produce more difficult problems than in transportation. That greater flexibility and strength in motor vehicles and aircraft will be required, whatever the nature of conflict, is generally assumed.

A. Land Transport

To improve land transportation, governments have stressed the improvement of highways and the development of vehicles that can be operated in all sorts of terrain and under climatic conditions ranging from the hot, sandy deserts of the tropics and semitropics to the snow, muskeg and ice of the polar regions. Because roads in these peripheral areas are few or nonexistent, off-the-road transport is needed; because commercial activity in them is limited, governments rather than private enterprise must bear the expense of development.

Note is, of course, being taken of the unconventional transport used by the mining, oil, logging and construction industries operating in such areas. In general, it is too specialized to be easily modified to fit military needs. Some characteristics, however, have been adopted. Among the most important are high-flotation tires, multiwheeled drive and power steering. All present serious technical and production problems. Costs are so high that even governments find them difficult to justify.

In the United States, where progress in off-the-road transport has been greater than elsewhere, several types were developed and tested. Among these were the marsh buggy, the sno-train and the rolling fluid transporter.

The marsh buggy, a vehicle with high-flotation tires, was designed for use in swampy areas. It was successfully tested in the muskeg of northern Canada and doubtless could with modifications be used in terrain like the Everglades of Florida or the Pripet marshes of Russia.

The sno-train, officially called the logistical cargo carrier, consists of a prime mover that pulls several trailers in trace. With three trailers, it is 175 ft. long. Equipped with tires four feet wide and ten feet high, the largest in the world, the sno-train can travel through deep snow and over the muddy terrain caused by spring thaws in the arctic and subarctic regions. That some modification of it would work equally well in desert, plain and rolling country seemed certain.

The rolling fluid transporter is a collapsible four-ply rubber container of 500 gal. capacity designed to transport liquid fuel over all but the most rugged terrain. It can be towed by truck or transported by plane to point of need and, being collapsible, quickly and easily returned to a fuel-dispensing point for refilling. Since it floats, water obstacles are no barrier to its movement.

In rail transport little progress was made after World War II. Most notable was the growth of "containerization" and the "piggyback" movement. Both represented an effort to bring rail and highway transport closer together. As for rail vehicles, a flatcar designed by the U.S. army transportation corps that could be quickly converted to either a boxcar or a gondola and a locomotive that could be operated on standard, wide- or narrow-gauge track were the chief new developments.

B. Air Transport

In military air transport, progress was considerable. Many types of fixed-wing planes and helicopters unknown in World War II came into use. In addition, advances were made in the development of convertiplanes which combined the best characteristics of the fixed-wing plane and the helicopter. In the United States, two promising convertiplanes were the XV-1 and the XV-3. The XV-1 was powered by a 550-h.p. Continental engine and a pressure jet unit located kt the tip of each of the three blades of the rotor. In forward flight the engine drove a pusher propeller and the rotor was free wheeling. To raise or lower the craft the rotors were used. The XV-3 was powered by a single 450-h.p. Pratt and Whitney engine that drove two rotors mounted on the tips of the wings. These rotors could be tilted to a vertical position by electric motors and then returned to a horizontal position by the same means, thus giving the convertiplsne vertical lift as well as forward thrust with the same propeller.

Used extensively by the United Nations in Korea to move patients and light cargo was the helicopter. This type of aircraft underwent a rapid development in all countries and there was a strong probability that it would soon be able to carry heavy loads. Some helicopters, such as the U.S.S.R. Yak-24 ("Horse"), shown in Moscow in May 1955, can carry 40 fully armed paratroopers for short distances. Fitted with a rear-loading ramp it can also load and discharge cargo with ease. Even more advanced is the Soviet MI-6 ("Hook") for which a record load was claimed. In the United States the Flying Crane, the S-60, was successfully tested. A newer model, the S-64, was designed to lift loads weighing eight tons. Another helicopter, the Hiller 17, using turbojet engines mounted on the tips of its propeller as a power unit, was also developed and was capable of lifting up to 25,000 lb. Since many of these new aircraft had commercial utility it was assumed that in the future nations would have large pools of helicopters and Flying Cranes as well as ships, railroad cars and planes on which they could draw for military transport in time of war.

In the late 1950s the U.S. army conducted tests of the Aerocyle, a unique one-man lift device powered by a two-cycle 43-h.p. outboard motor. Its weight was approximately 200 lb. and it had a payload capacity of 250 lb. To operate it the pilot took his position on a platform above the rotor blades and guided the craft by leaning in the direction in which he desired to travel. If was expected to have, when fully developed, a range of 50 mi. and a speed of 40 m.p.h. As a means of transporting a man and a small amount of compact emergency cargo over rough terrain and water hazards it appeared to have promising possibilities.

Most significant was the increase in the size, weight, speed, range and numbers of commercial planes carrying passengers and freight. The effect on preparation for future wars was startling. It will doubtless become greater and may revolutionize military transportation, particularly over long distances. It has given governments a sound industry and a large pool of aircraft on which they can draw for military purposes in case of emergency. So rapid are the developments in the aircraft industry and the air carrying field that a statement on their exact status one year would be out of date the next. Because the conversion of cargo planes to passenger service is a relatively easy matter the cargo plane is practically a dual-purpose craft.

C. Container Transporters

Since the movement of military cargo has always been hampered by huge volumes and a variety of small packages, those responsible for military transportation have constantly sought to consolidate loads so that they can be more easily handled and delivered. During World War II considerable progress was made in cargo-handling methods, especially in the U.S. army. Among these the palletization of uniform cargo was probably the most successful. It was accomplished by packing items on a sledlike wooden platform (pallet) that could be raised and moved by a fork-lift truck. With the close of the mar the practice fell into disuse and it was not until the outbreak of the Korean conflict that attention was once again directed to it. With the revival of palletization by the U.S. army, the search for new methods of simplifying and expediting cargo handling was resumed in earnest. This interest was part of the over-all effort by the military forces to increase their mobility and flexibility.

Along with the development of improved air and surface equipment and greater capability in over-the-beach and dispersed port operations, emphasis was put on the automation of cargo handling. The responsibility for research in this field in the U.S. army rested primarily with the transportation corps. Drawing on its experience with a container designed to carry household goods for military personnel on overseas assignments, it worked for years to produce a family of three standard containers that would fit the needs of all the supply services and the various types of land, sea and air carriers. This was no simple problem, for to arrive at the right specifications in regard to weight, dimensions and durability required close co-ordination with the railroad, trucking, air transportation and shipping industries as well as the several supply services in the army, navy and air force. Whatever containers were adopted would have to fit into foreign and domestic freight cars, trucks, vans, cargo ships and planes. For rail and motor vehicles it was relatively easy to design standard containers that would fit them singly or in numbers without loss of space, but to adapt the same containers to all ships without loss of space was impossible because of the great differences between their hatches. The only solution lay in designing and building vessels with hatches that could take an optimum number. Since this required the co-operation of the shipping industry, the policy of the armed services was to encourage shipping companies to consider the use of standardized containers in their future building programs.

In the belief that transport by containers will drastically reduce the cost of cargo handling, the largest single cost item in a steamship company's ledger, some shippers ordered such vessels; others plan to include them in future building. Commonly known as lift-on, lift-off ships, they load and discharge packed and sealed containers with their own gear. This not only simplifies handling and stowage but reduces the loss from damage and theft as well. Many transportation experts regard the container as the most revolutionary development in cargo-handling operations in centuries. It may be the universal catalyst that will cross the usual competitive boundaries of the various forms of sea, land and air transport.

D. Transport for Beach Operations

With the extensive use of large ports and the concentration of ships in convoys either precluded or extremely dangerous because of their vulnerability to nuclear attack, logisticians have been forced to think in terms of beach operations. For amphibious landings they visualize armies supported over numerous widely separated beaches to which vessels can be quickly dispatched and from which they can be just as quickly withdrawn in case of an approaching attack. Operations under such conditions will require, among other things, suitable equipment in large amounts. Since congested beaches would be as vulnerable as ports, transport and cargo-handling equipment would have to be of the sort that would permit rapid movement over beaches and quick delivery of men and cargo to hidden inland areas. These requirements are hard to meet. They account for the emphasis that the services are placing on special-purpose ships, vehicles and aircraft. They explain the demand for fast roll-on, roll-off vessels, families of amphibians, beach lighters that can readily tie up to vessels, aircraft that can carry supplies from ship to shore, cargo-handling equipment that can operate on soft beaches, chemicals that can harden sand quickly so that the beaches will stand up under traffic, portable docks that grip into the floor of the sea with platforms that can rise and fall with the tide, aerial tramways capable of being quickly installed between ships or docks at points where the natural shore obstacles prevent beach operations and amphibious vehicles that can move cargo from ships to points inland without a stop.

The United States made the greatest strides in most of these matters. Improved models of ships that can take on or discharge laden vehicles via ramps built into their bows have been designed and built. Among them is the U.S.N.S. "Comet," produced by the military ship transport service. Since roughly a quarter of the volume of army cargo consists of wheeled or tracked equipment the production of such ships is a matter of vital interest to the armed services. Efforts to induce the shipping industry to adopt such ships for commercial use met with little success, however, because they are considered uneconomical to operate. Until their profitability in coastwise trade can be proved, it is unlikely that many shippers will be interested.

E. Military Transport Problems in Nuclear Warfare

In operations involving nuclear weapons, it is generally agreed that armies will need a far greater capability for rapid movement and dispersal than in the past. Large fixed installations and heavy concentrations of troops in or near the combat zone will be too vulnerable to attack. Instead of fairly clear-cut lines of demarcation between the combat zone and the base areas in overseas theatres, the combat zone will probably extend back to the water's edge and possibly embrace the zone of the interior as well. Units the size of battalions must be able to remain unobserved and to move quickly, often on short notice. This means that accompanying supplies will have to be reduced to a minimum, that resupply in items normally consumed daily will have to be swift and regular and that additional supplies to meet an emergency will have to be delivered on call without fail.

Preparing logistically for general nuclear war involves, among other things, the organization of transportation and communications both within units and throughout the entire line of communication and the development of new and reliable means of transport on land, sea and in the air.

Insofar as transportation is involved, there is a strong conviction that many of the older methods of operation will be impractical for loading and discharge in theatres of combat. Because the use of railroads is likely to be strictly limited and the operation of large ports dangerous, the emphasis in preparations for nuclear warfare has been placed on the further development of motor vehicles, roll-on, roll-off ships and craft and air transport. Through their use it is hoped that balanced supplies can be provided and delivered in sufficient quantities to the forward units, thus curtailing and possibly eliminating vulnerable army depots, ports, beachheads and dumps. With warehouses on wheels, dependence on fixed installations will be reduced and armies will be able to move and disperse quickly.

To meet situations involving the destruction or denial of highways and railroads by nuclear weapons, off-the-road vehicles may be the answer. But their drawbacks are many, not the least being their size, weight, fuel requirements and cost. Since such vehicles have little commercial use, there is some doubt as to whether they can be quickly mass produced. For these reasons, increasing attention is being given to air transport, the feasibility of which was proved during the Berlin air lift. But air transport also has its limitations.

A possible solution to the problem of vulnerable airfields lies in the improvement of the air drop, begun in World War II. Considerable progress has been made in this method of delivery, and equipment weighing as much as 13 tons has been dropped by parachute. Another possible solution lies in the further development of the helicopter and the convertiplane with their ability to rise and descend vertically in limited areas.

In some regions where streams, lakes and other bodies of water with sufficient depth and straight courses exist for landings and take-offs, resupply by seaplanes appears practical. This is obviously a method that cannot be used in arid country or in the polar regions where the seas are frozen. In such areas combat forces will have to depend on conventional transport of the region, off-the-road vehicles and land-based air transport. Since no large forces are likely to be involved in such country, the transport problem is less baffling than in heavily populated areas. The difficulty of supporting large U.S. forces in western Europe in a nuclear war, for example, might place so great a strain on the transportation resources of the United States that it could not be met.

F. Trends in Transport Development

Among the possibilities in water transport not yet exploited fully is the submarine. That it can be used as a cargo carrier was first demonstrated in World War I when the German U-boat "Deutschland," loaded with dyestuffs and other scarce products, made two round trips to the United States before the latter's entry into the war without being intercepted by the British navy. In World War II the Axis powers employed submarines to shuttle supplies to north Africa. The obstacle to commercial use is the cost of construction and operation which is so high that only governments can bear it.

Much more likely to replace the surface vessel as a carrier in a nuclear war is the airplane. That it can move men and freight quickly across the seas is being demonstrated daily. That it can carry military cargo equally well was amply proved during World War II, the Berlin blockade, the Korean war, the landing in Lebanon and in peacetime military exercises. If the problems of greater carrying capacity and landing sites can be solved it may emancipate the services from dependence on surface vessels for overseas operations. When, if ever, heavy, ponderous military equipment can be exclusively moved by air transport is difficult to tell. Possibly the problem may be simplified by a drastic reduction in the weight and size of military equipment and new technical developments that will reduce the fuel requirements of aircraft and overcome their dependence on vulnerable airfields. The success achieved in powering vessels with atomic engines led to the belief that similarly powered aircraft might have a place in military transport. Nuclear power may prove to be the solution to the fuel problem that besets long-range aircraft. It may even herald the day of huge planes capable of carrying cargo of any size, weight and description, thus leaving only the problem of secure landing sites. In certain areas atomic-powered seaplanes might be usable. It may be also that fully satisfactory aircraft capable of rising and descending vertically with heavy loads will be developed. But the day of aircraft that can deliver any type of cargo in sufficient quantities anywhere has not yet dawned. Until it does armies will remain dependent on vessels and vehicles for military transport. See Index references under "Transport, Military" in the Index volume.

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TRANSPORT, MINISTRY OF: see Government Departments.

TRANSUBSTANTIATION, the term adopted by the Roman Catholic Church to express its teaching on the subject of the conversion of the Bread and Wine into the Body and Blood of Christ in the Eucharist. Its signification was authoritatively defined by the Council of Trent in the following words: "If any one shall say that, in the Holy Sacrament of the Eucharist there remains, together with the Body and Blood of Our Lord Jesus Christ, the substance of the Bread and Wine, and shall deny that wonderful and singular conversion of the whole substance of the Bread into (His) Body and of the Wine into (His) Blood, the species only of the Bread and Wine remaining—which conversion the Catholic Church most fittingly calls Transubstantiation—let him be anathema." (Sess. xiii, can. 2.) The word "transubstantiation" is not found earlier than the 12th century. But in the Eucharistic controversies of the 9th, 10th and 11th centuries the views which the term embodies were clearly expressed; as, for example, by Radbertus Paschasius (d. 865), who wrote that "the substance of the Bread and Wine is efficaciously changed interiorly into the Flesh and Blood of Christ," and that after the consecration what is there is "nothing else but Christ the Bread of Heaven." The words "substantially converted" appear in the formula which Berengarius was compelled to sign in 1079 We may take it that the first use of the word is in a passage of Hildebert de Savardin (d. 1133), who brings it into an exhortation quite informally, as if it were in common use. It is met with in a decretal of Innocent III. The fourth Lateran council fully adopted it (1215). It is clear from the treatise of Radbertus Paschasius already quoted that the word "substance" was used for reality as distinguished from outward appearance, and that the word "species" meant outward appearance as opposed to reality. The terms, therefore, were not invented by St. Thomas Aquinas and are not mere scholastic subtlety. The definition of the Council of Trent was intended both to enforce the accepted Catholic position and to exclude the teaching of Luther, who, while not professing to he certain whether the substance of the Bread and Wine could or could not be said to remain, exclaimed against the intolerance of the Roman Catholic Church in defining the question.

For a full exposition of the Catholic teaching on transubstantiation, see Ludovico Billot, S.J., De *ecclesiae* sacramentis (1896). See also the Catholic Encyclopaedia, article "Transubstantiation." (J. C. H.; X.)

TRANSURANIUM ELEMENTS. The term transuranium elements designates the chemical elements lying beyond uranium in the periodic table and hence includes all the elements with atomic numbers higher than 92, the atomic number of uranium. All transuranium elements are radioactive. They do not occur in appreciable amounts in nature, and were discovered and investigated as a result of their syntheses by transmutation reactions, starting with uranium (*q.v.*) as the primary material. All those known in the early 1960s were members of a group of chemically similar elements, the actinide series, a group that chemically resembles the rare-earth or lanthanide group of elements (see Rare Earths).

Discovery of the Transuranium Elements.—In the history of the transuranium elements, the growth of atomic science is seen as the product of an intellectual chain reaction of experiment, hypothesis and further experiment. In this process, it has been found more difficult to separate so-called practical science from pure science than to split the atom.

Ever since 1869, when D. I. Mendeléyev formulated the periodic table that showed uranium as the heaviest of the elements then known, the properties of uranium have been a challenge to chemists and physicists. In Italy in 1934, Enrico Fermi, Emilio Segrè and their co-workers, bombarding uranium with slow neutrons, obtained radioactive products that appeared to be transuranium elements. However, Otto Hahn and F. S. Strassmann and their co-workers in Germany, repeating the Fermi experiments, found that the elements so produced were lighter than uranium. Late in 1938 they discovered that one of the products of their experimental bombardment was the mediumweight element barium. The implication of this was soon realized; the uranium atom had been split into two almost equal parts (see Atomic Energy: Uranium Fission).

Among the many experiments that were stimulated by the news of atomic fission was a very simple one designed by E. M. McMillan at the University of California at Berkeley in 1940, with the object of testing the penetrating power of fission fragments. As a target in the cyclotron he used a piece of paper thinly coated with uranium oxide, backed by a stack of cigarette papers. After bombarding the uranium atoms with neutrons, he measured the radioactivity of each of the pieces of cigarette paper. He found in the uranium sample a radioactivity that evinced a different half life and different properties from those of the fission products with which the other sheets were impregnated. He realized that this radioactivity might be caused by a previously undiscovered element. In the task of identifying the new substance. he was joined by Philip H. Abelson. They succeeded in separating the first transuranium element, atomic number 93, which they named neptunium (*q.v.*).

The neptunium isotope found by McMillan and Abelson undergoes a 50% disintegration by radioactivity in 2.3 days. A study of this process indicated to McMillan that neptunium was the key to the element with atomic number 94, but his quest for this was interrupted by other duties. The search was continued by Glenn T. Seaborg, Arthur C. Wahl, Joseph W. Kennedy and Segrè. In late 1940 and early 1941, bombarding uranium first with deuterons and then with neutrons, they produced the 94-proton element, which was named plutonium (*q.v.*).

Only a very small specimen of plutonium was produced for the first experiments conducted with a weighable amount—approximately $\frac{2}{100,000,000}$ oz. However, this minute sample was sufficient to reveal that plutonium-239 was susceptible to fission by bombardment, with slow neutrons, and therefore that its production in substantial quantities was a matter of extreme importance. The implications of this to national defense became obvious, and the team of scientists, who sent communications concerning the discovery to the editor of the Physical Review in January, March and May of 1941, decided to withhold these reports from publication. In The Transuranium Elements, by Seaborg, it is pointed out that "the announcement to the world of the existence of plutonium was in the form of the nuclear bomb dropped over Nagasaki."

The task of producing and identifying neptunium had been hampered by the fact that an erroneous place had been calculated for it on the periodic table, leading the investigators to look for properties similar to those of rhenium rather than uranium. A similar obstacle was encountered at The University of Chicago in 1944 when Seaborg, Ralph James. Leon Morgan and Albert Ghiorso began the quest for the elements with atomic numbers 95 and 96. According to the periodic table then in use, these elements should evince properties similar to those of neptunium and plutonium; but experiments conducted along these lines led to a dead end.

Seaborg concluded that the elements heavier than actinium belonged in a separate group, the actinides, corresponding to the rare-earth or lanthanide elements. Experiments were planned to test this hypothesis. and they proved it correct; elements 95 and 96 were isolated, identified and named americium and curium (*qq.v.*). The actinide hypothesis was the key to the chemical identification of elements 97 and 98, berkelium and californium (*qq.v.*). These were produced at Berkeley in 1949 and 1950 by Stanley G. Thompson, Ghiorso, Kenneth Street, Jr., and Seaborg.

The next two numbers in the periodic table were filled as a result of the first hydrogen bomb test in the South Pacific in Nov. 1952. Testing planes that were flown by remote control through the vast radioactive cloud created by the explosion picked up specimens of extremely heavy isotopes that had been formed by the fission of U^{238} with neutrons. From these products, elements 99 and 100—einsteinium and fermium (*qq.v.*)—were isolated by teams of scientists working at the University of California Lawrence Radiation laboratory, the Argonne National laboratory and the Los Alamos Scientific laboratory.

The production and identification of element 101, mendelevium, are described in Elements of the Universe, by Seaborg and Evans G. Valens. In the series of experiments in which the discovery was made and validated (conducted at Berkeley early in 1955 by Ghiorso, Bernard G. Harvey, Gregory R. Choppin, Thompson and Seaborg), minute quantities of einsteinium were bombarded with helium nuclei, adding two helium protons to the 99 protons of einsteinium. Of the many problems involved, the most formidable was the chemical identification of the new 101-proton element before its radioactive decay, since mendelevium undergoes a 50% disintegration in approximately an hour. In about a dozen performances of the experiment, the team of scientists produced and identified 17 atoms of mendelevium.

The synthetic chemical element with atomic number 102 was prepared and identified by Ghiorso, T. Sikkeland, J. R. Walton and Seaborg in 1958 at the University of California, Berkeley. The first identification of this element earlier had been claimed by an international team of scientists working at the Argonne National laboratory in the U.S., the Atomic Energy Research establishment, Harwell, Eng., and the Nobel Institute for Physics, Stockholm, Swed. On the basis of the work of this team the element was given the tentative name nobelium and chemical symbol No. However, subsequent repetition of the experiment failed to confirm the discovery, and credit for the initial identification of the element passed to the research team at the University of California. Element 102 was produced there by the bombardment of Cm^{246} with C^{12} ions accelerated in a heavy-ion linear accelerator. The isotope prepared, with mass number 254, decays by alpha particle emission with a half life of 3 sec. It was identified through the chemical characteristics of its known "daughter" Fm^{250}, the atoms of the daughter element being separated from the parent element 102 by taking advantage of the recoil from alpha particle decay of the parent element.

The chemical element with atomic number 103 was synthesized in 1961 at the University of California by a research group consisting of Ghiorso, Sikkeland, A. E. Larsh and R. M. Latimer. The isotope identified of probable mass 257 was the first to be discovered solely by nuclear methods; no chemical techniques were used in its identification. The discoverers proposed that the new element be given the name lawrencium and the symbol Lw in honor of Ernest O. Lawrence, inventor of the cyclotron.

(*See* also ATOMIC ENERGY; NUCLEAR ENGINEERING.)

Properties of the Transuranium Elements.—The resemblance between the lanthanide and actinide elements suggests that their electronic structure must also be similar. An inner electron shell, consisting of 14 5f electrons in the case of the actinide elements and 14 4f electrons in the case of the lanthanide elements, is filled in progressing across the series. (See PERIODIC LAW; NUCLEUS) The evidence for this lies in the chemical properties. absorption and fluorescence spectra in aqueous solution and crystals and in the crystallographic-structure, magnetic susceptibility, atomic beam and spectroscopic data.

Plutonium early assumed the position of dominant importance among the transuranium elements because of its successful use as an explosive ingredient in the atomic weapon and the excellent prospects it offered as the base material for developing industrial uses of atomic power. In the early 1960s, plutonium was the only member of this group of synthetic elements for which methods had been developed for production in relatively large, *i.e.*, multikilogram, amounts. From a purely scientific point of view, however, the other transuranium elements are of nearly as great interest as plutonium.

Electronic Configurations (Beyond Radon) for Gaseous Atoms of Transuranium Elements

Atomic no.	Element	Configuration*
93	Neptunium	$5f^4 6d 7s^2$
94	Plutonium	$5f^6 7s^2$
95	Americium	$5f^7 7s^2$
96	Curium	$5f^7 6d 7s^2$
97	Berkelium	($5f^8 6d 7s^2$ or $5f^9 7s^2$)
98	Californium	($5f^{10} 7s^2$)
99	Einsteinium	($5f^{11} 7s^2$)
100	Fermium	($5f^{12} 7s^2$)
101	Mendelevium	($5f^{13} 7s^2$)
102	Nobelium	($5f^{14} 7s^2$)
103	Lawrencium	($5f^{14} 6d 7s^2$)

*Configurations in parentheses have not been determined experimentally.

There had been much speculation concerning the upper limit of atomic number for the existence of transuranium elements, with considerations that such a limit might arise from either atomic or nuclear (radioactivity or spontaneous fission) instability. It appeared likely that the half lives for even the longest-lived isotopes of elements with atomic number over 100 would be so short as to make tracer chemical investigations difficult.

Speculation also arose about the chemical properties of the undiscovered, higher transuranium elements. The elements through atomic number 103 should complete the rare-earthlike (actinide) transition group. The element with atomic number 104 should be chemically similar to hafnium (atomic number 72). The following 14 hypothetical elements, with atomic numbers 105 through 118, should be chemical homologues, consecutively, to the 14 known elements with atomic numbers 73 (tantalum) through 86 (emanation or radon). However, the predicted decay rates are too great to make it likely that more than a few of these elements can be synthesized and identified.

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TRANSVAAL, a province of the Republic of South Africa (area 110,450 sq.mi.), occupying the northern portion of the country. It abuts on Southern Rhodesia and the Bechuanaland protectorate on the north, on the Bechuanaland protectorate and the Cape province on the west, on the Orange Free State and Natal on the south and on Swaziland and Mozambique on the east. Save on the southwest, frontiers are mostly well-defined natural features.

PHYSICAL FEATURES

More than three-quarters of the country lies on the Great Inland plateau, while the remainder is situated between the Drakensberg escarpment and the Lebombo range of mountains and forms part of the country known as the low veld. The eastern, central and northern portions of the plateau are drained by the Komati and Limpopo rivers which flow to the Indian ocean, while the southern portion is drained by the Vaal river which has its outlet through the Orange river to the Atlantic ocean. In the north the plateau is broken up by the Zoutpansberg and Blouberg mountain ranges into smaller plateaus, some of which are featureless and bush-covered, while others are characterized by isolated koppies and granite-bouldered hills. The central portion of the plateau is beset with large blocks of diversified country in which much bare rock is exposed, as a result of the presence of the mountain ranges of the Witfonteinrand, the Waterberg and the Strydpoortberg. South of these ranges is a wide expanse of flat, bush-covered country consisting of the Rustenburg bushveld, the Pretoria bushveld and the Springbok flats. From there the land rises sharply to the south and, after encountering the very broken country formed by the Magaliesberg and Witwatersrand, opens out into wide plains and rolling downs forming the high veld in the southern and southeastern portions of the province.

Four natural zones are recognized — the mist belt, the high veld, the middle veld and the low veld. The mist belt occupies the upper eastern slopes of the Drakensberg escarpment and includes the country which lies at 6,000 ft. and higher. It is the region of highest rainfall. The high veld covers the southeastern and southern portions of the province and lies between 4,000 and 6.000 ft. It extends 120 mi. from east to west, and north to south 100 mi., and consists of rolling, grass-covered downs, naturally treeless, the crests of the rolls being known as *bults* and the hollows as *laagtes.* The surface is occasionally broken by koppies, either table-shaped or pointed, rising sometimes 100 ft. above the general level. Small springs of fresh water are frequent, and the eastern portion is characterized by numerous sheets of water or "pans," as they are locally called — flat-bottomed depressions with no outlet, the water being usually brackish.

The middle veld lies between the high veld on the south and the low-lying country on the east, north and west. It is traversed by the Olifants river, and results from the denudation of the plateau, giving rise to broken country. Average altitude is 3,000–4,000 ft. It is marked by stony ridges (rands), and these and the koppies are often covered with scrub.

The low veld includes the country lying below 3,000 ft. Rands and koppies occur but the general characteristic is its uniformity. The low veld east of the Drakensberg begins at about 3.000 ft. above the sea and slopes to 1,000 ft. or less until it meets the ridge of the Lebombo hills. The lowest point is at Komatipoort, a gorge through the Lebombo hills only 476 ft. above the sea. North of the Zoutpansberg is a large salt pan. The parklike low veld is everywhere covered with dry forest. Along the river valleys the vegetation is much more luxuriant. The greater part of this is composed of thorn bush and thorn trees, especially in the dry open country. On the east the low veld is situated below the Drakensberg escarpment, on the north below the foothills of the Zoutpansberg; on the west it occupies the valleys of the Limpopo and Crocodile rivers. It is an area of low rainfall, considerable heat and high aridity.

There are four river basins in the Transvaal. Of these the Komati (*q.v.*) and the Pongola rise in the high veld and, flowing eastward to the Indian ocean, drain comparatively little of the province, of which the Pongola forms for a considerable distance the southeastern frontier. The rest of the country is divided between the drainage areas of the Vaal and Limpopo.

The destruction of wildlife has been great, but a vast area on the northeastern border, the Kruger National park, has been set aside as a reserve. (I. B. P. E.)

HISTORY

At the beginning of the 19th century, the land between the Limpopo and Vaal rivers was inhabited by native tribes. From Rhodesia there had infiltrated offshoots of the Karanga people, skilled metalworkers and builders in stone. Sotho-speaking tribes entered from Bechuanaland, and included the Barolong, also skilled metalworkers and agriculturalists. Third came the Ndebele, a group of the same stock as the Natal Nguni. They settled in the region where Pretoria now stands. Apart from odd raids by slavers from the east coast, the Transvaal tribes had no contact with Europeans until 1818 when Conrad de Buys, a refugee from Cape justice, led a swarm of coloureds and adventurers to plunder along the Marico valley. Missionaries such as J. Campbell followed. From their reports it is clear that if the Transvaal tribes were primitive by western standards, they were peaceable and skilled in many crafts. Two events violently dislocated the pattern: one was the eruption of the tribes displaced by Shaka (Chaka or Tshaka) in Zululand; the other was the arrival of the trekkers.

The refugee tribes from Zululand and Natal crossed the Drakensberg first into the Free State and then into the Transvaal. Some of the Hlubi fell upon the Batlokwa tribe under the queen regent Mantatisi and her son Sikonyela. In their turn, Mantatisi and her tribe murdered and plundered (1822) right across the Vaal, where they dislodged Broadbent's mission station. Hard on their heels came Mzilikazi (Moselekatse), the Khumalo, dodging the vengeance of Shaka. He first attacked the Sotho peoples in the region of the Olifants river, then, with his remnants and conscripted victims, founded a new tribe, the Matabele (the name, like Ndebele, means refugee people), and devastated the whole area between the Marico and the Drakensberg. He placed his chief kraal near the junction of the Aapies and Limpopo rivers. Traders such as R. Schoon and missionaries including Robert Moffat have left reliable accounts of a despot terrorizing a ruined land. In 1832 a Zulu impi sent by Dingaan cut the Matabele to pieces and Mzilikazi withdrew from the Aapies valley, destroyed the Hurutse tribe and settled in their territory 40 mi. N. of Mosega in a paradise of wild game, on the west side of the Great Marico river. There he was visited by Andrew Smith, accompanied by the missionary Robert Moffat. Having worked havoc in the land across the Vaal, Mzilikazi was driven thence by the trekkers and settled across the Limpopo. There in Matabeleland he was visited by Moffat in 1854, 1857 and 1859. Mzilikazi admired Moffat.

Moffat had no illusion about Mzilikazi as his journals show, but he pays tribute to the way in which Mzilikazi had welded the broken remnants of tribes into a compact, disciplined and on the whole less brutal people.

THE TREICICER STATE

Trekkers in the Transvaal (**1837-52**).—In 1835 Boer frontiersmen had begun to probe beyond the borders of Cape colony with a view to organizing an exodus from British-controlled territory (see SOUTH AFRICA, UNION OF). One party, led by Louis Trichardt and Janse van Rensburg, reached the Zoutpansberg in what is now the northern Transvaal. In June 1836 Rensburg with a party of 49 Europeans moved off along the Pafuri river. He and his party were annihilated. In Sept. 1837 Trichardt set out via the Sabie river for Delagoa bay, which the fever-stricken survivors reached in April 1838. Thence they journeyed by sea to Port Natal.

A. H. Potgieter had crossed the Orange in Feb. 1836 and joined forces with Carel Cilliers and the Liebenbergs. On his return from the Zoutpansberg he found that S. Erasmus and a hunting party had been disastrously attacked, while a section of the Liebenbergs had been annihilated on the west bank of the Vaal by the Matabele. At Vegkop in Oct. 1836 he beat off the Matabele but lost most of his cattle and fell back with difficulty to Thaba Nchu. Reinforced by the party of Gert Maritz, he again advanced, destroyed Mzilikazi's kraal at Mosega and made good his retreat with all and more than the trekkers had lost at Vegkop. Throughout 1837 the number of trekkers steadily increased. In Nov. 1837 Potgieter inflicted the decisive defeat on Mzilikazi at the Marico river. The Matabele decamped beyond the Limpopo, and Potgieter claimed all the land over which Mzilikazi had ruled. South of the Vaal he also claimed the Vet river district (Winburg) in terms of a treaty with Makwana, a local Bataung chief.

There was, however, rivalry among the trekker leaders and no unanimity of council or plan once the colonial frontier had been crossed. Even after the murder of Piet Retief by Dingaan (Feb. 1838; see NATAL), though Potgieter and Jacobus Uys moved from the high veld into Natal in support of Maritz, they could not agree to an undivided command. Potgieter recrossed the Drakensberg and had no direct share in the making of the trekker republic in Natal.

The British annexation of Natal in 1843 and the resultant trekker exodus from it in 1844 and 1845 broke what had promised to be Potgieter's monopoly of the Transvaal. Some of the refugees from Natal settled at Winburg, others, among them Andries Pretorius and his son M. W. Pretorius, crossed the Vaal and were further reinforced in numbers when in Feb. 1848 Sir Harry (Henry George Wakelyn) Smith (high commissioner. 1847–52) annexed the land between the Orange and the Vaal as the Orange River sovereignty (see ORANGE FREE STATE). Inevitably the British annexation involved theattempt to assert the Vaal river as a frontier between the trans-Orange and the trans-Vaal Boers. This was not easy to achieve. In the first place the Transvaal claimed the Klip river as the source of the Vaal, while the Orange River sovereignty (which after 1854 became the Orange Free State) wanted the frontier pushed north to the Likwa Spruit so as to secure the Harrismith route into Natal. Further, the Vaal was a geographical line rather than a political frontier: Winburg constantly looked to the Transvaal for help during the British annexation of the sovereignty and thereafter was frequently at loggerheads uith the Free State raad at Bloemfontein. Conversely, first Andries Pretorius and then his son M. W. Pretorius kept alive the tradition that the Free State and the Transvaal were both legatees of Boer traditions and should therefore act together.

The thesis of trekker unity was strangely at variance with the situation across the Vaal. Groups of farmers were scattered over 100.000 sq.mi of territory, and at times each family group or personal following tended to act as a law unto itself. Potgieter settled originally at Potchefstroom in the southwest Transvaal, while Pretorius when he trekked in from Natal settled not far off in the Magaliesberg. In 1845, though, Potgieter moved anay to the northeastern Transvaal. A born leader of men, he would play second fiddle to none, least of all to Pretorius. But his main objectives in moving off from Potchefstroom were two. His new centre, Andries Ohrigstad, was just north of the limits of British jurisdiction claimed by the Cape of Good Hope Punishment act (1836). Equally important, it was well placed for trade with the Portuguese. Later Ohrigstad proved to be fever-stricken, and the capital of the eastern Transvaal was moved to Lydenburg.

Meantime Potchefstroom had become a rather more vigorous growing point in the southwestern Transvaal, and from it a steady and on the whole well-thought-out opposition to Potgieter developed. For Andries Pretorius transferred to Potchefstroom the policy of trekker unity and central control evolved at Pietermaritzburg, and he was supported by most former Natalians. In eastern Transvaal Potgieter's autocracy led there also to opposition. When challenged by the raad Potgieter appealed to Het Volk (roughly the people against parliament). In May 1849 an agreement between the eastern and western section for a united raad was contrived at Derde Poort, but only because Potgieter's faction stayed away. They did more. Incensed by criticism and thwarted in Lydenburg by the constitutionalists, Potgieter moved north to the Zoutpansberg. Thus by 1851 instead of two main groups there were three, that of Andries Pretorius at Potchefstroom (southwest Transvaal), that of W. F. Joubert at Lydenburg (southeast Transvaal) and that of Potgieter at Zoutpansberg (north Transvaal). However, in March 1852 Pretorius and Potgieter agreed together on the vital matter in hand, namely the ratification of the Sand River convention by the raad.

Sand River Convention. — The Sand River convention was signed as a result of negotiation between Andries Pretorius and special commissioners W. Hogge and C. M. Owen representing Queen Victoria. It was signed to regularize the position and to prevent the intervention of the Transvaal either to the south, in the Orange River sovereignty, or to the west, where traders had been turned back from the missionary-trader road to the north.

From one point of view the Sand River convention was a brilliant demonstration of common sense. Britain faced the fact that the Transvaal was de facto independent of British control, and since at the time British sovereignty was still exercised in what is now the Free State further intervention by the "emigrant farmers beyond the Vaal river" would be an act of aggression. But in every other respect the convention was faulty. The Boer signatories were not the accredited agents of a well-organized state (neither Potgieter nor Joubert was a signatory), and there was no administration across the Vaal to implement the undertakings. Though the convention conceded to the "emigrant farmers beyond the Vaal river the right to manage their own affairs," the undertaking of the Boers not to practise slavery was faulty. It exposed the Transvaal to missionary criticism, attracted the attention of the antislavery commissioners and led to the threatened inquiry by Sir Philip Wodehouse into allegations of slavery in the Transvaal as late as 1865. Britain was left with an implied paramountcy without legal machinery for the exercise of it. In the convention Britain foreswore alliances with native chiefs north of the Vaal river, but whereas Britain pictured the emigrant farmers as living within the arc cut by the course of the Vaal river, the Boers, as was made explicit in the grondwet of 1858, visualized a straight line drawn right across the' subcontinent. This ambiguity Hogge and Owen did not grasp. No consideration therefore was given by Britain to vital problems already existing west of Potchefstroom, although missionary stations at Kuruman antedated the Great Trek and missionaries were active along the road to the north. This neglect was to lead to the incident at Kolobeng in 1852 when David Livingstone's mission station was ransacked first by Secheli and then by the Boer commando in pursuit of him. For their part the Boers complained that the missionaries provided the natives with guns in contravention of the Sand River convention, and they invoked a power to control which in fact in 1852 Britain had neglected to assert. By a little prescience not only these difficulties but also the confused animosities of 1868–71 could have been averted. The position to the east of the Transvaal was no more satisfactory. In. 1852 Natal was a crown colony. To a great extent its tranquillity depended on the tranquillity of the three independent native states to the north and west of it. Basutoland, Zululand and Swaziland. The acquisition of the Pongola strip in 1855 by Lydenburg from the Swazi vassals of the Zulus and the acquisition of the Blood River territory by the South African republic in 1861 (see ZULULAND) sharply disturbed the position in Natal for many years.

The weakness of the Sand River convention lay then not so much in the renunciation of responsibilities as in the failure to define more precisely the frontiers of renunciation.

SOUTH AFRICAN REPUBLIC

Creation of the Republic. — When Andries Pretorius died in 1853, his son M. W. Pretorius inherited, though without conspicuous ability to implement it, the best traditions of the *voortrekker* policy. In 1856, under his guidance, the burghers of Potchefstroom, Rustenburg and newly founded Pretoria united to make the nucleus of the South African republic (S.A.R.). In practice the authority of the new republic was limited to the southwestern Transvaal, for though in 1849 at Derde Poort a united raad had been agreed upon, there were still four separate units. In the southwest was the newly founded S.A.R.; in the north Schoemansdal in the Zoutpansberg was the centre of the ivory trade and of occasional and unofficial blackbirding. Lydenburg, in the eastern Transvaal, in 1858 joined forces with the fourth unit. Utrecht, which, founded in 1848 by former Natalians, projected expansion at the expense of Zululand. The first steps of Pretorius were necessarily confined to the southwestern Transvaal.

In 185j a committee was appointed to draft a code of fundamental law, a grondwet (constitution) which would make the de jure state of the Sand River convention into a de facto sovereignty. In part, the grondwet established in 1858 reflected the accumulated experience of trekker constitutionalists who since 1837 had striven to translate Boer ideals into a political structure. But it was the society not the state which had its traditions.

The grondwet of 1858, though not so mature as that of the Orange Free State (*q.v.*), was a remarkable experiment in constitution making. The keynote was struck in article 8, which may be said substantially to measure the difference between the Afrikaner and the English approach to politics: "The people demand as much social freedom as possible and expect to obtain it by retaining their religious faith . . . by submitting to law, order and freedom and by upholding these. The people permit the spread of the Gospel among the heathen subject to definite safeguards against fault and deception." In article 12 the people are described as delegating the function of legislation to a *volksraad;* but it is also implied that ultimate sovereignty rested with the people, and a three months' delay for all save emergency legislation was stipulated; and until 1889 a 75% majority was required for the passage of all ordinary legislation. All offices and membership of the raad, until 1889, were limited to members of the Dutch Reformed congregations; at the time this proscribed none. Citizenship was limited to adult male European members of the Dutch Reformed Church, and it was expressly stated: "The people desire to permit no equality between coloured people and white inhabitants, either in church or state." Executive power was vested in a president elected for five years, assisted by an executive council wherein the commandant-general held a key position.

Progress toward implementing the grondwet, while chaotic in detail, was none the less clear. In 1860 Lydenburg, having first joined forces with Utrecht (1858), joined the S.A.R. But the attempt of M. W. Pretorius to hold simultaneously the presidency of the Free State (Feb. 1860–April 1863) and that of the S.A.R. (Jan. 1857–Sept. 1860) not only perturbed the British high commissioner but accentuated trouble nearer home. Already there was a three-cornered tussle (with Utrecht as a variable fourth factor) between the Potchefstroom district, the Zoutpansberg and Lydenburg. In 1859 this dissension was exaggerated when two new ministers from the Netherlands arrived in the Transvaal, so that more than once it looked as if religious differences would reinforce political frictions.

In 1860 Pretorius took officeas president of the Free State and, blind to political reality at home and the precarious position on his frontiers, embarked on a policy of territorial consolidation and expansion. In 1861 he supported the negotiations with Cetywayo and Mpande (Panda) which strengthened the Pongola strip by the cession to Lydenburg-Potchefstroom of the Blood River territory. In the Free State he bought up the Pniel reserves and, in 1861, the lands of Adam Kok in Griqualand. That this was done in the face of mounting opposition in the Free State and chaos in the S.A.R. was attributable less to fanatical pursuit of preconceived ends than to obstinate indifference to reality. As often as Pretorius sought to concentrate on Free State problems his opponents in the S.A.R. sabotaged the position in the Transvaal. No well-thought-out constitutional issue was at stake and theories were adapted to fit circumstances. Stephanus Schoeman took up arms against S. J. P. (Paul) Kruger, the most able of Pretorius' supporters, and fought a series of miniature battles. In Jan. 1863, Oct. 1863 and Jan. 1864 successive presidential elections were held in the S.A.R. The last one was final, partly because Pretorius was elected, chiefly because it was prefaced by a more vigorous action by Kruger against Schoeman and J. Viljoen in which five were killed and 37 wounded for a cause which all would have found difficult to define or justify. It was fantastic that, beset by enemies, the Transvaal for three years should have luxuriated in a series of irrelevant burgher tournaments.

Native **Affairs.**—At no point since the trekkers had entered the Transvaal had there been firm administration. A sparse European population was scattered over a vast area, and each place or farm was normally self-contained and under one master. It was these conditions which explained the dichotomy between what was ordered and what was done. The Transvaal settlers denied on principle any equality between black and white. Native chiefs were left in control of their tribes, and those natives who, as returned refugees from Mzilikazi's dispersal, acknowledged no chief had to have a master to vouch for them. There was a *plakkerswet* which limited the number of native families allowed to squat on European farms so that theoretically there were native areas and European areas. Substantially the domination of the white minority in the Transvaal depended on three things: superior armaments and the swift intelligent strategy of commandos; the fact that Mzilikazi had broken the initial resistance of the indigenous tribes; the fact that the two most dangerous native states, that of the Zulus and that of the Basutos, were obliquely subject to British control, while the Swazi normally looked to the Transvaal Boers as masters who could at a pinch rescue them from the Zulus.

Neither slavery, slave trading nor the market in apprentices that undoubtedly existed in the Transvaal were sanctioned by the government of Pretorius, and there are cases on record of brutality to servants, when detected, being sharply punished. But the very repetition of laws against trafficking in apprentices is evidence that the laws were repeatedly violated, especially in the northern Transvaal. There, where the writ of government barely ran, Juwawa Albasini, native commissioner of the Zoutpansberg, and others less notorious, engaged in any and every practice that was profitable. The same was true of the western Transvaal, which had no effective administrative frontier. Probably the chief weakness of the whole structure was insecurity on both sides. There were no European magistrates in the native territories to bolster or to modify tribal authority. The labour tax (*corvée*) was erratic in its incidence. Above all, not only were the natives denied individual tenure but tribal units had no communal security against European infiltration or malpractices. Missionaries, belonging to what were technically foreign powers, acted not merely as missionaries but necessarily as tribal agents; for instance, the missionary J. Ludorf fought an acrimonious battle to keep the *fonteins* (springs) of Montsioa the Molapo clear from European monopoly. European hunters either killed or drove off the game which was just as much part of the native economy as it was of the European. Since, moreover, the western frontier of the Transvaal was ill-designed, what to the missionaries was encroachment-was to the Boers the legitimate expansion of quasi-nomadic cattle farmers. Concentrated European settlement, organized advance, closer restraint, all these might have enriched trekker life and made an intelligible native policy possible. But it was to avoid these very things that the Boers had defied the policy of the Cape and the advice of their own church in the Cape, and it was not until the 1890s, when it was too late, that they found their Moses in Paul Kruger, who as a child of ten had accompanied the Boers when, beginning in 1835, they wove the epic of the Great Trek.

Second Presidency of Pretorius, 1864–71.—Effectively, M. W. Pretorius had secured his re-election as president of the S.A.R. at the price of abandoning the design to link the two Boer republics. Economically the position of the Transvaal stagnated even where it did not deteriorate. In 1863 the public debt was £10,joo; six years later it had not only grown to £74,000 but bills stood at 75% discount. The South African Mining company began in 1867 to export a little copper, and the discovery of gold at Tati on the fringe of Matabeleland brought about a promising but abortive gold rush which caused prices to rise and adventurers to stream in. The S.A.R. was now at least the mirage of El Dorado. By 1868–69 C. Mauch had discovered signs of alluvial gold in the Lydenburg district, where by 1872 there were to be more than 1.000 diggers.

Though his state was bankrupt, Pretorius became all the more a man of vision, his diplomacy sharpened by the prospects of the Tati gold fields. He made a series of bold moves. He announced the annexation of a strip a mile wide on both sides of the Maputa river to Delagoa bay. This Portugal would not accept, but in July 1869 it concluded with the S.A.R. a free trade treaty on which the subsequent negotiations for the railway from the S.A.R. to Delagoa bay were largely to depend. Second, having stationed a landdrost by Nylstroom in the newly proclaimed district of Waterberg, Pretorius asked Mzilikazi (then on his death bed) and Matsheng the Shoshong to enter at least into a treaty with the republic. Guided by his missionary, J. Mackenzie, Matsheng not only refused but appealed for British protection, while far to the south Ludorf renewed his clamour on behalf of Montsioa the Barolong. For in 1868 Pretorius had already made his third and most challenging move. He announced a western frontier for the S.A.R. which, it was clear, would put the missionary-trader road to the north within the maw of the Transvaalers so that, with a route through to Delagoa bay to the east also in his hands, Pretorius would have a monopoly of trade to and from the Tati gold fields. The 1868 frontier would also have given the S.A.R. the lion's share of the new diamond fields and much of their traffic. Pretorius proclaimed a new district along the Harts river with its centre at Bloemhof and enlarged the control of the field-cornetcy at Zeerust on the Marico river. To some of this western territory he could lay good claim, but he neither mustered nor used his evidence wisely.

In 1871 the Keate award (see SOUTH AFRICA, UNION OF), inescapable on the evidence submitted by Pretorius, designated the Makwassie Spruit as the western boundary of the Transvaal. This not only removed the missionary road from the tenuous and questionable grasp of the Transvaal but also, on paper, stripped away much which Transvaalers had unquestionably settled and developed. More dramatic, the Keate award was followed by the precipitate annexation of the diamond fields by Sir Henry Barkly (high commissioner, 1870–77). Pretorius had promised much and performed little, and the penalty of failure was enforced resignation. Yet much of his grand design was never erased from the politics of the republic.

Presidency of Burgers, 1872–77.—The successor of Pretorius was T. F. Burgers, who was invited to come from the Cape to serve the Boer republic. There can be no doubt about the integrity and vitality of Burgers, but he was handicapped from the start by three factors. He had been a leader in the liberal struggle against the rigid orthodoxy of the Cape synod and had little sympathy with the orthodox separatism of the Transvaal synod; more serious, from the first he was opposed by the Dopper Church in general and Kruger in particular. Second. the S.A.R. was a concept rather than a compact state. In 1871 it was on the defensive against tribes within its own frontier, and it was on the verge of bankruptcy. The third factor in the situation was one over which Burgers lacked control. For 1871 saw the beginnings of economic revolution as a result of the opening of the diamond fields, the rumours of greater treasure trove in the hinterland and the building of railways. In the 1870s British policy in South Africa sought to sponsor the recreation of unity which the conventions of 1852 (Sand River) and 1854 (Bloemfontein) had made fragmentary. Many in South Africa itself felt that a single framework against which the new railway and commercial economy could develop was imperative. Many realized also that the new economic developments demanded the evolution of a common native policy. But if the diamond fields were a golden apple they were also an apple of discord, and the earl of Carnarvon, secretary of state for the colonies in 1874–78, partly because of tactical blunders, partly because of colonial frictions and partly because of general scepticism as to the stability of British policy, found it impossible to win support for his policy of federation. Four years of strain (1877–81) showed that a commercial mentality tended to be a quasi-imperial mentality, while hinterland aversion to possibly premature growth sought spiritual reinforcement in the creation of an Afrikaner tradition.

It is impossible to visualize Burgers' presidency apart from this metamorphosis in South Africa as a whole. Of the changing fronts he was acutely aware, and he attempted a tour de force which, had it succeeded, would have made the Transvaal the hub and not the outwork of southern Africa. But he was alien to the idiom of Transvaal thinking. By encouraging immigrants from the Cape, Natal and the Free State as well as from the Netherlands, he sought to give a fillip to private enterprise and to find an abler type of public servant. In 1874 he used the minor discoveries of gold to order the making of a gold coinage. He tried with the help of E. J. P. Jorissen completely to reorganize the structure of education, and founded the Pretoria gymnasium, the first high school north of the Vaal. But his prohibition of doctrinal teaching was regarded as an atheistical conspiracy, the use of his own profile on coinage was regarded as idolatrous profanity, and his ill-timed attempt to alter the flag was condemned as sabotage; he provided a butt for the old school and a very uncertain beacon for progressives, whose capital ventures were just as precarious as they had been under his predecessor. In 1872 diamonds were found in the Transvaal near Christiana. In 1873 gold was discovered at Spitskop near Sabie and at Pilgrim's Rest. The year 1874 saw the beginning of gold mining in the Kaap valley and at Bloubank. This resulted in a series of local trade booms and some overspeculation. Using his personal credit, Burgers raised a loan of £60,000 from the Dutch-owned Cape Commercial bank and bought up the debased government bills.

There was one field where the "new policies" of Burgers secured a measure of common consent, the field of territorial expansion and transport development. In 1874 he denounced the Keate award, which none had observed anyway, and by negotiation with minor chiefs across the Vaal sought elbow room for expansion across the west. The farm mas still regarded as a great cattle run. and little effort was made to develop more intensive agriculture. Tobacco. but no wheat or maize, was grown for export to the Cape. When the family grew and needed provision it was to the seemingly endless veld that farmers turned. The mortgaging of public lands, quite as much as the refusal of the Venda and the Bapedi to abandon their ranges in the northeastern Transvaal, made the west the natural soft frontier for probing. Hard on the heels of this move followed another equally significant—the effort to secure a reliable route to the sea at Delagoa bay which in the MacMahon award (1875) was assigned to Portugal, not England. Delagoa bay was closer to the Transvaal than Durban; also, it was the one port which, it seemed, Britain could not control.

With momentary unanimity of opinion behind him, Burgers set out in 187j to visit three capitals, London, Amsterdam and Lisbon In London he reassured Carnarvon about confederation without committing himself. At Amsterdam he toyed with federation. but not under the British flag, and raised a heavy loan at rates approaching usury. In Lisbon he negotiated a trade and railway agreement.

Triumphant, he returned to the S.A.R. to confront disillusionment. The Lebombo Railway Co. was floated only to collapse. The railway stock he had ordered was dumped to rust at Lourenço Marques, and the Dutch artisans were dismissed as they arrived at the port. On what little of the loan was taken up the republic could not meet the interest charges. Since the Transvaal debt was secured on land the land market tightened. Drought began in 1876–77. In the Lulu mountains the Bapedi, long a sporadic nuisance, burst into open revolt under Sekukuni (Sikukuni, Secocoeni). Few of the Boers rallied to the commandos which Burgers called out, and Kruger was both ill and disaffected. When Burgers was reduced to creating a volunteer legion he could neither pay nor control them, and the so-called peace of Dec. 1877 registered thinly disguised defeat.

The S.A.R. was bankrupt financially and politically, and its bankruptcy threatened the economic and political stability of the rest of South Africa. Its plight coincided with Carnarvon's growing determination to spring federation on South Africa. In Oct. 1876 Theophilus Shepstone left the colonial office with a discretionary power to annex the Transvaal should its inhabitants desire it; subsequent instructions virtually advised that annexation take place and the desirability be demonstrated afterward. In April 1877 the *raad*, which had indignantly refused to consider reforming that with which it was satisfied, was dismissed and the Transvaal was annexed, after a formal, lukewarm and ambiguous protest by Burgers. It is thought that if Shepstone had put his cards on the table and taken a vote of approval for British action at that point he would have secured the necessary majority. As it was, Burgers' halfhearted protest became a manifesto against usurpation, which, however mishandled, at the time had at least the same merit as plucking a suicide from the edge of a precipice. Burgers retired to the Cape a broken man. He received a pension of £500 from the British government and died in 1881.

BRITISH ANNEXATION AND SUZERAINTY

From Annexation to Retrocession.—As to the necessity or the wisdom of the annexation, opinion remains divided. There were certainly many groups in the Transvaal that welcomed it, and the Transvaal's multifarious creditors in the rest of South Africa openly rejoiced; so too did many in exposed frontier districts, harassed by the Bapedi, uncertain of the Swazi and afraid that Cetywayo's impis were about to wash their spears. But the attitude of the average farmer seems to have been noncommittal rather than favourable. In his annexation speech Shepstone, on behalf of the crown, promised a separate government with its own legislature. Yet at no point was true self-government given. Partly because of this, the British officials failed to gauge Boer opposition.

From April 1877 until Jan. 1879 Shepstone administered the land he had annexed. The proposed Delagoa bay railway plan was quietly dropped in the interests of the projected Natal line from Durban, yet Natal consistently refused to consider a rebate of customs dues on goods in transit to the Transvaal. The imperial treasury made a grant of £100,000 to the Transvaal administration and subsequently agreed to be responsible for the military expense of the war against Sekukuni. The grant was not ungenerous but it was not adequate. The public debt was £300,000 and in a community notoriously averse to direct taxation, accustomed to hoard rather than to invest its savings, taxation was regarded as tyranny and any administration was an infringement of privacy. The defeat of Sekukuni followed by the tardy triumph over the Zulu at Ulundi in July 1879 gave that frontier security which by its existence made the continuous presence of British troops superfluous. The beginning of the Natal system of taxing the natives settled in defined locations helped substantially to restore solvency. Gradually, and at the cost of increasing estrangement of the Boers, security and solvency returned to the Transvaal. Sir Owen Lanyon, who succeeded Shepstone (March 1879–Aug. 1881), was more efficient but even more remote from Transvaal opinion.

In 1877 Kruger headed a deputation which interviewed Carnarvon at the colonial office. He was promised local autonomy for the Transvaal and the retention of the Dutch language, but little else, for the colonial office professed to be assured that the occupation was desired by the inhabitants. Less than a year later, after £3,000 had been collected for his expenses, Kruger returned to the colonial office, this time with convincing evidence of the attitude of the republicans. But Sir Michael Hicks Beach (later Earl St. Aldwyn), the new colonial secretary (1878–80), while renewing protestations of Britain's good intentions insisted that there could be no retrocession of sovereignty. However, by this time both Hicks Beach and Sir Henry Bartle Frere (high commissioner March 1877–Sept. 1880) were convinced of the need for making constitutional concessions. In April 1879 Frere undertook to forward a Boer petition to the colonial office, but in June the appointment of Sir Garnet Wolseley to a separate high commissionership for southeast Africa limited Frere's field to the Cape. Wolseley was an excellent soldier and administrator of occupied territories, but he was impatient of politicians and was himself no statesman. By 1879 Pretorius, Kruger and P. J. Joubert were organizing an independence movement, for Wolseley failed to convince anyone that the council which he created in July 1879 was any different from the legislative council of the old Cape from which the trekkers had fled.

Meanwhile there was much to encourage the Boer opposition. To the north and east the frontier was secure. For the first time in Transvaal history the finances were sound. Both facts steeled waverers to rally to the patriots. In Britain Gladstone's exuberant attack on Disraeli's Balkan policy lured him into defending oppressed nationalities in general and the Transvaal in particular. Kruger and the independence party had grounds then for expecting a total reversal of British policy in South Africa when, in April 1880, Gladstone displaced Disraeli as prime minister. Yet once in office Gladstone faltered and fumbled. There is evidence that he intended to move very much along the lines etched later at the convention of Pretoria (see below), but dissensions in the cabinet and obstruction in the commons led to postponement. In the transvaal Lanyon underestimated the swelling tide of Boer patriotism, gave Gladstone no warning and the Boers no reassurance. But in fact the ubiquity and efficiency of British administration had created a national temper in the Transvaal of such a calibre that had it existed in the previous decade annexation would have been unnecessary.

At the close of 1880 the Transvaal sprang to arms. The republic was proclaimed at Paardekraal on Dingaan's day, 1880. Lanyon was besieged in Pretoria and the 94th regiment, hastening to his relief, was cut to pieces in ambush, while the Boers advanced on Natal. Without waiting for reinforcements G. P. Colley moved to intercept, was worsted at Laing's Nek and Ingogo (Feb. 8, 1881) and overwhelmed at Majuba on Feb. 27. There can be little doubt that the Boers would have been defeated had Britain decided on a major military move to restore the status quo before negotiating. But already, before Majuba, Gladstone's policy had belatedly crystallized, and on Feb. 7 (the day before Ingogo) Colley had received notice of Britain's intention to negotiate with the Boers. But Colley delayed getting in touch with Kruger and the crucial dispatch was, ironically, not delivered until after Majuba. Victory or defeat, Gladstone was resolved on principle to proceed with negotiations wherein he sought to reconcile Transvaal liberty with imperial responsibility for a beneficent native policy. But after Majuba negotiation to the Afrikaner spelled weakness and to the English-speaking colonials betrayal. Gladstone's policy failed to correct either impression.

Conventions of Pretoria and London.—From Aug. 1881 until May 1883 the Transvaal was administered by the triumvirate, Kruger, Pretorius and Joubert. In 1883, by an overwhelming majority, Kruger was elected president and was thereafter re-elected cntil the second annexation of the Transvaal in Sept. 1900. In Aug. 1881 a convention was concluded at Pretoria by direct negotiation between a royal commission and the triumvirate. The convention of Pretoria established a *modus* vivendi which as late as 1879 might have worked fruitfully but which after Majuba was ratified only with difficulty by the volksraad. But Kruger, if not the volksraad, had learned to grasp the substance which was de facto independence, with a view to dispelling the shadow of suzerainty at some more convenient point. The Transvaal took over about half the debt incurred by the British administration and secured the Harts river as its western boundary in place of the Makwassie Spruit specified in the Keate award. Britain retained a crown veto on native legislation and the right to appoint a British resident with a seat on the Native Locations commission; no treaties, either with foreign powers or with native chiefs beyond the frontiers, were to be concluded without British consent.

The immediate reaction in the Transvaal was an economic slump. In little more than a year the Transvaal had defaulted in its debt to Britain; it had crippled free enterprise by the sale of monopolies; it had estranged many in South Africa by the imposition of customs barriers; and it regarded as traitors those both in the Free State and the Cape who realized that, repugnant though British blunders often were, the security of South Africa and much of its economic stability depended on the insurance of the British connection. Many Transvaalers trekked in search of fresh pastures. In 1882 the new republics of Stellaland and Goshen, west of the Harts river between Taungs and Mafeking, were founded, and Boers from the Cape and the Free State as well as the Transvaal pushed back the Batlapin and the Barolong. The colonial office expressed concern over the fate of the native peoples whose chiefs, without forethought or scruple, sought alternately British and Boer protection. Whether victor or vanquished in intertribal conflicts, the natives invariably forfeited much of their land to European speculators. Cecil Rhodes grasped that the issue was one of territories not peoples, vital territory, since once again the only route to the north between the Kalahari and the republics was in peril. He urged the Cape to annex, but the Cape, having annexed much of the Transkei in 1879 and paralyzed to the point of defeatism in Basutoland, was chary of the responsibility of further annexations.

In 1884 accordingly, at London, Kruger on behalf of the Transvaal, Sir H. G. Robinson (high commissioner, 1881–89) on behalf of the Cape and the earl of Derby (colonial secretary, 1882–85) signed what was at once a revision and an amplification of the convention of Pretoria. All mention of the suzerainty categorically asserted in 1881 was tacitly dropped, and the republic secured acknowledgment of the title of the South African republic. On the west the frontier was rectified. The lands of Massouw and Mashete, both of whom were pro-Boer, were recognized as belonging to the republic, which thus secured a part of Stellaland and Goshen. Article 12 reiterated the independence of the Swazi to the east. Article 4 prohibited the conclusion of treaties with foreign powers or with native chiefs outside the borders of the S.A.R. without crown sanction. Article 14 guaranteed that no discriminatory regulations should be imposed on immigrants into the Transvaal. But by dropping the claim to appoint a resident to sit on the Native Locations commission and dropping the veto on native legislation, Britain no longer retained reasonable grounds for interfering in the internal affairs of the Transvaal.

The convention of London was ratified by the volksraad in Aug. 1884. But already new causes of dissension, made more tense by the German annexation of South-West Africa, had arisen. In April 1884 a group of Transvaal Boers moved into Zululand to join Lukas Meyer of Utrecht, who was officially in alliance with Dinizulu. For services rendered, they claimed what was in effect a drastic extension of the Blood River territory and Pongola strip—a new republic thrust down to the Indian ocean between the Umhlatusi and White Umfolosi to secure the littoral of St. Lucia bay. Zulus, displaced by tribal war and dislocated by Boer surveyors, poured into the Natal reserves, while the colonial office, perturbed by German policy in the Pacific as well as in Africa, claimed St. Lucia bay in terms of the 1843 treaty with Mpande (Panda), and in Jan. 1885 claimed a protectorate over the whole of the Pondoland coast. The new republicans claimed to have divested themselves of their former citizenship so that the letter of the convention was not technically broken. In 1886 Britain recognized the new republic. now shorn of its coastal territories, and in 1887 annexed Zululand as logically it should have done in 1879. In 1888 the new republic joined the Transvaal and was incorporated as the district of Vryheid, so that the boundaries of the S.A.R. in 1888 were effectively not those agreed upon in 1884.

To the west of the Transvaal the position was at first no more stable. Bechuanaland was a tribal chaos, but the colonial office, which in 1884 had reluctantly resumed responsibility for Basutoland, hesitated to intervene. In the confusion one resolute action might turn the issue. Kruger annexed Goshen. His action goaded Britain into action already overdue. In 1885 Bechuanaland south of the Molapo river became a crown colony, and north of the river a protectorate was declared and policed. In brief, the road to the north forged mainly by hunters and British missionaries was kept open, a highway for all, the sealed monopoly of none.

Kruger was by no means unaware of the exigencies of British diplomacy. For instance, Berlin as well as Pretoria protested at the annexation of St. Lucia bay, and the new republic had openly sought the aid of three continental powers. From London, Kruger in 1884 had journeyed to the Netherlands, Belgium, France, Portugal, Spain and Germany. In the Netherlands the Netherlands South Africa Railway Co. was given valuable concessions and the monopoly of railway construction in the S.A.R. In Lisbon Kruger discussed the recent concession of the Portuguese government to the American Col. E. McMurdo, who had undertaken to build a railway up to the Transvaal frontier from Delagoa bay. This was Burgers redivivus; but Kruger was a natural politician, persuasive, evasive, studying the art of the possible without ever losing sight of the desirable. He sought a free-growing and prosperous Transvaal with its own route to the sea. The Transvaal in the early days under Kruger was as near bankruptcy as it had ever been under Burgers; no part of South Africa had been so hardly hit by the recent slump; yet his diplomacy was still firm and his confidence unshaken. On paper his plans were the plans of Pretorius and of Burgers before him. But, though the discovery of gold played its part, what differed was the calibre of the man.

Discovery of the Witwatersrand Gold Fields.—When the economic collapse of the Transvaal seemed imminent. the discovery of the Sheba mine in the Barberton area and the more important gold-bearing complex of the Witwatersrand started an industrial revolution which was to metamorphose not only the republic but the whole of South Africa. At the same time the concentration of urban population was a great stimulus to agriculture. Hitherto, apart from tobacco, most farmers had been content with little above a subsistence economy. Henceforward maize, wheat, fruit, etc., were grown as a commercial proposition made more attractive by the development of railway transport. As a result a kind of imperialism beckoned to all the Dutch-speaking people of southern Africa, to make the now wealthy Transvaal the centrepiece of a revival of the trekker pattern of life.

External Relations, 1886–95.—Externaliy the policy of the Transvaal continued to be a logical extension of trekker politics. From 1886 onward Kruger. whose tentative overtures for a customs union in 1884 and 1885 had been rebuffed by the Cape, concentrated on forging a path to the sea, independent of British control and untrammelled by colonial tariffs. In particular he regarded the Netherlands Railway Co. with its preponderance of Dutch and German shareholders as his special creation. When in Jan. 1895 he officially opened the completed Pretoria-Delagoa Bay railway, the tenacity of Transvaal policy seemed justified. Having declined to enter the projected customs union of 1889, Kruger nevertheless concluded a belated railway convention with Natal. In this way the Transvaal sought the best of both worlds.

At Kosi bay, which the Transvaal could reach by driving through Swaziland, was the one port not yet covered either by Portuguese or by British claims. Since the independence of Swaziland had been expressly guaranteed by the conventions of Pretoria and London, a railway concession through Swaziland could be achieved only with British connivance. But though the London convention had defined both the eastern and the western frontiers of the Transvaal, the northern limit had not been so precisely fixed. In 1887 a concession was secured by the Boers from the Matabele north of the Limpopo. Kruger sought to barter forbearance in the north against privilege to the east in Swaziland and the development of Kosi bay. Three Swazi conventions were signed (1890, 1893 and 1894), and in the third Britain finally visualized the rule of the republic in Swaziland subject to safeguards for the natives.

By 1894 the high commissioner, Sir Henry (later Baron) Loch (1889–95), had been prepared to raise the question of the *Uitlander* franchise on a *quid pro quo* basis had German protests not prevented it. The German government regarded the commercial federation of South Africa, which was Rhodes's minimum objective, as a menace to German commerce in the Transvaal. In Jan. 1895 Kruger openly boasted of German protection, and to discreet British remonstrance at Berlin, Baron von Marschall replied that "interests demanded the maintenance of the Transvaal as a state economically independent and the safety of the *status quo* regarding railways and Delagoa bay." British reaction was sharp and legitimate. In response to the appeal of Queen Sambili, Britain in Feb. 1888 had pronounced Tongaland a British sphere of influence. In May 1895 the coast, including Kosi bay, was annexed.

The Transvaal was in fact surrounded. But it was not surrounded by foes. Railway agreements could be made with the Cape and the Free State, as they had been with Natal. But within the Transvaal, railway transport was the monopoly of the Netherlands Railway Co., which placed differential rates on goods in transit from colonial ports. Consequently merchants from the south unloaded at the border and reverted to wagon transport for the rest of the journey to the Rand. In Oct. 1895 Kruger closed the Drifts (ford across the Vaal). An ultimatum from Joseph Chamberlain (colonial secretary, 1895–1903), sent with the backing of the Cape government, forced Kruger to withdraw in November. If Kruger's policy within the Transvaal had been the most liberal in the world, his external relations would have provoked criticism.

Effects of the Discovery of Gold.—From being the poorest, the Transvaal had become the wealthiest of the South African communities. Inevitably a flood of immigrants of all nationalities (British and German preponderating) invaded the republic and their numbers soon exceeded that of the burghers. Their whole economy and social habits were the product of urban life overseas, whereas the burghers cleaved, at least officially, to the habits of life engendered by a diffuse rural economy. The immigrants (dubbed *Uitlanders)* threatened to overwhelm the old order and to metamorphose the state. Given time, social fusion and political readjustment could have been brought about, for the leaven of a money economy was altering the structure of Boer society; Kruger did not face a simple issue of a burgher community of the elect ranged against the servants of mammon, though many of his supporters visualized it as such. From the first he perceived that the *Uitlanders* were not a solid bloc. Some came to settle and would make permanent contributions to the country. Many came to make fortunes and depart. Further, joint-stock undertakings rapidly displaced the private enterprise of the digger. That meant that there was not one but, broadly, three classes, the mining capitalist, the commercial class and the skilled artisans. A third factor was that without native labour the mines could not be worked. Hitherto the natives had been blocked on tribal land, where since the British occupation of 1877–81 they had, if cramped, enjoyed increasing security of tenure. Now the simple territorial approach to the native problem no longer sufficed.

Kruger had a shrewd insight into realities. But his memory and burgher traditions were long and bitter. The new wealth seemed to provide the opportunity to thrust against the geographical encirclement dictated by British policy and the more insidious commercial suction which Rhodes sought to apply to bring back the trekkers into the vortex of the Cape. In the second place Kruger's presidency was subject to re-election every five years, and the rivalry of P. J. Joubert and later of Schalk Burger was formidable.

Franchise Issue.—Unfortunately neither the burghers nor the Hollanders whom Kruger imported had the ability and scruples necessary to make administration fit the needs of the *Uitlanders.* The monopolies and other concessions, including the dynamite monopoly, were vested interests developed before the Rand was discovered. The Netherlands Railway Co. provided a harvest of contracts for Hollanders and charged excessive and discriminating rates. Though in 1882 Dutch had been recognized as the official language in the Cape, English was not so recognized in the Transvaal. The provision of schools and municipal services was hopelessly inadequate. When petitions to the *volksraad* failed, malcontent *Uitlanders,* many of whom were colonials, pressed for the franchise which alone could give them political expression. On this point neither the president nor the *volksraad* would budge. To the contrary, as *Uitlander* pressure increased, the franchise, which in 1882 had been reasonably limited to burghers and to settlers of five years' standing, was made more limited. In 1891 a significant pointer was given. All who had fought for the republic at Majuba were enfranchised. A year earlier a second *raad* (for which a vote was obtainable after two years' registration) was established to deal with the concerns of the mining areas, but since it had no taxing powers, and its decisions were subject to review by the first *mad*, it could never be more than a talking shop. A minimum of 14 years' residence was required to qualify for the franchise for the first *raad* and for presidential elections. Moreover, the status of the child born in the Transvaal depended on the status of his parent, so that the franchise was entailed. Since the first *raad* could legislate in a self-diagnosed emergency by *ad hoc* resolution or *besluit,* there was no guarantee that the residence qualification would not be indefinitely extended by this means. This situation consolidated a discordant opposition which Kruger might otherwise have divided.

In 1892 there was a slump on the Rand; drought hit the farms; customs and railway rates kept up the cost of living. Charles Leonard, an attorney who had come from the Cape, founded the National Reform union, to agitate for better administration and an extension of the franchise. This was a popular and, it should be noted, an indigenous, even local, South African movement; and the prime objectives seem to have been neither imperial nor Cape-federal. As the spirit of the Transvaal became more obdurate in its attitude to reform, so British policy hardened. In 1894, encouraged, and in part misled, by German diplomacy, Kruger began to arm. Over Swaziland, over customs rates, wherever the Transvaal encountered either the high commissioner or the Cape (where Rhodes was now prime minister) there was deadlock. Increasingly it seemed to many that only by solving the franchise issue across the Vaal could South African, not to mention Transvaal, problems be solved.

Jameson Raid.—On Dec. 29, 1895, L. S. Jameson, friend and agent of Rhodes, invaded the Transvaal from his base at Pitsani in Bechuanaland, where he had been stationed in Rhodes's railway concession strip, theoretically to police the route to the north, in practice to watch events at Johannesburg. It had been anticipated that the *Uitlanders* would rise in revolt in the cause of reform. In that case Jameson's task force was to intervene and hold the position for Rhodes. But proceedings in Johannesburg and Pretoria had moved slowly and clumsily, so much so that Kruger had paced their every move. Some favoured reform only with no change of status; some favoured a republican revolt with complete independence as the goal; some favoured revolt and federation with the Cape; some favoured revolt and the hoisting of the British flag. Rhodes advised that the decision about the flag could be taken afterward by plebiscite, but that meantime the projected revolt should be postponed. However, Rhodes's message did not reach Jameson, who attempted a coup aimed as much against the critics of Rhodes as against Kruger. The raid was a fiasco. On Jan. 2 Jameson, surrounded at Doomkop, surrendered to the Boers, while the leaders of the feeble revolt that had followed his advance were likewise arrested and imprisoned. Jameson and his men were handed over to Sir Hercules Robinson (later Baron Rosmead; high commissioner, 1895–97). The Johannesburg leaders, Lionel Phillips, Frank Rhodes, J. H. Hammond, George Farrar and others were condemned to death for high treason. Sentence was commuted to fine and imprisonment, the latter in most cases being also commuted. Rhodes paid the fines.

The high commissioner acted promptly and correctly, and the peaceful surrender of Johannesburg on Jan. 7 was attributable in part to his efforts. There was resentment against the raid among both the British and the Afrikaners, but the edge was blunted somewhat outside the Transvaal, when the kaiser congratulated Kruger in an open telegram on breaking the raid "without appealing to the help of friendly powers." For the time being Rhodes's power in the Cape was broken. He withdrew to Rhodesia. The commission of inquiry in Britain which reported in 1897 censured him but proved no complicity on the part of the colonial office. Joseph Chamberlain, in the house of communs, emphasized that the raid as such had been countermanded by Rhodes and (it is thought under pressure) whitewashed Rhodes in a general defense of his policy. Modern research, though some vital documents are destroyed, has shown that both the high commissioner and the colonial office were, at the very least, in a position to know and therefore to have condemned what was being planned.

WAR AND THE UNION

From the **Raid** to War.—Tension in South Africa had been marked before the raid; after the raid the position became increasingly grave, for the fruitful partnership in the Cape which Rhodes had maintained with J. H. Hofmeyr, and through Hofmeyr with the Afrikaner Bond, was snapped. Throughout South Africa Kruger, who to many at the time of the Drifts crisis had seemed an obstacle to progress, now to the Afrikaners everywhere appeared as the bulwark against chauvinist imperialism. Unfortunately, legitimate resentment was translated by Kruger into four moves which aggravated the position. The Transvaal moved into closer touch with Germany and accelerated its armaments; it built on to the defensive alliance with the Free State and worked for a federal link between the two republics; Kruger pursued with redoubled skill the drive to absorb Swaziland in defiance of the conventions; and in the republic he was forced to yield increasingly to the implacables in the volksraad. His own views also had hardened. In 1896 a new press law crippled the English press in the Transvaal. More serious, since by implication they raised the suzerainty issue, laws providing for the expulsion of aliens and a drastic tightening of immigration laws were passed. The executive was given increasingly autocratic powers. Only a military demonstration at Ladysmith and the dispatch of warships to Delagoa bay secured the repeal of the immigration laws. In 1897 Judge J. G. Kotze (in R. E. Brown v. Dr. Leyds) ruled that legislation by *besluit* was contrary to the constitution and claimed for the courts a testing power analogous to that of the U.S. supreme court; then Kruger, with an election in the offing, secured from the volksraad the right to dismiss any judge who claimed the testing power, but, on the intervention of Chief Justice de Villiers of the Cape, did not exert the right pending some amendment of the *grondwet*. At the election the rival candidature of Joubert and Burger split the opposition vote and Kruger was returned in triumph.

After the election Kotze was dismissed (Feb. 1898) and opposition against Kruger hardened again. Concentration on franchise reform seemed the only rational procedure. In Feb. 1899 a petition to Queen Victoria signed by 21,000 British subjects was drawn up. This was supported by a dispatch (May 4, 1899) telegraphed to London by Sir Alfred (later Viscount) Milner (high commissioner, 1897–1905). In June a conference took place at Bloemfontein. Some of Kruger's delegation, among them Schalk Burger, opposed any change. Kruger offered an equivocal seven-year franchise but insisted that it be bartered against the incorporation of Swaziland in the Transvaal and the submission of future disputes to an arbitration procedure which would carry the implication that the conventions were a dead letter. The feeling was that if the issue broadened into the general issue of suzerainty, and if Britain yielded on that point, in the existing constitutional confusion in the Transvaal there would be no guarantee of the permanency of any concessions Kruger might make. In July 1899 the Transvaal executive resolved to increase the number of seats in both raads and, eschewing Milner's stipulated five-year franchise, proposed to substitute, albeit in simplified form, a seven-year franchise, which Milner had already rejected at Bloemfontein. Though feeling on both sides was mounting, Chamberlain sanctioned a new joint inquiry in August, wherein Conyngham Greene acted for Britain and J. C. Smuts for the republic. Before the end of the month Smuts had agreed on the five-year franchise but again at a price which he left discreetly vague but which F. W. Reitz hardened, namely the dropping of the suzerainty claim. Chamberlain therefore could make only a qualified acceptance. Kruger's answer to Chamberlain's reservations on the suzerainty issue was to revert to the seven-year franchise. Thereupon Chamberlain claimed that if his reservations were ignored, he must consider the whole question anew. Parallel with the adoption of this stiffer tone went the drafting of troops from India and the Mediterranean. On Oct. 9 the Transvaal presented an ultimatum to Conyngham Greene in Pretoria, demanding the withdrawal of all reinforcements and cancellation of the troop movements. Throughout, the Free State had striven to avert the war, in which, in terms of its alliance with the Transvaal, it was bound to be involved. But when, as was inevitable, Britain declared war, the Free State moved loyally if belatedly to support the Transvaal. If there was justice on both sides so too was there bigotry and arrogance, and the war was an index of failure on both sides. In the event it solved nothing.

From War to Union.—For the events of the war itself *see* SOUTH AFRICAN WAR. Peace proposals were rejected by the Boer leaders at Middelburg in March 1901, and the treaty of Vereeniging, May 31, 1902, was signed only when the resources of the Boers had been broken by unceasing strain against superior forces.

Already in March 1901 Milner had arrived at Pretoria to inaugurate a civil administration, for the rate of South African recovery would depend in part on the rapidity with which gold production could be resumed, in part on the skill with which men were resettled on the derelict farms. Farming, hit seriously by rinderpest in 1895–96, had suffered severely during the war period, and it was estimated that half the livestock in the republics had perished. As high commissioner and governor of the Transvaal and Orange River colony (the former Free State), Milner treated the problem of rehabilitation as involving a single unit and this went far to complete the links between the two Boer states which Kruger and Pretorius before him had striven to forge.

Milner created an efficient four-judge supreme court and made no attempt to substitute British for Roman-Dutch law. Municipal government was organized, the Rand Water board was created by ordinance in 1903, and improvement little short of spectacular was made in the provision of schools and teachers. Some blocks of land were bought and earmarked for British settlers (596 immigrants were settled under this scheme), but the main effort was made to restore the rural economy by the prompt granting of relief. the assessment of war damage, the provision of seed and the loan of agricultural equipment. More than £10,000,000 in grants and loans was spent on development projects. As an emergency measure labour difficulties in the mines were met by the importation of Chinese coolie labour. It served its purpose and by 1908 the mines were producing £30,000,000. Parallel with the most brilliant piece of administrative reconstruction that to that time had been attempted anywhere by Britain went Milner's moves to set the points right for federation. He bought out the Netherlands Railway Co. and placed the railway system of the Transvaal and the Orange River colony under joint administration. Between 1903 and 1905 an intercolonial Commission on Native Affairs met under the chairmanship of Sir Godfrey Lagden and examined in detail the structure of native administration in each colony. The problems of railway rates, customs and tariffs were studied, and each deadlock emphasized the need for union.

Meanwhile Louis Botha and J. C. Smuts, neither of them Transvaalers by birth, began the political education of the Afrikaner in the Transvaal. In Jan. 1904, having deliberately declined to participate in Milner's nominated legislative council, Botha formed Het Volk, a party with two objectives, conciliation and self-government. The latter was also the objective of the former *Uitlanders*, and Milner and his council became the target of both. In April 1905 Milner was replaced by another Tory peer, Lord Selborne (high commissioner, 1905–10), who was empowered by letters patent to institute representative government. But largely as the result of Smuts's unofficial visit to London soon after the Liberal ministry of Sir Henry Campbell-Bannerman took office, the Liberal cabinet advised the immediate granting of responsible government. New letters patent were issued in Dec. 1906. The first election was held at the beginning of 1907 and Het Volk secured 37 of the 69 seats in the new legislative assembly. Selborne therefore asked Louis Botha to form a ministry and Botha included Smuts in his team. Between 1907 and 1910, when the Transvaal was merged in the union, the ministry displayed great ability. Smuts's Education act, which provided for mother-tongue education in the primary years with English instruction thereafter and five hours of Dutch per week, though it annoyed extremists on both sides, was a much more tolerant approach to a difficult problem than that of J. B. M. Hertzog in the Orange River colony. There was no blind panic about the Chinese coolies, though all were agreed they must go. They were repatriated as their indentures expired, and by 1910 the exodus was completed. A firm but inconclusive approach was made to the Indian problem. In 1907 Smuts supported a stringent immigration and registration law which was met by the first passive resistance campaign of Mohandas K. Gandhi, who secured for the moment the repeal of the laws in question without any improvement otherwise in the position of Asians.

But the major problem was the one the ministry had inherited from Milner; namely, the problem of federation. Intercolonial conferences on such vital matters as a common appeal court, a common native policy and railway rates and customs proved sterile in spite of repeated efforts. Failure of the Customs conference of May 1908 provided the occasion for Smuts to move six resolutions in favour of taking concrete steps toward attaining political union.

At the national convention which met in Durban in Oct. 1908 Smuts proved his mettle. He broke the Natal move to substitute federation for a closer union, and whenever rupture threatened he smoothed away objections or found a compromise formula. Botha's more sober approach was equally impressive and did more probably to convince the Afrikaners than the mental agility of Smuts. Together they made a perfect team, and the result was that Pretoria became the axis of political gravity.

Transvaal After the Union. — The structure and powers of the Transvaal provincial council as established by the South Africa act. 1909 (see SOUTH AFRICA, UNION OF), were precisely those of the other provinces; but the wealth and resources of the Transvaal, the problems created by its rapid industrialization, and the fact that the union was substantially made and moulded by Botha and Smuts, all conspired to make the Transvaal province the touchstone of South African politics. The first prime minister of the Union was Botha (1910–19), and for 29 of the first 40 years of union his successor, Smuts, was a member of the Union cabinet and for 14 years prime minister.

The economic development of the Transvaal after union was phenomenal: stable government, a stronger diplomatic position vis-à-vis Portugal and a national approach to customs and transport provided a framework for growth. In 1910 Johannesburg was already the largest town in the union, and it retained its primacy. In 1951, of 16 South African towns with populations of more than 20,000, 9 were in the Transvaal. The weight of the population shifted from the Cape to the Transvaal, and by periodic redistribution of seats, the Transvaal representation in the assembly increased to 68—14 more than the Cape. In the 1946 census, 397,497 of the Europeans in the Transvaal were English-speaking, 621.035 were Afrikaans-speaking and 16,056 were bilingual. A provincial education ordinance required children to attend the school whose medium of instruction was the certified home language of the parent, irrespective of the parent's stated wishes. This evoked bitter controversy in the Transvaal and in the Union.

Developments in the Transvaal which at first sight seem to be merely provincial have reacted, because of its economic importance, on the Union as a whole. It was on the Rand that the three main problems which haunted the Union government after 1910 first crystallized: the relations between capital and European labour; the relations between European and both native and coloured labour; and the problem of trying to maintain the territorial *apartheid,* or segregation of races, traditional in the Transvaal, while at the same time feeding the labour market.

In 1913 a labour dispute at Kleinfontein gold mine at Benoni developed into an armed clash with the troops in which 27 were killed and 47 wounded. If the Rand were paralyzed the Union would be crippled, and renewed strikes in 1914 were answered by the deportation of the leaders. The victory of Labour in the Transvaal provincial election made it impossible for the central government to evade legislation. In 1914 workmen's compensation was improved; it was extended to cover benefit for miners' phthisis and marked the beginning of an industrial code. As industrialization developed to the point of economic revolution, so the labour legislation of the Union government increased in scope.

It was on the Rand, moreover, that the question of the relation between European and non-European workers presented itself in its most acute form. Fear of unemployment and low wages when the Chamber of Mines sought economy by reducing the proportion of European labour, and when wage rates in the coal mines fell, led to the great miners' strike of 1922. It was suppressed only after a loss of life greater than that in the South-West Africa campaign of 1915. In the 1924 election Transvaal labour voted either Labour or Nationalist, and Hertzog in quasi-coalition with F. H. P. Creswell secured and extended the colour bar which in practice already existed in the mines. There was temporary identity of interest rather than of theory between the two parties, and the pressure of Afrikaner nationalism alienated a section of the Labour council. Native trade unions were not recognized by the Industrial Conciliation act of 1936, but by 1942 more than 30 unofficialnative unions existed on the Rand and the example was followed elsewhere. The Native Labour Settlement of Disputes act, 1953, prohibited strikes and lockouts but provided new machinery for settling native industrial disputes. Some native unions are affiliated to the European unions in the respective trades, so that yet another experiment that may affect the Union as a whole has emanated from the Transvaal.

Just as the Transvaal by its precocious industrial development provided the spearhead of a labour thrust, so too it seems that the Transvaal attitude toward both rural and urban natives has increasingly influenced the native policy of the Union government. The Group Areas act of 1950 was one of a series of acts which sought to implement Smuts's Natives Land act of 1913, which checked the penetration of natives into European areas and vice versa as firmly as Boer commandos had held the frontiers in the old Transvaal. The Native Resettlement bill, 1954, proposed an arbitrary clearance of native townships over the heads of the johannesburg city council, where the Native Trust and Land Amendment bill, 1953, removed the necessity, hitherto incumbent on the authorities, to provide alternative accommodation for natives evicted under the Natives (Urban Areas) Consolidation act, 1945. Many of the devices of the old Transvaal system — the pass laws, the segregation, the colour, as distinct from the civilization, test of the old Cape franchise--mutatis mutandis passed into the national structure of native policy. The half century which opened with the British annexation of the Transvaal in 1900 saw not merely the triumph of a policy of union sponsored by Transvaal statesmen who were opposed on principle to a liberal franchise. but also the triumph within the Union of the trekker spirit translated into the idiom of a commercial society. (W. A. ML.)

SOCIAL AND ECONOMIC CONDITIONS

Population. — The population in 1951 numbered 4,801,708, including 1,204,712 whites. The largest proportion of these latter is centred in gold and uranium production areas, in coal mining and iron and steel industrial areas. The natives in 1951 numbered 3,472,640. Apart from the large numbers employed in the gold and coal mines and in the iron and steel industry, they are concentrated chiefly in the native reserves. These are mainly in the Pietersburg, Potgietersrust, Zoutpansberg, Letaba, Rustenburg, Brits, Pretoria, Middelburg, Lydenburg, Pilgrim's Rest, Nelspruit and Barberton areas. Basutos are numerous in the Zoutpansberg and Lydenburg districts, Bechuana are largely confined to the west and southwest, Amazulu are found principally in the Wakkerstroom and Standerton districts and Amaswazi in the Barberton, Ermelo and Wakkerstroom districts. Shangaan and other east coast tribes form an appreciable element in Barberton, Lydenburg and Zoutpansberg. Asians numbered 49,342 in 1951. They are largely engaged in trade and are settled on the Witwatersrand, in Pretoria and in Barberton. Other nonwhites numbered 75,014.

Towns.—Pretoria (*q.v.*) is the administrative capital of the Transvaal and of the Union of South Africa. Johannesburg is the largest city. Other towns of more than 50,000 inhabitants are Germiston, Springs, Brakpan, Roodeport-Maraisburg, Benoni, Krugersdorp, Boksburg and Vereeniging. Further towns of importance are Pietersburg, Barberton, Witbank, Lydenburg, Blyvooruitzicht.

Education.—Primary and secondary education for Europeans and non-Europeans (other than Africans) and the training of teachers are administered by the province. University, technical and vocational, agricultural and special education and, since 1954, the preuniversity education of Africans is administered by the Union. European primary and secondary education (785 schools in 1951) is mainly public education and is financed by the province. Private schools (111 in 1951) cater for only a small percentage of the children. Non-European primary and secondary education (1,406 schools in 1951) is mainly state-aided (before 1954 through the provincial administration; in and after 1954 by the Union government), and is partly financed and controlled by mission enterprise. The relative contribution of the state (Union and province combined) to non-European education is small in comparison with that for European education—in 1954 approximately £2,500,000 as against nearly £10,000,000. Segregation of the races in primary and secondary education is complete. From 1950 every white child in the Transvaal was taught through the medium of his home language. There are two technical colleges, Witwatersrand and Pretoria. Agricultural education is available in farm schools, at the Agricultural college (Potchefstroom) and at two universities (Pretoria and Potchefstroom). There are three universities, Witwatersrand, Pretoria and Potchefstroom.

Provincial Government.—At the head of the executive is a provincial administrator, appointed by the governor general in council. He holds office for five years and is assisted by an executive committee of four members elected by the provincial council consisting of 50 members, elected for the same constituencies and by the same electorate as are the members of the house of assembly. The provincial council, which has strictly local powers, sits for a statutory period of three years.

Provincial expenditure in 1949 was £19,965,081, of which £9,019,930 was for education.

Agriculture.—Next to mining, agriculture is the most important occupation in the Transvaal. Mixed farming is practised by most of the white farmers. Good summer grazing is available on the high veld, but during the winter months stock loses condition and requires supplementary feed. In the low veld good pastures are found but low rainfall is a limiting factor. Much stock is moved from the high veld to the bushveld and the low veld for winter grazing. The low veld and middle veld are unsuited in summer for horses and sheep because of horse sickness, blue tongue, etc. The tsetse fly used to be deadly to cattle in the low veld, but it disappeared naturally in 1898 after the rinderpest outbreak. The prevalence of ticks is one of the main drawbacks to stock farming. In 1951 there were 2,232,008 cattle owned by whites and 3,386,972 owned by natives, 2,747,776 sheep owned by whites and 3,047,940 owned by natives and 71,747 goats owned by whites and 803,817 owned by natives.

The amount of land under cultivation is small in comparison with the area of the province, chiefly because, for physical reasons, it cannot be plowed. Moreover, while large areas on the high veld are suitable for the raising of crops of a very varied character, in other districts, including a great part of the low veld, arable farming is impossible or unprofitable. Many regions suffer permanently from deficient rainfall; in others, because of the absence of irrigation works, the water supply is lost, while the burning of the grass at the end of summer, a practice adopted by many farmers, tends to impoverish the soil and render it arid. The country suffers also from periods of excessive heat and general drought, and formerly was often devastated by locusts. After 1950, however. there was no invasion of the province by these pests, largely as a result of successful methods of destruction, in which chemicals are used. The districts with the greatest area under cultivation are Heidelberg, Witwatersrand, Pretoria, Standerton and Krugersdorp. The chief crops grown for grain are maize (mealie), kafir and wheat. Maize is the staple food of the natives. Oats, barley and millet are largely grown for forage. The chief vegetables grown are potatoes, pumpkins, carrots, onions and tomatoes. Fruit farming is a large industry on the slopes of the plateaus and in the warmer valleys, where citrus and other subtropical fruits thrive where irrigation is available; *e.g.*, about Rustenburg, Waterberg, etc. Citrus production (all varieties) was 10,850,000 pockets in 1950, 9,600,000 in 1951, 8,600,000 in 1952, one pocket being equal to 30 lb. of fruit. In 1950 there were 582,000 nonbearing trees and 2,023,000 bearing trees. Considerable expansion, however, took place and brought the number of nonbearing trees up to about 706,000 by the mid-1950s. Apples, deciduous fruits and grapes are also grown.

In 1950 cotton was grown, by whites only, chiefly in the Barberton, Rustenburg, Piet Retief, Nelspruit, Waterberg, Pilgrim's Rest and Letaba areas. The yield varied from 2,390,756 lb. at Barberton to 80,970 lb. at Letaba. Tobacco is grown chiefly in the Brits, Marico, Rustenburg, Waterberg, Piet Retief, Letaba, Pietersburg, Potgietersrust and Zoutpansberg districts. The Transvaal produces about four-fifths of the total tobacco crop of the Union, which in 1951–52 amounted to more than 53,000,000 lb.

Mineral Resources.—The Transvaal, the principal gold-producing country in the world, is noted for the abundance and variety of its mineral resources. Besides gold, the minerals chiefly mined are diamonds and coal, but the province also possesses platinum, asbestos, silver, iron, copper, lead, tin, cobalt, sulphur, saltpetre and many other mineral deposits. The production of uranium was being undertaken in three of the gold mines in the 1950s, and great expansion was expected.

Gold.—The principal gold-bearing reefs are found along the Witwatersrand (the "Rand"). Probably connected with the Rand reefs are the gold-bearing rocks in the Potchefstroom and Venterskroon districts. Other auriferous reefs are found all along the eastern escarpment of the Drakensberg and are worked in the Barberton district, on the Swaziland frontier in the Lydenburg district, in the Murchison range and in other places in the Zoutpansberg. Gold fields also exist in the Waterberg and on the western frontier in the Marico district. Production of gold in 1952 amounted to 11,594,271 oz. with a value of £143,913,888.

Diamonds.—The chief diamond fields are in the Pretoria district. The ground was discovered to be diamantiferous in 1897, but it was not until 1903, when mining began on the Premier mine, 20 mi. N.E. of Pretoria, that the wealth of the fields was proved. In June 1903 mining began, and the diamonds found in the first five months realized more than £90,000. On Jan. 27, 1905, the largest diamond in the world, weighing 3,106 carats, or about $1\frac{1}{3}$ lb., was found in the mine and named the Cullinan. The Premier mine is of the same character as the diamond mines at Kimberley (see DIAMOND) and is considerably larger. The area of the "pipe" containing blue ground is estimated at 350,000 sq.yd. Besides the Pretoria fields there are diamantiferous areas (alluvial diggings) in the Bloemhof district on the Vaal river northeast of Kimberley and in other regions. In 1951 alluvial diamonds to the value of 6727,669, weighing 111,429.85 carats, were produced; from mines diamonds weighing 1,134,942 carats were produced, at an average price of 47*s*. 3d. per metric carat.

Platinum.—Platinum is produced in the Rustenburg district. In 1952, 172,766 oz. were exported and were valued at 64,135,866.

Coal and Other Minerals.—There are extensive beds of good coal including thick seams of steam coal near the Rand and other gold fields. Coal appears to have been first discovered in the neighbourhood of Bronkhorst Spruit between the Wilge and Olifants rivers, where it was so near the surface that farmers dug it up for their own use.

In 1887 coal was found at Boksburg in the east Rand, and a mine was at once started. The principal collieries are those at Boksburg and at Brakpan and on the east Rand, at Vereeniging, at Klerksdorp, at Watervaal north of Pretoria and in the Middelburg district, which in 1945 supplied most of the coal used by the gold mines. Like that of Natal, the Transvaal coal burns with a clear flame and leaves little ash. The mines are free from gas and fire damp. In 1952 the output was 20,869,087 tons valued at £8,951,-409.

Iron and copper are widely distributed. The Yzerberg near Marabastad in the Zoutpansberg consists of exceedingly rich iron ore which has been smelted by the natives for many centuries. An important iron and steel industry has been established. During 1952, 1,612,211 tons of iron ore were produced, valued at £875,402. In that year also, 1,158,700 fine oz. of silver were produced. valued at E358,905; 997 tons of tin valued at £868,805; and 12,660 tons of copper valued at £3,626,012. (I. B. P. E.)

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TRANSYLVANIA, a large region of distinct geographical identity which from the 11th century until 1918 formed the easternmost part of Hungary, but was then ceded to Rumania. The Latin name, which appears in the 12th century, signifies "beyond the forest" (*i.e.,* from Hungary); the Hungarian name. Erdély, means "the land at the foot of the forest," and from this the Rumanian Ardeal is taken. The German name, Siebenbiirgen, is usually derived from the seven principal fortified towns founded by German colonists.

Transylvania proper is a D-shaped area of 23,324 sq.mi. contained on the north and east by the Carpathians, on the south by their continuation, the Transylvanian Alps, and on the west by the lower and more broken Bihar mountains. The name of Transylvania is used, however, to include the neighbouring regions of Maramures and Crisana (10,133 sq.mi.) and part of the Banat (*q.v.;* 7,228 sq.mi.), also transferred after 1918 from Hungary to Rumania; *i.e.,* a total area of 40.685 sq.mi. with a total population (1910 census) of 5,216,000, including 2,826,000 Rumanians, 1,550,000 Magyars and 520,000 Germans.

HISTORY

Transylvania formed the nucleus of the extensive Dacian (Getic) kingdom, which can be traced back to the 3rd century B.C. and was to become the Roman province of Dacia (*q.v.*) following the final victory of Trajan over the Dacian king Decebalus in A.D. 105.

After the withdrawal of the legions by Aurelian (A.D. 271) the history of the region remains a blank for many centuries. It was overrun by successive barbarian tribes: Germanic (Goths, Gepidae), Ural-Altaic (Huns. Avars and probably Bulgars and Petchenegs) and Slavonic. The debated question whether a Daco-Roman (Vlach) population survived these storms is discussed elsewhere (see VLACHS).

Magyar Conquest.— The Magyars did not fully establish their rule until A.D. 1003, when their newly crowned King Stephen made himself master of the country, defeating, tradition has it, a native prince, Gyula, variously claimed as Vlach or Bulgarian by race. The local rulers were not strong enough to exact concessions from their new masters, but the remote and mountainous character of the country hindered complete integration with Hungary. The administration was, however, consolidated soon after the conquest by the settlement, probably as frontier guards, of the Szeklers (*q.v.*), a tribe akin to the Magyars, in the east and southeast. and of the "Saxons" (Germans from Luxembourg and the Rhineland) on the southern and northeastern passes. Both Saxons and Szeklers were free! self-governing communities under the king; the former proved a great civilizing influence. The chief of the many privileges of the Saxons was the charter (Goldener *Freibrief*) granted them in 1224 by Andrew II. They formed the communities of the sieben *Stühle* round Hermannstadt (Sibiu), the *zwei Stühle* (Medias), the Burzenland (Kronstadt or Brasov) and the Ndsnerland (Bistrita). Very few early documents on Transylvania survive, so no conclusion can be drawn from the fact that there is no mention of the Vlachs before 1222, when they appear as shepherds. Soon afterward they figure as settled peasants and in the 13th and 14th centuries Vlach nobles are mentioned, but these were shortly to be Magyarized.

The great Mongol invasion of 1241 checked Transylvanian development and hindered Magyar immigration, while the local Vlach peasant population increased. At first a prince of the Hungarian royal house usually acted as governor, but from the 13th century onward the province was under a special voivode. A diet met as early as 1229, but the dominant communities, nobles (Magyars), Szeklers and Saxons, did not combine to develop strong local institutions until the 15th century, when the power of Hungary began to decline under Turkish pressure. Exactions to meet the Turkish danger caused unrest among the Magyar and Vlach peasants, which burst out in a serious uprising in 1437. To counter this the nobles, Szeklers and Saxons concluded at Kapolna on Sept. 14 of that year a "brotherly union" whereby they swore fealty to the king of Hungary, promised to support each other against the peasants and the Turks and agreed to settle internal disputes by arbitration. This union was renewed in 1438 and 1459, and in 1506 a supreme court of justice was established for all the communities, then referred to as "nations." This third union formed thenceforward the basis of the Transylvanian local constitution. relations with the serfs being regulated by the codex tripartitus introduced in Hungary in 1514 after the peasant uprising of that year

Transylvania a **Principality.**—With the subjugation of Hungary by the Turks after the battle of Mohacs (1526), Transylvania became de *facto* independent under local Magyar princes. The voivode John Zapolya, who arrived too late for the battle, aas left the strongest power in Hungary and was elected king by the anti-Habsburg party (Oct 14 and Nov 10, 1526) For the next 12 years, however, Ferdinand of Habsburg disputed his claim, the matter being settled by the secret treaty of Nagyvarad (Oradea Mare) (1538), which confirmed Zapolya as king of Transylvania and part of Hungary on condition that on his death these territories should revert to the Austrian crown. This stipulation was violated by the estates when he died in 1540; electing his son as prince, they cut themselves loose from Hungary and became tributary to the sultan. Under the dynasties of Zapolya and Bathory Transylvania preserved its independence by the playing off of sultan against emperor and took an important part in international affairs, especially under Stephen Bathory (see STEPHEN [ISTVAN] BATHORY), who was also king of Poland (1575–86).

The chief internal event of the 16th century was the triumph, after a severe struggle, of the Reformation. The Saxons were converted to Lutheranism, the majority of the Magyars to Calvinism, while many of the Szeklers went farther and became Unitarians; in 1556 the most famous Unitarian community of the continent, with its own bishop, was founded at Kolozsvar (Cluj). A certain party, usually identified with the Habsburg cause, remained in the Roman obedience. At a time of bitter religious controversy Transylvania set Europe a notable example of tolerance; the diet in a series of resolutions declared the Calvinist, Lutheran. Roman Catholic and Unitarian religions to be "received" and entitled to free exercise and equal rights for all time. A flaw in this enlightened settlement was the exclusion of the Orthodox Church to which the Vlach (Rumanian) peasants belonged and which had more adherents than any one of the "received" creeds. The Orthodox, subject to the metropolitan of Walachia, were impeded in contacts with their ecclesiastical superiors; Calvinist pressure was exerted on them with the unintended result of fostering national consciousness by the translation of scriptures and liturgy into the Rumanian language. The various Protestant groups formed the backbone of Transylvanian nationalism; the efforts of the Catholic Bathorys to carry through the Counter-Reformation with Jesuit aid were the main cause of the confused wars which filled the last years of the century. It was in the course of these campaigns that Michael the Brave, voivode of Walachia, intervened and for a year

(1600) actually united Moldavia, Walachia and Transylvania in a single state, for which he did homage to the emperor. This brief episode was later to fire Rumanian national aspirations. Michael was murdered in 1601 by order of the imperial commissioner Gen. George Basta. and in 1604 the emperor Rudolph secured Transylvania: but the prosecutions indulged in by Basta's troops and the proselytizing fury of the Jesuits speedily provoked a rebellion.

On April 5, 1605, the diet elected as prince Stephen Bocskay (*q.v.*), who by the peace of Vienna (June 23, 1606) forced the emperor to recognize him as prince of an enlarged Transylvania and secured the confirmation of all traditional liberties; while by the treaty of Zsitvatorok (Nov. 1606) he negotiated a 20 years' truce between the emperor and the sultan. Unfortunately. Bocskay died on Dec. 29. 1606. Gabriel Bathory (1608–13) was the most tyrannical ruler Transylvania ever had, but the reign of Gabriel Bethlen (1613–29) restored the principality's former glories and is generally regarded as its golden age.

Under Bethlen and George Rakoczy I (1630–48; *see* RAKOCZY) Transylvania was again a power of international importance and the chief bulwark of Protestantism in eastern Europe. The emperor, distracted by the Thirty Years' War, was obliged to treat with the princes of Transylvania as equals. while the Ottoman empire, for the time, was unable to interfere with its nominal vassal. Only when George Rakoczy II (1648–60) was defeated in an unlucky campaign against Poland did the reviving Porte again intervene. depose Rakoczy, and, after six princes had died violent deaths within three years, appoint a Szekler. Michael Apafi (1661), who ruled as a mere vassal of the Turks; and Transylvania sank again into extreme misery.

When the Turks were defeated before Vienna by John III Sobieski (1683), and their power again declined, the estates opened secret negotiations with the emperor Leopold I. whose suzerainty they recognized under the treaties of Vienna (1686) and Blasendorf (Blaj; 1687). Apafi died in 1690. being succeeded by his son, Apafi II. On Dec. 4. 1691, the emperor Leopold, after long negotiations, issued the diploma which regulated relations between him and his subjects.

Period of **Habsburg Rule.**—By this most important document the emperor swore to uphold the constitution of Transylvania. which was again considered *de jure* a part of Hungary while remaining *de fncto* a separate unit. He confirmed the privileges and liberties of the three "nations" and four "received religions," and agreed that the diet should meet annually; but he also imposed a tribute on Transylvania. stationed a garrison in it and put it under a *gubernium,* directed after 1694 from the *Siebenbürgische Hofkanzlei* in Vienna. In 1697 Apafi was induced to abdicate. The Porte recognized the situation under the peace of Karlowitz (1699). In Transylvania itself the resistance to the imperial troops and the Jesuits ceased only after the peace of Szatmar (1711).

During the succeeding century the pressure of Catholic and bureaucratic rule gradually broke down the old individuality of Transylvania. which was promoted, in compensation, to the title of a grand principality in 1765. The privileges of the Szeklers had already almost vanished in the 16th century, and many of them had sunk into serfdom. In the 18th the Saxons were in danger of following suit, but were saved by their great minister Samuel Brukenthal.

The Rumanians, however, their numbers rising rapidly both by natural increase and by the influx during the 18th century of refugees from the Phanariot regime of Moldavia and Walachia, were at last able to develop a national consciousness. This was unexpectedly fostered by the creation in 1698 of a Uniate Church in Transylvania. In that year the Orthodox metropolitan and his clergy, harassed by poverty and by Calvinist pressure, yielded to Jesuit offers and signed an act of submission to Rome, while retaining their own rites and customs. By imperial diploma of 1699 the Uniates were to have the same privileges as the members of the Latin rite, though they never in fact enjoyed the full status of the Latin Catholics. None the less the removal of some of their disabilities allowed educational and social advance. to the ultimate benefit of all Rumanians. The Orthodox who refused to join the union were deprived of all contact with their co-religionists over the border and had no proper organization until 1759 when they were placed under the archbishop of Pest.

Some Rumanians emerged from serfdom when Maria Theresa in 1766 extended the system of the Military Frontier (*q.v.*) to three Walach districts in Transylvania. The visits of Joseph II to the country (1773, 1783) gave rise to rumours that the serfs were to be liberated and armed against their masters; he actually abolished the constitution in 1784, dissolving the three "nations."

In 1785 the Rumanian peasants led by Nicolae Horia, Oarga Ion Closca and Gheorghe Crisan rose and massacred many Magyar nobles before their revolt could be suppressed. On Joseph's death in 1790, a strong demand arose among the Magyars for the full union of Transylvania with Hungary. Alarmed by this the Rumanians, led by Uniate and Orthodox ecclesiastics, submitted to Leopold II the *supplex libellus Valachorum* in which they demanded recognition as the fourth nation of the country and that the Uniate and Orthodox churches should figure as the fifth and sixth "received" religions. The petitioners inaugurated the modern "Vlach controversy" by appealing to their "ancient rights" as the autochthonous inhabitants of Transylvania. The document was passed by Leopold to the Transylvanian diet of 1791, which, busily engaged in reaffirming its position, rejected it and restored the old constitution. Under Francis I and Ferdinand II, however, there was in fact little liberty for any party.

On the outbreak of the revolution of 1848 the Magyars petitioned for union with Hungary, promising the Rumanians the abolition of serfdom and other reforms in return for their support. The Rumanians, however, rejected the alliance, and at the "field of liberty" of Blaj declared themselves a free nation, forming an integral part of Transylvania, and swore fealty to the Habsburgs (May 15). A political program, based on "the principles of fraternity and liberty," was drawn up, but rejected by the diet at Cluj. which proclaimed the union with Hungary, the Saxon representatives accepting this decision by a majority. and declared the new Hungarian laws to he sufficient guarantee that all necessary reforms mould be granted.

In the subsequent fighting between the Hungarian and the Austro-Russian troops, much of which took place in Transylvania, both Saxons and Rumanians took up arms against the Magyars, and a very bitter racial war resulted. The Austrian constitution of 1851, which abolished both the Military Frontier and the Saxon privileges, treated all nationalities with equal severity. The diploma of Oct. 20, 1860, restored the old constitution and the *Hofkanzlei,* but these were abolished when Transylvania became an integral portion of Hungary under the Austro-Hungarian compromise of 1867. In the following year it was reorganized in "comitats" with the rest of Hungary.

From 1868 to 1918 Transylvania was dominated by the Magyar racial policy. The basic Nationalities law of 1868 was in theory extremely liberal, but in practice remained almost a dead letter. The Saxons, in view of their numerical inferiority, confined themselves to building up a close organization for the defense of their social and religious individuality. In spite of this they lost ground, especially after their ancient national status was abolished in March 1876.

The Rumanian national movement was more active. The idea of uniting all Rumanians in one body politic had never been wholly dormant since the days of Michael the Brave's brief achievement, but so long as the Danubian provinces remained under Turkish suzerainty, the goal was generally conceived as a Rumanian state under Habsburg rule. Austria, however, lost its last chance of securing Moldavia and Walachia through its unsuccessful diplomacy during the Crimean War, and the compromise nith Hungary of 1867 finally alienated its Rumanian subjects. In past centuries the main trend of the Rumanian movement in Transylvania had been social, but with the abolition of serfdom in 1853–54 the national struggle proper began to occupy the attention of the few intelligentsia and middle classes. Rumanian irridentism, though provided with a focus by the creation of an independent Rumanian kingdom. never assumed the proportions of the Serbian because of the discouragement of King Charles of Rumania, who was allied with Austria-Hungary. It gathered momentum however in the last years before World War I, and the severity of the measures taken during that war in Transylvania by the Hungarian authorities, especially after the advance into the territory of the Rumanian army in 1916, were an indication of the strength of the desire for the dissolution of Austria-Hungary among almost all Rumanians.

Union With Rumania.—In Oct. 1918 the Rumanians of Transylvania announced their decision to direct their own destinies. On Oct. 27 a national council was established at Arad; and on Dec. 1 a convention assembled at Alba Iulia proclaimed the union of Transylvania with the kingdom of Rumania, at the same time promising to respect the rights and liberties of the other nationalities. The Saxons adhered to this resolution on Jan. 21, 1919, the representatives of the Magyars not till 1921, and then under protest. The union was thus carried through without calling on the secret treaty of Aug. 17, 1916, under which the Allies had promised Transylvania to Rumania. The frontier was determined by the treaty of Trianon (June 4, 1920). The effect was to leave a western fringe with a considerable Magyar population; it represented the results of a difficult endeavour to reconcile conflicting ethnical and other claims. The Rumanian minorities treaty guaranteed the rights of the non-Rumanian population; but, for all that, the transference of the administration from Magyar to Rumanian hands was accompanied by considerable friction. This resulted in part from the discontent prevalent in Hungary because of the new frontier, in part from certain undeniable weaknesses in the new regime, aggravated by the confusion of the postwar period.

In July 1940 Hungary took advantage of the international situation to press its claims. which had never been dropped, and forced Germany and Italy to impose on Aug. 30, 1940, the Vienna award, which restored to Hungary about two-fifths (16,830 sq.mi.) of the enlarged Transylvania, with a population of about 2,500,000, composed of Magyars and Rumanians in about equal numbers. The new frontier ran from a point near Salonta (Nagyszalonta) eastward and southeastward, passing just south of Cluj and including the Szekler cities in Hungary but leaving Brasov, Sibiu, Alba Iulia, Arad and Timisoara to Rumania. Both countries were dissatisfied with the partition. and Rumania in particular thereafter based its policy largely on the hope of increasing the award. The Allied-Rumanian armistice of Sept. 12, 1944, promised Rumania the restoration of "all or the greater part" of the territory lost by it. The peace treaty of Feb. 10, 1947, finally re-established the 1920 Rumanian-Hungarian frontier. Under the Communist constitution of 1952 the mainly Szekler districts of Transylvania were constituted as a Magyar autonomous region for local government.

(B. Br.)

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TRANSYLVANIAN MOUNTAINS. This is an inclusive name for the mountainous region which abuts against the southeastern end of the Carpathian range south of the Jablonica pass. In the east they form a continuation of this range, but across the rest of the tract the mountains are arranged in scattered groups, in broken connection with one another, the land between forming the Transylvanian basin. Formed in Tertiary times, they are part of the eastern arm of the Alpine fold system which passes in a wide arc through the Carpathians, turns abruptly westward at Pietrite Fetei into the Transylvanian Alps, again turns almost as abruptly southward at Retezat through the Szretinye mountains and across the Danube at the Iron Gate to turn eastward into the Balkan mountains.

The eastern mountains, the Moldavian Carpathians, are divided parallel to their trend by the upper valleys of the Mures and the Olt, separating the outer (eastern) ranges which consist of highly folded Flysch (Cretaceous, Eocene and Oligocene) lying upon an (inner) crystalline massif of plutonic rocks, gneisses and schists with Carboniferous, Permian and Triassic rocks. The western of these two ranges. the Harghitei complex of Tertiary volcanic rocks (andesites, andesitic tuffs, etc.), forms the eastern boundary of the Transylvanian basin, and through it break the rivers Olt and Mures. The Transylvanian basin seldom rises above 1,600 ft. in altitude and is covered by Miocene deposits. The southern boundary is formed by the Transylvanian Alps, which consist almost entirely of a crystalline massif of gneiss, schist and granite with a very narrow and broken fringe of Flysch on its southern (outer) edge. This forms the most continuous range in the region and contains the highest peak (Negoi, 8.346 ft.).

The mountains of the southwest and west, which do not form a continuous range but are isolated by wide valleys, have a more complex structure than the Transylvanian Alps, for around crystalline massifs, which beneath the covering rocks are probably continuous with that of the latter chain, are Triassic, Rhaetic, Jurassic and Cretaceous beds and to a less extent Carboniferous and Permian. There are three main masses, the Szretinye mountains, the Transylvanian ore mountains and the Bihor mountains. There, as well as in the Nagybanya district in the north, are Tertiary volcanic rocks of andesitic composition associated with which are important gold and silver lodes. Some of the mines (*e.g.*, Rosia-Montana, or Verespatak) have been worked since Roman times, and the district still contains the most valuable gold deposits in Europe. These volcanic rocks are probably associated with north to south faulting uhich occurs in this region. The northern boundary is less well defined and comprises a low range in the west with the higher range, the Rodna Hegyseg, farther east.

There are evidences of past glaciation among the highest peaks, which nowhere reach 9,000 ft., so that none of them are permanently snow-capped. Precipitation in the Transylvanian basin averages 24 in., and great extremes of temperature are experienced. This basin cannot be called a plateau for it does not possess extensive plains but is cut up by a network of valleys formed by mountain streams that drain into it from the peripheral ranges. The three main streams are the Somes, which, draining the northern half of the basin, flows northwest to join the Tisza; the Mures, which crossing from east to west enters the Hungarian plain along the southern scarp of the Transylvanian ore mountains and also joins the Tisza; and the Olt, which breaks through the Transylvanian Alps by the Turnu Rosu pass to join the Danube. Other passes in this range, all of which are followed by railways, are the Bodza, Tomos, Vulcan and Teregova, while those in the Moldavian Alps are the Prislopul, Rodna, Borgo, Tolgyes, Bekas, Ghimes and Oitoz passes, several of which are used by railways. (See Rumania.)

TRAP, a mechanical device for snaring or catching anything, and especially wild animals. The term trap is also used to designate a wooden instrument, shaped something like a shoe, used in playing trapball; a machine used for throwing clay pigeons or balls into the air; a bent or partitioned chamber, as in a drainpipe (see Plumbing), in which the liquid forms a seal to prevent the passage of sewer gas, etc.; and the term has been used colloquially to designate a light horse carriage.

"Trap" is derived from O.E. *treppe* or traeppe, properly a step, as that on which an animal places its foot and is caught; cf. Ger. *Treppe,* a flight of stairs. Traps for animals are of great antiquity, and no savage people has ever been discovered, whatever its culture, that did not possess some variety of snare.

In the most primitive form of wild animal trap no mechanism need be present; *e.g.*, a cavity into which the animal walks, as the pitfall of the Arabs and Africans or the snow hole of the Eskimos. O. T. Mason divided traps into three classes: enclosing traps, which imprison the victim without injury; arresting traps, which seize the victim without killing it, unless it is caught by the neck or round the lungs; and killing traps, which crush, pierce or cut to death.

Enclosing traps include the pen, cage, pit and door traps. Pen traps are represented by the fences built in Africa into which antelopes and other animals are driven; and by fish seines and pound nets. Among cage traps may be mentioned bird cones filled with corn and smeared with bird lime, which adhere to the bird's head, blinding it and rendering its capture easy; the fish trap and lobster pot; and the coop traps, of which the turkey trap is an example. This consists of a roofed ditch ending in a cul-de-sac into which the bird is led by a row of grains of corn. Over the farther end a kind of coop is built; the bird, instead of endeavouring to retrace its steps, always seeks to escape upward and remains cooped. Pitfalls include not only those dug in the earth, at the bottom of which knives and spears are often fixed, but also several kinds of traps for small animals. One of these consists of a box near the top of which a platform is hung, in such a way that when the animal leaps upon it to secure the bait it is precipitated into the bottom of the box, while the platform automatically swings back into place.

The door traps range in size from the immense cage with sliding door, in which such beasts as tigers are caught, to the common box trap for mice or squirrels, the door of which falls when the spindle upon which the bait is fixed is moved. Four classes of arresting traps are: the mesh, the set hook, the noose and the clutch. The mesh traps include the mesh and thong toils used of old for the capture of lions and other large game, and the gill net in the meshes of which fish are caught by the gills. To the set-hook division are reckoned the set lines of the angler, several kinds of trawls and the toggle or gorge attached to a line, which the animal, bird or fish swallows only to be held prisoner. The noose-trap class is a very extensive one. The simplest examples are the common slip-noose snares of twine, wire or horsehair, set for birds or small mammals either on their feeding grounds or runways, the victim being caught by the neck, body or foot as it tries to push through the noose. When the noose is used with bait it is generally attached to a stout sapling, which is bent over and kept from springing back by some device of the figure-4 kind. This is constructed of three pieces of wood, one the horizontal spindle on which the bait is placed, one the upright driven into the ground and the third the connecting crosspiece. fitted to the others so loosely that only the strain of the elastic sapling keeps the trap together. When the victim tries to secure the bait he dislodges the crosspiece and is caught by the noose. which is spread on the ground under the bait or is so arranged as to encircle the neck.

Besides the figure-4, several other very effective trigger devices are in use. There are two widely different types of clutch traps: bird lime and other tenacious substances, and jaw and claptraps. The simplest form of the first is adhesive flypaper. Some examples of the claptrap are the clapnet, consisting of two nets laid flat on the ground and attached to cords in such a manner that they fly up and close when the draw cord is pulled by a concealed trapper; and the various other springtraps used by birdcatchers. The jaw traps are the most important class of device for the capture of fur-bearing animals. Steel traps consist of two jaws, with or without teeth, which are worked by powerful single or double springs and are sprung when the victim steps upon the pan, which is placed between the jaws and attached to a lever. They are made in many sizes, from the smallest, designed for rats, to the "great bear tamer," weighing over 40 lb., with jaws of 16 in. in which lions, tigers and grizzly bears are trapped. The steel trap is set and concealed in such a rnanner that the animal must step on its pan in passing over it to secure the bait. Many types of traps, designed to reduce suffering and to displace the ordinary steel trap, have been devised, but are not in general use.

With the clutch traps must also be reckoned the oldest form of steel trap, now to be seen only in museums, the mantrap, which was used first about the middle of the 18th century when the systematic preservation of game rendered protection against poachers a necessity. Such a trap, from Gloucestershire, is more than 6 ft. long, has 19 in. serrated jaws and weighs 88 lb. Another form of mantrap, the spring gun, belongs to the next category, the killing traps, which are divided into traps of weight, point and edge. The most important of the weight class is the deadfall, of which the typical form consists of a pen over whose narrow entrance one or more logs are laid across a lighter log. which is balanced upon a spindle necessarily struck by the entering animal, causing the logs to fall upon its back. In some cases the bait is attached to the spindle itself. The deadfall was always the favourite trap of the American Indians and is in use among many aboriginal tribes in Africa and South America. A slab of stone is often used as a weight. The common mousetrap which kills either by a blow or strangulation is a variety of deadfall. Of point traps may be mentioned those of the impaling and the missile classes. An example of the former is the stake or spear placed by Arab and African tribes at the bottom of pitfalls for big game. Another impaling trap common in Africa is the harpoon downfall, generally used for the hippopotamus. It consists of a heavily weighted harpoon suspended in such a way that the animal, passing beneath, breaks a cord and precipitates the harpoon upon itself. Another example of impalement is the hawk trap, consisting of a circle of stout sharp wires, in the centre of which a live fowl is placed. A bird of prey attempting to secure the fowl is impaled upon the wires. Of missile traps the most universal are the ancient spring bow and its modern representative the spring gun. This is fixed upon stakes, or against a tree, with a line attached to the trigger and stretched immediately in front of the muzzle. An animal pressing against the string pulls the trigger and discharges the piece into its own body. An arrangement of sticks holding the bait in front of the muzzle is sometimes substituted for the string. Of edge traps a curious example is the wolf knife of western America, which consists of a very sharp blade embedded in frozen fat. One of the wolves, licking the fat, cuts its tongue and a flow of blood ensues, with the result that not only the wolf itself but its companions become infuriated by the smell and taste, and the wounded beast, and often many of the others, are killed and devoured. The Alaskan knife trap for large game consists of a heavy blade attached to a lever, which, when released by the animal biting at the bait, moves over and strikes the victim.

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TRAPANI (anc. DREPANUM), a city and episcopal see of Sicily, capital of the province of the same name, on the west coast, 3 mi. W. of the Monte San Giuliano, which rises above it, 121 mi. S.W. of Palermo by rail and 47 mi. direct. Pop. (1951) 72,289 (commune). The ancient Drepanum (δρέπανον, "sickle," from the shape of the low spit of land on which it stands) was originally the port of Eryx. It is represented by Virgil in the Aeneid as the scene of the death of Anchises. It was an important Carthaginian naval station in the First Punic War (260 B.C.), part of the inhabitants of Eryx being transferred thither. Near Drepanum the Roman fleet was defeated in 250 B.C.. while the struggle to obtain possession of it ended in the decisive Roman victory off the Aegates lslands in 241, which led to the conclusion of peace. (See PUNIC WARS.) Under the Norman kings, at the time of the first crusade, it became a place of importance: it was a residence of the Aragonese kings. In the 16th and 17th centuries it was strongly fortified.

There are some fine Gothic and baroque palaces, and a few churches with interesting details. Trapani has a harbour of some importance. There are also large salt pans near by. Trapani was heavily bombed by the Allies in World War II.

TRAPPISTS, Cistercian monks of the reform instituted by Armand Jean le Bouthillier de Rancé (*q.v.*), abbot of La Trappe, 1664. La Trappe was a Cistercian abbey near Soligny, in the diocese of Sées, in Normandy, founded 1140. It suffered grievously from the English wars and from commendatory abbots. De Rancé became commendatory abbot at the age of ten, in 1636; and on his conversion from a worldly life he began to interest himself in his abbey and in 1662 conceived the project of restoring the monastic life therein. With this object he visited La Trappe, but the monks were recalcitrant and threatened his life; through the intervention of Louis XIV he was able to pension them off; they were replaced by a community of Cistercians of the strict observance, and the monastic buildings, which had fallen into ruin, were repaired at De Rancé's expense. He himself then entered the novitiate in one of the reformed Cistercian abbeys. and came to La Trappe as regular abbot in 1664. He persuaded his community to adopt a manner of life beyond Cistercian practice and far beyond St. Benedict's rule. The Trappist regime is probably the most penitential that has ever had any permanence in the western church. Yet it attracted vocations in such numbers that De Rancé had 300 monks under him. Through age and ill health he resigned his abbacy in 1695 and died five years later.

During the 18th century La Trappe continued faithful to De Rancé's ideas, but the observance spread only into two monasteries in Italy. It was the dispersal of the community at the French Revolution that turned the Trappists into a congregation in the Cistercian order and finally into a separate order. Dom Augustine de Lestrange, the novice-master at the time of the suppression in 1790, kept 20 of the monks together and obtained permission for them to settle at Val-Sainte in Fribourg, Switz. There they made their life still stricter than that of La Trappe, and postulants flocked to them in such numbers that in two years' time colonies went forth to establish Trappist monasteries in England, Belgium. Piedmont, Spain and Canada; and in 1794 Dom Augustine was named by the Holy See father abbot of all these foundations, thus formed into a congregation. In 1817 they returned to La Trappe, many new foundations were made, and by Dom Augustine's death in 1827 there were in all about 700 Trappist monks. In the course of the century three or four congregations arose—a Belgian, an Italian and two French—each with a vicar subject to the general of the Cistercians. In 1892 these congregations were united into a single Order of Reformed Cistercians, or of Strict Observance, with an abbot-general resident in Rome and independent of the general of the Cistercians of the Common Observance. In 1898 the Trappists recovered possession of Citeaux, the mother house of the Cistercians, secularized since the Revolution, and it was declared to be the mother house of the Reformed Cistercians.

The Trappists are a thriving and vigorous order, represented in all the countries of western Europe, and in the United States and Canada. In addition, they have a house in China, one each in Japan, Asia Minor, Palestine, Bosnia and Dalmatia, and four in various parts of Africa. In heathen countries the Trappists now give themselves up to missionary work.

The first Trappist nunnery was the abbey of Les Clairet, near Chartres, which De Rancé persuaded to adopt his reforms. Dom Augustine de Lestrange established another in 1796, and now there are 15 with 350 choir nuns and 500 lay sisters. One is in England at Stapehill, near Wimborne, founded in 1802.

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TRAPSHOOTING AND SKEET SHOOTING both involve firing shotguns at clay birds called pigeons, released from traps. Trapshooting, the forerunner of skeet shooting, started seriously in England about 1830, live birds being used. The first clay pigeon, resembling a saucer in size and shape, was originated in 1860. Previously glass balls combined with feathers served as targets. These were hurled by springs from cups. In 1880 a lighter type of clay pigeon improved the sport. It was followed by a target composed of river silt and pitch, invented by an Englishman, McCaskey, who later perfected an ideal trap.

Trapshooting was introduced to the United States in the late 1870s; enthusiasm soon spread throughout the country, and the Interstate Association of Trapshooters was formed. In 1900 the American Trapshooting association, controlled by gun and ammunition manufacturers, became the national governing body. However in 1924 the sportsmen themselves organized the Amateur Trapshooting association, which later established headquarters at Vandalia, O., site of the famed Grand American shoot. The first of these events was held on Long Island, N.Y., in 1900 with 71 entries. By the mid-1950s the shoot drew more than 2,000 gunners each year from every state and Canada. In 1954 a five-man squad broke the world's amateur record by smashing 995 out of a possible 1,000 clays. The marksmen were Fred Waldock, Jr.. Fred Waldock. Sr., Robert Allen, George Genereux and Marvin Driver. In 1938 Joseph Hiestand set a one-man mark by breaking 900 16-yd. targets in a single week at the Grand.

Skeet shooting's creator mas C. E. Davies of Andover, Mass., who pioneered the sport in 1910. The name was selected in a contest sponsored by the *National Sportsman* and *Hunting and Fishing* magazines. Skeet differed from trap in that the field was laid out in a semicircle, gunners shooting "round the clock."

After the first skeet club was formed at Everett, Mass., in 1925, other clubs sprang up in many states. As a result, the National Skeet association was inaugurated, with headquarters in Boston, Mass.

Headquarters were later established in Dallas. Tex.

Competitive skeet shooting began on a large scale in 1929, with the first Massachusetts state championship being conducted in April. The initial National Skeet championship was held in 1935, L. S. Pratt winning with 244 out of a possible 250 hits.

In the 1954 National Skeet Shoot, Salvador T. Roig of Puerto Rico broke 100 straight targets to win the .28 gauge title. For the first time a woman, Mrs. Leon Mandel, won the .20 gauge title, smashing 100 consecutive clays, followed by 50 more straight in a shootoff.

Richard Shaughnessy of Dedham. Mass., has been considered the most consistent skeet shooter of all time. He won national titles in 1936, 1938, 1939, 1940. 1941 and 1942. In 1950 he won the Amateur Trap championship of America.

Trapshooting and skeet shooting have become popular pastimes in the United States. (T. GH.)

TRASIMENUS, LAKE (Lat. TRASUMENUS LACUS; Ital. LAGO TRASIMENO), a lake of Umbria, Italy. 12 mi. W. of Perugia, 850 ft. above sea level, 50 mi. in circumference and 10 mi. to 13 mi, across.

Having no natural outlet, it was formerly subject to sudden rises, which occasioned inundations, and these in turn malaria. An artificial outlet was completed in 1898 from the southeast corner of the lake to the Caina, a small tributary of the Tiber. The locality was the scene of the second great defeat suffered by the Romans during the Second Punic War.

In the early spring of 217 B.C. Hannibal left the winter quarters (probably near Modena or Bologna) to which he had withdrawn after the victory of the Trebia (*q.v.*) and crossed the Apennines: continuing his march by a shorter route than the usual one, a route which obliged him to march through an inundated and marshy district for four days and three nights. Which pass it was that he took has been much discussed, but it is most likely that he followed the modern route from Bologna to Bagni della Porretta, and thence went by the Collina pass to Pistoia. Frcm there he passed through the (at that time) marshy district between Pistoia and Florence, and after resting his troops advanced toward Cortona and Lake Trasimenus, his object in taking this route being, as Polybius relates, to move onto the rear of the consul Flaminius, who was at Arretium (Arezzo) and, by this strategic surprise, gain an opportunity to fight with the advantage. Fulfilling Hannibal's calculation, Flaminius, on hearing that Hannibal was plundering the countryside, hastily started in pursuit; while the other consul Servilius, who was at Ariminum, marched along the Via Flaminia, their object doubtless being to attack him from two sides before he could reach Foligno. But Flaminius advanced rapidly and without taking the most elementary precautions of scouting. He probably reached the lake in a single day's march from Arezzo, in any case late in the evening, and encamped by it, probably to the east of Monte Gualandro and west of Tuoro, and started early on the following morning along the north side of the lake, which was covered with a thick mist.

Hannibal, as he marched along the shores of the lake, had not failed to notice the exceptionally good opportunities of surprise which the terrain afforded. From the hill of Montigeto, a little to the west of Passignano, to Torricella, where the road to Perugia and Foligno leaves the lake and climbs 300 ft. in half a mile to the pass of Montecolognola over the hills which surround it, is a distance of six or seven miles. For the greater part of this the road runs along a narrow level strip of ground completely commanded by the hills which rise from the lake, while the ascent to the pass is shut in by hills in front and on each side, uith the lake behind; so that it corresponds extremely well with the description of Polybius. Even without the mist, which was of course an added advantage, Hannibal would have been able to conceal the greater part of his troops behind hills or in dead ground at a comparatively short distance away from the road. Flaminius, on the other hand, was in an exceptionally unfavourable situation for resistance; there were three points at least at which his army of about 30,000 men (which, marching in column, would have formed a length of about ten miles) could be easily split up by an attack; the narrow strip of land along the shores of the lake afforded them no room for retreat nor to rally, and there was no point where they could easily break through to the north.

Hannibal therefore encamped on the pass, from which he could command a view of the defile as far back as Passignano, and kept his heavy Spanish and African troops under his own command to hold the pass, while the light troops were placed on the left. behind Montecolognola itself, and the Gauls and cavalry formed the right wing, which extended along the hills above the lake as far as Montigeto, the cavalry being placed at the beginning of the defile, and concealed behind the hill of Montigeto, so as to be able to close the defile as soon as the last units of Flaminius' army had entered it. So the Romans marched on to their doom; and when the head of their column came into contact with the troops in the centre at the pass of Montecolognola, concealment was neither possible, nor indeed necessary, and Hannibal gave the signal for a general attack. The greater part of the army was already in the trap and was attacked on all sides from the higher ground, so that, we are told, the centurions and tribunes could not even understand the situation. still less do anything to help it; the Romans were mostly slain in their marching formation, without having any opportunity of defending themselves or realizing what was to be done. Many of them were driven into the lake and met their death there.

The head of the column however, which was naturally more prepared to offer effective resistance, to a number of about 6,000 men, rallied and advanced against the pass They succeeded in piercing through the light troops on Hannibal's left in a southerly direction, and only when they had done so found that there were no other troops opposed to them. From the high ground they had reached, they were able, now that the mist had cleared, to see the full extent of the disaster, but as they were unable to offer any assistance they marched off to an unnamed Etruscan village. where they surrendered to Maharbal on the following day, in the vain hope of being set free if they laid down their arms; but with the rest of the prisoners (another 10.000 or so) they were all thrown into chains. The number of killed was about 15,000; while the Carthaginian losses were only about 1,500.

It is the only instance in history of a general lying in ambush with the whole of a large army and accounting for practically the whole of the troops opposed to him, and it mas, thanks to the favourable nature of the ground, the carelessness of Flaminius and the fortunate circumstance of the morning mist, a brilliant success.

Immediately after this terrible defeat the Romans suffered a minor discomfiture. Servilius, who was hastening to his colleague's assistance, had sent his cavalry, about 4,000 men, under C. Centenius, ahead of his main body. Hannibal sent Maharbal with the light troops and part of his cavalry against him, and an engagement followed in which, according to Polybius, the Romans lost half their forces, while the rest sought shelter on a hill, but were surrounded and taken prisoners the next day.

See J Kromayer, Antike *Schlachtfelder,* iii, 1, 148 *et* seq. (1914).
(T A.)

TRAT, a remote province in southeast Thailand, is bordered by Cambodia on the east and has a long coast line on the Gulf of Siam, including several large offshore islands. Area 1,127 sq.mi. Pop. (1960) 66.328. Its products include coconuts, fruit and rubber and enough rice to meet local needs. Trat town (pop. [1960] 3,813), the capital, locally known as Ban Bangphra, has some port facilities on the Trat river and is connected by road with Chanthaburi, 43 mi. N.W. (G. W. SK.)

TRAUBE, ISIDOR (1860–1943), German physical chemist who can be designated the founder of capillary chemistry, was born March 31, 1860, at Hildesheim. After receiving his Ph.D. at the University of Berlin in 1882 he rose to the rank of professor at the Technische Hochschule in Berlin in 1900. He made contributions to critical temperature studies, osmosis, colloids and surface tension.

His practical interests included physical chemical studies of gastric juice, urine, blood and milk. For his work he designed a viscometer and capillarimeter. He advocated a physiotherapeutical science to supplement the chemotherapeutical one. Traube's rule, which has been applied to investigation of alcohols, paraffin solution interfaces, corrosion prevention of fatty acids and adsorption of homologous series: states that the surface tension of capillary active organic compounds belonging to one homologous series decreases with each additional CH_2 group in a constant ratio which is approximately 3 to 1. Traube died in Edinburgh, Scot., Oct. 27, 1943. (V. BW.)

TRAUN, OTTO FERDINAND, COUNT VON ABENSPERG UND (1677–1748). field marshal of the Holy Roman empire, was born at Sopron (Ödenburg), Hung., on Aug. 27, 1677, of a Transylvanian noble family. After studying at Halle till 169.3, he went to serve with the Brandenburgers in the War of the Grand Alliance and was present at the Allies' siege of Namur (1695). Entering the imperial army in 1697, he distinguished himself in Italy, on the Rhine and from 1709, in Spain, during the War of the Spanish Succession, being promoted colonel in 1710 and given an infantry regiment in 1712. In the ensuing War of the Quadruple Alliance against Spain he was severely wounded at Francavilla in Sicily (1719). Promoted major general in 1723 and appointed governor of Messina in 1727, he was made lieutenant field marshal in 1733. In the War of the Polish Succession he enhanced his reputation by holding the pass of San Germano for 23 days with 3,000 men. and by his long defense of Capua against the Spaniards (1734). Promoted commander in chief, he was next employed on a mission in Hungary and then appointed interim governor general of Milan (1736).

On the outbreak of the War of the Austrian Succession (*q.v.*) Traun, now a field marshal (1741), at first retained the command in Italy, capturing Modena (1742) and checking the Spaniards at Campo Santo (1743). Sent in 1744 to succeed Count Khevenhiiller as principal military adviser to Prince Charles of Lorraine in the Rhineland, he was called thence to oppose the Prussian invasion of Bohemia, where he completely outmanoeuvred King Frederick II, driving him from the country without having to engage in a pitched battle. The success of his last campaign, against the French on the Main and on the Lahn in 1745, assured the grand duke of Tuscany's being chosen emperor, as Francis I, by the electors at Frankfurt. Appointed to the command of Transylvania in 1747, he died at Hermannstadt (Sibiu) on Feb. 18, 1748.

TRAVANCORE, a former princely state of southern India which on July 1, 1949, joined with Cochin to form the union of Travancore-Cochin (*q.v.*), now Kerala (*q.v.*), a state of India. Travancore extended for 150 mi. along the west coast as far as Cape Comorin, the southernmost point of the peninsula. It formed part of the ancient Tamil kingdom of Kerala (Chera) which is mentioned in Asoka's inscriptions and later in Pliny and in the *Periplus* of *the Erythraean Sea.* Toward the end of the 11th century it was absorbed by the Cholas and. after the decline of Chola power. it was annexed by the powerful rulers of Vijayanagar until their defeat at Talikota in 1565. Afterward it came under Moslem control, and it was not until the first half of the 18th century that Travancore became independent under its own raja, Martanda Varma. His successor, in 1761, constructed the historic Travancore lines as a protection against the incursions of Hyder Ali of blysore. He also allied himself with the rising British power. Tipu Sahib's attack on Travancore in 1789 led to the third Mysore mar, in which he was defeated by Lord Cornwallis in 1792. In 1795, in return for British protection, the raja of Travancore entered into a subsidiary alliance. Resentment of

British influence in the state gave rise to two rebellions in 1804 and 1809 but these were easily suppressed.

The ruling family followed the marumakathayyam law of inheritance through the female line. After the Mutiny of 1857 the raja was granted the right to adopt a successor on the failure of natural heirs. The state was conspicuous for good administration and prosperity. In 1936 the maharaja issued a proclamation throwing open a large number of temples to Hindus of all castes, including the untouchables. Education made great headway in the state, and according to the 1941 census report the percentage of literacy mas 58 for men and 36 for women.

Capital punishment. was abolished in 1944.

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(C. C. D.)

TRAVANCORE-COCHIN (KERALA), the southernmost state of India; a union of two former princely states, Travancore (*q.v.*) and Cochin (*see* KERALA). It lies southwest of Madras state along the western coast of India from the Bharata river to the tip of the peninsula at Cape Comorin. Area 15,003 sq.mi.; pop. (1961) 16,875,199. Trivandrum is the capital, pop. (1951 census) 186,931; the other important city is Alleppey. The broad sea belt consists of sandy soil and loam; east of this flat strip undulating plains and irregular hill ranges gradually blend into the Western Ghats. On these slopes are plantations and thick forests. Numerous rivers and waterways intersect the state and provide easy means of communication. Throughout the area the climate is in general temperate although the rainfall is heavy; on the Cardamom hills the annual rainfall is more than 200 in. Rice, tapioca, oilseeds, tea, coffee and rubber are grown, the coastal lowlands having dense coconut plantations. The forests yield much teak, ebony and rosewood. Rubber, cotton, soap and coir provide the main industries.

The beach sands contain large deposits of ilmenite and monazite which are extracted and exported to the United States and other countries. There is a rare-earths factory at Eloor. The natural harbour at Cochin receives ships throughout the year and has extensive sheltered backwaters.

The state is served by two sections of the Southern railway system—one line starting from Ernakulam and running northward into western Madras, the other having a terminus at Trivandrum and going along the coast north to Quilon; there a west-east line crosses to Tinnevelly in southern Madras.

The union of Travancore-Cochin mas inaugurated on July 1, 1949. The maharaja of Travancore is the *rajpramukh* (prince-governor) and governs on the advice of a ministry. There is an elected state assembly of 109 members. The name Travancore-Cochin was changed to Kerala in 1956. (S. GL.)

TRAVELER'S-TREE, a remarkable treelike plant, *Ravenala madagascariensis,* of the banana family (Musaceae), native of Madagascar and Réunion. The straight palmlike stem reaches 30 ft. in height and bears at the top a number of large long-stalked leaves which spread vertically like a fan. Each leaf has a large sheath at the base in which water collects in such quantity as to yield a copious supply—hence the popular name.

TRAVERSARI, AMBROGIO (AMBROSE THE CAMALDULIAN or FRA AMBROGIO) (1386–1439), Italian humanist, ecclesiastic and translator of Greek patristic texts into Latin, was born at Portico, near Florence. on Sept. 16, 1386. He entered the Camaldolese order in 1400, and became its minister general and visitor in 1431. His journey of visitation (1431–34) is described in his *Hodoeporicon* ("Itinerary"). He attended the Council of Basel as papal legate, and was responsible for the decree of union accepted at the Council of Ferrara–Florence He died at Florence on Oct. 21, 1439. Ambrose translated Dionysius the Areopagite, John Moschus and John Climacus, as well as works by Xthanasius. Basil. John Chrysostom. Ephraim the Syrian and Manuel Kalekas. He was a friend of most of the great contemporary humanists, including Cosimo de' Medici, for whom he translated Diogenes Laertius. He was also a discerning bibliophile, and many of his manuscripts, formerly in the celebrated library of Camaldoli. are now in St. Mark's library, Venice.

EDGAR AUBERT DE LA RUE

TRAVELER'S-TREE (RAVENALA MADAGASCARIENSIS). IN SWAMP VEGETATION NEAR TAMATAVE ON THE EAST COAST OF MADAGASCAR

BIBLIOGRAPHY.—Ambrose's letters were published by P. Canneto (1759); ten unpublished letters ed. by G. Mercati in *Studi e testi,* vol. xc (1939); *Hodoeporicon* and three unpublished letters ed. by A. Dini-Traversari, *Ambrogio Traversari e i suoi tempi* (1912). *See* also G. G. Coulton, *Five Centuries of Religion,* vol. iv (1950), and J. Gill, *The Council of Flovence* (1959).

(T. ED.)

TRAVERSER. A long, very shallow structure running on a number of wheels. used to transfer locomotives, carriages and freight cars from one line of rails to another. The vehicle is hauled onto the rails which are fixed to the platform of the traverser. and the latter is then moved on its several sets of rails. by hand. steam or electric power, until the vehicle comes into line with the desired position. There are two types, surface traversers for carriages and freight cars, and pit traversers for locomotives. carriages and freight cars. The surface type has the traverser tracks and the vehicle tracks at the same level, enabling through ways to be provided at any position across the traverser track. The pit design has the traverser rails sunk at a lower level. and is used chiefly in or between shops manufacturing or repairing rolling stock. The vehicle rails are level with those from which the stock is taken and replaced, so that running on and off is simple. The surface machine must have a certain depth of construction. hence the rails upon which it receives the carriage must be at some distance above the ground rails. and to enable the stock to mount the traverser, ramps (inclined rails) have to be provided at the ends.

The Stokes surface traverser is built up of steel plates and girders in such a manner that the distance between the respective heights of the rails can be as little as four inches. This is important because of the large amount of bogie stock used, the six or eight inches difference in ordinary surface traversers being too great to enable these to mount without seriously straining or damaging the bogie and its parts. Another style, the Bowtell, has the traverser vehicle rails ramped for a short distance from the ends. Thus when the back mheels of the bogie begin to mount the ordinary ramps not on the traverser, the front wheels are mounting those on the traverser. By this means a vehicle may mount a traverser which has deep construction. without injury. the angle of tilt being no greater than that which occurs when mounting the Stokes shallow type above mentioned.

TRAY, a flat receptacle with a raised edge used for a variety of purposes. chiefly domestic. The tray takes many forms—oblong, circular, oval, square—and is made in a vast number of materials. from papier-mâché to the precious metals. The tea tray is the most familiar form; next to it comes the small round tray. usually of silver or electroplate, chiefly used for handing letters or a glass of wine. When thus employed it is usually called a "waiter." The English tea trays of the latter part of the 18th century were usually oval in shape and sometimes had handles: mahogany and rosewood were the favourite materials. Sheraton and Shearer. among other cabinetmakers of the great English period, are credited with trays of this type. These were succeeded in the early and mid-Victorian period by trays of japanned iron. which possessed no charm but had the virtue of durability. Sheffield plate snuffer trays of satisfying simplicity were made in large numbers and are now much sought after.

TRAY LANDSCAPE: see MINIATURE LANDSCAPE.

TRAZ, ROBERT DE (1884–1951), French author. was born in Paris on May 14. 1684. He studied law in his native city and afterward lived in England and in Italy, establishing himself finally in Geneva, Switz., where in 1920 he founded *La Revue de Genève.* He first won notice as a novelist by his *Au temps de la jeunesse* (1908) and subsequently published a series of novels and short stories: *Vivre* (1910); *Les Désirs du coeur* (1912); *L'Homme dans le rang: esquisses de la militaire* (1913); *La Puritaine et l'amour* (1917); *Fiançailles* (1922); *Complices* (1924); *L'Ecorché* (1927); *A la poursuite du vent* (1932); and *Les Heures de silence* (1934). His early work dealt mostly with love. His later work showed a delicate understanding of social evils. He travelled widely, and his essays collected in *Dkpaysements* (1923) and *Le Dépaysement orienfal* (1926) were of more than ordinary interest. *L'Ombre et le soleil* (1942) and *La Blessure secrète* (1944) were published during World War II. He died at Nice on Jan. 9, 1951.

TRAZ-0s-MONTES, an ancient frontier province in the extreme northeast of Portugal, bounded on the north and east by Spain, south by the Douro river which separates it from Beira, and west by the Gerez. Cabreira and Marão mountains, which separate it from Entre-Minho-e-Douro. In 1936 the northern part of the old province of Beira was added to Traz-0s-Montes to form the province of Tras-0s-Montes e Alto Douro. Pop. (1950) 639,-846.

TREACLE, the thick viscid syrup obtained in the early processes of refining sugar, the uncrystallizable fluid obtained in the process of procuring refined crystallized sugar being known as golden syrup and the drainings from the crude sugar as molasses *(see* SUGAR). The word was properly and first used for a medical compound of varying ingredients which was supposed to be a sovereign remedy against snake bites or poison generally. A well-known specific was Venice treacle, *Theriaca Andromachi,* a compound of a large number of drugs reduced to an electuary, a medicinal compound prepared with honey, which dissolves in the mouth. The old French *triacle,* of which "treacle," earlier "triacle," is an adaptation, is a corruption of *thériaque,* Latin *theriaca,* Greek *θηριακά (sc. φάρμακα)*, literally drugs used as an antidote against the bite of poisonous or wild animals (*θήριον*, dim. of *θήρ*, "wild beast"). The word "triacle" came to be used of any remedy or antidote. The composition of electuaries with honey or syrup naturally transferred the name to the most familiar syrup, that obtained from the drainings of sugar.

TREADMILL, a penal appliance introduced by Sir William Cubitt in 1818 and intended by him as a means of employing criminals usefully. It was a large hollow cylinder of wood on an iron frame, round the circumference of which were a series of steps about $7\frac{1}{2}$ in. apart. The criminal, steadying himself by handrails on either side, trod on these, his weight causing the mill to revolve and compelling him to take each step in turn.

By the British Prison act, 1865, a male prisoner over 16, sentenced to hard labour, had to spend three months at least of his sentence in labour of the first class. This consisted primarily of the treadmill or, as an alternative, the crank. The latter consisted of a small hand wheel, like the paddle wheel of a steamer, revolving in a box. Both treadmill and crank mere in time made to subserve useful purposes, but both gradually were abolished; in 1895 there were 39 treadmills and 29 cranks in use in English prisons, and these had dwindled down to 13 and 5 respectively in 1901. They are no longer used.

The fundamental idea of Cubitt's invention (*i.e.*, procuring rotary motion for industrial purposes by the weight of men or animals) is very old. "Treadwheels," of this type, usually consist of hollow cylinders, round the inner surface of which a horse, dog or man walks, foothold being kept by slabs of wood nailed across at short intervals.

TREASON, a general term for the crime of attacking the safety of a sovereign state or its head. The law which punishes treason is a necessary consequence of the idea of a state, and is essential to the state's existence. Most, if not all, nations have at an early period of their history made provision by legislation or otherwise for its punishment.

ENGLISH LAW

The law of England as to treason corresponds to a considerable extent with Roman law. In both systems the law was settled by legislation at a comparatively early period, and subsequently developed by judicial construction. In both, too, there were exceptional features distinguishing this crime from other offenses. Treason was the subject of legislation in many of the pre-Conquest codes. The laws of Alfred and Aethelred punished with death anyone plotting against the life of the king. The *Leges Henrici Primi* put anyone slaying the king's messenger in the king's mercy. The crime was shortly defined by Ranulf de Glanvill and at greater length by Britton and by Henry de Bracton, who follows Roman law closely.

The offense of high treason was not precisely defined by the common law (1 Hale, 76), and until the passing of the Treason act, 1351, depended much on the opinions of the king and his judges. That statute appears to be the answer to a petition of the commons in 1348 (1 Hale, 87), praying for a definition of the offense of accroaching royal power, a charge on which several persons—notably Piers Gaveston and the Despensers—had suffered. The offenses made high treason by the statute which still remain are these: (1) to compass or imagine the death of the king, the queen or their eldest son and heir; (2) to violate the king's companion, or his eldest daughter unmarried, or the wife of his eldest son and heir; (3) to levy war against the king in his realm, or be adherent to the king's enemies in his realm, giving them aid and comfort in the realm or elsewhere; (4) to slay the chancellor, treasurer or the king's justices of the one bench or the other, justices in eyre or justices of assize, and all other justices being in their places doing their offices. The statute, so far as it defines the offense of high treason, is still law.

The statute also treated as high treason forgery of the great or privy seal, counterfeiting the king's coin and importing counterfeits thereof; and this was the law until 1832. These offenses are now felonies under the Coinage Offences act, 1861, and the Forgery act, 1913. It also defined petty treason (now merged in wilful murder by s. 8 of the Offences against the Person act, 1861) as the slaying of a master by his servant, a husband by his wife or a prelate by a man secular or religious owing him allegiance. Between 1351 and 1553 many new offenses were made treason, but most of the acts creating these new treasons were repealed at the earliest opportunity by parliament. The reign most prolific in statutory additions to the law of treason was that of Henry VIII. The acts of this period were repealed in 1553 and the act of 1351 was then made the standard of the offense.

Besides the acts of 1351 and 1553 the following statutes are still in force with respect to the substantive law of treason. By a statute of 1495 persons serving the king *de facto* in war are not to be convicted of treason against the king *de jure.* By an act of 1702 it is treason to endeavour to hinder the next successor to the crown from succeeding, and by the Succession to the Crown act, 1707, it is treason maliciously, advisedly and directly by writing or printing to maintain and affirm that any person has a right to the crown otherwise than according to the Acts of Settlement and Union, or that the crown and parliament cannot pass statutes for the limitation of the succession to the crown. By the Treason act, 1796, made perpetual in 1817, the definition of treason is extended so as to include plots within or without the realm to cause the death or destruction or bodily harm of the king, his heir or successors, if such plots are expressed by publishing any writing or by any overt act or deed. Since that date no new forms of treason have been created.

Important Trials.—Trials for treason in Great Britain and Ireland were at one time frequent and occupy a large part of the numerous volumes of the *State Trials.* Some of the more interesting may be mentioned. Before the Statute of Treasons were those of Gaveston and the Despensers in the reign of Edward II on charges of accroaching the royal power. After the statute were those (some before the peers by trial or impeachment, most before the ordinary criminal courts) of Sir Richard Empson and Edmund Dudley, John Fisher, Sir Thomas More, the earl of Surrey, the duke of Somerset, Anne Boleyn, Lady Jane Grey, Sir Thomas Wyat. Thomas Cranmer, Mary, queen of Scots, Sir Walter Raleigh, the earl of Strafford, William Laud, Sir Henry Vane and other regicides, William, Lord Russell, Algernon Sydney, the duke of Monmouth, and those implicated in the Pilgrimage of Grace, the Gunpowder, "popish," Rye House and other plots. In some of these trials the law was considerably strained in order to ensure a conviction. Since the Revolution there have been the cases of those who took part in the risings of 1715 and 1745, Lord George Gordon in 1781, Thomas Hardy and John Horne Tooke in 1794, the Cato street conspirators in 1820, John Frost in 1840, William Smith O'Brien in 1848.

Most of the early treason trials are reported in W. Cobbett's and T. B. Howell's *Complete Collection of State Trials* (33 vol., London, 1809–26) and the *New Series of State Trials,* edited by Sir J. Macdonnell (8 vol., London, 1888–98). There are, however, three later trials which may be referred to. A case arising out of the South African War was the trial at bar of Arthur Lynch for high treason in 1903 *(Rex* v. *Lynch,* 20 Cox C.C. 468). It was there decided that the Naturalization act, 1870, does not permit naturalization in a foreign state at war with Great Britain, and therefore a British subject who renounces his allegiance and attempts to procure himself to be naturalized in an enemy's country in time of war is guilty of high treason. The accused was sentenced to death, but the sentence was afterward commuted and he subsequently received a pardon.

Sir Roger Casement (*q.v.*) was charged with high treason during World War I, and it was there held by the court of criminal appeal, affirming the decision of the king's bench division at the trial at bar, that if a man is adherent to the king's enemies in his (*i.e.,* the king's) realm by giving to them aid and comfort in the realm, or if he is adherent to the king's enemies elsewhere, he commits the offense declared to be high treason by the Treason act, 1351. It was also held by the king's bench division that if a British subject does any act which strengthens or tends to strengthen the enemies of the king in the conduct of a war against the king. or if he does any act which weakens or tends to weaken the power of the king and of the country to resist or attack their enemies, he is guilty of high treason. Sir Roger Casement was convicted, sentenced to death and executed *(Rex* v. *Casement,* 25 Cox C.C. 480 [account of trial], 503 [decision of court of criminal appeal]).

No amount of residence abroad exempts a British subject from the penalty of treason if he bears arms against the king, unless he has become naturalized as the subject of a foreign state before the outbreak of the war in which he bears arms. It is well established that an alien resident within British territory owes local allegiance to the crown and may be indicted for high treason, and there are numerous instances of prosecution of foreigners for treason. The case of William Joyce *(Joyce* v. *Director* of *Public Prosecutions,* reported in 1946 Appeal Cases, p. 347) is in a sense the converse of such cases. The main issue was as stated by Lord Jowitt. the then lord chancellor, at p. 364 of the report: "Whether an alien who has been resident within the realm can be held guilty and convicted in this country in respect of acts committed by him outside the realm." Joyce, who during World War II was the leading figure in the propaganda in English from German broadcasting stations. was a U.S. citizen of Irish extraction who had resided in Ireland from 1909 until 1921 and thereafter until 1939 in England. In 1933 he obtained a British passport, describing himself inaccurately as a British subject by birth. In Sept. 1938, and on Aug. 24, 1939, he obtained renewals of his passport, each for a period of one year; and he was proved to have been employed by the German radio company after the outbreak of war and before the expiration of his passport. The house of lords were of the opinion that an alien abroad holding a British passport enjoys the protection of the crown and if he adhered to the king's enemies he was guilty of treason, so long as he had not renounced that protection.

Court of Trial. — Three modes of trying high treason still remain, viz., impeachment, trial by court-martial and trial by jury on indictment before the high court or a court of assize or a special commission. The offense is not triable at quarter sessions. At common law and under the act of 1553 a peer, and by an act of 1441 a peeress in right of her husband, were triable for treason before the house of lords, or, when parliament was not sitting, in the court of the lord high steward. S. 30 of the Criminal Justice act, 1948, abolished this right.

Procedure. — Until 1945 the position was that in certain cases of treason the procedure on the trial was the same as upon a charge of murder. Those cases, which were statutory exceptions from the statutory procedure prescribed for the trial of high treason and misprision thereof, were: (1) assassination or killing of the king, or any heir or successor of the king, or any direct attempt against his life or any direct attempt against his person whereby his life may be endangered or his person may suffer bodily harm (1800, 1817) ; (2) attempts to injure in any manner the person of the king (1842).

The effect of the Treason act, 1945, was to extend the above provisions to all cases of treason, so that the procedure and rules of evidence are now the same as on charges of murder. Witnesses for the defense have since 1702 been examinable upon oath. The accused may by the Criminal Evidence act, 1898, consent to be called as witness for the defense. The wife or husband of the accused is not a compellable witness for the crown and it is doubtful whether he or she is even competent for this purpose *(see* J. F. Archbold, *Pleading, Evidence and Practice in Criminal Cases,* 33rd ed., 497, London, 1954).

Prosecutions for treason must be begun within three years of the offense, except in cases of attempts to assassinate the king. The rules as to the indictment are stricter than in the case of felony and misdemeanour, much of the modern statutory power of amendment not extending to indictments for the graver offense. No evidence may be given of any overt act not expressly stated in the indictment. The accused is entitled to peremptory challenge of 35 of the jurors summoned for the jury; but they need not now be freeholders. Before 1945 the accused could be convicted only on his own confession in open court, or by the oath of two witnesses either both to the same overt act charged, or one to one overt act and the other to another overt act of the same treason. If two or more treasons of different kinds were charged on the same indictment, one witness to prove one treason and another to prove another were not sufficient for a lawful conviction. Persons charged with treason are not admitted to bail except by order of a secretary of state or by the high court or a judge thereof in vacation. Finally it must be noted that there can be no accessories before or after the fact to treason. Every person who incites, aids or abets treason is a traitor, and must be indicated as a principal.

Punishment. — The punishment of treason at common law was barbarous in the extreme. The sentence in the case of a man was that the offender be drawn on a hurdle to the place of execution, that there he be hanged by the neck but not till he be dead, and that while yet alive he be disembowelled and that then his body be divided into four quarters, the head and quarters to be at the disposal of the crown. Until 1790 at common law a woman was drawn to the place of execution and there burned. In that year hanging was substituted for burning in the case of female traitors. In 1814 the part of the sentence relating to hanging and to disembowelling was altered to hanging until death supervened. Drawing and beheading and quartering after hanging were abolished in 1870. The act of 1814 in the case of men enables the crown by warrant under the sign manual, countersigned by a secretary of state, to change the sentence to beheading. Attainder and forfeiture for treason are abolished by the Forfeitures act, 1870, except where the offender has been outlawed.

Offenses Allied to Treason. — Misprision of treason consists in the concealment or keeping secret of any high treason. This offense was in 1552 declared to be high treason, but the former law was restored in 1553–54. It is an indictable common-law misdemeanour, not triable at quarter sessions, and the procedure for the trial of misprision of treason is the same as in the case of high treason. The punishment is imprisonment for life and forfeiture of the offender's goods and of the profits of his lands during his life. The forfeitures are not abolished by the Forfeitures act, 1870. There is no case of prosecution of this offense recorded during the last century.

The necessity of prosecutions for treason has been greatly lessened by a series of statutes beginning in 1744 which provide for the punishment as felonies of certain acts which might fall within the definition of treason; *e.g.*, piracies (1744), incitement to mutiny (1797), unlawful oaths, including oaths to commit treason (1797, 1812), and aiding the escape of prisoners of war (1812). By the Treason act, 1842, it is a high misdemeanour, punishable by penal servitude for seven years, wilfully to discharge, point, aim or present at the person of the king any gun or other arms, loaded or not, or to strike at or attempt to throw anything upon the king's person, or to produce any firearms or other arms or any explosive or dangerous matter near his person with intent to injure or alarm him or to commit a breach of the peace.

By the Treason Felony act, 1848, s.1, it was made a felony punishable by penal servitude for life within or without the United Kingdom to plot (1) to deprive or depose the king from the style, etc., of the imperial crown of the United Kingdom; (2) to levy war against the king in any part of the United Kingdom in order to change his measures or counsels or to put force or constraint on or to intimidate either or both houses of parliament; (3) to move or stir any foreigner with force to invade the United Kingdom or any of the king's dominions. The plot to be within the act must be expressed by publishing in printing or writing or by an overt act or deed.

The act of 1848 does not abrogate the Treason act of 1351, but merely provides an alternative remedy. The procedure in the case of all the offenses under the act of 1848 is governed by the ordinary rules as to the trial of indictable offenses, and the accused may be convicted even though the evidence proves acts constituting high treason. Principals in the second degree and accessories before the fact are punishable as principals, and accessories after the fact by two years' imprisonment. (W. T. Ws.)

UNITED STATES

The law punishes treason in order to protect the social interest in the safety of the political community. But English political history taught the framers of the United States constitution that men in power might falsely or loosely charge treason against opponents to destroy peaceful political combat and change. Because they saw that the law of treason was two-edged, the framers made this the only crime defined in the constitution. Thus they denied congress the authority to enlarge or reshape the offense; moreover. they spoke in terms which emphasized restrictions upon the definition and prosecution of the offense as much as they underlined the security of the nation: "Treason against the United States shall consist only in levying War against them, or in adhering to their Enemies, giving them Aid and Comfort. No Person shall be convicted of Treason unless on the Testimony of two Witnesses to the same overt Act, or on Confession in open Court. The Congress shall have power to declare the Punishment of Treason, but no Attainder of Treason shall work Corruption of Blood, or Forfeiture except during the Life of the Person attainted" (art. iii, sec. 3). Treason may be committed against a state of the union, and state constitutions or statutes define the crime substantially as does the federal constitution.

The restrictive definition of treason thus became part of what amounts to a constitutional code of political fair play. This code included the bans on bills of attainder or ex post facto laws, the provision of impeachment as the only regular procedure of removing high officials, the veto power given the chief executive to defend the separation of powers, the control of the purse given popular assemblies to curb the executive and the guaranteed tenure given to judges to insulate them from the heat of party.

The United States supreme court did not have occasion to interpret the treason clause decisively until 1945 and 1947, in the Cramer and Haupt cases (325 U.S. 1, 330 U.S. 631), where defendants were charged with aiding German saboteurs during World War II. Partly, the supreme court's scant opportunities to define treason reflected the general security of the United States over its first 150 years. The Burr conspiracy occasioned the only classic 19th-century consideration of the crime; there. John Marshall, as circuit justice, directed a verdict of acquittal (1807), ruling that conspiracy to levy war was not a sufficient overt act within the constitutional definition. Only slender doctrine emerged from the few other lower federal court cases, notably those arising out of the Whisky rebellion, the embargo and the War of 1812 and resistance to the Fugitive Slave law. The Dorr rebellion in Rhode Island and John Brown's Virginia raid brought the only completed prosecutions for treason against a state (1844, 1859). The Civil War presented resistance on a scale too great for ordinary penal process; a presidential proclamation of pardon and amnesty finally cut off treason prosecutions. The constitution was never treated as barring legislation defining other affenses against security; World War I saw three reported treason cases, but most action against persons charged with opposing the war effort was taken under statutes against espionage or trading with the enemy.

Any violent group resistance to an officer or to the making or execution of any particular official policy was treason by levying war under the broader English precedents. There is evidence that the constitution's framers meant to bar such a broad reach of the crime. Apart from wholesale attacks on established legal order (Dorr's rebellion, John Brown's raid), the offense of "levying war" became obsolete through nonuse; consistent United States practice after 1850 was to prosecute as riot conduct which older English law punished as treason.

Treason by adhering to an enemy can be committed only during declared war. The Cramer and Haupt cases made clear that intent to betray and some overt act (showing that intent had moved into action) are distinct elements of the crime, each of which must be proved; the required proof by two witnesses applies, however, only to proving the act. The supreme court had the most difficulty in defining the required act. Probably the act need not be such as in itself to evidence treasonable intent; it may be an act innocent or ambiguous on its face, like giving food or shelter (which, unlike surrendering a fort, would not necessarily appear treasonable without other evidence of intent). But, a majority of the court insisted, the act must confer tangible benefit then and there on the enemy; a mere meeting mas held not a sufficient act, but the giving of shelter was. Dissenting justices challenged both the correctness and the application of this test. But all the justices made plain that, following the lead of the constitution's framers, the court would administer the law of treason both with care to make it a bulwark of security and with caution against its political abuse.

See Willard Hurst, "Treason in the United States," 58 *Harvard Law Review*, 226, 395, 806 (1945), "English Sources of the American Law of Treason," *Wisconsin Law Review*, 315 (1945). (W. Ht.)

TREASURE TROVE, the legal expression for coin, bullion, gold or silver articles, found hidden in the earth, for which no owner can be discovered.

As feudalism spread over Europe and the prince was looked on as the ultimate owner of all lands, his right to the treasure trove became, according to Grotius, *jus commune et quasi gentium*, in England, Germany. France. Spain and Denmark. In England for centuries the right to treasure trove has been in the crown, which may grant it as a franchise. It is the duty of the finder, and indeed of any one who acquires knowledge, to report the matter to the coroner, who must forthwith hold an inquest to find whether the discovery be treasure trove or not. Concealment is an indictable offense. In the statute De *officio coronatoris*, 1276, the coroner is enjoined to inquire as to treasure trove, and the Coroners act of 1887 continued this power as previously. In Scotland the law is similar. Such articles are presumed to have once had an owner, and, in his absence, they belong not to the finder but to the crown. Their concealment is not a criminal offense unless accompanied by intent to appropriate. In India the Treasure Trove act (16 of 1878) defines treasure as "anything of value hidden in the soil." The finder has three-fourths and the owner of the land one-fourth.

In the United States the common law, following English precedent, would seem to give treasure trove to the public treasury, but in practice the finder has been allowed to keep it. In Louisiana one-half goes to the finder and one-half to the owner of the land. Modern French law is the same, as it is also in Germany, Italy and Spain.

See Blackstone's *Commentaries;* J. Chitty, *Prerogatives of the Crown*

(1820); J. Rankine, Landownership, new ed. (1909); J. Murray, Archaeologtcal Survey of the United Kingdom, containing copious references to the literature of the subject (1896); R. Henslowe Wellington, The King's Coroner (1905–06).

TREASURY DEPARTMENT: see GOVERNMENT DEPARTMENTS.

TREATY, an instrument binding two or more states under international la . The word is derived, through the French traitk (Fr. *traiter,* "to negotiate") from the Latin *tractatus,* the term which from the end of the 17th century began to be used in diplomacy instead of the older technical terms conventio *publica* ("public convention") and foedus ("alliance"). According to modern diplomatic usage the term treaty is confined to the more important international agreements and those of lesser or subordinate importance have been called conventions, agreements, arrangements, protocols and acts, but all of these conform to the definition of treaty given above.

Making of Treaties.—Treaties are normally negotiated between plenipotentiaries provided by their respective governments with "full power" to conclude the treaty within the scope of their instructions. Signature, however, is today presumed to be subject to ratification by the government unless explicitly waived. Apart from such express provision the instrument does not become formally binding until ratifications have been exchanged. Multilateral treaties are usually negotiated at a diplomatic conference ending with signature of the instruments agreed upon. In the case of the Japanese peace treaty of 1951, however, the United States presented a text seriatim to the other parties, gaining in most cases their consent. The San Francisco conference of Sept. 1951 was called for formal signature with the understanding that changes in the text would not be permitted. The Soviet Union, its satellites and India refused to sign under these conditions.

Multilateral treaties provide for deposit of ratifications at a particular foreign office or at the secretariat of the United Nations or other international organization. A prescribed number of ratifications must usually be deposited to bring the treaty into force. Provision is often made for the accession of nonsignatory states before a prescribed date.

The problem of reservations after signature presents few difficulties in the case of bilateral treaties. A reservation, whether in the form of an interpretation or amendment, constitutes a new offer which prevents the treaty coming into force unless the other party accepts it, which may happen when ratifications are exchanged. In the case of a multilateral treaty, however, serious complications occur when a reservation is accepted by some signatories and rejected by others. The status of such a treaty has been the subject of conflicting views by the International Court of Justice and the United Nations International Law commission. The tendency has been to forbid reservations to multilateral treaties unless explicitly permitted by the signed text.

Form.—In making a treaty it is not essential to employ any special form. A treaty often takes the form of a contract, but it may take the form of a joint declaration or of an exchange of notes (as in the case of the Rush-Bagot agreement between the United States and Great Britain in r817 for mutual disarmament on the Great Lakes). It is, however, customary to draw up all important treaties on a fixed plan. First comes the preamble, giving the names and styles of the high contracting parties, a statement of the general objects which they have in view, the names and official designations of the plenipotentiaries charged with the negotiation and a statement that their full powers have been verified. Then follow the articles containing the stipulations agreed upon. If the treaty is concluded for a definite period, this is next stated or, if it be in form perpetual, there may be a provision inserted that either party may "denounce" (*i.e.,* give notice to terminate) the treaty. Next follows an article providing for ratification and for the time and place for the exchange of ratifications. At the end is a clause stating that "in witness whereof (en foi de *quoi*) the respective plenipotentiaries have affixed their names and seals." The signatures follow, with the place and date. "Additional articles" are often appended and signed by the plenipotentiaries, with the declaration that they have the same force and value as if they had been included in the body oi the treaty or convention.

General Treaties.—Treaties with a large number of parties, called general, multilateral or multipartite treaties, often have the character of legislation rather than of contract. They have frequently been negotiated at permanent or periodic conferences such as the League of Nations assembly (see LEAGUE OF NATIONS), the Cnited Nations general assembly or the conferences of the specialized agencies under the United Nations (q *v.*), or in special conferences called to deal with a particular subject such as the San Francisco conference on the United Nations organization. Treaties which emerge from such conferences usually refer to the conference in the preamble. though frequently the high contracting parties are individually listed as in bilateral treaties. The democratic tendency of diplomacy during the 19th century can be detected in the increasing utilization of such treaties in preference to bilateral treaties and in the references to popular participation as in the Kellogg-Briand pact in which the high contracting parties "solemnly declare in the names of their respective peoples" and in the United Nations charter the preamble of which begins with the phrase "We the peoples of the United Xations determined . . ." In the interpretation of such treaties there is a tendency to make less use of preparatory discussion which usually discloses the views of only a few of the parties and to rely mainly on the customary or legal meaning of terms and on general rules of construction. Among important treaties of this type mention may be made of the declaration of Paris, 1856; the Geneva Convention on the Red Cross. 1864; the Convention of the Universal Postal Union, 1874; The Hague conventions, 1899 and 1907; the League of Nations covenant, 1919; the Constitution of the International Labour Organization. 1919; the Statute of the Permanent Court of International Justice, 1920; the Geneva Protocol for the Pacific Settlement of International Disputes, 1924; the General Act of Geneva for the Pacific Settlement of International Disputes, 1928; the Treaty for the Renunciation of War (Kellogg-Briand pact), 1928; the Cnited Nations charter, 1945; the Agreement for the Establishment of an International Military Tribunal and the Charter for the International Military Tribunal, 1945; the Convention on the Crime of Genocide, 1948; and the International Covenant on Human Rights, of which a draft was submitted in 1954. These instruments, it may be observed, have a great variety of designations. To these may be added numerous agreements, acts, arrangements, declarations, mandates, protocols, regulations, resolutions, rules and trusteeships proceeding from international conferences or organizations and often having the character of treaties. Manley O. Hudson lists 257 multipartite instruments made from 1864 to 1919 and 700 made from 1919 to 1946. D. P. Myers estimated in 1920 that about 30,000 treaties, both bilateral and general, had been concluded among civilized states of which about one-fifth were then in force. More than 5,000 treaties have been concluded since 1920 and published in the treaty series of the League of Nations or of the United Nations.

Classification of Treaties.—International jurists have classified treaties on a variety of principles. Aside from the distinction between general and bilateral treaties already referred to, the distinction has been drawn between those which represent a definite transaction such as a cession of territory (Rechtsgeschaft) and those which seek to establish a general rule of conduct, such as the "renunciation of war" (*Rechtssatz*). They may be classified in a more practical way according to their object, as follows: (1) political, such as treaties of peace, of alliance, of cession of territory, of pacific settlement and of disarmament; (2) commercial, including tariff, consular, fishery and navigation conventions (see COMMERCIAL TREATIES); (3) constitutional and administrative such as the conventions establishing and regulating international unions, organizations and specialized agencies; (4) relating to criminal justice, as treaties defining international crimes and providing for extradition (*q.v.*); (5) relating to civil justice, as conventions for the protection of human rights, trade-marks and copyright, and the execution of the judgments of foreign courts; (6) codifying international law such as procedures for the peaceful settlement of international disputes. rules for the conduct of war and definitions of the rights and duties of states. In practice it is often difficult to assign a particular treaty to any one of these classes.

Antiwar Treaties. — Treaties for the renunciation of war, for disarmament and for pacific settlement of international disputes might be called "treaties of peace," but that term has been employed to refer to treaties which end a particular war rather than to treaties which are intended to prevent future wars. Antiwar treaties belong in the class of political treaties, but they often contain provisions of administrative or codifying character. Arbitration clauses have often been included in commercial and other treaties and numerous bilateral treaties of arbitration and conciliation have been made providing either for the submission of past controversies to pacific settlement or for the submission of classes of future controversies. The Hague conventions (1899, 1907), the League of Nations covenant (1919), the statutes of the Permanent Court of International Justice (1920) and the International Court of Justice (1945), the General act (1928) and the United Nations charter (1945) provided procedures and institutions for pacific settlement. The optional clause of the court statute, which has been ratified by a large number of states including the United States, the United Kingdom and France, provides for compulsory jurisdiction of the court in legal disputes on application of one party.

Bilateral disarmament treaties have been made, such as the Rush-Bagot agreement of 1817 disarming the Great Lakes. Defeated powers have often been compelled to disarm partially in treaties of peace. General treaties for limited disarmament have been made, as the Washington treaties of 1922 and the London treaty of 1930. Effortsat general disarmament in the League of Nations conference of 1932 failed, as have efforts to eliminate atomic weapons and to reduce conventional armaments in the United Nations. (See DISARMAMENT.)

Treaties for the renunciation of war may apply to particular areas such as neutralized states (see NEUTRALIZATION) or boundanes, or to limited periods of time as the Bryan "cooling-off treaties" negotiated by the United States in 1913–15 with many countries and providing for commissions of conciliation to function for a period of a year during which the parties agreed not to resort to hostilities This idea was included in art. 12 of the League of Nations covenant. By the Kellogg-Briand pact of 1928, 63 states. all in the world except a few Latin-American states, condemned uar, renounced it as an instrument of national policy and agreed never to seek the settlement of any dispute or conflict except by pacific means. This treaty did not prevent hostilities, but it did "outlau war." Third states were no longer obliged to be impartial but mere free to differentiate between the "aggressor" and the "victim." As a consequence, states were not free to recognize that the aggressor's conquest gave legal title; nonbelligerents were free to discriminate against the aggressor; and high officers of governments instituting hostilities in violation of the pact were criminally liable and unable to defend themselves behind the alleged "act of state" of the aggressor state. War in the material sense continued, but the legal sense of war, as understood in the 19th century, a condition which equally permits two or more states to settle their controversies by the use of armed force, had been so altered that it is proper to say war had been "outlawed." (See WAR: International Law and *War*)

Validity. — I. A treaty, like a contract in private law, is only valid when made between competent parties, normally sovereign states. Semisovereign states such as protectorates, vassal states and members of federations may make valid treaties uithin the range of their international capacity. The members of the British Commonwealth are recognized to have sovereign capacity in international relations.

2. In principle a treaty is not valid unless accepted in accord with the treaty-making procedure of each state as determined by its municipal law. A government, however, can understand the provisions of foreign constitutions concerning treaty making only through communications with the foreign office of that state. Consequently, treaties made in accord with the procedure which the foreign office, acting in the name of the representative authority of the state, considers constitutional are deemed internationally valid. The Permanent Court of International Justice said in the East Greenland case that a reply "giyen by a Minister of Foreign Affairs on behalf of his government in response to a request falling within his province is binding upon the country to which the minister belongs." Judge Dionisio Anzilloti in a separate opinion concurred on this point but clarified the phrase "within his province" by saying it was the foreign minister's "duty to refrain from giving his reply until he had obtained any assent that might be requisite" under his country's law (3 World Court Reports 192, zoo). In Great Britain the treaty-making power resides in the executive. In the United States, treaties in the constitutional sense, though negotiated by the president through the state department, can only be concluded "with the Advice and Consent of the Senate." In practice the senate has shown itself very jealous of its right to insist on reservations or amendments before ratification. The two-thirds vote required by the constitution has added to this tendency because it normally makes it necessary to gain the consent of many senators of the minority party. The president has therefore increasingly made use of executive agreements which he can make on his own responsibility if his independent powers are adequate to execute them, or with support of a simple majority of both houses of congress if the normal legislative powers of congress are sufficient to provide for their execution. When the main obligation of the treaty is the payment of money or tariff regulation, the latter method has normally been used. In many countries the treaty-making power is shared between the executive and the legislature only for certain purposes. In France, for instance, treaties of peace, treaties of commerce and those involving financial obligations or relating to the rights of French citizens are not valid until ratified by a majority in both chambers.

3. A treaty, to be valid, must be the expression of an agreement. Unlike a private contract, however, under customary international law a treaty was not voidable on proof that one of the parties to it had been subject to duress, but only if it could be proved that the individual negotiator had been so subject. Thus a treaty imposed by the victor upon the vanquished remained valid, though signed under pressure of force. The Stimson doctrine held that this rule was modified among the parties to the Kellogg-Briand pact for the renunciation of war if the treaty had been made through coercion in violation of that pact, on the principle that rights do not arise from wrongs (jus ex injuria non oritur).

4. In modern practice a treaty, though signed by agents with full powers, is not valid until it has been ratified by both parties and ratifications have been exchanged or, in the case of a general treaty, ratifications have been deposited at a designated place. This condition applies only to instruments subject to ratification. Many agreements, protocols and exchanges of notes become valid uhen signed.

5. Art. 18 of the covenant of the League of Nations provided that every treaty or international agreement entered into after the signature and ratification of the covenant, by any member of the League, should be forthwith registered with the secretariat and should as soon as possible be published by it; and that no such treaty or international agreement should be binding until so registered. A similar provision in art. 102 of the United Nations charter merely declares that a party to an unregistered treaty may not invoke it before any organ of the United Nations.

6. Art. 20 of the covenant provided that treaty obligations among the members were abrogated if inconsistent with the covenant and such obligations with nonmembers should be terminated by members. Art. 105 of the United Nations charter merely provides that the obligation of members under the charter shall in case of conflict supersede their obligations under any other international agreement.

Interpretation and Application. — I. Treaties are to be interpreted in accord with international law. That law gives guidance as to the meaning of technical terms and establishes presumptions useful for construction such as that against sacrifices of sovereignty by the parties. However, evidence in the negotiations or subsequent practice may overrule these presumptive meanings or constructions by indicating that the parties had a different intention in the particular instance. Such historical evidence is, however, more useful in the case of bilateral than of general treaties.

2. The question of the language employed in treaties has often caused trouble. In the 16th century international treaties were drawn up in Latin, more rarely in French. It was not till the 18th century that the latter was generally accepted (except by the pope and the emperor) as the language of diplomacy. The Anglo-French commercial treaty of April 11, 1713, was in Latin. Before World War I general conventions were usually drawn up in French, but the League of Nations and the United Nations adopted both English and French as working languages and treaties related to these organizations were official in both languages. The San Francisco conference recognized, in addition, Spanish, Russian and Chinese as official languages and the United Nations charter appears officially in five languages. Spanish was added to French and English as a working language by the United Nations in 1949. Bilateral treaties are usually in two texts, one in each language, both of which are signed by the plenipotentiaries of the two parties. Such bilingual treaties have sometimes been accompanied by a third version in French, to be decisive in case of a difference of opinion arising as to the precise meaning of the language of the other texts

3. Treaties are in first instance interpreted and applied by the parties. Constitutions of some countries (*e.g.*, the United States) make treaties automatically the supreme law of the land to be applied by courts and administrative officers, while others (*e.g.*, Great Britain) do not consider treaties applicable rules of municipal law until the legislature has acted giving domestic force to the provisions of the treaty. This distinction, however, is in reality one of degree. In all countries some treaties are in some circumstances "self-executing" while others are not. Thus in Great Britain treaties dealing with maritime captures are automatically applied in prize courts and in the United States treaties requiring appropriations or modifications of criminal law are not applicable until congress has acted. Proposals were introduced by Sen. John Bricker of Ohio and others in 1952 to amend the U.S. constitution in order to require congressional action for the internal enforcement of treaties in the United States and to prevent encroachment upon the normal powers of the states. These proposals were opposed by the administration and, after extensive debate, rejected by the senate in 1954.

4. The ultimate interpretation of treaties is an international question. Because of the lack of certainty that a dispute concerning interpretation and application of the treaty will be decided through diplomatic negotiation, treaties frequently include a "compromissary clause" by which the parties agree to submit such questions to arbitration or judicial settlement. The optional clause of the Statute of the International Court of Justice (art. 36, par. 2) provides for the compulsory jurisdiction of the court in "all legal disputes concerning the interpretation of a treaty." This applies only among states which have deposited with the secretary-general of the United Nations a declaration accepting the clause.

5. A treaty sometimes provides for acts intended to secure its due performance; *e.g.*, the occupation of the German Rhine provinces by the Allied powers pending the payment of the reparations imposed by the treaty of Versailles (art. 428–431). The enforcement of treaties is in general secured by the mutual interest of the parties and the right of each to abrogate on nonobservance by the other and by the procedures of customary international law and the Cnited Nations for the maintenance of obligations of states under international law.

Duration of Treaties. — The question of when, and in what circumstances, the obligations incurred under treaties come to an end has been the subject of much debate. A treaty may lapse naturally by the destruction of one of the states party to it, by the object of the agreement ceasing to exist, by the conclusion of a new-agreement among the parties abrogating or superseding it or by denunciation by one of the parties under powers reserved in the treaty itself. Treaties are also in most cases suspended if not terminated by war between the contracting parties, and are therefore usually revived in express terms of the treaty of peace. More debatable is the proposition upheld by certain jurists, *e.g.*, Cornelius van Bynkershoek, that the condition rebus sic stantibus ("things remaining thus") is implicit in every treaty. Bismarck, in his Reminiscences, considered it self-evident that treaties were valid only as long as they are useful to the parties. In practice this was certainly often the case even after the London protocol of 1871, which laid down the principle that "no Power can liberate itself from the engagements of a treaty, nor modify the stipulations thereof, unless with the consent of the contracting Powers, by means of an amicable agreement." Art. 19 of the League of Nations covenant provided that "the Assembly may from time to time advise the reconsideration by members of the League of treaties ahich have become inapplicable." The same purpose is intended by art. 14 of the United Nations charter, though it does not specifically refer to treaties. It authorizes the general assembly "to recommend measures for the peaceful adjustment of any situation, regardless of origin, which it deems likely to impair the general welfare or friendly relations among nations." Jurists, however, recognize these procedures as political measures for modifying undesirable or dangerous treaties and not as applications of the jural principle rebus sic stantibus. The latter holds that treaties may be declared at an end by proper proceedings which find that conditions deemed by the negotiators essential to the agreement have changed.

Treaties of peace usually provide for the continuance or the termination of prewar treaties between the belligerents. The treaties ending World War I listed the treaties of the Central Powers to be continued and explicitly provided that certain treaties were to be abrogated.

The provisions of the treaties of peace after World War II were similar but less complicated. Each Allied power was entitled to notify Italy within six months which bilateral treaties it wished to preserve. Treaties not so notified would be considered abrogated. Express provisions were included in regard to certain general treaties. For example Italy renounced its interest in the mandate system. but the situation of general treaties was not covered comprehensively. The treaties of peace with Bulgaria, Hungary. Rumania, Finland and Japan had similar provisions.

The Inviolability of Treaties. — The principle *pacta* sunt *servanda* ("agreements ought to be observed") is considered basic in international law. Maintenance of this principle, however. requires that nothing should be included in a treaty which the parties to it are not reasonably sure that they and their successors will be able to carry out in any circumstances. This principle led British statesmen during the 19th century from Pitt and Lord Castlereagh onward to avoid commitments "for external exertion" in circumstances which could not be foreseen. For the same reason, in the days of the old diplomacy, there was in the language of the treaties of peace, and of diplomatic intercourse generally, a studied avoidance of anything that might keep open old sores by any unnecessary wounding of the feelings of the vanquished. In this respect the treaty of Versailles of 1919 compared unfavourably with the treaty of Versailles of 1783. In the former the defeated nation was compelled to confess its "war guilt" as the price of its restoration to the community of nations. This condition rankled in the minds of the Germans, and contributed to the rise of Hitler and World War II. Art. i of the treaty of 1783, on the other hand, ended with the words: "There shall be complete oblivion of, and amnesty for, all that may have been done or committed before or during the war which has now come to an end."

This change is a manifestation of the shrinking of the world, the increasing destructiveness of war and the democratization of the conduct of international relations. These conditions have led to the concept of a world community, sustaining principles of peace and justice the violation of which ought to be universally condemned. War crimes trials. applied much more extensively after World War II than after World War I. provided evidence of this change (see WAR CRIMES). The newer view considers treaties by analogy to municipal law, while the old considered them instruments of power politics. Some statesmen, including Theobald von Bethmann-Hollweg, adhering to the new view, held that Germany committed a breach of international law in invading Belgium in defiance of the treaty of 1839 Others, among whom was Sir

Ernest Satow, adhering to the older view, maintained that Germany by violating Belgium in 1914 merely gave any other guaranteeing state the right to attack it. In other words, Germany risked its existence but did not specifically break international law. The first relies upon law to establish the sanctity of treaties, and the latter relies upon the balance of forces. The difficulty of the first view lies in the fact that the community of nations may lack the solidarity necessary to maintain its law. For instance, it was formally declared by the great powers in 1871 that no great power which had joined the other great powers in signing a treaty could violate the provisions of that treaty without the consent of the other signatories; that is, without a European conference. But Russia's violation of the Black sea clauses of the treaty of Paris (1856) was acquiesced in 1871 and in 1908 Austria-Hungary violated art. 25 of the treaty of Berlin (1878) by annexing Bosnia and Herzegovina with apparent impunity.

The peacemakers of 1919, therefore, tried to set up a state of things whereby the sanctity of treaties would be upheld by the general co-operation of all states. Pres. Woodrow Wilson condensed this aspiration into a single sentence: "What we seek is the reign of law, based upon the consent of the governed and sustained by the organized opinion of mankind." The League of Nations covenant attempted to give a general guarantee of territorial integrity and independence to all the members of the League. This general guarantee, embodied in art. 10 of the covenant, was, however, in fact succeeded by a system of special or regional guarantees, including the treaty of Locarno (1925) and the little entente (1920–21) (*qq.v.*). Similarly it was recognized in art. 21 of the covenant that the Monroe Doctrine was "a regional understanding," which meant a practical admission by the principal powers that the United States guaranteed other states on both American continents against the aggression of non-American neighbours. The violation of both general and regional guarantees in the 1930s and the temporary acquiescence in these violations by the powers indicated that the solidarity of the community of nations was still insufficient to enforce treaties.

The United Nations charter agreed to at the end of World War II sought to strengthen the universal guarantees of the League of Nations by making them less rigid and more organized, and sought also to strengthen the outlawry of war formally established by the Kellogg-Briand pact in 1928. The Security council was given the power to decide what measures to take when it found that aggression had occurred or was threatened (art. 41) and all members were obliged to act accordingly (art. 25, 48). Provision was made for a General Staff committee to organize forces provided by advance commitment of the members. The veto given the great powers in the Security council and the consequent inability of that body to function satisfactorily has, as in the interwar period, resulted in a new resort to regional agreements and pacts for "collective self-defense" authorized by the charter (art. 51, 52). The transition from a regime of treaties subject to the exigencies of power politics to a regime of treaties supported by a lax-enforcing community of nations has not yet been effected.

Treaties and the World Order.—Treaties containing what were technically known as transitory provisions with reference to recognition, boundaries or cessions of territory have been considered the title deeds of the nations to which they relate. The treaties of Osnabruck and Munster (Westphalia) in 1648, which were the work of the first modern international congress, were recognized as giving a new juridical basis to the territorial system of Europe. (*See* WESTPHALIA, PEACE OF.) Although, in the 18th century treaties were often violated, it was considered expedient to veil even the most flagrant acts of aggression under legal forms, as in the case of the three partitions of Poland which, as Friedrich von Gentz observed, set an unhappy precedent for the aggressions of Revolutionary France.

The treaties concluded between the powers after the downfall of Napoleon (Paris, 1814; Vienna, 1815; Paris, 1815) represented an attempt to reorganize the European territorial system by endowing the reconstituted states with unimpeachable title deeds and ensuring their stability by establishing a balance of power among them. Other treaties (Chaumont, March 1814, and treaty of alliance, Nov. 20, 1815) provided for the continuance of the quadruple alliance for the purpose of watching over and safeguarding the settlement thus made. Though this "federal system" for Europe broke down for various reasons (*see* EUROPE), the idea of the treaties as the foundation of the European system, and of the Concert of Europe as their guardian, survived long enough to secure an unprecedented period of peace. The principle that the treaties could not be altered without the consent of "Europe" was also more or less effectively asserted: effectively in the case of the treaties of 1831 and 1839 which separated Belgium from the Netherlands, ineffectively in the protests of France and Great Britain against Russia's violation of the terms of the treaty of Vienna by its treatment of the Poles in 1830 and 1863.

The principle of the solidarity of Europe in the matter of territorial changes was even extended to the questions arising out of the disintegration of the Ottoman empire, which had been excluded from the treaties of 1815; and the Concert of Europe survived in the eastern question (*q.v.*) long after the results of the Italian war of 1859 and of the Prussian wars of 1864, 1866, and 1870–71 had blown the Vienna settlement to pieces. Thus the partition of Turkey was regulated by the great powers, or some of them, in the treaties of London, 1832, 1863, 1864, and of Constantinople, 1881, with reference to Greece; and by the treaties of Paris, 1856, London, 1871, Berlin, 1878, and London, 1885, with reference to Montenegro, Rumania, Serbia, Bulgaria and the navigation of the Danube. These settlements underwent extensive and important changes as a result of World Wars I and II, but they still have an effective existence as the ultimate title deeds of the Balkan states. The settlements of World Wars I and II, however, in response to changing military, political and social conditions, gave increasing recognition to the superiority of political rights of "national self-determination" and "collective self-defense" over legal rights to territory established by treaty. As a result, changes have taken place in the political map, especially of Europe and Asia, frequently and often accompanied by violence.

The League of Nations and the United Nations provided more effective machinery than existed in the earlier Concert of Europe both for the maintenance and the peaceful change of treaties and territorial settlements. They were designed less to preserve a *status quo* established by treaties than continuously to adapt national rights and interests to changing conditions, but they remain inadequate to assure such dynamic stability.

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TREATY, COMMERCIAL: *see* COMMERCIAL TREATIES.

TREBIA (mod. TREBBIA), a river of Cisalpine Gaul, a tributary of the Padus (Po), into which it falls about 4 mi. W. of Placentia (Piacenza). Its valley is followed past Bobbio by the modern high road from Piacenza to Genoa (88 mi.). It is remarkable for the victory gained on its banks by Hannibal over the Romans in 218 B.C. Kromayer's investigations made it clear that Polybius' account, according to which the battle took place on the left bank of the river, is to be preferred to that of Livy. T. Frank suggests that the Placentia referred to in both accounts lay west of the river; *i.e.*, about 15 mi. W. of the later Placentia, refounded in 190.

Scipio (the father of Scipio Africanus) had advanced to meet Hannibal two days' march west of Pavia, but was defeated in a cavalry engagement, and in a forced night march recrossed the Ticinus and the Padus (probably at Placentia) and then took up a new position near Clastidium on the south bank of the latter river, about 20 mi. W. of Placentia: while Hannibal, finding himself unable to cross the Ticinus, marched westward up the Padus until he could cross it, and so came up with the Romans and offered battle, which was, however, not accepted; he therefore encamped 5 mi. away from them. Scipio, however, in consequence of the desertion of more than 2,000 of his Gaulish auxiliaries, retreated to the further bank of the Trebia, where he was joined by Sempronius, the other consul, who had brought his army from Ariminum. Hannibal followed them and encamped once more about 4 mi. from them; and as a decisive victory was imperative, in order that he might win over the Gauls to his side, and he had about 40,000 men, or as many as the two armies together, he did nothing to prevent their junction. A successful cavalry skirmish with the Carthaginian foragers encouraged Sempronius to overcome his colleague's objections to a general engagement, and the Romans marched across the Trebia. The battlefield was almost flat, but on the south was rising ground traversed by a number of fairly deep, broad stream beds, in one of which Hannibal concealed a force of 2.000 men under his young brother Mago, which was to have a decisive effect on the fortunes of the day. At the same time he sent his 8,000 light troops out to cover the advance of his main body of infantry, consisting of 20,000 Iberians, Celts and Libyans, while his cavalry (over 10,000, including his Celtic allies) were placed on the wings, with the elephants in advance of them. The Roman cavalry was soon driven back, and the Carthaginian light troops, Numidian cavalry and elephants attacked the Roman infantry on the flanks, so that the wings were put to flight and driven into the river, while Mago's force suddenly fell on the rear of the Roman centre and worked destruction on the rear ranks. The front ranks of the Roman centre, on the other hand, to a number of some 10,000 men broke through the Carthaginian centre with great slaughter, but seeing that the wings had been completely driven back, they took no further part in the battle but marched in good order into Placentia, where they were joined by the cavalry. The greater part of the rest of the army, entirely surrounded by superior numbers, met its death in the river itself. The battle has been rightly described as a Cannae on a small scale, and the similarities are certainly striking, as will be seen by a comparison of the two accounts. (T. A.)

TREBIZOND or TRABZON (Gr. *Trapezus)*, city of Turkey, on the Black sea, near its southeastern angle. From the time of its foundation as a Greek colony to the present day, it has always been a considerable emporium of commerce, and it was for two centuries and a half the capital of an empire. Its importance is due to its command of the point where the chief trade route from Persia and central Asia to Europe, over the tableland of Armenia by Bayezid and Erzerum, descends to the sea. Its safety also was secured by the barrier of rugged mountains (7,000 to 8,000 ft.) which separates its district from the rest of Asia Minor. So complete is the watershed that no streams pass through these ranges, and there is hardly any communication in this direction between the interior of Asia Minor and the coast. For the same reason, together with its northern aspect, the climate is humid and temperate, unlike that of the inland regions, which are exposed to great extremes of heat in summer and cold in winter. The position which was occupied by the Hellenic and mediaeval city is a sloping table of ground (whence the original name of the place, Trapezus, the "Tableland"), which falls in steep rocky precipices on the two sides, where two deep valleys, descending from the interior, run parallel at no great distance from one another down to the sea. The whole is still enclosed by the Byzantine walls, which follow the line of the cliffs and are carried along the sea-face; and the upper part of the level, which is separated from the lower by an inner cross wall, forms the castle; while at the highest point, where a sort of neck is formed between the two valleys, is the keep which crowns the whole. On each side, about halfway between the keep and the sea, these ravines are crossed by massive bridges, and on the farther side of the westernmost of these, away from the city, a large tower and other fortifications remain. The area of the ancient city is now called the Kaleh; eastward of this is an extensive quarter, and beyond this again a low promontory juts northward into the sea, partly covered with the houses of a well-built suburb, which is the principal centre of commerce. The harbour lies on the eastern side of this promontory, but it is an unsafe roadstead, being unprotected towards the northeast and having been much silted up, so that vessels cannot approach within a considerable distance of the shore From here the caravans start for Persia. The population in 1955 was 42,273.

History.—The city of Trapezus was a colony of Sinope, but it first comes into notice at the time of the Retreat of the Ten Thousand. who found repose there. Notwithstanding its commercial importance, the remoteness of its position prevented it from being much known to fame either in the Hellenic or the early mediaeval period. Its greatness dates from the time of the fourth crusade (1204), when the Byzantine empire was dismembered and its capital occupied by the Latins. During the confusion that followed that event, Alexius Comnenus escaped into Asia and, having collected an army of Iberian mercenaries, entered Trebizond, where he was acknowledged as the legitimate sovereign, and assumed the title of Grand Comnenus. Though only 22 yr. of age. Alexius was a man of ability and resolute will, and he succeeded without difficulty in making himself master of the greater part of the southern coast of the Black sea.

The empire thus founded continued to exist until 1461, when the city was taken by Mohammed II. Trebizond was able to defy both the Seljuks and the Ottomans and to maintain its independence against the emperors of Nicaea and Constantinople. But for the same reason its policy was always narrow, so that it never exercised any beneficial influence on the world at large. It was chiefly in the way of matrimonial alliances that it was brought into contact with other states. Members of the imperial family were renowned for their beauty, and the princesses of this race were sought as brides by Byzantine emperors of the dynasty of the Palaeologi, by western nobles and by Mohammedan princes, and the connections thus formed originated a variety of diplomatic relations and friendly or offensive alliances.

The palace of Trebizond was famed for its magnificence, the court for its luxury and elaborate ceremonial, while at the same time it was frequently a hotbed of intrigue and immorality. The Grand Comneni were also patrons of art and learning, and in consequence of this Trebizond was resorted to by many eminent men, by whose agency the library of the palace was provided with valuable manuscripts and the city was adorned with splendid buildings. The writers of the time speak with enthusiasm of its lofty towers, of the churches and monasteries in the suburbs and especially of the gardens, orchards and olive groves. It excited the admiration of Gonzales Clavijo, the Spanish envoy, when he passed through it on his way to visit the court of Timur at Samarkand (Clavijo, *Historia del gran Tamorlan*); and Cardinal Bessarion, who was a native of the place in the latter part of his life when the city had passed into the hands of the Mohammedans and he was himself a dignitary of the Roman Church, was so impressed with Trebizond that he wrote a work entitled *The Praise of Trebizond* (Ἐγκώμιον Τραπεζοῦντος). Little was known of the history of the empire of Trebizond until the subject was taken in hand by Professor Fallmerayer of Munich, who discovered the chronicle of Michael Panaretus among the books of Cardinal Bessarion, and from that work and other sources of information which were chiefly unknown up to that time, compiled his *Geschichte des Kaiserthums von Trapezunt* (Munich, 1827). From time to time the emperors of Trebizond paid tribute to the Seljuk sultans of Iconium, to the grand khans of the Mongols, to Timur the Tatar, to the Turkoman chieftains and to the Ottomans, but by means of skilful negotiations they were enabled practically to secure their independence.

They are found also at war with many of these powers and with the Genoese, who endeavoured to monopolize the commerce of the Black sea. The city was several times besieged, the most formidable attack being that which occurred in the reign of Andronicus I, the second emperor, when the Seljuks, under the command of Melik, the son of the great sultan Ala-ed-din, first assaulted the northern wall in the direction of the sea and afterwards endeavoured to storm the upper citadel by night. They failed, however, in both attempts; and in the latter, owing to the darkness and to the occurrence of a violent storm which suddenly swelled the torrents in the ravines, their force was thrown into inextricable confusion, and they were compelled to abandon their camp and make the best of their escape from the country. So great was the strength of the fortifications that Mohammed II might have experienced much difficulty in reducing it, had it not been for the pusillanimous conduct of David, the last emperor, who surrendered almost unconditionally.

Ancient Memorials. — Several interesting monuments of this period remain at Trebizond in the form of churches in the Byzantine style of architecture. One of these is within the area of the old city, viz., the church of the Panaghia Chrysokephalos, or Virgin of the Golden Head, a large and massive but excessively plain building, which is now the Orta-hissar mosque. On the farther side of the eastern ravine stands a smaller but very well-proportioned structure, the church of St. Eugenius, the patron saint of Trebizond, now the Yeni Djuma djami, or New Friday mosque.

Still more important is the church of Haghia Sophia, which occupies a conspicuous position overlooking the sea, about 2 mi. west of the city. The porches of this are handsomely ornamented, and about 100 ft. from it rises a tall campanile, the inner walls of which have been covered in parts with frescoes of religious subjects, though these are now much defaced. But the most remarkable memorial of the middle ages that exists in all this district is the monastery of Sumelas, which is situated about 25 mi. from Trebizond, at the side of a rocky glen, at a height of 4,000 ft. above the sea. Its position is most extraordinary, for it occupies a cavern in the middle of the face oi a perpendicular cliff 1,000 ft. high, where the white buildings offer a marked contrast to the brown rock which forms their setting. It is approached by a zigzag path at the side of the cliff, from which a flight of stone steps and a wooden staircase give access to the monastery. An antiquity of 1,500 yr. is claimed for the foundation of the monastery, but it is certain that the first person who raised it to importance was the emperor Alexius Comnenus III of Trebizond, who rebuilt it in 1360.

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TREBONIUS, GAIUS (*d.* 43 B.C.), Roman general and politician. The son of an aristocrat, he favoured the conservative party during his quaestorship (60 B.C.), the first public office he held; but by the time he became tribune (55 B.C.), he had switched political beliefs and was a strong supporter of Caesar's party. He was responsible for the passage, over the opposition of the conservatives, of the so-called Lex Trebonia, which he sponsored at the instigation of the consuls of the year, Pompey and Crassus. This act provided that the provinces of Spain should be given to Pompey and the province of Syria to Crassus for an additional five years and that the two should have the power to levy troops both in the provinces and in Italy.

During the period of the Gallic Wars, Trebonius served as a general under Caesar, and at the final battle at Alesia he was one of Caesar's most trusted and valuable aides. During the Civil War he commanded three legions at the successful siege of Massilia. He was praetor in 48 B.C. and the following year was governor of farther Spain, a position he was forced to abandon when some of his troops mutinied.

In 45 B.C. Caesar made him consul, promising him also the governorship of Asia, but notwithstanding his friendship and patronage, Trebonius was one of the leaders in the conspiracy which resulted in Caesar's death. His assignment was to engage Mark Antony in conversation outside the senate while the other conspirators assassinated Caesar, and this duty he performed successfully. In 43 B.C. he became proconsul in Asia but had been in office only a short time when Publius Cornelius Dolabella, then governor of Syria, murdered him.

TRÉBUCHET, a mediaeval siege engine, employed either to batter masonry, or to throw projectiles over walls. It was developed from the post-classical Roman *onager* (wild ass), which derived its name from the kicking action of the machine. It consisted of a frame placed on the ground to which a vertical frame of solid timber was rigidly fixed at its front end. Through the vertical frame ran an axle, which had a single stout spoke; on the extremity of the spoke was a cup to receive the projectile. In action the spoke was forced down, against the tension of twisted ropes or other springs, by a windlass, and then suddenly released. The spoke thus kicked the crosspiece of the vertical frame, and the projectile at its extreme end was shot forward. In the trbbuchet the means of propulsion was a counterweight. The axle which was near the top of a high strutted vertical frame served as the bridge of a balance, the shorter arm of which carried the counterweight and the longer arm the carrier for the shot. An alternative name for the trébuchet is the mangonel (*mangonneau*). (*See* also ENGINES OF WAR.)

TREBULA, the name of five ancient towns in Italy. (1) TREBULA in Samnium, a town of the Caraceni, on the left bank of the Sangro, some 20 mi. below Castel di Sangro. It appears to have been a *municipium,* but we know only of its existence in Hadrian's time. (2) TREBULA in Campania, between Saticula and Suessula. The site is probably identical with the hills (about 1,000 ft. above sea level) above the entrance to the valley of Maddaloni. It is possibly the citizens of this Trebula who received Latin rights in 303 B.C. Its territory extended as far as the Via Appia, and its place was taken in imperial times by the Vicus Novanensis, on the road itself, near Suessula. (3) TREBULA BALLIENSIS, also in Campania, 22 mi. north of Capua, in the mountains, about 1,000 ft. above sea level. It revolted to Hannibal and was reduced to obedience by Fabius. Remains of walls, aqueduct and tombs exist. Its territory was mentioned in the projected distributions of land in Cicero's time and its wine was well thought of under Nero. It was a *municipium.* (4) TREBULA MUTUESCA in the Sabine country, 2 mi. east of the point where the Via Caecilia diverges from the Via Salaria. It lies about 1 mi. southwest of the modem Monteleone, and an amphitheatre and other remains are visible. In a dedication made there by the consul Mummius in 146 B.C. it is spoken of as a *vicus,* but when the *praefecturae* were abolished it became a *municipium.* The post station of Vicus Novus on the Via Salaria belonged to its territory. (5) TREBULA SUFFENAS is generally placed 6 mi. south of Reate (mod. Rieti, *q.v.*) on the Via Quinctia, but is with considerable probability identified with Ciciliano, 10 mi. east of Tivoli, 2,030 ft. above sea level, by O. Cuntz. There are remains of an ancient road with substructures in rough polygonal work ascending to it in zigzags.

TRÉCUL, AUGUSTE-ADOLPHE-LUCIEN (1818-1896), French botanist, was born in Mondoubleau, Loir-et-Cher, on Jan. 8, 1818. In 1848 he went to the United States where he remained for two years, studying the flora of the western and southern states, travelling as far west as the Rocky mountains and as far south as Texas and Mexico. He specialized particularly in plant morphology, being among the first to pursue this study systematically. His principal work is *Observations sur le fruit du prismatocarpus* (1842). The genus Treculia of the family Moraceae was named for him. Trécul died in Paris, Oct. 15, 1896.

TREDEGAR, an urban district in the Ebbw Vale parliamentary division of Monmouthshire, Eng., on the Sirhowy, 22 mi. N.N.W. of Newport and 29 mi. W. of Monmouth by road. Pop. (1951) 20,376. Area 12.7 sq.mi. In addition to the town of Tredegar the urban district contains the villages of Bedwellty Pits, Troedrhiwgwair, Trefil and Tafarnaubach. It stands about 1,000 ft. above sea level and owes its existence to the establishment at the beginning of the 19th century of large ironworks. With the use of coal for smelting purposes the region developed industrially. It has a spacious public park.

Coal mining is the chief industry and there are a number of factories.

TREDGOLD, THOMAS (1788–1829), English engineer, who wrote a pioneer work on the strength of materials, *Elementary Principles of Carpentry* (1820). Born near Durham, Aug. 22.

1788, he was apprenticed at the age of 14, after a few years at a village school, to a cabinetmaker in Durham where he worked for six years studying, during his spare time, the subjects of mathematics and architecture. During five years more in Scotland at his trade of joiner and carpenter he devoted all his extra energies to his learning—so much, indeed. as to undermine his health. He then spent six years in London in an architect's office, permitting him to extend his investigations to all subjects connected with architecture and engineering.

Several editions of *Elementary Principles* were published. In 1823, he struck out for himself and in 1824 published two editions of *Principles of Warming and Ventilating Public Buildings* and a third in 1836; A *Practical Treatise on Railroads and Carriages* (1825) ; and a pamphlet on steam navigation, 1825. His last significant work was the *Steam Engine* (1827), which went through three editions and was translated into French.

Tredgold edited other engineering works, contributed several articles to the periodicals of the day and to the 6th edition of Encyclopædia Britannica. He died at London, Jan. 28, 1829, leaving his widow and four children with little property. (W. E. HD.)

TREE, SIR HERBERT BEERBOHM (1853–1917), one of the great figures of the English theatre, who became the most successful actor-manager of his time, was born in London on Dec. 17, 1853, the son of Julius Beerbohm, a London merchant of German parentage; his half brother, Max Beerbohm (*q.v.*), became famous as a writer and caricaturist. Taking the stage name of Herbert Beerbohm Tree, he made his first professional appearance in London in 1876. He was a striking success in 1884 as the curate in *The Private Secretary*. In 1887 he became lessee and manager of the Haymarket theatre, which he ran with great success for ten years.

His range of plays and parts was very wide—dramas such as *Jim the Penman, The Red Lamp* and *A Man's Shadow*, modern dramas like H. A. Jones's *The Dancing Girl*, romantic parts such as Gringoire and literary plays such as W. E. Henley's *Beau Austin* made him outstanding. His Shakespearean productions carried on and even exceeded the beauty created by Henry Irving, and he proved the finest Falstaff and Malvolio the stage had seen, though his Hamlet was not so successful. But his performance as Svengali in *Trilby* put the crown on his career, being perhaps the best individual performance ever seen.

In 1897 Tree moved to the new Her Majesty's theatre, which he had built, and there produced all sorts of plays from poetic drama by Stephen Phillips to children's plays. His Shakespearean productions drew audiences from all over the world. Among the most remarkable were *Richard 11, King John, Henry VIII* and *A Midsummer Night's Dream*. His stage versions of Dickens' works were magnificent and his Fagin was outstanding. He was above all a romantic actor with a strong liking and genius for character parts and comedy, in which he was unequaled.

In 1904 he founded what is now the Royal Academy of Dramatic Art. He was knighted in 1909.

In 1882 Tree married Helen Maud Holt, who frequently acted with him. He died in London on July 2, 1917.

See Max Beerbohm, *Herbert Beerbohm Tree* (1920). (W. J. M.-P.)

TREE, a woody, perennial, seed-bearing plant which at maturity is at least 20 ft. tall and which is characterized by a single trunk that terminates in a well defined crown. Several ferns indigenous to lush, tropical rain-forests attain the stature of trees, but they are not usually regarded as such since reproduction of plants of this category is accomplished by means of spores.

The distinttion between small trees and large shrubs is often effected with difficulty and is occasionally further complicated by the fact that many tree species assume shrub-like habits at or near the extremities of their range or when growing under severe adverse conditions. It is of interest also to record that a few forms, as for an example, the strangler fig, are vine-like (lianas) during the early stages of their development and become tree-like only as they approach maturity.

Plants of arborescent proportions are found in both of the two major divisions of the spermatophyta; *i.e.*, the gymnosperms and the angiosperms (*qq.v.*). The gymnosperms are of very ancient lineage, and by means of fossil remains have been traced backward 300,000,000 yr. through the Carboniferous to the Devonian, where they occurred in great profusion and in vast unbroken forests over the land surfaces from pole to pole. Only a vestige of this once great flora remains; countless forms being long since extinct.

The modern gymnosperms comprise a group of four orders which include the cycads, the gnetums and their allies, the ginkgo and the conifers. Of these only the conifers are of primary economic importance. Several of them, notably the pines, spruces, Douglas-firs, redwood, cypresses, cedars, podocarps, araucarias and cryptomerias are productive of excellent timber. Coniferous wood, because of its long fibres and high cellulose content, is especially suited for pulp and paper manufacture. The wood of the spruces, balsam-firs, hemlocks, Douglas-fir and yellow pines is used in quantity for such conversion. Much of the cellulose employed in the manufacture of cellulose-acetate and cellulose-nitrate plastics is a highly purified form of spruce pulp. Naval stores, oils, resins, waxes, pharmaceutical compounds and gums are other derived products. Because of their pleasing symmetry, showy evergreen foliage and ready response to horticultural treatment, many conifers are prized for decorative purposes.

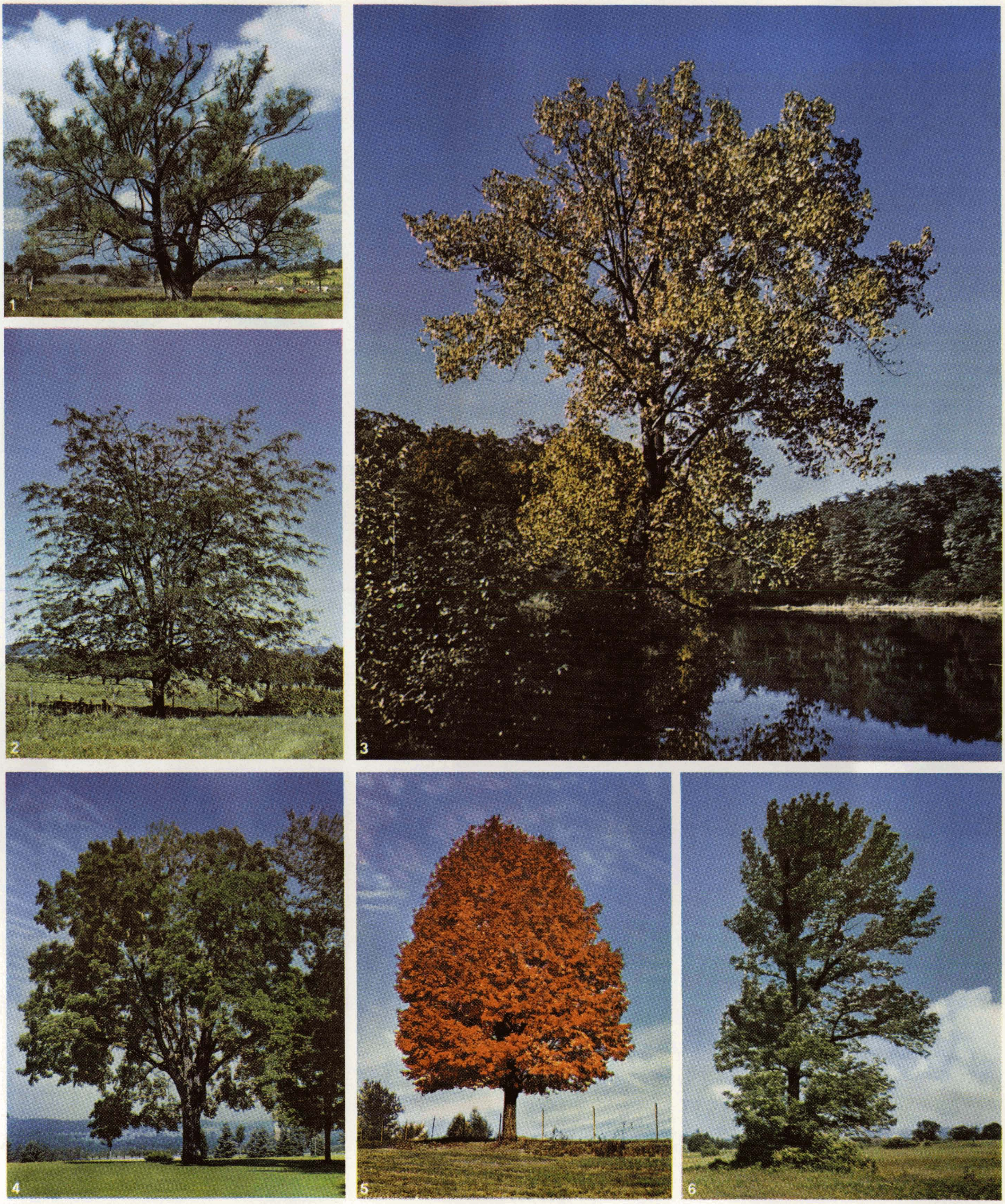
The angiosperms are the commonest and most widely distributed plants inhabiting the surface of the earth. Fossil evidence indicates that they are of comparatively recent origin, dating back only to the Jurassic (160,000,000 yr.). Since their evolution they have developed very rapidly; and today there are over 150,000 species, many of which are arborescent. This division of the seed-bearing plants is divided into two classes, the *Monocotyledoneae* and *Dicotyledoneae*, respectively. The former comprises but 8 orders; the latter, 32. Palms, yuccas and their allies are arborescent moncots. As a group they are of little value as timber trees, although certain species are sometimes cut and used in the ground for piling. This group of trees is better known for its food products which include the coco-nut, banana, date and sabal starch. The large fern-like leaves of many tropical species are used by aborigines for thatching huts.

Arborescent dicots are legion. Many are productive of excellent cabinet timbers, of tannin, dye principles, oils, waxes, perfumes, powerful alkaloids, pharmaceutical compounds, varnish components, gums and palatable fruits such as the citrus forms, apple and its allies, bread-fruit, mango, persimmon, pomegranate, etc.

Lumbermen, in an attempt to distinguish the broad-leaved species from the conifers, have designated them as the hardwoods and softwoods, respectively. These two terms are used merely to distinguish between classes of material and have no mechanical significance whatever since the range of mechanical properties manifested in each group is very broad.

The various species of trees are treated under their individual titles; *e.g.*, oak, ash, elm, etc.; the articles FIR and PINE treat of two large groups of conifers (*q.v.*); general information is provided by the articles PLANTS AND PLANT SCIENCE and GYMNOSPERMS. Tree cultivation will be found under FORESTS AND FORESTRY and HORTICULTURE, and the various types of trees whose wood enters into commerce under TIMBER. *See* also LANDSCAPE ARCHITECTURE and LUMBERING. (E. S. HR.)

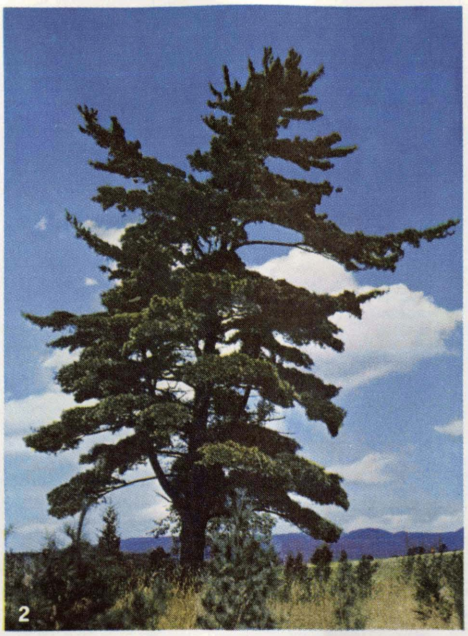
Tree planting involves the removal of a tree from one location and planting in another. In its original position the tree maintains a growth balance between the trunk and branches above ground and the roots below. The roots absorb water and mineral nutrients from the soil, and the growth of the top is limited by the amount of these materials which can be supplied. A portion of the water is transpired by branches (especially when in full leaf), and the remainder, together with the mineral nutrients, is the raw material from which organic food is synthesized. When a tree is lifted from the soil to be transplanted, a large part (25%–75%) of the root system must be cut off. Unfortunately, the terminal parts left behind are the most effective absorbing organs. The balance normally maintained between the top and the roots is, therefore, upset when a tree is lifted. For that reason it is advisable to prune off approximately $ of the branches of a transplant. Roots normally extend far beyond the base of the tree

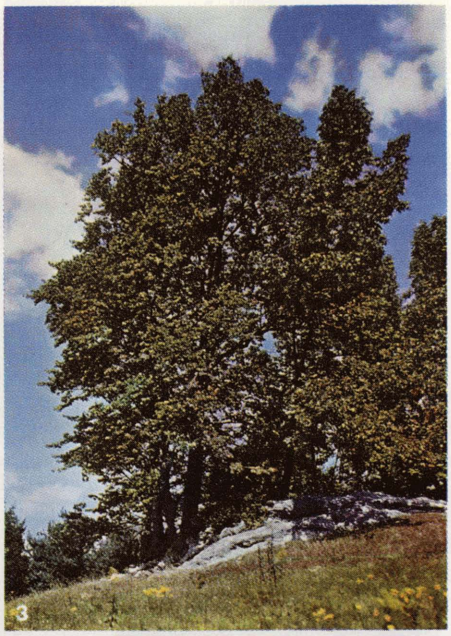


PHOTOGRAPHS, RUTHERFORD PLATT

TREES OF NORTH AMERICA

1. Black willow (*Salix nigra*). This tree reaches a height of 120 ft. and a trunk diameter of 3 ft.
2. Common honey locust (*Gleditsia triacanthos*). The maximum height is 75–140 ft.; the trunk usually has a diameter of 2 or 3 ft., sometimes 5 or 6 ft.
3. Quaking or American aspen (*Populus tremuloides*), often called a poplar, to which genus it belongs. It has a maximum height of 100 ft. and a trunk diameter of 3 ft., but is usually smaller
4. Sugar maple (*Acer saccharum*). It sometimes grows to a height of 120 ft., with a trunk 4 ft. in diameter
5. A sugar maple in fall
6. White ash (*Fraxinus americana*). It grows to a height of 120 ft. and often has a trunk diameter of 5 ft.





PHOTOGRAPHS, RUTHERFORD PLATT

TREES OF NORTH AMERICA

1. White oak *(Quercus alba)*. Full height, 80-100 ft.; trunk diameter, 3 4 ft.
2. White pine *(Pinus strobus)*. Some attain a height of more than 200 ft., and a trunk diameter of 4-6 ft. or more
3. Linden (Lime), often called basswood. There are a number of North American species
4. American elm *(Ulmus americana)*. Full height, 100-120 ft.; trunk diameter, 6-11 ft.
5. Paper birch *(Betula papyrifera)*. Full height, 60-70 ft.; trunk diameter, 2-3 ft.

PHOTOGRAPHS, (TOP LEFT, TOP RIGHT, BOTTOM RIGHT) IRVIN L. OAKES FROM NATIONAL AUDUBON SOCIETY, (BOTTOM LEFT) J. HORACE McFARLAND COMPANY

TREES OF NORTH AMERICA

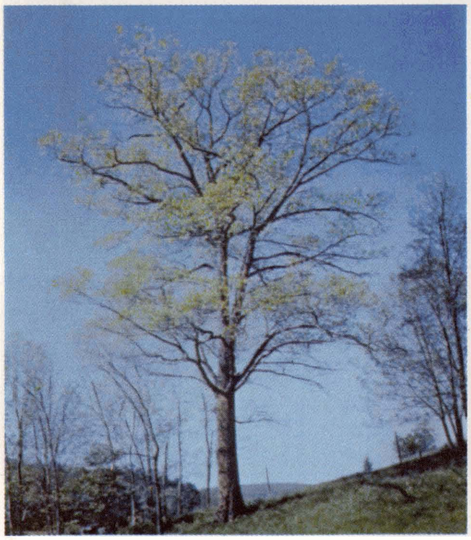
Top left: Sycamore ***(Platanus occidentalis)***, the most massive hardwood trees in the eastern United States. It averages 60–120 ft. in height

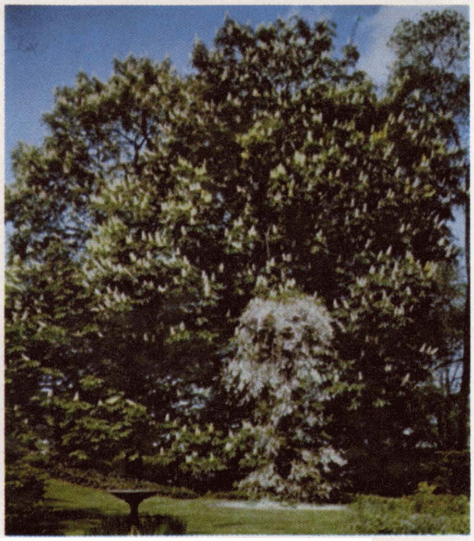
Top right: Eastern cottonwood ***(Populus deltoides)***. This tree has a broad, open crown supported by a massive trunk. Average height is 80–100 ft.

Bottom left: Flowering dogwood ***(Cornus florida)***, the most important of some 60 species, many of which are native to North America. Occasionally attains height of 40 ft.

Bottom right: Sassafras ***(Sassafras albidum)***. Little more than a shrub in the north, it attains heights of 40–90 ft. in the south

TREE





PHOTOGRAPHS, (TOP LEFT, TOP RIGHT) W. H. HODGE, (CENTRE RIGHT, BOTTOM LEFT, BOTTOM CENTRE) RUTHERFORD PLATT, (BOTTOM RIGHT) J. HORACE MCFARLAND COMPANY

TREES OF NORTH AMERICA

Top left: **Tuliptrees (*Liriodendron tulipifera*), also** known as **yellow-poplars,** are allied to the magnolia family. **Tuliptrees** reach a height of **190** ft. and a diameter of **10** ft. They are **characterized** by a straight trunk with **deeply** furrowed bark

Top right Everglade palms **(*Paurotis wrightii*),** native *to* Florida, reach a height of about 30 ft. and usually grow In **large thickets**

Centre right: Joshuatree (*Yucca* ***brevifolia*****),** found in the southwest and in California. Photograpn shows a small **specimen, but Joshuatrees** may **grow** 35 ft. high

Bottom left: Bur oak **(*Quercus macrocarpa*) leafing** out in the **spring.** One of the largest American oaks, the bur is usually about **80 ft.** high at maturity but may grow to **170** or **180** ft.

Bottom centre: **Shagbark** hickory **(*Carya ovata*). Widely** distributed throughout eastern United States, the **shagbark** grows **to** a height of **120** ft. with a diameter of about 3 **ft.** its long **plates** *of* gray bark are **distinctive**

Bottom right: Horse **chestnut (*Aesculus hippocastanum*)** covered with flower **clusters.** Height, **60 ft. or more**

PHOTOGRAPHS, (TOP LEFT, TOP CENTRE, TOP RIGHT, BOTTOM LEFT, BOTTOM CENTRE, CENTRE RIGHT) RUTHERFORD PLATT, (BOTTOM RIGHT) W. H. HODGE

CONIFER TREE8 OF NORTH AMERICA

Top left: **Engelmann spruce (*Picea engelmannii*),** a tree of high altitudes native to the Rocky mountains. **It grows** from 20 to **150 ft. high**

Top centre: **Bigtree** or **Giant Sequoia (*Sequoiadendron*** gigantea) **has** been known to stand over **300** ft. **high** with a 35-ft. diameter and to exceed 3,000 years in age

Top right: Douglas-flr (***Pseudotsuga menziesii***), commonly **180-190 ft.** high with a slender trunk, **sometimes** attains a height of **250** ft. **and** a **trunk diameter of 10–12 ft.**

Bottom left: Western hemlock (***Tsuga heterophylla***), often **200** ft. **high** with a trunk diameter from 6–10 ft.

Bottom centre: Eastern red cedar (*Juniperus* ***virginiana***); generally net more than 40–50 ft. high, **it** occasionally **stands** over 100 ft.

Centre right: **Piñon** pine (***Pinus edulis***), **most widely** distributed nut pine of the Southwest, averages **15-20** ft. in height.

Bottom right: Bald cypress (***Taxodium distichum***), a deciduour **conifer,** native of southern United States and Mexico. Average height is 170 **ft.**





PHOTOGRAPHS (ALL EXCEPT BOTTOM LEFT) J. ALLAN CASH, (BOTTOM LEFT) J. HORACE MCFARLAND COMPANY

TREES COMMON IN ENGLAND

Top left: Rows of beech trees (*Fagus sylvatica*) In autumn foliage
Top right: Beech trees (*Fagus sylvatica*) at Burnham Beeches
Centre left: Apple trees (*Malus*) in bloom. The Romans are believed to have introduced the tree to England
Bottom left: Weeping willow (*Salix babylonica*) is an ornamental tree both in England and the US. It is native to China
Bottom right: Qrove of young English oaks (*Quercus robur*) in the autumn

trunk, depending upon the species, the physical condition of the soil and the water supply. For example, a willow tree 4 ft. high growing in sandy soil was found to have a lateral root system 50 ft. in length. A much larger tree in a clayey soil with a high water level had a root system only 10 ft. long. Some species like pine, spruce and holly have what is known as "tap roots"; that is, primary roots uhich tend to taper off from the trunk and grow straight down from the tree. Other species have semi-tap roots with many lateral roots which grow in all directions but not far below the surface of the soil.

The immediate problem in transplanting shrubs or trees is to provide a set of conditions which will keep the plants from drying out until new roots can be regenerated. The top of the plant must remain more or less at a standstill until the new roots are formed and begin to function as absorbing organs. When the natural balance between the roots and the top has been re-established, new branches with green leaves appear and the tree resumes natural growth.

The best time to transplant deciduous trees such as elm, apple, cherry, maple, linden and oak is when they are dormant, without leaves. In the temperate zone of the United States fall and spring planting is practised. In the southern part of the zone, where the ground rarely freezes, planting may be practised during the winter. In tropical or subtropical regions, planting can be done at any season if water and soil requirements are provided.

The size of trees to be planted may vary from one-year-old seedlings a few inches in height to large trees six to ten feet in height. Ten to 20-year-old trees can be moved, but only with special equipment and by expert workmen.

The size of the hole prepared for planting must be determined by the size of the root system of the tree. A root system with a two-foot spread would require a hole 3 to 4 ft. wide and 2 ft. deep. When the transplant is in position, the ground level should be from one to five inches above the original level, which can usually be seen on the trunk. The soil which is removed from the hole can be used to refill around the tree. It is often advisable to discard poor soil and replace with good soil to tamp around the roots. Well-rotted manure and fertilizer are sometimes used when trees are transplanted; however, inexperienced gardeners often injure the trees with this practice. If manure and fertilizer are used, they should be mixed well with soil and placed in the bottom of the hole with an inch or more of soil on top. The fertilizer should not come in direct contact with the roots. If used to the extent of one tablespoonful of commercial fertilizer per gallon of soil, it should not injure the tree. After the tree is established, fertilizer can be broadcast on the ground above the roots and turned under with a spade, care being taken not to dig out the roots.

Evergreen trees such as pine, spruce, fir, hemlock and holly are far more difficult to transplant than the average nursery stock. Nurserymen usually move such plants with a ball of earth around the roots held together with burlap. If plants are properly root-pruned a year or two before digging, they will have a goodly number of fibrous roots near the plant which can be included in the ball. It is usually best to transplant evergreens growing in the temperate regions of the United States in late summer, but they can be successfully planted also in the spring. The requirements as to the size of the hole in which to set the tree, the soil and fertilizer for evergreens are similar to those described for deciduous trees.

The water supply for transplanted trees is important. More failures result from a water shortage than from most other causes. It is advisable to plant the tree as soon as possible after lifting and to water it immediately after planting. It is advisable not to fill the hole entirely with soil so that the water will not run off. After the first soaking the tree should be watered at least once a week or more. Thereafter the hole should be filled and the soil kept cultivated until the tree is established. If there is a shortage of rain, it may be necessary to water transplanted trees throughout the summer months. *See* also ARBORICULTURE.

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(P. W. Z.)

TREE BEAR, a name given in West Africa to the tree hyrax *(Dendrohyrax). See* HYRACOIDEA.

TREE BURIAL. Among the Andamanese, burial upon a platform placed in a tree is an honourable form of burial and adopted only in the case of a man or woman dying in the prime of life. It is not clear whether this honour is reserved for those who have had children—the point may be significant. A tree sometimes used for this purpose is *Ficus laccifera,* allied to the fig, and the belief of the natives is apparently that the souls of unborn children live in these trees and that if a baby dies before it has been weaned its soul goes back to the tree. *(See* A. R. Brown, *The Andaman Islanders* [1922].)

In Australia tree burial is forbidden to those who violate the law of exogamy—who are thereby excluded from reincarnation. In Indonesia "the position with regard to tree burial may be put in this way, that wherever a myth of origin exists which states that the first men came from trees or bamboos, then it will generally be found that the dead are placed in trees or disposed of in a way derived from tree disposal" (W. J. Perry, *Folklore,* xxvi, pt. 2, p. 147). There are cases of tree burial in central India among the primitive Gonds; the semi-Hinduized Gonds in Bengal tie the corpses of adult males to a *malua* tree previous to burial. The Oraons "revere the tamarind and bury their dead in its shade. One special rite among the Dravidian races is the *imli ghoutna* or 'the gnnding of the tamarind' when the mother of the bridegroom grinds on the family curry stone some pods of the tamarind" (W. Crooke, *Popular Religion of Northern India,* vol. i, p. 109).

TREE CREEPER, one of the smaller British birds, and generally distributed. It is *Certhia familiaris,* and is remarkable for the stiffened shafts of its long and pointed tail feathers, aided by which, and by its large feet, it climbs the trunks or branches of trees, proceeding upward or outward, generally in a spiral direction, as it seeks the small insects that are hidden in the bark and that form its chief food. It never climbs head downward as the nuthatch (*q.v.*) does. Inconspicuous in its upper plumage of brown mottled with white, buff and tawny—for the silvery white of its underparts is not usually visible—the tree creeper is commoner than the incurious suppose; though a shy singer, its song is loud and sweet. The nest is placed behind a half-detached piece of bark, and a mass of material is used to give a sure foundation for the tiny cup, in which are laid from six to nine eggs of a translucent white, spotted or blotched with rust colour.

The tree creeper inhabits almost the whole of Europe as well as Algeria and has been traced across Asia to Japan. It is an inhabitant of the greater part of North America. On the European continent a second species, *C. brachydactyla,* is found. This is similar to C. *familiaris* in appearance but has a quite different song and lives in gardens and parks rather than in woodland.

Allied to the tree creeper, but without its stiff tail feathers, is the genus *Tichodroma,* the single member of which is the beautiful wall creeper *(T. muraria)* of the Alps and some other mountainous parts of Europe and Asia. It is occasionally seen in Switzerland, fluttering up the face of a rock, conspicuous from the scarlet-crimson of its wing coverts and its white spotted primaries. Its bright hue is hardly visible when the bird is at rest, and it then presents a dingy appearance of gray and black. It is a species of wide range, extending from Spain to China.

The passerine family *Certhiidae* contains a number of genera of birds to which the general name "creeper" is applied; they occur in North America, Europe and Asia, the greater part of Africa, and Australia and New Guinea.

TREE CULTS. Primitive man, observing the growth and death of trees, the elasticity of their branches, the sensitiveness and the annual decay and revival of their foliage, anticipated in his own way the tendency of modern science to bridge the gulf between the animal and the vegetable world. Sober Greek philosophers (Aristotle, Plutarch) thought that trees had perceptions, passions and reason. The beliefs of primitive man were part of a small stock of fundamental ideas which persist in one form or another over a large portion of the world and have found a place in the higher religions.

Trees and Human Life.—Numerous popular stories reflect a firmly rooted belief in an intimate connection between a human being and a tree, plant or flower. Sometimes a man's life depends upon the tree and suffers when it withers or is injured. and we encounter the idea of the *external soul*, already found in the Egyptian "Tale of the Two Brothers" of 3,000 years ago. Here one of the brothers leaves his heart on the top of the flower of the acacia and falls dead when it is cut down. Sometimes, however, the tree is an *index,* a mysterious token which shows its sympathy with an absent hero by weakening or dying as the man becomes ill or loses his life. These two features easily combine and represent a mysterious sympathy between tree and human life, which, as a matter of fact, frequently manifests itself in recorded beliefs and customs of historical times. Thus, sometimes a newborn child is associated with a newly planted tree with which its life is supposed to be bound up; or, on ceremonial occasions (betrothal, marriage. ascent to the throne), a personal relationship of this kind is instituted by planting trees, upon the fortunes of which the career of the individual depends. Sometimes, moreover, boughs or plants are selected, and the individual draws omens of life and death from the fate of his or her choice. Again, a man will put himself into relationship with a tree by depositing upon it something which has been in the closest contact with himself (hair, clothing, etc).

The custom of transferring disease or sickness from men to trees is well known. Sometimes the hair, nails, clothing, etc., of a sickly person are fixed to a tree; or they are forcibly inserted in a hole in the trunk, or the tree is split and the patient passes through the aperture. Where the tree has been thus injured, its recovery and that of the patient are often associated. In India when a man is supposed to be tormented by a demon, ceremonies are performed to provide it with a tree where it will dwell peacefully without molesting the patient so long as the tree is left unharmed. Such ideas do not enter, of course, when the rite merely removes the illness, but endangers the health of those who approach the tree. Again, sometimes it is believed that man's personality is mystically united with some healthy and sturdy tree, and in this case we may often presume that such trees already possessed some appropriate reputation. Again hair, nail-clippings, etc., are hung upon a tree for safety's sake lest they fall into the hands of an enemy.

Spirits in Trees.—Among the Arabs the sacred trees are haunted by angels or by *jinn;* sacrifices are made, and the sick who sleep beneath them receive prescriptions. Here, as frequently elsewhere, it is dangerous to pull a bough. This dread of damaging special trees is familiar: Cato instructed the woodman to sacrifice to the male or female deity before thinning a grove *(De re rustica,* 139), while in the Homeric poem to Aphrodite the tree nymph is wounded when the tree is injured and dies when the trunk falls. Early Buddhism decided that trees had neither mind nor feeling and might lawfully be cut; but it recognized that certain spirits might reside in them, and this the modern natives of India firmly believe. Propitiation is made before the sacrilegious axe is laid to the holy trees; loss of life or of wealth and the failure of rain are feared should they be wantonly cut; and there are even trees which it is dangerous to climb. The Talein of Burma prays to the tree before he cuts it down, and the African woodman will place a fresh sprig upon the stump as a new home for the spirit. In the Gold Coast the silk-cotton and odum (poison) trees are especially sacred as the abode of the two deities, who are honoured by sacrifices--even of human victims; these can be felled only after certain purificatory ceremonies. In general, sacred trees must not be injured unless they (*i e.,* their spirits) have been appeased or means taken to provide the occupant with another abode. That the difference between the sacred *object* and the sacred *occupant* was not always clearly drawn is quite intelligible from those beliefs of much less rudimentary religions which confuse the unessential uith the essential.

Forms of Cult.—Often the tree is famous for oracles. One of the best known is the oak of Dodona tended by priests who slept on the ground. The tall oaks of the old Prussians were inhabited by gods who gave responses, and the old Hebrews had their "terebinth of the teacher" (Gen. xii, 6), and "terebinth of the diviners" (Judg. ix, 37). Sacred trees are also the object of pilgrimage, one of the most noteworthy being the branch of the Bo tree at Ceylon brought thither before the Christian era. Again, tree-spirits will hold sway over the surrounding forest or district, and the animals in the locality are sacred and must not be harmed. Thus, the pigeons at the grove of Dodona, and the beasts around the north European tree-sanctuaries, were left untouched; even as the modern Dyak allows no interference with the snake by the side of the bush which enshrines a dead kinsman. Sacred fires burned before the Lithuanian Perkuno and the Roman Jupiter; both deities were closely associated with the oak, and, indeed, according to Frazer, the oak seems to have been very commonly used for the perpetual holy fires of the Aryans.

The powers of the tree-deities, though often specially connected with the elements, are not necessarily so restricted, and the sacred trees can form the centre of religious, and sometimes, also, of national life. Such deities are not abstract beings but are potent and immediate, and the cultus is primarily as utilitarian as the duties of life itself. They may have their proper ministrants: the chief sanctuary of the old Prussians was a holy oak around which lived priests and a high priest known as "God's mouth"; in Africa there are sacred groves into which the priest alone may enter, and among the Kissil-Bashi (or Kizilbashes) of the Upper Tigris and Euphrates, the holy tree of the village stands in an enclosure to which only the father-priest has access. The trees may be the scene of religious festivals and of periodical fairs and markets. Among the Lousiade group in British New Guinea the religious feasts are held under the sacred tree and a portion is laid aside for the spirit-occupants. That the invisible spirit naturally enjoyed only the *spiritual* part of the offerings is a belief which has been shared by others than the African Negro (Tylor ii, 216). Human sacrifice is known on the Slave Coast and in the Punjab; it was practised among the Druids and at Odin's grave at Uppsala. It is also said that the pollution of old Prussian sacred groves and springs by the intrusion of Christians was atoned for by human victims.

Development of Ideas.—As ideas advanced, the spirits associated with trees were represented by posts, idols or masks; altars were added, and the trunk was roughly shaped to represent the superhuman occupant. There is reason to believe that the last-mentioned transformation has frequently happened in the development of iconography. Indeed, the natives of the Antilles suppose that certain trees instructed sorcerers to shape their trunks into idols and to instal them in temple-huts where they could be worshipped and could inspire their priests with oracles. When the tree-spirit was conceived to be of human shape the numerous stories which associate trees with men or deities of flesh and blood would easily arise; and just as Indian natives have gods which are supposed to dwell in trees, so in higher religions we find a Zeus or a Dionysus *Endendros,* gods, "occupants of trees," who have been identified with one or other of the leading members of a recognized pantheon.

Syrian writers speak of a "king of the forest" and of a tall olive tree to the worship of which Satan seduced the people. But these "trees of the demons" were hewn down by zealous Syrian Christians. So also the caliph Omar cut down the tree at Hodaibaya visited by pilgrims lest it should be worshipped, and the Council of Nantes (A.D. 895) expressly enjoined the destruction of trees which were consecrated to demons.

Tradition has preserved some recollections of the overthrow of tree-cult in Europe. Bonifacius destroyed the great oak of Jupiter at Geismar in Hesse and built of the wood a chapel to St. Peter. (A similar continuity was maintained near Hebron when Constantine destroyed the idols and altars beneath the oak or terebinth of Abraham at Mamre and replaced them by a basilica.) On the Heinzenberg near Zell the Chapel of Our Lady stands where the old tree uttered its complaint as the woodman cut it down; and at Kildare (*cilldara,* church of the oak), "Saint" Brigit or Bridget built her church under an oak tree.

On the other hand. at Samosata, the sacred tree worshipped in Christian times was honoured as the wood of Christ's cross.

TREE FARMING: *see* FORESTS AND FORESTRY.

TREE FERN: *see* PTERIDOPHYTA.

TREE FROG in a general sense is a term identifying any tailless Amphibia *(see* FROG) adapted to arboreal life. The term in a special sense, or tree toad, which is equivalent, is often used for the family Hylidae.

The adaptation for an arboreal existence is indicated by adhesive discs on the tops of the fingers and toes. These discs adhere by rapid and intense pressure of the distal phalanx and special muscles upon the lower surface, which is also provided with glands producing a sticky secretion.

The family Hylidae is related to the Bufonidae or toads, being distinguished by the presence of teeth in the upper jaw and by the clawlike shape of the terminal phalanx of the digits. It is a large family, with about 300 species, 250 of which belong to the genus *Hyla,* distributed over Europe, temperate Asia, North Africa, North and South America, New Guinea and Australia.

The best-known European tree frog is the little *Hyla arborea,* which rarely reaches two inches in length. Its upper parts are smooth and shiny, normally of a bright grass green, which may change rapidly to yellow, brown, olive or black; some specimens, however. are sky blue or turquoise blue; the lower parts are white. The commonest North American species are *H. versicolor,* green, gray or brown, with a loud croaking voice, and *H. crucifer,* the spring peeper, having a shrill piping voice.

Other genera of the Hylidae include *Gastrotheca* of South America, which, in the female, develops a broad dorsal pouch in which the eggs undergo their development, and *Phyllomedusa,* also from tropical America, which has the inner finger and toe opposable to the others. Frogs of the latter genus deposit their spawn bet een the leaves of branches overhanging water, into which the tadpoles drop and spend their larval life. (K. P. S.; X.)

TREE KANGAROO, the name of certain arboreal marsupials. forming the genus *Dendrolagus (see* MARSUPIALIA). Four species are inhabitants of New Guinea and two others are found in north Queensland, in dense scrub high up on the mountains. They are nocturnal in habit and feed on bark, leaves and fruit. Reaching a length of four feet (half of which is tail), the tree kangaroo is shorter and broader than the true kangaroo and has relatively shorter hind limbs and longer. more robust fore limbs with strong curved and pointed claws. The flesh of the Queensland species is much prized by the Australian aborigines.

TREE MARRIAGE. In Chota Nagpur, the tribes who speak languages of the Munda group, and in Bengal, low castes such as the Rautias, Bagdis and Murmis, perform the rite of tree marriage as an integral part of the marriage service. The nuptial pair are fastened to trees by thread. The trees selected are either the mahua or the mango, the two most important and conspicuous trees in that area. In the marriage rites for a number of castes in Mysore, whose language is Dravidian, the marriage is celebrated in a booth, one of the posts of which is called the milk post. This, so we are told, is to secure the continuity of the line, and it has to be cut by the maternal uncle—the male representative of an important social grouping. A fig tree is here specified, while in parts of the Punjab, a branch of a jhand tree. *Prosopis spicigera,* is essential to the due performance of the marriage rites. Quite obviously, trees of such economic importance as the mahua, the mango, the jhand and the fig are selected as conspicuously, essentially fertile, but it is not a general fertility, but a specific fertility, that must be looked for as the reason for their selection. They are associated with the beliefs of the people as to the fate of those who are destined or desired to return and be reborn. In general, too, trees, notably the pipal, are in India associated with the spirits, and for this reason barren women walk around them in order that they may be fertilized by a spirit denizen of the tree. In west Africa "nearly all Yoruba believe that souls about to be born live in or among trees, and it is for this reason that women so often pray to the tree spirits to send them children." (P. A. Talbot, *The Peoples of Southern Nigeria,* vol. ii, p. 267.)

There are cases where tree marriage affords a means of attaining the social status of marriage, as where a bachelor who seeks to marry a widow is obliged to marry a tree, which is then cut down. He is then a widower, equal in status with his human bride. It may be a substitute and intended to avoid the curse of widowhood, or to confer the status of married woman on a girl, and thus escape the social and religious penalties attaching to those whose daughters do not marry. Lastly, there is the common practice in India of marrying a newly-constructed tank to a plantain tree for the purpose of blessing the tank.

Tree marriage is part of a series of rites by means of which the continuity of the group life is secured.

TREE SHREW, a small, arboreal, insectivorous mammal of the family Tupaiidae, found in southern Asia and in the islands of the Malay archipelago. It is squirrellike but has a long pointed muzzle; the teeth are like those of the Insectivora *(q.v.)*, and the eye socket is ringed by bone. The common tree shrews *(Tupaia)* are dark olive brown with bushy tails. Pen-tailed tree shrews *(Ptilocercus)* are dark gray-brown with a black facial mask and narrow tail, ending in a featherlike tuft; they are found in Malaya, Sumatra, Borneo and Palawan. Slender-tailed tree shrews *(Dendrogale)* occur in Indochina and Borneo; a similar genus *(Urogale)* is found in Mindanao, the Philippines. Tree shrews, active during the day, feed on insects, some vegetable matter and the young and eggs of birds. Mammals of this type doubtless gave rise to the Primates *(q.v.)*, and some authorities classify these forms with that order. (J. E. HL.)

TREE TOAD: *see* TREE FROG.

TREGELLES, SAMUEL PRIDEAUX (1813–1875), English biblical scholar, editor of a critical text of the New Testament, was born at Wodehouse place, near Falmouth, on Jan. 30, 1813. His parents were Quakers, and he himself for many years was in communion with the Darbyite Plymouth Brethren but afterward became a Presbyterian. For a time he worked at the ironworks, Neath abbey, Glamorgan, and then set up as a private tutor in Falmouth, finally devoting himself to a laborious student life, until he was incapacitated by paralysis in 1870. He died at Plymouth, April 24, 1875.

Most of Tregelles' numerous publications had reference to his critical edition of the New Testament, which he began to plan in 1838. Between 1854, when *An Account of the Printed Text of the Greek New Testament* appeared, and 1870 he published the texts of all the books of the Kew Testament except Revelation. Tregelles wrote also *Heads of Hebrew Grammar* (1852), translated Gesenius' *Hebrew Lexicon* and was the author of a little work on the *Jansenists (1851)* and of various works in exposition of his special eschatological views.

TREILHARD, JEAN BAPTISTE (1742–1810), French revolutionary, was born at Brives (Corrèze). In Paris he gained reputation as an *avocat* at the *parlement,* and was a deputy to the states-general in 1789. In the constituent assembly he showed great capacity in dealing with the reorganization of the church and in the nationalization of ecclesiastical property. Ineligible, like all the members of the constituent assembly, for the legislative assembly, he became president of the criminal tribunal of Paris, but failed through lack of firmness. The *département* of Seine-et-Oise elected him to the Convention, where he attached himself to the group known as The Mountain and voted for the death of Louis XVI. He was a member of the committee of public safety, and became president of the Convention on Dec. 27, 1792.

Under the directory Treilhard entered the Council of the Five Hundred (of which he was president during the month of Nivose, year IV), was a member of the Tribunal of Cassation, plenipotentiary at the congress of Rastatt and became a director in the year VI.

After the *coup d'état* of 18 Brumaire he became president of the tribunal of appeal and councilor of state. He took an important part in drafting the civil code, the criminal code, the code of civil procedure and the commercial code.

Treilhard died on Dec. 1, 1810, a senator and count of the empire.

TREINTA Y TRES, a department in east-central Uruguay, bordering on Lake Merim across from Brazil. Pop. (1954 est.) 80,923; area 3,743 sq.mi. The north and northwest parts of Treinta y Tres reach heights of between 650 ft. to almost 1,000 ft. above sea level, high elevations for low lying Uruguay. The eastern area is level and some corn and wheat are grown there. The principal activity is cattle and sheep ranching on the high rolling lands which make good pastures. The Olimar river drains much of the area. (M. I. V.)

TREINTA Y TRES, capital of the department of Treinta y Tres, Uruguay, is a short distance north of the Olimar river, 200 mi. N.E. of Montevideo. Pop. (1954 est.) 19,400. The city and the department are named for the band of 33 (Spanish, *treinta y tres)* patriots who, commanded by Juan Antonio Lavalleja, in 1825 began the campaign which ultimately produced Uruguay's independence from both Brazil and Argentina. The city, like other Uruguayan departmental capitals, is built around a square with the government house and the parish church as the principal buildings. There is a park on the banks of the Olimar. Treinta y Tres is connected by rail and road with Montevideo and other points, and has an airport. The city's principal function, aside from administration of the department's political, judicial and police affairs, is as a commercial and cattle trading centre. (M. I. V.)

TREITSCHKE, HEINRICH VON (1834–1896), German historian and political writer, the son of a Saxon officer, was born at Dresden on Sept. 15, 1834. Prevented by deafness from entering the public service, he studied at Leipzig and Bonn, where he was a pupil of Dahlmann. He established himself as a *Privatdozent* at Leipzig, lecturing on history and politics, and at once became very popular with the students, but his political opinions made it impossible for the Saxon government to appoint him to a professorship. He was at that time a strong Liberal; he hoped to see Germany united into a single state with a parliamentary government, and all the smaller states swept away. In 1863 he was appointed professor at Freiburg; in 1366, at the outbreak of war, he showed his Prussian sympathies by moving to Berlin, became a Prussian subject, and was appointed editor of the *Preussische Jahrbücher*.

After holding appointments at Kiel and Heidelberg, Treitschke was in 1874 made professor at Berlin; he had already in 1871 become a member of the *Reichstag,* and from that time until his death in 1896 he was one of the most prominent figures in the city. On Sybel's death he succeeded him as editor of the *Historische Zeitschrift.* He had outgrown his early Liberalism and become the chief panegyrist of the house of Hohenzollern.

Treitschke did more than any one else to mold the minds of the rising generation, and he carried them with him even in his violent attacks on all opinions and all parties which appeared in any way to be injurious to the rising power of Germany. He supported the government in its attempts to subdue by legislation the Socialists, Poles and Roman Catholics; and he was one of the few men of eminence who gave the sanction of his name to the attacks on the Jews which began in 1878. As a strong advocate of colonial expansion, he was a bitter enemy of Great Britain; and he was to a large extent responsible for the anti-British feeling of German chauvinism during the last years of the 19th century. In the *Reichstag* he had originally been a member of the National Liberal party, but in 1879 he was the first to accept the new commercial policy of Bismarck, and in his later years he joined the Moderate Conservatives.

Treitschke died at Berlin on April 28, 1896.

As a historian Treitschke confined himself to those periods and characters in which great political problems were being worked out; above all, he was a patriotic historian, and he never wandered far from Prussia.

His great achievement was the *History of Germany in the Nineteenth Century* (Eng. trans. by E. and C. Paul, 7 vol. 1915–19). The first volume was published in 1879, and during the next 16 years 4 more volumes appeared, but at his death he had advanced only to the year 1847. The work shows extreme diligence and scrupulous care in the use of authorities. It is discursive and badly arranged, but it is marked by a power of style, a vigour of narrative and a skill in delineation of character which give life to the somewhat unattractive period of German history with which he was concerned; notwithstanding the extreme spirit of partisanship and some faults of taste, it remains a remarkable monument of literary ability.

The most important of the essays were collected under the title *Historische und politische Aufsatze (4* vol., 1896) ; a selection from his more controversial writings was made under the title, *Zehn Jahre deutscher Kämpfe;* in 1896 a new volume appeared, called *Deutsche Kämpfe, neue Folge.* After his death his lectures on political subjects were published under the title, *Politik* (Eng. trans., 2 vol., 1916). He brought out also in 1856 a short volume of poems called *Vaterlandische Gedichte,* and another volume in the following year. His *Briefe,* edited by M. Cornicelius, 3 vol. (1859–96), were reprinted at Leipzig (1913–20).

TRELAWNY, EDWARD (1699–1754), British governor of Jamaica, was born in Trelawne. Cornwall, in 1699, and attended Christ Church college, Oxford. In 1732 he entered parliament as member for West Looe, Cornwall. In 1736, after several terms in parliament, he was appointed governor of Jamaica. He took office two years later, on April 30, 1738. Trelawny's first task as governor was to suppress the war between the native Negroes, known as Maroons, and the whites on the island. The struggle was a long-standing one but within **a** year Trelawny had concluded a peace which gave the Maroons their freedom and assigned to them 1,500 ac. of land, the chief town of which was for many years known as Trelawnytown. In return, the Negroes were to assist the colony in the event of war with an outside power and deliver fugitive slaves to the government. Scarcely had this difficulty been settled when England became embroiled with Spain in the War of Jenkins' Ear, so-called because of the alleged amputation of the ear of an English seaman. Robert Jenkins, by Spanish sailors. Trelawny not only assisted Adm. Edward Vernon in mapping strategy but took. a personal role in the fighting. Trelawny resigned from office in 1751 and left Jamaica in 1752. He died in London, Jan. 16, 1754.

TRELAWNY, EDWARD JOHN (1792–1881). English sailor and friend of Shelley and Byron, was born in London on Nov. 13, 1792. After a short term in the navy and a naval school, he shipped for India but deserted at Bombay. For several years he led an adventurous life in India, but about 1813 returned to England. Early in 1822 he met Shelley and Byron at Pisa and passed nearly every day with one or both of them until the drowning of Shelley (*q.v.*) and Williams on July 8. He superintended the recovery and cremation of the bodies, snatching Shelley's heart from the flames. He added the lines from the *Tempest* to Leigh Hunt's "Cor Cordium"; and, finally, he supplied the funds for Mrs. Shelley's return to England.

In 1823 he set out with Byron for Greece, to aid in the struggle for independence. Distressed by his companion's dilatoriness, Trelawny left him and joined the insurgent chief, Odysseus, and afterwards married his sister. Tersitza. While in charge of the former's fortress on Parnassus, he was assaulted by two Englishmen and nearly killed. Returning to England, he lived for a time in Cornwall with his mother and afterward in London.

Permission having been refused him to write the life of Shelley, he began an account of his own life in the *Adventures of a Younger Son* (1835; new ed. by E. C. Mayne, 1925), followed much later by a second part: *Recollections of Shelley and Byron* (1858), which was recast as *Records of Shelley, Byron and the Author* in 1878 (new ed. by E. Dowden, 1906). This gives an admirable portrait of Shelley and a less truthful one of Byron.

He died at Sompting. near Worthing, on Aug. 13, 1881.

TRELAWNY, SIR JONATHAN, Bart. (1650–1721), English prelate, was born at Pelynt, Cornwall. on March 24, 1650. Educated at Westminster school and at Christ Church, Oxford, Trelawny took holy orders in 1673. Having rendered good service to James II during Lionmouth's rebellion, Trelawny was consecrated bishop of Bristol on Nov. 8, 1685. He was loyal to King James until the first declaration of indulgence in April 1687, when, as a bishop, he used his influence with his clergy against the king, and, as a Cornish landowner, resisted the attempt to assemble a packed parliament.

In May 1688 Trelawny signed the petition against the second declaration of indulgence and in the following month was imprisoned in the Tower of London with Sancroft and five other bishops, sharing their triumphant acquittal. In spite of Burnet's assertion, it is probable that Trelawny did not sign the invitation to William of Orange. although he certainly welcomed his army into Bristol. Before this James II. anxious to regain the bishop's support, had nominated him to the see of Exeter, but Trelawny lost nothing as this appointment was almost at once confirmed by William III. Unlike five of his colleagues among the "seven bishops," Trelawny took the oaths of allegiance to William and Mary, but he was soon estranged from the new king and sided with the princess Anne.

In 1707 Trelawny was appointed bishop of Winchester and became prelate of the Order of the Garter. but henceforward he took very little part in politics. He died at his residence at Chelsea on July 19, 1721, and was buried at Pelynt.

Trelawny is the hero, or one of the heroes, of the refrain of R. S. Hawker's modern ballad:

"And shall Trelawny die,
Here's twenty thousand Cornishmen
Will know the reason why."

TREMATODES (FLUKES), a class of Platyhelminthes (*q.v.*), in uhich the body is unsegmented and without a cellular epidermis or external cilia, and an alimentary canal is present. All the members of the group are parasitic.

General Morphology. — The body is generally flattened and leaf-like or ribbon-like in shape, but may be relatively stout and oval or circular in transverse section. One or more muscular suckers are usually present on the ventral surface. In general structure the Trematodes closely resemble the free-living Turbellaria (q u.). They differ from them in the development of suckers and other organs for attachment to the host, and in the absence (in the adult) of a ciliated epidermis.

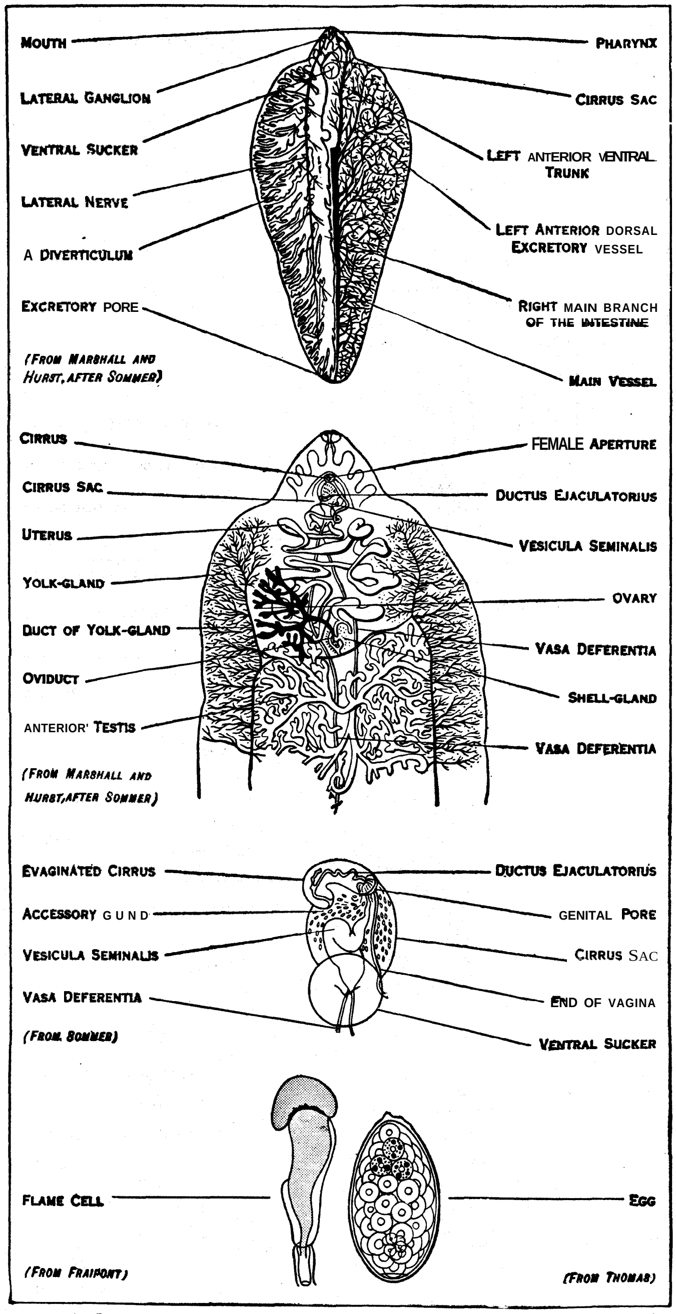
The external covering is a stout cuticle, often armed with spines, below which is a subcuticular layer containing unicellular glands. The number and arrangement of the suckers are very variable. Usually there is an anterior sucker or pair of suckers, and a posterior sucker, or a posterior disk-like organ of attachment provided with subsidiary suckers or with cuticularized hooks of various kinds. The complex development of the posterior organ of attachment is characteristic of the ectoparasitic forms (Monogenea). In endoparasitic forms (Digenea) the posterior sucker is usually a simple muscular disk or cup and may be situated at the posterior end of the body, but is more often displaced anteriorly so as to lie in front of the middle or even close behind the oral sucker.

Pigment is rare in Trematodes, but occurs in the parenchyma of certain species, more especially among the Monogenea. The body of endoparasitic species may, honever, appear more or less brightly coloured on account of the contents of the intestine and uterus, and the vitelline glands. showing by transparency.

The musculature usually consists of an outer circular and an inner longitudinal layer of fibres. Oblique and dorso-ventral fibres are also frequently present.

Except in one family, the mouth is situated at or near the anterior extremity. It may open through an anterior. or oral, sucker or, in certain ectoparasitic forms, may be flanked by a pair of adoral suckers. The alimentary canal may be a simple, blind sac, but usually consists of a relatively short median anterior portion and two posterior branches arising by the bifurcation of the former. These branches may be simple or secondarily branched, and may join again posteriorly, or may remain distinct. In the great majority of forms they are without any posterior opening, but in a few species they have been found to open to the exterior by one or a pair of pores. The median anterior portion of the gut may be differentiated into a muscular sucking bulb, or pharynx, and a simple tubular portion between this and the bifurcation, called the oesophagus.

The whole of the space between the wall of the alimentary canal and the external cuticle is filled up with a spongy connective tissue, or parenchyma, in which the other organs are embedded, as in other classes of Platyhelminthes. The nervous system consists of a pair of central ganglionic masses (the "brain"), situated anteriorly and dorsally, and longitudinal nerve-cords (of which there may be as many as four pairs) running posteriorly throughout the body, and connected at intervals by transverse



AFTER (A, B, C.) SOMMER IN "ZEITSCHRIFT FUR WISSENSCHAFTLICHE ZOOLOGIE," (ENGELMANN), (D) FRAIPONT IN "ARCHIVES DE BIOLOGIE" (MASON & CO.), (E) THOMAS IN "QUARTERLY JOURNAL OF MICROSCOPIC SCIENCE" (CLARENDON PRESS)

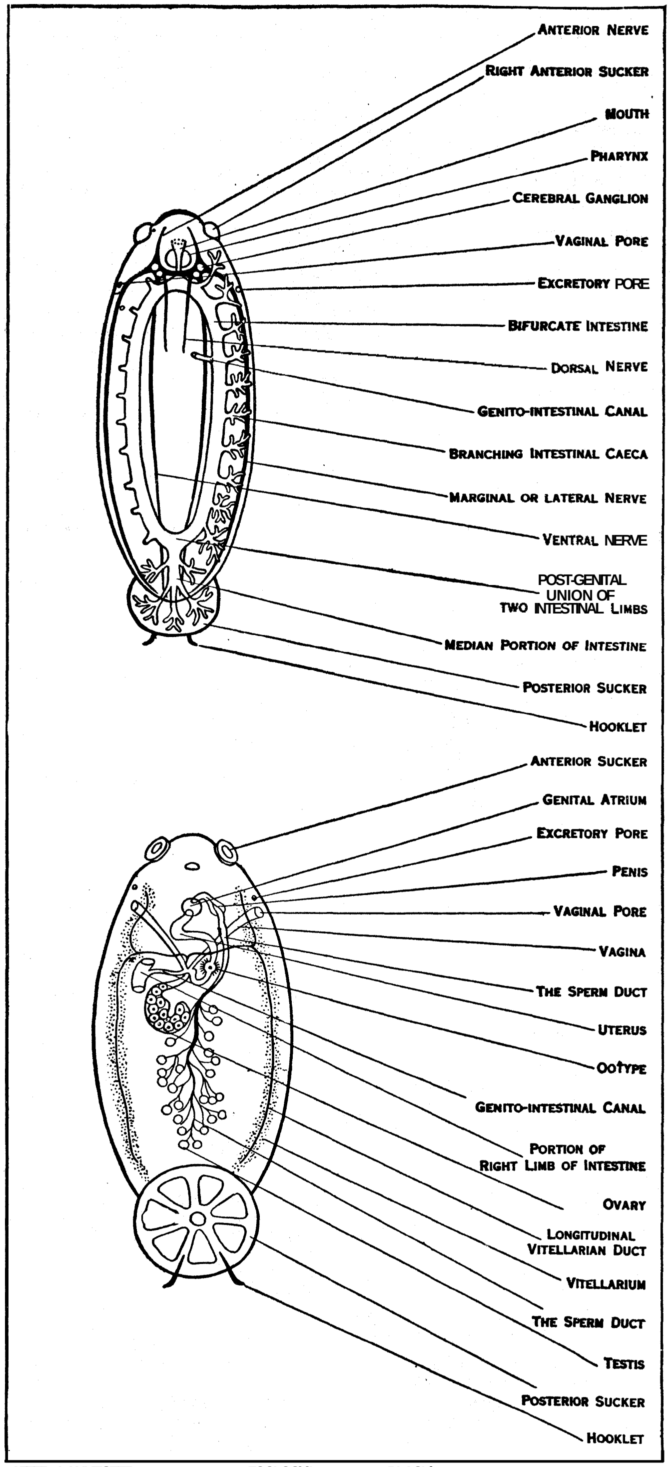
FIG. 1.—LIVER-FLUKE (FASCIOLA HEPATICA), SHOWING FROM ABOVE DOWNWARDS. VENTRAL ASPECT, ANTERIOR PORTION MORE HIGHLY MAGNIFIED, GENITAL SINUS AND OTHER PARTS. FLAME CELL FROM EXCRETORY APPARATUS. EGG

commissures. Eyes are present in some of the ectoparasitic forms, and in the larval stages of some endoparasitic species, but are absent in the adults of the latter. There may also be "tactile cones" on the surface of the cuticle, consisting of small elevations surmounted by groups of stiff cilia.

The excretory system is composed, as in other Platyhelminthes, of branching canals whose smallest branches end in flame-cells.

There are usually two main longitudinal canals, which may open independently, through a pair of excretory sacs, on to the dorsal surface, or may lead into a common posterior "bladder."

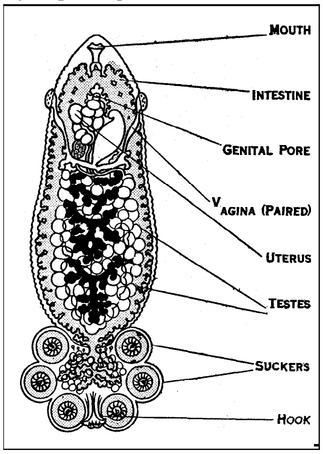
With few exceptions, the Trematodes are hermaphrodite. The complex system of genital organs is arranged on the same general plan as in other groups of Platyhelminthes, but is subject to much variation in details, and is of great importance from the taxonomic standpoint. The testes are almost invariably paired, and are usually compact organs, though they may be deeply lobate or even elaborately branched. The male ducts unite and open through a muscular intromittent organ, or cirrus, which is usually contained in a special pouch (the cirrus-sac). The ovary is single, and, like the testes, may be compact or more or less branched. The vitellaria generally consist of two lateral series of follicles, those of each side being connected by branching ducts with a main yolk-duct, and the two main ducts crossing the body to join in the median region, near the shell-gland.



AFTER LANKESTER. "TREATISE ON ZOOLOGY" (A. & C. BLACK)

FIG. 2.—SCHEMATIC FIGURE OF A MONOGENETIC TREMATODE, ILLUSTRATING STRUCTURE (AFTER BENHAM)

In ectoparasitic forms there is a vagina, opening to the exterior by a pore quite distinct from that of the uterus, or there may be a pair of such structures. In the endoparasitic forms (Digenea) a duct known as Laurer's canal, springing from the oviduct and either opening on the surface of the body or ending blindly below the skin, is usually present. The eggs, after being fertilized and supplied with yolk, are enclosed in a cuticularized shell of variable form, sometimes stalked or with terminal filaments, and very commonly provided with an operculum at one end.

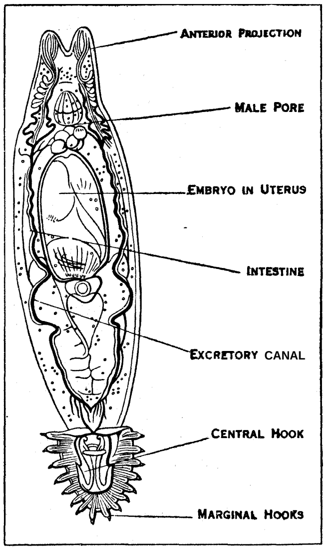


FROM "ZEITSCHRIFT FUR WISSENSCHAFTLICHE ZOOLOGIE" (ENGELMANN)

FIG. 3.—VENTRAL VIEW OF *POLYSTOMUM INTEGERRIMUM* (AFTER ZELLER)

Classification.—The division of the class Trematoda into two main orders, Monogenea and Digenea. proposed by van Beneden in 1858, is still accepted by modern authorities. These orders represent two well marked groups differing fundamentally in structure, habits and life-history.

The order Monogenea comprises forms of almost exclusively ectoparasitic habit. without an alternation of generations in their life-history, and having the following structural peculiarities, among others. The mouth is simple and is not surrounded by an oral sucker, though paired accessory suckers may be present in its neighbourhood. The posterior sucker may be single (but in this case is usually of complex structure and often provided with accessory cuticularized organs of attachment) or there may be a number of paired posterior suckers, which also have cuticularized armatures. There is a vagina, or a pair of vaginae. distinct from the uterus, and there are usually paired excretory pores situated dorsally near the anterior end of the body.



FROM "ARCHIV FÜR ANATOMIE, PHYSIOLOGIE UND WISSENSCHAFTLICHE MEDIZIN" (DE GRUYTER & CO.)

FIG. 4—VENTRAL VIEW OF GYRODACTYLUS ELEGANS (AFTER WAGENER)

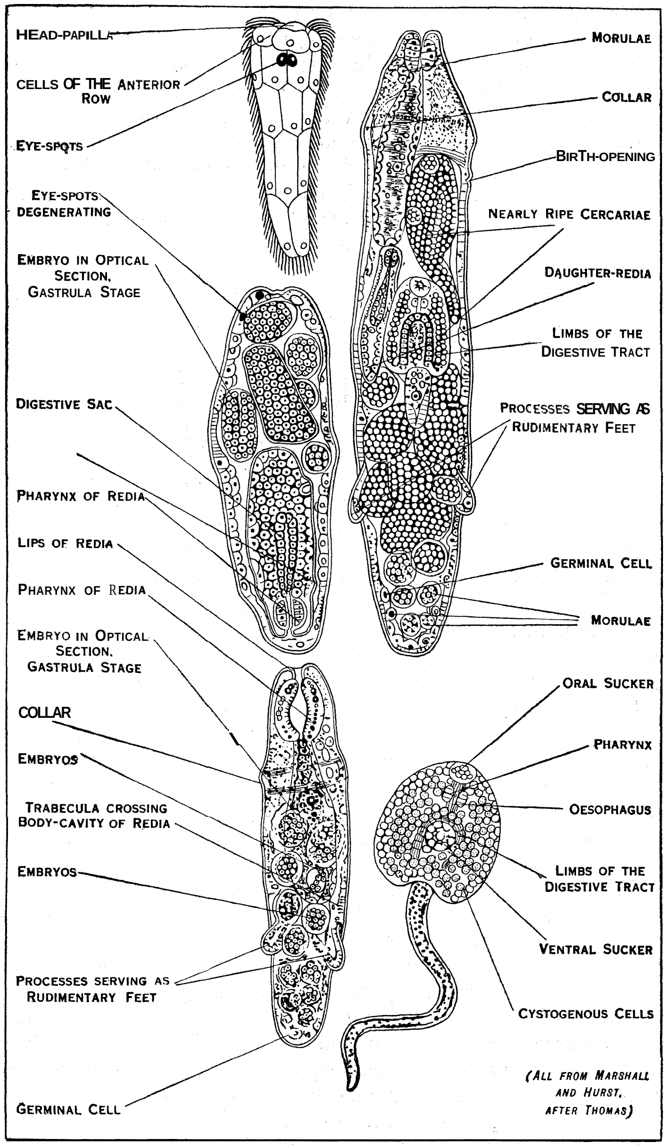
These forms live mainly on the external surface or on the gills of fishes and other cold-blooded aquatic animals, and feed on mucus and other matter, or occasionally on the blood of the host. The order includes 13 families, among which are the Tristomatidae, Gyrodactylidae, Polystomatidae and Octocotylidae.

The order Digenea includes all the forms which live as endoparasites within the bodies of other animals. These have a complex life-history involving an alternation between a sexual phase and an asexual or polyembryonic phase of multiplication. They have an oral sucker surrounding the mouth, and usually a posterior sucker which is a simple muscular organ without armature. There is no vagina, as distinct from the uterus, and the excretory pore is usually single and posterior.

The adult forms occur in all classes of vertebrates, the larval forms in both vertebrates and invertebrates.

The old order Aspidocotylea, for many years merged with the

Prosostomata, is again recognized as distinct. It comprises a few genera, as *Aspidogaster* and *Cotylaspis,* parasitic in molluscs, fish and turtles, with simple life cycles and with or without alternation of hosts. They are distinguished by the large ventral sucker sub-



FROM THOMAS IN "QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE" (CLARENDON PRESS)

FIG. 5.— FIVE STAGES IN THE LIFE-HISTORY OF THE LIVER-FLUKE
Above, the miracidium; left centre, a sporooyst containing young rediae; right centre, adult redia containing daughter redia and two almost mature cercariae; left bottom, a young redia; right bottom, a free cercaria (all highly magnified)

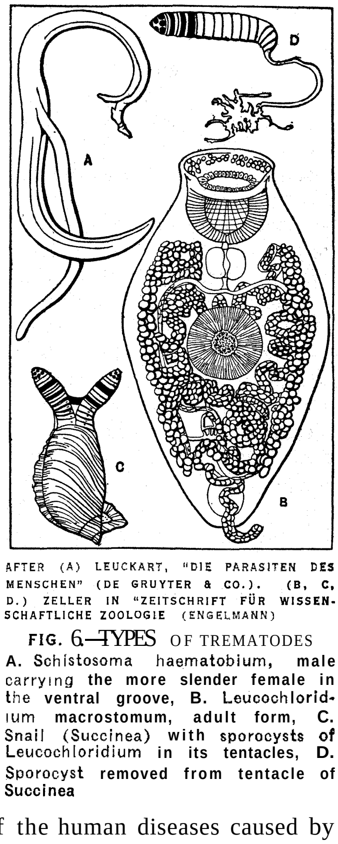
divided into longitudinal rows of compartments.

Development and Life-histories.—The eggs of the Monogenea are either deposited in water or attached to the host by means of stalk-like processes. In some cases (*Gyrodactylus,* a parasite of the gills of minnows and other fishes) but a single egg is produced at a time, and this develops nithin the body of the parent into an embryo, within which another embryo is formed before its birth. There may be a ciliated free-snimming larval stage, as in *Polystomum* (a form inhabiting the bladder of frogs and toads). The larva of this form invades the gill chamber of tadpoles. and migrates by way of the alimentary canal to its definitive habitat. *Diplozoon* (found on the skin of the minnow) also has a free-swimming stage, and is remarkable for the fact that tno larvae (called *Diporpae*) unite, each holding the other by its ventral sucker, and fuse into a single X-shaped organism, the two original sets of genitalia becoming permanently interconnected. In other cases there appears to be no free-swimming stage, and the larvae hatching from the eggs develop directly into the adult form.

In the Digenea the development is indirect, and may involve one or more changes of host, and sometimes a free-swimming stage. The life-history of the liver-fluke of the sheep and other animals may be taken as typical. This form, as an adult fluke, inhabits the bile-ducts of the vertebrate host. The eggs are passed out of the host's body with the faeces, and hatch in a short time in the open if the conditions of moisture and temperature are suitable. The embryo, on escaping from the egg, is a ciliated organism known as a *miracidium*, provided with a pair of eye-spots and an anterior boring organ. It swims about until it meets with a suitable intermediate host (certain snails—in Europe, *Limnaea truncatula*). Boring its way into this through the skin, it sheds its ciliated coat and penetrates into the internal organs. Here it grows into an irregular, sac-like body known as a sporocyst. Within this there are formed by budding numerous bodies called rediae. The redia has an oral sucker and a sac-like intestine. Each redia gives rise, by internal budding. either to a further generation of rediae or to larvae of a different type, called cercariae. The cercaria is somewhat tadpole-like, having a broad body and a narrow tail. It has two suckers and a bifurcate intestine. The cercaria escapes from the snail and swims or ariggles about in water, finally coming to rest on some solid body, such as a blade of grass, where it loses its tail and secretes round itself a "cyst." Should this be swallowed by a suitable vertebrate animal, the cercaria is liberated from the cyst and migrates into the body-cavity and thence into the liver, where it grows into an adult fluke.

An interesting modification of the life-history is found in the genus *Leucochloridium.* The sporocyst of this form sends branches into the head and tentacles of its snail host. The branches are brightly coloured and capable of pulsating movements. making the snail conspicuous and particularly liable to the attacks of birds. The transference of the cercariae contained within the snail to suitable final hosts among the birds is thus ensured.

In most genera the cercariae, instead of remaining passive until swallowed, swim about in water and penetrate actively through the skin either of the final or of a second intermediate host. The fork-tailed cercariae of the blood-flukes (*Schistosoma*) thus attack man and other warm-blooded vertebrates, and the adults inhabit the blood-vessels. The human lung-fluke, *Paragonimus,* leaves its first intermediate host (a mollusc) as a cercaria, and enters certain fresh-water crabs and crayfishes, in which it becomes encysted. Human infection, in the Orient, is acquired by eating these animals. Several small flukes belonging to the genera *Opisthorchis, Clonorchis* and *Metagonimus* make use, in a similar manner, of fresh-water fishes as second intermediate hosts, the first host being always, so far as is known, a snail.



AFTER (A) LEUCKART, "DIE PARASITEN DES MENSCHEN" (DE GRUYTER & CO.). (B, C, D.) ZELLER IN "ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE (ENGELMANN)

FIG. 6.—TYPES OF TREMATODES
A. Schistosoma haematobium, male carrying the more slender female in the ventral groove, B. Leucochloridium macrostomum, adult form, C. Snail (Succinea) with sporocysts of Leucochloridium in its tentacles, D. Sporocyst removed from tentacle of Succinea

Economic Importance.—Schistosomiasis (or Bilharziosis) is probably the most important of the human diseases caused by Trematodes. In Egypt and many other parts of Africa two species of *Schistosoma,* S. *haematobium* and S. *mansoni*, are prevalent. The former also occurs in Asia, certain localities in the south of Europe, and Australia, and the latter in the West Indies and South America. In the Far East their place is taken by a third species, S. *japonicum*. These flukes inhabit the mesenteric and portal veins, and their eggs cause obstruction and rupture of the capillaries either in the wall of the bladder or in that of the bowel, with consequent haemorrhage and ulceration.

The cotnmon liver-fluke *(Fasciola hepatica)* is an important parasite of sheep, sometimes causing serious and fatal outbreaks of the disease known as "liver-rot." As a human parasite this worm is rare, but certain smaller liver-flukes (*Opisthorchis* and *Clonorchis*) are not uncommon in eastern countries.

The lung-fluke, *Paragonimus westermani*, is a human parasite of some importance in the Far East, and occurs also in South America and Mexico. The various species of flukes appear to be. on the whole, of little economic significance. (H. A. B ; X)

TREMBLEU, ABRAHAM (1710–1784), one of the outstanding biologists of the 18th century, best known for his *Mémoires* (1744) on the fresh-water polyp, hydra, was born at Geneva on Sept 3, 1710, of a family prominent in the history of that city. He made his chief discoveries between 1739 and 1747, while tutor to two boys at The Hague.

Trembley was the first to prove conclusively that reproduction by budding occurs among animals; the first to show that certain animals can be artificially multiplied by division; the first to make permanent grafts of animal tissues; and the first to witness the multiplication of Protozoa by division and true cell division in algae. He superintended the young duke of Richmond in a grand tour around Europe (1752–56). The duke was so generous in his recognition of Trembley's services that the latter never again had occasion to earn his living. After marriage in 1757 Trembley settled near Geneva and devoted himself to the education of his children and to religious, philosophical and political studies. He died at his home on May 12, 1781.

See J. R. Baker, *Abraham Trembley of Geneva,* etc. *(1952).*

(J. R. Br.)

TREMOLITE: *see* AMPHIBOLE.

TRENCH, RICHARD CHENEVIX (1807–1886), Anglican archbishop and poet, was born at Dublin on Sept. 9, 1807. He was educated at Harrow, and Trinity college, Cambridge. While incumbent of Curdridge chapel near Bishops Waltham, Hants, he published (1835) *The Story of Justin Martyr and Other Poems,* which was favourably received, and was followed in 1838 by *Sabbation, Honor Neale, and Other Poems,* and in 1842 by *Poems From Eastern Sources.* He became rector of Itchenstoke (1845), Hulsean Lecturer (1845–46) and professor of divinity at King's college, London. In 1851 he wrote *The Study of Words,* followed by *English Past and Present* (1855) and *A Select Glossary of English Words* (1859). All have gone through numerous editions and have contributed much to promote the historical study of the English tongue. His paper, read before the Philological society "On Some Deficiencies in Our English Dictionaries" (1857), gave the first impulse to the great Oxford *New English Dictionary.* His advocacy of a revised translation of the New Testament (1858) helped to promote another great national undertaking. In 1856 he published a valuable essay on Calderon, with a translation of a portion of *Life Is a Dream* in the original metre. In 1841 he had published his *Notes on the Parables,* and in 1846 his *Notes on the Miracles,* popular works which are treasuries of erudite and acute illustration.

In 1856 Trench was raised to the deanery of Westminster. There he instituted evening nave services. In Jan. 1864 he was advanced to the more dignified but less congenial post of archbishop of Dublin. He died in London on March 28, 1886.

See his *Letters and Memorials,* 2 vol. *(1886).*

TRENCHARD, HUGH MONTAGUE TRENCHARD, 1ST VISCOUNT (1873–1956), British air marshal whose energy and foresight laid the foundations of Royal Air Force (R.A.F.) efficiency, was born on Feb. 3, 1873, at Taunton, Somerset. Entering the army in 1893, he served in the South African War and later in Nigeria. Invalided home in 1912, he learned to fly and in 1913 became assistant commandant of the central flying school. As commander of the royal flying corps during World War I he began the offensive policy which became traditional to the R.A.F., and in Jan 1918 became first chief of air staff. He resigned in April but in 1919 nas recalled when Winston Churchill was appointed air minister, and remained until 1929, becoming the first marshal of the R.A.F. in 1927. His emphasis on staff training led to the foundation of Cranwell cadet college, the Andover staff college and the apprentices' school at Halton, and also to the introduction of auxiliary squadrons and the system of short service commissions. As commissioner of the metropolitan police, 1931–35, he introduced far-reaching reforms, including a short-term service plan and increased application of scientific methods to police nork. His founding of the Hendon Police college to train men from the ranks and from outside as officers caused much controversy. During 1936–53 he was chairman of the United Africa company. He was created a baronet in 1919. baron in 1930 and viscount in 1936; in 1951 he was awarded the Order of Merit. He died in London on Feb. 10, 1956.

TRENCH WARFARE, the term applied to tactics resorted to nhen defensive fire power compels the opposing forces to "dig in" so extensively as to sacrifice mobility to gain protection. The tactical ancestor of modern trench warfare may be found in the system worked out for the attack of fortresses by Sabastien Le Prestre de Vauban (*q.v.*) during the wars of Louis XIV of France. A typical defense complex of World War I had as its basic elements three lines facing the enemy — first, second and reserve lines of trenches comparable to Vauban's three parallels *(see* FORTIFICATIONS). They were linked from front to rear by communication trenches serving the same purpose as Vauban's approaches, which enabled the besiegers to remain under cover while passing from one parallel to another.

The Standard Trench. — The elements of the standard trench have changed but iittle since Vauban's day. Earth from the excavation is used to create parapets both to the front and rear. Within the trench are firing positions, and duck boards provide dry footing The network of trenches defending a sector of any importance becomes in effect a military community — an intricate system of command posts, forward supply dumps, first aid stations, kitchens, latrines, mortar and machine gun emplacements and dugouts deep enough to shelter large numbers of troops during an enemy bombardment.

Trenches follow a zigzag or curving course to localize casualties from a shell explosion and to limit the effectiveness of flanking small arms fire. When fire power becomes so destructive that men can survive only by burrowing into the earth, they accept immobility reluctantly as a lesser tactical evil. Offensive operations of trench warfare are usually confined to raids, patrols and harassing fires, but commanders plan to launch an attack at the first opportunity for the purpose of smashing through the opposing trenches and resuming a warfare of mobility.

The Petersburg lines, as the foremost example of trench warfare in the 19th century, held the Federal and Confederate forces deadlocked during the final months of the American Civil War. Defensive fire power was so deadly that neither army could gain more than a fleeting advantage, and even the explosion of an enormous Federal mine failed to gain a decision.

In World War I, the opposing trenches of the western front, stretching from the North sea to Switzerland, were manned by millions of troops after the mobile warfare of the early months shattered against the destructiveness of the machine gun. By day no sign of life could be seen in a ravaged landscape pocked with shell holes and bristling with barbed wire. The slightest movement in chis "no man's land" was enough to arouse the nervous chatter of a machine gun or the cough of a mortar.

Similar lines of trenches scarred the earth in eastern Europe and the Italian foothills of the Alps. So complex were these systems that the military catacombs had to be identified by names and numbers. The trenches even had their own diseases (trench mouth and trench foot) afflicting men who lived underground.

Observation balloons and reconnaissance aircraft were the "eyes" of the hidden armies. Generalship sank to dismal depths in efforts to blast a path with hundreds of massed guns for infantry frontal attacks. Gains of a few hundred yards, achieved at a frightful cost in casualties, were reported in front-page headlines.

These futile offensives seldom penetrated as far as the enemy's rear areas. After three years of trench warfare the earthbound armies of France, Italy, Austria and Russia were corroded by defeatism.

Eventually the tactical countermeasure to the machine gun was found in the tank (*q.v.*), which restored mobility to the western front in the summer of 1918. But many thousands of men had died during the two years when British and French generals failed to make decisive use of a weapon introduced in 1916.

The Korean War.—Trench warfare mas the exception in World War II, and not until the last two years of the Korean war did it have a revival conditioned by mountain terrain. Red China's tactical system, developed during long years of civil war, was based on semiguerrilla night attacks combined with the defense of earthworks by day. "Better to sweat now than to bleed later," was a motto of Mao Tse-tung's soldiers, who had no superiors in their ability to burrow or to infiltrate enemy positions with noiseless stealth on the darkest night.

By 1952 two opposing belts of trenches crossed the Korean peninsula. Judged by World War I standards, each United Nations division defended a huge sector. Beyond a thinly held main line of resistance were outposts reached by communication trenches. They were manned by picked troops who gave the alarm by radio if an enemy attack threatened. The main body of troops was sheltered by trenches and log-faced bunkers—the equivalent of the World War I dugout. Both sides set out nightly reconnaissance patrols and occasionally launched attacks on a local front.

The Chinese often went to such elaborate lengths as tunneling through a hilltop to the military crest facing the enemy. Mortars or howitzers were fired from these camouflaged outlets and withdrawn to escape enemy counterbattery fire. Such outposts served as a first line of resistance for Chinese who could retreat to trenches on the topographical crest or retire through the tunnel to bunkers on the reverse slope.

Chinese defenses in depth, sometimes including every hill in a belt five to ten miles wide, could be penetrated by United Nations forces only at a prohibitive cost in casualties. Thus the conflict turned into a prolonged stalemate which ended with both sides holding the same ground they had occupied for the past two years.

That trench warfare may have a future in the atomic age is indicated by tests held during the 1950s at the Nevada proving grounds of the U.S. Atomic Energy commission. Troops kneeling in trenches were found to be protected from atomic blast effects at distances much nearer to ground zero than had originally been thought possible.

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TRENCK, FRANZ, FREIHERR VON DER (1711–1749), Austrian soldier, was born on Jan. 1, 1711. Educated by the Jesuits at Sopron (Oldenburg), he entered the Imperial army in 1728 but resigned in disgrace three years later. In 1737 he offered to raise an irregular corps of "Pandours" against the Turks, but this offer was refused and he then entered the Russian army. After serving against the Turks for a short time he was accused of bad conduct, brutality and disobedience, and condemned to death, the sentence being commuted to degradation and imprisonment.

Trenck returned to Austria, but came into conflict with every one and actually took sanctuary in a convent in Vienna. Prince Charles of Lorraine obtained for him an amnesty and a commission in a corps of irregulars. At the battle of Soor his irregulars plundered when they should have been fighting and Trenck was accused of having allowed the king of Prussia to escape. He was condemned to death, but the sentence was commuted by the queen into one of cashiering and imprisonment for the rest of his life. He died on Oct. 4, 1749.

His cousin, FRIEDRICH, FREIHERR VON DER TRENCK (1726–1794), the writer of the celebrated autobiography, was born on Feb, 16, 1726, at Konigsberg. He entered the Prussian army in 1742 and became an orderly officer on Frederick's own staff. But within a year he fell into disgrace because of a love affair—whether real or imaginary—with the king's sister Princess Amalie, and in 1743 Frederick had him arrested and confined in the fortress of Glatz, whence in 1746 he escaped. In 1754 he visited Prussia, but was there arrested and confined for ten years. After the close of the Seven Years' War, Maria Theresa requested his release. Returning to his Hungarian estates, he composed his autobiography and undertook various diplomatic or secret service missions. He went to Paris in 1791 to witness the Revolution. He was denounced as an Austrian spy and guillotined on July 24, 1794.

TRENDELENBURG, FRIEDRICH ADOLF (1802–1872), German philosopher and philologist., who reverted to Aristotelian principles in his criticism of the 'prevailing Kantian and Hegelian systems, was born on Nov. 30, 1802, at Eutin near Liibeck. He was educated at the universities of Kiel, Leipzig and Berlin. He became more and more attracted to the study of Plato and Aristotle, and his doctor's dissertation was an attempt to reach through Aristotle's criticisms a more accurate knowledge of the Platonic philosophy (*Platonis de ideis et numeris doctrina ex Aristotele illustrata,* 1826). He spent seven years as tutor in a private family, occupying his leisure in preparing a critical edition of Aristotle's *De anima* (1833). In 1833 K. von Altenstein, Prussian minister of education, appointed him extraordinary professor in Berlin; four years later Trendelenburg was advanced to an ordinary professorship.

In 1865 he engaged in an acrimonious controversy on the interpretation of Kant's doctrine of space with Kuno Fischer, whom he attacked in *Kuno Fischer und sein Kant* (1869), which drew forth the reply *Anti-Trendelenburg* (1870). He died in Berlin on Jan. 24, 1872.

Das Naturrecht auf dem Grunde der Efhik (1860) may be taken as in a manner the completion of Trendelenburg's system, his working-out of the ideal as present in the real. The ethical end is taken to be the idea of humanity, not in the abstract as formulated by Kant, but in the context of the state and of history. Law is treated throughout as the vehicle of ethical requirements. The state he held to be the ethical organism in which the individual (or "potential" man) first emerges into actuaiity.

Trendelenburg was also the author of the following works: *Elementa logices Aristotelicae* (1636; Eng. trans. 1881), a selection of passages from the *Organon* with Latin translation and notes, containing the substance of Aristotle's logical doctrine, supplemented by *Erlauterungen zu den Elementen der Aristotelischen Logik* (1842); *Logische Untersuchungen* (1640) and *Die logische Frage in Hegels System* (1843), important factors in the reaction against Hegel; *Historische Beiträge zur Philosophie, 3* vol. (1846–67), vol. i containing a history of the doctrine of the categories; and *Lücken im Volkcrrecht* (1870), a treatise on the defects of international law, occasioned by the Franco-German war.

A number of papers on nonphilosophical subjects (mainly politics and education) were collected as *Kleine Schriften,* 2 vol. (1871).

TRENT, JESSE BOOT, 1ST BARON OF NOTTINGHAM (1850–1931), British pioneer of the chain store and of workers' welfare, was born at Hockley, Nottingham, on June 2, 1850. Upon the death of his father in 1860, he began to help in the family herbalist shop. Through bulk buying, convenient packaging and very long hours of work, he was able to bring such products as epsom salts, camphor and bicarbonate of soda within the reach of a large public. By 1885, with the then revolutionary practice of low profit margins applied to drugs and proprietary medicines, Boot had laid the foundations of Britain's first chain of shops with branches at Nottingham and Sheffield. Diversifying his merchandise as a result of his wife's influence, he started manufacturing his own drugs in 1888, and by 1908 had several factories and 300 shops. Although ill, he continued to direct a business which, by the beginning of the 1960s, had grown to over 1,300 branches and 40,000 employees. Boot was quick to offer financial incentives to employees taking the examinations of the Pharmaceutical society and was among the first British employers to introduce pension schemes, industrial health units and facilities for recreation. He devoted his last years to public benefactions amounting to some

£2,000,000, including a gift of the land and a grant toward the building of what is now Nottingham university. Having been knighted in 1909 and created a baronet in 1917, he was elevated to the peerage in 1929. Lord Trent died at Millbrook, Jersey, on June 13, 1931. (Jo. P. S.)

TRENT, the chief river of the English midlands and the third longest in the country. It rises on Biddulph moor in north Staffordshire and after following a southward curving course for about 170 mi. enters the Humber estuary 40 mi, from the open sea. Its basin covers an area of a little more than 4.000 sq.mi. Its course is first southerly. skirting the Potteries. and then southeasterly from Stone to Rugeley where it turns eastward. So far it has flowed in a normal upland valley but it then begins to meander over a wide flat floor. At Burton the hilly country which has bordered the valley finally recedes and the river crosses a wide flood plain thence over southern Derbys., Notts.. the Notts.-Lincs. border and a corner of Lincs. to its outfall. Especially below Newark the fall becomes slight and the lowest section of its course resembles the Fen country. The Trent is believed to have originated on an eastward sloping surface of Mesozoic rocks reaching far to the west into north Wales. The Dee, before it makes its northward bend. is thought to follow the line of the upper Trent of that time: It continued eastward near its present middle course beyond Nottingham, and thence through the Ancaster gap to the North sea near the present mouth of the Witham. After the Cretaceous cover was removed the ancestor of the present lower Trent developed its valley southward along the soft Keuper Marls and so captured the older river. Its southern tributaries — the Penk, Tame and Soar— drained northward from a divide running east and west from Market Harborough through Birmingham to mid-Wales. The upper Trent. Churnet, Dove. Derwent and Erewash flowed south from a northern watershed. All these streams have maintained their general courses throughout the long intervening period.

The Trent is tidal from its outfall for about jo mi. to Cromwell lock 3 mi. north of Newark. At spring tide a bore is developed with a wave front about 4 ft. in height. Barge traffic is possible on the river as far as the Erewash junction. Vessels drawing up to 9 ft. can reach Gainsborough and that section is under the control of the Humber Conservancy board. By the construction of weirs and locks above Newark the river was opened as far as Nottingham for craft drawing as much as 6 ft. Canals along the Erewash valley to Langley Mill and by the Soar valley to Leicester join the Trent near Long Eaton. The Fossdyke navigation links it with the Witham at Lincoln and the South Yorkshire navigation with Sheffield. Plans for the improvement of the latter were being carried out in the later 1950s. The Trent and Mersey canal is now only of importance from the Potteries to the Mersey, The river is mentioned as Trisantona by Tacitus. (T. HER.)

TRENT (ITALY): see TRENTO.

TRENT, COUNCIL OF. The Council of Trent (1545–1563) has a long antecedent history of great significance for the fortunes of the Catholic Church. During the 15th and the earlier half of the 16th century, the conception of an "ecumenical council" remained an ideal of which the realization was expected to provide a solution for the serious ecclesiastical difficulties which were then prevalent. The emperor Charles V. urged on the papacy the necessity of convening a general assembly of the church. The passive resistance of the Curia was so stubborn that the decisive step was postponed time and again. But the goal was finally attained, and this result was the work of Charles, aided by three powerful cardinals.

The bull *Laetare Hierusalem* (November 19, 1544) fixed the meeting of the council for March 1j, 1545, in Trent, and assigned it three tasks: (1) the pacification of the religious dispute by doctrinal decisions, (2) the reform of ecclesiastical abuses, (3) the discussion of a crusade against the infidels.

The opening of the council was deferred once again. Towards the end of May 1545, twenty bishops were collected at Trent; but there was no sign of action, and the papal legates— Del Monte, Corvinus and Reginald Pole — delayed the inauguration, the emperor and the pope being at cross purposes as to procedure. In the eyes of Paul III. the council was simply the means by which he expected to secure a condemnation of the Protestant heresy, in hopes that he would then be in a position to impose the sentence of the Church upon them by force. For him the question of ecclesiastical reform possessed no interest whatever. In contrast to this, Charles demanded that these very reforms should be given precedence, and the decisions on points of dogma postponed till he should have compelled the Protestants to send representatives to the council. The pope, however, alarmed by the threat of a colloquy in Germany, at last ordered the synod to be opened (December 13, 1545).

The procedure adopted secured the predominance of the Roman chair from the first. As the voting was not to be by nations, as at Constance, but by individuals, the last word remained with the Italians, who were in the majority.

The council began its work in the region of dogma by defining the doctrines of the Church with reference to the most important controversial points — a procedure which frustrated the emperor's hopes for a reconciliation with the Protestants. The doctrines dealt with, up to March 1547, were the Holy Scriptures and tradition (sessio iv.), original sin (sessio v.), justification (sessio vi.), and the sacraments in general, and baptism and confirmation in particular (sessio vii.). In March the council was moved to Bologna on the pretext that an epidemic was raging in Trent (sessio viii.), though, at the imperial command, part of the bishops remained behind. But on the 2nd of June the council of Bolcgna resolved (sessio x.) to adjourn its labours. At the Diet of Augsburg the emperor secured a *modus* vivendi, leavened by the Catholic spirit, between the adherents of either religion; and this provisory settlement — the so-called Interim of Augsburg—was promulgated as a law of the empire (June 3, 1548), and declared binding till the council should reassemble. But the confusion of ecclesiastical affairs had grown worse confounded through the refusal of the pope to continue the council, when his death (November 10, 1549) changed the situation.

Pope Julius III., the former legate Del Monte, caused the council to resume its labours on May 1, 1551 (sessio xi.), under the presidency of Cardinal Crescentio. The personnel was, for the most part, different; and the new members included the Jesuits, Laynez and Salmeron. The French clergy had not a single delegate, while the Spanish bishops maintained an independent attitude under the aegis of the emperor, and Protestant deputies were on this occasion required to appear at Trent. Their participation, however, was useless, for the discussion of doctrine on the basis of Holy Writ was from the Catholic standpoint impossible; and the revolt of the elector Maurice of Saxony (March 20, 1552) compelled the emperor to leave Innsbruck, and dissolved the conclave. Its dogmatic labours were confined to doctrinal decrees on the Lord's Supper (sessio xiii.), and on the sacraments of penance and extreme unction (sessio xiv.). On April 28, 1552, the sittings were suspended.

Ten years elapsed before the council reassembled for the third time in Trent. During the intervening period, the religious problem in Germany had received such a solution as the times admitted by the peace of Augsburg (155j); and the equality there guaranteed between the Protestant estates and the Catholic estates had left the former nothing to hope from a council. The incitement to continue the council came from another quarter. It was no longer anxiety with regard to Protestantism that exercised the pressure, but a growing conviction of the imperative need of more stringent reforms within the Catholic Church itself. In France and Spain — the very countries where the Protestant heresy had been most vigorously combated — a great mass of discontent had accumulated; and France already showed a strong inclination to attempt an independent settlement of her ecclesiastical difficulties in a national council. Pius IV. therefore announced (Nov. 29, 1560) the convocation of the council; and on Jan. 18, 1562, it was actually reopened (sessio xvii.).

The Protestants indeed were also invited but the Evangelical princes, assembled in Naumburg, withheld their assent. To secure freedom of action, France and the emperor Ferdinand required that it should rank as a new council; Pius IV., however, designated it a continuation of the earlier meetings. Ferdinand, in addition to regulations for the amendment of the clergy and the monastic system, demanded above all the legalization of the marriage of the priesthood, while France and Spain laid stress on the recognition of the divine right of the episcopate, and its independence with regard to the pope. In consequence of these reformatory aspirations, the position of the pope and the council was for a while full of peril. But the papal diplomacy, by concessions, threats, and by exploiting political and ecclesiastical dissensions, broke the force of the attack. In the third period of the council, which, as a result of these feuds, witnessed no session from September 1562 to July 1563, doctrinal resolutions were also passed concerning the Lord's Supper *sub utraque specie* (*sessio* xxi.), the sacrifice of the Mass (*sessio* xxii.), the sacrament of ordination (*sessio* xxiii.), the sacrament of marriage (*sessio* xxiv.), and Purgatory, the worship of saints, relics and images. On Dec. 4, 1563, the synod closed.

The dogmatic decisions of the Council of Trent make no attempt at embracing the whole doctrinal system of the Roman Catholic Church, but present a selection of the most vital doctrines, partly chosen as a counterblast to Protestantism, and formulated throughout with a view to that creed and its objections.

The reformatory enactments touch on numerous phases of ecclesiastical life — administration, discipline, appointment to spiritual offices, the marriage law (*decretum de reformatione matrimonii "Tametsi," sessio* xxiv.), the duties of the clergy, and so forth. The resolutions include many that marked an advance; but the opportunity for a comprehensive and thorough reformation of the life of the Church — the necessity of which was recognized in the Catholic Church itself—was not embraced. No alteration of the abuses which obtained in the Curia was effected, and no annulment of the customs, so lucrative to that body and deleterious to others, was attempted.

The Council of Trent in fact enjoyed only a certain appearance of independence. For the freedom of speech which had been accorded was exercised under the supervision of papal legates, who maintained a decisive influence over the proceedings and could count on a certain majority in consequence of the overwhelming number of Italians. That the synod figured as the responsible author of its own decrees (*sancta oecumenzca et generalis tridentina synodus in spiritu sancto legitime congregata*) proves very little, since the following clause reads *praesidentibus apostolicae sedis legatis;* while the legates and the pope expressly refused to sanction an application of the words of the Council of Constance—*universalem ecclesiam repraesentans.*

The whole course of the council was determined by the presupposition that it had no autonomous standing, and that its labours were simply transacted under the commission and guidance of the pope. This was not merely a claim put forward by the Roman see at the time; it was acknowledged by the attitude of the synod throughout. The legates confined the right of discussion to the subjects propounded by the pope, and their position was that he was in no way bound by the vote of the majority. In difficult cases the synod itself left the decision to him, as in the question of Clandestine Marriages and the Administration of the Lord's Supper *sub utraque specie.* Further, at the close of the sessions a resolution was adopted, by the terms of which all the enactments of the council *de morum reformatione atque ecclesiastica disciplina* were subject to the limitation that the papal authority should not be prejudiced thereby (*sessio* xxv. *cap.* 21). Every doubt as to the papal supremacy is removed when we consider that the Tridentine Fathers sought for all their enactments and decisions the ratification (*confirmatio*) of the pope, which was conferred by Pius IV in the bull *Benedictus Deus* (January 26, 1564); and in its last meeting (*sessio* xxv.) the synod transferred to the pope a number of tasks for which their own time had proved inadequate. These comprised the compilation of a catalogue of forbidden books, a catechism, a short conspectus of the articles of faith and an edition of the missal and the breviary. Thus the council presented the Holy See with a further opportunity of extending its influence and diffusing its views. The ten rules *de libris prohibitis* were published in March 1564; the *Professio fidei tridentinae* in November 1564; and the *Catechismus a decreto concilii tridentini ad parochos,* early in 1568.

The oecumenical character of the council was never seriously questioned. On the motion of the legates, the resolutions were submitted to the ambassadors of the secular powers for signature, the French and Spanish envoys alone withholding their assent. The recognition of the council's enactments was, none the less, beset with difficulties. So far as the doctrinal decisions were concerned no obstacles existed; but the reformatory edicts—adhesion to which was equally required by the synod — stood on a different footing. In their character of resolutions claiming to rank as ecclesiastical law they came into conflict with outside interests, and their acceptance by no means implied that the rights of the sovereign, or the needs and circumstances of the respective countries were treated with sufficient consideration. The consequence was that there arose an active and, in some cases, a tenacious opposition to an indiscriminate acquiescence in all the Tridentine decrees, especially in France, where only those regulations were recognized which came into collision neither with the rights of the king nor with the liberties of the Gallican Church. In Spain, Philip II. allowed, indeed, the publication of the *Tridentinurn,* but always with the reservation that the privileges of the king, his vassals and his subjects, should not thereby be infringed.

In his official confirmation Pius IV. had already strictly prohibited any commentary on the enactments of the council unless undertaken with his approval, and had claimed for himself the sole right of interpretation. In order to supervise the practical working of these enactments, Pius created (1564) a special department of the Curia, the *Congregatio cardinalium concilii tridentini interpretum;* and to this body Sixtus V. entrusted the further task of determining the sense of the conciliar decisions in all dubious cases. The *resolutiones* of the congregation — on disputed points—and their *declarationes*—on legal questions — exercised a powerful influence on later development of ecclesiastical law.

The Council of Trent attained a quite extraordinary significance for the Roman Catholic Church; and its pre-eminence was unassailed till the *Vaticanum* subordinated all the labours of the Church in the past — whether in the region of doctrine or in that of law—to an infallible pope. On the theological side it fixed the results of mediaeval scholasticism and drew from it all that could be of service to the Church. Further, by pronouncing on a series of doctrinal points till then undecided it elaborated the Catholic creed; and, finally, the bold front which it offered to Protestantism in its presentation of the orthodox faith gave to its members the practical lead they so much needed in their resistance to the Evangelical assault. It showed that Church as a living institution, capable of work and achievement; it strengthened the confidence both of her members and herself, and it was a powerful factor in heightening her efficiency as a competitor with Protestantism and in restoring and reinforcing her imperilled unity. Indeed, its sphere of influence was still more extensive, for its labours in the field of dogma and ecclesiastical iaw conditioned the future evolution of the Roman Catholic church.

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mation, i (Stuttgart, 1889); P. Tschackert, *s.v.* "Trienter Konzil," in Herzog-Hauck, *Realencyklopadie für protestantische Theologie,* vol. xx, *ed.* 3 (1908). (C. Mi.; X.)

TRENTE ET QUARANTE (Rouge et Noire), a French gambling game of cards played at Monte Carlo and other continental casinos. It is not popular in North America. The name *trente et quarante* ("thirty and forty") is derived from the fact that the winning point always lies between these two numbers. Its other title, *rouge et noire* ("red and black"), comes from the colours marked on the layout, or tapis, such as the one illustrated. The table usually carries two identical layouts. All betting is done against the house or bank. Before the deal begins, a player may place his bet on *rouge, noire, couleur* or *inverse.* Six 52-card packs are shuffled together by the dealer and cut by any player against the house. The dealer then deals out the first row, called *noir;* he first deals one card whose suit is specially noted, face upward. He then continues to deal to either side, alternately, of the card already placed, announcing the cumulative total of the spots with each card dealt. Dealing stops with the card which causes the total to reach or exceed 31. Since aces count 1 each, face (court) cards and tens count 10 each and every other card counts its numerical or pip value, the total cannot exceed 40. The second row, *rouge,* is dealt below the first and in the same manner.

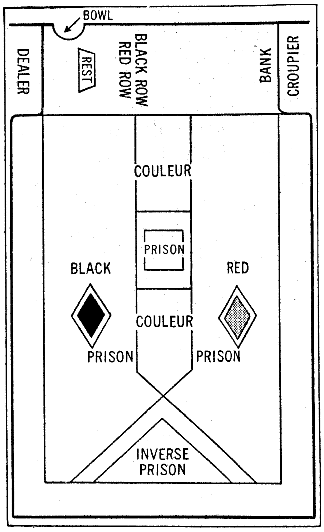

DIAGRAM SHOWING HALF OF TRENTE ET QUARANTE TABLE

The row with the total nearer to 31 is the winning row. For example, a bet on *noir* wins if the count of the first or *noir* row is 34 while the *rouge* row totals 36. A bet on *couleur* wins if the very first card dealt is the same colour as that designating the winning row. If this card is of the opposite colour, a bet on *inverse* wins. The croupier traditionally announces the result for red and colour only, calling "*rouge gagne* (wins)" or "*rouge perd* (loses)," "*couleur gagne*" or "*couleur perd.*"

If both rows count the same (tie), it is called a *refait* and all bets are called off. If there is a *refait* at *31—refait de trente et un*—the bank takes half of all bets. In such cases, however, the player has the option of leaving his bet in "prison," where it remains for the next game or coup. If he wins on this coup, he withdraws his bet; but if he loses, he loses the whole.

As bets are settled, the cards dealt for that coup are brushed into the bowl. When there are insufficient cards for the next coup all the cards are reshuffled. A *refait* at 31 occurs more frequently than at any other number. Estimates of its frequency vary from once in 45 coups (giving the bank about 1.1% of all money bet against it) down to once in 31 coups (1.6% advantage to the bank). All bets are at even money. (P. Fr.)

TRENTINO, a mountainous area of north Italy, extending east and west of the middle course of the Adige river. Before World War I it was part of the Austrian province of Tirol. The Trentino frontier, which had been delimited after the war of 1866, was strategically most unfavourable to Italy, as it left the mountain ranges in Austrian hands and formed a wedge where a dozen military roads branched outward threatening the richest and most fertile parts of Italy. It also left 400,000 Italians under Austrian rule.

During World War I the region was the scene of heavy fighting between the Italians and Austrians. Some of this (around Stelvio pass, the Adamello mountain group, Ampezzo and San Martino di Castrozza) was at very high altitude, with the Austrians usually holding the more favourable positions. The Austrian object was to cut the communications of the Isonzo army, but although after the battle of Caporetto (*q.v.*) the Italians had to evacuate the Ampezzo and Cadore areas, their positions on the outer edge of the Asiago plateau held firm. For the history of the area *see* Tirol: Venetia.

TRENTO (Lat. Tridentum; Ger. Trent or Trient), the capital of a province of the same name in the region of Trentino-Alto Adige, Italy. Pop. (1951) 39,287. It stands on the left bank of the Adige where this river is joined by the Fersina and is a station on the Brenner railway, 35 mi. S. of Bolzano and $56\frac{1}{2}$ mi. N. of Verona, while a railway runs along the Fersina valley and the Val Sugana to Bassano (60 mi.). There is also an electric railway to Mali: (45 mi. N.). It has a very picturesque appearance, especially when approached from the north, with its embattled walls and towers filling the whole breadth of the valley. A conspicuous feature in the view is the isolated rock Doss Trento (the site of the Roman Verruca), that rises on the right bank of the Adige to a height of 308 ft. above the city. The cathedral (dedicated to San Vigilio, the first bishop) was altered at various times between the 11th and 15th centuries and was restored in 1882–89.

Outside is the fine fountain of Neptune (1767–69). The Renaissance church of Santa Maria Maggiore, built in 1520–39, was the scene of the sessions of the famous ecumenical council which lasted, with several breaks, from 1545 to 1563, during the episcopate of Cristoforo Madruzzo. To the east of the city rises the Castello del Buon Consiglio, for centuries the residence of the prince-bishops, which is decorated with interesting frescoes and contains the museum of antiquities and fine arts for the district. Opposite the railway station a statue of Dante by Zocchi was erected in 1896.

Tridentum, the capital of the Tridentini, was a station on the great road from Verona to Veldidena (Innsbruck) over the Brenner. It was later ruled by the Ostrogoths (5th century) and the Lombards (6th century) after the conquest of whom by the Franks (774) Trento became part of the medieval kingdom of Italy. But in 1027 the emperor Conrad II bestowed all temporal rights in the region on the bishop (the see dates from the 4th century) and transferred it to Germany. Venetian attacks were finally repulsed in 1487, and the bishop retained his powers until 1803, when they passed to Austria until 1809.

From 1810 to 1814 Trento was part of the Napoleonic kingdom of Italy and capital of the Alto Adige province. In 1814 the Trentino was annexed to the Austrian province of Tirol and in 1918 was ceded to Italy.

TRENTON, the capital of New Jersey, U.S., and seat of Mercer county, is located at the head of navigation on the Delaware river, 30 mi. N.E. of Philadelphia and 55 mi. S.W. of New York city. The population of the city in 1960 was 114,167, a decrease of 10.8% in the decade; that of the standard metropolitan statistical area (Mercer county) was 266,392, an increase of 15.9%. For comparative population figures *see* table in New jersey: *Population.*

History.—The Dutch established a trading post and fort at the site of the present city of Trenton during the 1630s. Mahlon Stacy, a Quaker from Lancashire, Eng., established a gristmill there in 1679. William Trent purchased these holdings from his son, Mahlon Stacy, Jr., and proceeded to lay out the town which in 1721 was named Trenton in his honour. His home, erected in 1719, still stands. King George II of England granted the municipality a charter as a town and a borough in 1745. Barracks were erected in 1758 to house British troops engaged in the French and Indian War. During the American Revolution these quarters were occupied at various times by British, Hessian and American soldiers. Constructed of stone and of early Georgian architecture, a section, now termed the Old Barracks, is open to the public as a museum.

In the midst of a heavy snowstorm on Christmas night, 1776, George Washington and his army crossed the ice-choked Delaware river at McKonkey's ferry, now Washington crossing, marched downstream and the next morning launched an attack on the Hessian troops quartered at Trenton under the command of Col. Johannes Rall. The Hessians, completely confused by the unexpected onslaught, quickly surrendered. On Jan. 2, 1777, Lord Cornwallis arrived to face the Americans at Trenton. Because his troops were fatigued from their long march, he postponed his attack until morning. During the night Washington withdrew and marched to Princeton where he defeated a detachment under Col. Charles Mawhood. This series of actions caused the British to evacuate all of New Jersey and turned the tide of the war. *(See* also TRENTON *AND* PRINCETON, BATTLES OF.)

Trenton served as the temporary capital of the United States in 1784 and again in 1799. Several proposals to establish the national capital there permanently were rejected. It became the capital of the state of New Jersey in 1790 and the state house was erected two years later. Since that time numerous additions have been made and it has become a massive stone structure, of Renaissance style. To the north of it stands the State Capitol annex, completed in 1931, and containing numerous offices, courtrooms, the state museum and the state library.

Industry.— The iron industry was established in Trenton as early as 1734. In 1845 Peter Cooper opened a rolling mill and in 1868 his associate. Abram Hewitt, introduced into America the open-hearth system of making steel. At Cooper's suggestion John A. Roebiing moved his wire mill from Pennsylvania to Trenton in 1848 and produced cable for suspension bridges. Although he died during its construction, the success he achieved with the Brooklyn bridge brought acclaim to him and to his firm, which continues to supply cable for that type of span all over the world.

Potteries have operated in Trenton since 1723 and by the middle of the 13th century some of the finest china was being produced there. In 1889 Walter Scott Lenox founded the firm which bears his name and is world famous for the quality of its products.

The industrial structure of the city and its metropolitan area has become highly diversified. The establishment of the integrated steel mills across the Delaware at Morrisville, Pa., in 1952, exerted a tremendous impact on the entire area by bringing to it more industrial plants and many housing developments. Despire the industrial expansion, Mercer county continues to be important in the value of agricultural products, with dairying and truck-farming predominating.

Education.— Educational institutions in the metropolitan area include Princeton university; Trenton State college, established in 1885; the Trenton Junior College and School of Industrial Arts, established in 1890; and Rider college, a private institution established in 1865. Private preparatory schools in Mercer county are the Pennington school, Pennington; Peddie school, Hightstown; and Lawrenceville school, Lawrenceville, whose 19th-century atmosphere was depicted in the novels of Owen Johnson.

(E. R. D.)

TRENTON AND PRINCETON, BATTLES OF (1776–1777). These battles in the American Revolution *(q.v.)* are noted as the first successes won by George Washington in the open field. Following close upon a series of defeats, their effect upon his troops and the population at large was marked. They put new life into the American cause and renewed confidence in Washington.

After the capture of Ft. Washington on Manhattan Island, on Nov. 16, 1776, the British general, Sir William Howe, forced the Americans to retreat through New Jersey and across the Delaware river into Pennsylvania. Howe then went into winter quarters, leaving the Hessian, Col. Johannes Ral!, at Trenton on the river with about 1,400 men. Although Washington's army was discouraged by the year's disasrers, it could still be trusted for a promising exploit and by reinforcements had been brought up to about 6,000 effectives. Ascertaining that the Hessians at Trenton were practically unsupported, Washington determined to attempt their capture.

He planned to recross the Delaware with three columns, but only his own got across. The passage was made on the night of Dec. 25, 1776, through floating ice, to a point 9 mi. above the enemy, whom he expected to reach at dawn of the following day, Dec. 26. Dividing his force of 2,500 men into two divisions under Gen. John Sullivan and Gen. Nathanael Greene, he approached the town by two roads, surprised the Hessian outposts and then rushed upon the main body before it could form effectively. The charge of the American troops and the fire of their artillery and musketry completely disconcerted the enemy. A few hundred escaped but the majority (over 900) were surrounded and forced to surrender. Colonel Rall was mortally wounded.

Washington carried his army and prisoners back across the river. Eager to harass the enemy's posts at other points, he again crossed the Delaware on Dec. 30 and occupied Trenton. Hearing of this move, Lord Cornwallis marched with about 7,000 troops upon the Americans on Jan. 2, 1777, and drove them across the Assunpink, a stream running east of the town. The Americans, who encamped on its banks that night, were placed in a precarious position. As they had no boats at their disposal at that point they were unable to recross the Delaware into Pennsylvania, and all the roads led toward the British lines to the northeast. Washington accordingly undertook a bold maneuver. Fearing an attack by Cornwallis on the next morning, he held a council of war, which confirmed his plan of quietly breaking camp that night and taking a byroad to Princeton. He would cut through any resistance that might be offered there and push on to the hills of northern New Jersey, thus placing his army on the flank of the British posts. His tactics succeeded.

At Princeton he came upon three British regiments, which for a time held him at bay. The 17th foot especially, under Col. Charles Mawhood, twice routed the American advanced troops, inflicting severe losses, but were eventually driven back toward Trenton. The other regiments retreated northeast toward New Brunswick, and Washington continued his march to Morristown, N.J., where he was on the flank of the British communications with New York. Cornwallis retired to New Brunswick. Washington, besides his success in breaking through Howe's lines, had placed himself in an advantageous position for recruiting his army and maintaining a strong defensive in the next campaign.

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TREPOV, DIMITRI FEODOROVICH (1855–1906), Russian general, chief of the imperial police, born at St. Petersburg, was city prefect of Moscow. In the disturbances of 1905 he was placed in command of St. Petersburg, when he immediately took steps to expel all those who had taken part in the procession led by Father Gapon to the Winter palace. The result was an epidemic of strikes throughout the empire. In the railway strike (Oct. 20) Trepov gave the famous order to the troops "not to spare their cartridges." He was made commandant of the imperial police and used his great power to undermine the authority of Count Witte with the tsar. He then became assistant minister of the interior. An unsuccessful attempt to assassinate him was made on March 30, 1905.

Trepov died on Sept. 15, 1906.

TRESCOT, WILLIAM HENRY (1822–1898), U.S. diplomatist and historian, was born in Charleston, S.C., on Nov. 10, 1822. He graduated from Charleston college in 1841, read law and was admitted to the bar in 1843. He studied diplomatic history and published *The Diplomacy of the Revolution* (1852), *An American View of the Eastern Question* (1854) and *The Diplomatic History of the Administrations of Washington and Adams* (1857).

Trescot was appointed assistant secretary of state in 1860 and served as acting secretary during the secession crisis. While serving as a channel of communication between President Buchanan and the governor of South Carolina, he encouraged both to maintain the *status quo* in the Charleston forts pending negotiations for their evacuation. He resigned his position when South Carolina seceded and thereafter served in the Confederate forces.

After the Civil War his services were primarily diplomatic. He was one of the U.S. representatives before the Halifax Fishery commission in 1877; was sent on special missions to China in 1880, to Chile in 1881, and to Mexico in 1882; and was a delegate to the Pan-American conference in 1889. He died at Pendleton, S.C., on May 4, 1898. (H. S. S.)

TRESPASS, in law, any transgression of the law less than treason, felony or misprision of either. The term includes a great variety of wrongs committed to land, goods or person. Up to 1694 the trespasser was regarded, nominally at any rate, as a criminal, and was liable to a fine for the breach of the peace, commuted for a small sum of money, for which 5 Will. and Mar. c. 12 (1693) substituted a fee of 6s. 8*d*. recoverable as costs against the defendant. Trespass is not now criminal except by special statutory enactment, *e.g.*, the old statutes against forcible entry, the game acts and the private acts of many railway companies. When, however, trespass is carried sufficiently far it may become criminal, and be prosecuted as assault if to the person, as nuisance if to the land. At one time an important distinction was drawn between trespass general and trespass special or trespass on the case, for which *see* TORT.

In its more restricted sense trespass is generally used for entry on land without lawful authority by either a man, his servants or his cattle. To maintain an action for such trespass the plaintiff must have possession of the premises. The most minute invasion of private right is trespass. In addition to damages for trespass, an injunction may be granted by the court.

Trespass may be justified by exercise of a legal right, as to serve the process of the law, or by invitation or licence of the owner, or may be excused by accident or inevitable necessity, as deviation from a highway out of repair.

In Scots law trespass is used only for torts to land. By the Trespass (Scotland) act 1865 trespassers are liable on summary conviction to fine and imprisonment for encamping, lighting fires, etc., on land without the consent and permission of the owner.

In the U.S., common law doctrines as to trespass hold in most states. It means, more particularly, an injury to the person, property or rights of another, as the immediate result of a wrongful act committed with actual or implied force. The statutes have provided for criminal trespass in many states, but not to the extent as existed prior to 1694 in England. Trespass on the realty of another often is a criminal offence, through statutory enactment in the states.

TRESVIRI (TRIUMVIRI), in Rome, a board of three, either ordinary officials or extraordinary commissioners.

1. *Tresviri capitales,* who assisted the higher magistrates in their judicial functions, especially criminal. were first appointed about 289 B.C. They possessed no criminal jurisdiction or right of arrest themselves. They kept watch over prisoners; carried out the death sentence; took accused or suspected persons into custody; exercised general control over the city police; went the rounds by night to maintain order; and were present at fires. They assisted the aediles in burning forbidden books. They collected the deposit forfeited by the losing party in a suit and examined the plea of exemption put forward by those who refused to act as jurymen. In imperial times most of their functions passed to the *praefectus vigilum*.

2. *Tresviri epulones,* a priestly body, assisted at public banquets. They were first created in 196 B.C. to superintend the *epulum Iovis* (banquet of Jupiter) on the Capitol, but they also served on the occasion of triumphs, imperial birthdays, the dedication of temples, games given by private individuals, and so forth, when public entertainments were provided.

3. *Tresviri monetales* were superintendents of the mint; after the Social War, permanent officials. As they acted for the senate they only coined copper money under the empire, gold and silver coinage being exclusively controlled by the emperor.

4. *Tresviri reipublicae constituendae* was the title bestowed upon Octavianus, Lepidus and Antony for five years by the Lex Titia. 43 B.C. The coalition of Julius Caesar, Pompey and Crassus has also been called a "triumvirate," but they never had the title *tresviri*, and were not a formally appointed commission.

See W. E. Heitland, *The Roman Republic* (1923).

TREVELYAN, GEORGE MACAULAY (1876–), English historian, whose belief that the same book should appeal to the general reader and to the history student gives his work vividness and warmth, was the third son of Sir George Otto Trevelyan (*q.v.*). Born at Stratford-on-Avon, Feb. 16, 1876, he was educated at Harrow and Trinity college, Cambridge. became regius professor of modern history at Cambridge in 1927 and master of Trinity college in 1940. He received the Order of Merit in 1930. He retired in 1951.

Essentially liberal by training and temperament, Trevelyan shows as a historian a love of England also indicated by his association with the National trust and youth hostels; a respect for the Whig tradition in English thought, exemplified in his *Lord Grey of the Reform Bill* (1920) and *Grey of Fallodon* (1937); and a keen interest in the Anglo-Saxon element in the English constitution. The romantic aspect of his liberalism led to three books on Garibaldi: *Garzbaldi's Defence of the Roman Republic* (1907); *Garibaldi and the Thousand* (1909); and *Garibaldi and the Making of Italy* (1911). Other works are *England in the Age of Wycliffe*, new ed. (1904); *England Under the Stuarts* (1905); *Lifr of Jolzn Bright* (1913); *British History in the Nineteenth Century* (1922; rev. ed., 1938); *History of England* (1926; new enlarged ed., 1937); *England Under Queen Anne, 3* vol. (1930–34); *The English Revolution, 1688–1689* (1939); *English Social History* (1942); and *The Seven Years of William IV* (1952). His *An Autobiography and Other Essays* appeared in 1949.

TREVELYAN, SIR GEORGE OTTO (1838–1928), English historian and statesman, is chiefly remembered for his *Life and Letters* of his uncle, Lord Macaulay (1876) and for his part in the complex political events following Gladstone's introduction of Irish Home Rule in 1886.

The son of Sir C. E. Trevelyan and Hannah More Macaulay, he was educated at Harrow and Trinity college, Cambridge, and in 1862 went to India as his father's private secretary. While there he wrote *The Competition Wallah* (1864) and *Cawnpore* (186;). He returned to England in 1864 and in the parliament of 1865–68 (in which he sat for Tynemouth as a Palmerstonian) he became friendly with John Bright. In 1868 he was returned for the radical seat of Hawick Burgh's, and was made civil lord of the admiralty in Gladstone's first ministry. He resigned in 1870, as a protest against W. E. Forster's Education act, and although during the Liberal opposition years, 1874–80, he advocated a measure for extension of the working class franchise subsequently adopted by Gladstone, he was passed over in the ministry of 1880. In 1881, however, he became secretary to the admiralty and in 1882 chief secretary for Ireland.

In 1884 Trevelyan was made chancellor of the duchy of Lancaster with a seat in the cabinet, and in 1885 secretary for Scotland, but when Gladstone introduced Home Rule in 1886 he resigned, with Joseph Chamberlain; standing as a Liberal Unionist at the general election, he was defeated. Preferring Gladstone and Home Rule to alliance with the Conservatives, however, he stood as a Gladstonian for a Glasgow division in 1887 and held his seat until his retirement in 1897.

Apart from his life of Macaulay, his chief historical works were the *Early History of Charles James Fox* (1880), valuable for its evocation of an age; and *The American Revolution,* part i, *1766*–1776 (1899), part ii (1903–05), part iii (1907), concluded in *George III and Charles Fox* (1912–14). The last was especially important in the United States, where its sympathetic attitude to the U.S. position helped to dispel anti-British prejudice. Trevelyan died at Wallington, Northumberland, on Aug. 17, 1928.

TREVET (or **TRIVET**), **NICHOLAS** (*c.* 1258–*c.* 1328), English chronicler, was the son of Sir Thomas Trevet (d. 1283), a judge, and became a Dominican friar. After studying at Oxford and in Paris, he spent most of his subsequent years in writing and teaching, and died about 1328. His chief work is his *Annales sex regum Angliae,* a chronicle of English history covering the period between 1135 and 1307; this is valuable for the later part of the reign of Henry III and especially for that of Edward I.

The *Annales* were published in Paris in 1668, in Oxford in 1719, and were edited by Thomas Hog for the English Historical society in 1845. Manuscripts are at Oxford and in the British museum.

TREVISO (anc. TARVISIUM), a town and episcopal see of Veneto, Italy, capital of the province of Treviso, 49 ft. above sea level. Pop. (1951) 53,165. It is on the plain between the

Gulf of Venice and the Alps, 18 mi. by rail north of Venice, at the confluence of the Sile with the Botteniga. The cathedral of San Pietro, dating from 1141 and restored and enlarged in the 15th century by Pietro Lombardo, with a classical façade of 1836, has seven domes. It contains a fine "Annunciation" by Titian (1519), an important "Adoration of the Shepherds" by Paris Bordone (born at Treviso in 1500), and frescoes by Pordenone. There are also sculptures by Lorenzo and Battista Bregno and others. The baptistery is Romanesque. The Gothic church of San Nicolb (1310–52) contains important works of art, including a large altarpiece by Fra Marco Pensabene and others; in the church and adjoining chapter-house are frescoes by Tommaso da Modena (1352), some frescoes by whom (life of S. Crsula) are also in the Museo Civico. The churches of S. Leonardo, S. Andrea, S. Maria Maggiore, and S. Maria Maddalena also contain art treasures. The Piazza dei Signori contains picturesque brick battlemented palaces —the Palazzo dei Trecento (*c.* 1207) and the Palazzo Pretorio (1218–68).

The ancient Tarvisium lay off the main roads, and is hardly mentioned by ancient writers. In the 6th century it appears as an important place and was the seat of a Lombard duke. Charlemagne made it the capital of a marquisate. It joined the Lombard league, and was independent after the peace of Constance (1183) until, in 1339, it came under the Venetian sway. From 1318 it was for a short time the seat of a university. Its walls and ramparts were renewed under the direction of Fra Giocondo (1509), two of the gates, the Porta Mazzini and Porta Cavour, dating from 1517–18. Treviso was taken in 1797 by the French under Mortier (duke of Treviso). In March 1848 the Austrian garrison was driven from the town by the revolutionary party, but in the following June the town was bombarded and compelled to capitulate.

TREVITHICK, RICHARD (1771–1833), English engineer, pioneer builder of high-pressure steam engines and "father of the locomotive," was a prolific inventive genius of great energy and physique. He was born on April 13, 1771, near Illogan, Cornwall, the son of a manager of mines. At 19 he was already engineer at various Cornish mines. In 1797–98 he constructed his improved plunger-pole pump and water-pressure engine for mining. He made high-pressure noncondensing steam engines, which were smaller and cheaper than low-pressure condensing beam engines. He built his first high-pressure steam road carriage at Camborne in 1801. On Christmas Eve he drove it, carrying passengers, part way up Beacon hill but it ran out of steam; three days later it was destroyed by fire. In 1802 Trevithick and his cousin Andrew Vivian obtained their epoch-making patent covering the high-pressure engine for stationary and locomotive use. Trevithick drove his second steam carriage in London from Holborn to Paddington and back in 1803, but public opinion and road surfaces were not ready. He returned to building stationary engines at Samuel Homfray's Penydarren ironworks, Merthyr Tydfil, Wales! and at his suggestion constructec! his first steam locomotive there. On Feb. 21, 1804, it successfully hauled five wagons, ten tons of iron and 70 men at nearly 5 m.p.h. on the 10-mi. tramway to Abercynon. Heavier loads broke the cast-iron tram plates, bur the trials proved that useful loads could be hauled solely by adhesion of locomotive wheels on the track, ten years before William Hedley's and George Stephenson's earliest locomotives. In 1808 Trevithick drove his locomotive "Catch-me-who-can" on a circular railway near Euston road, London, at 12 m.p.h. He constructed steam dredgers on the Thames, but his work on the Thames driftway was stopped after tunneling 1,000 ft. He patented the use of iron for ship construction.

Returning to Cornwall, in 1812 he introduced his Cornish boiler with long shell and single flue, and built at Wheal Prosper the first Cornish pumping engine, a condensing engine of Watt type working with high-pressure steam expansively. Cornish engines later created records for economy. Trevithick applied steam power to agriculture and made his small, high-pressure, single-acting expansive engine (preserved in the Science museum, London) for Sir Christopher Hawkins of Trewithen for threshing corn. In 1813 Francisco Uvillé came from Peru and ordered high-pressure engines for the Cerro de Pasco silver mines. In 1816 Trevithick sailed to Peru, installed his engines and worked at the mines there and in Chile. After crossing Nicaragua he reached Cartagena, Colombia, and eventually landed penniless in England in 1827. Trevithick petitioned parliament unsuccessfully for a reward for his inventions. He finally worked for John Hall at Dartford, Kent, where he died on April 22, 1833. A window in Westminster abbey and a statue at Camborne perpetuate his achievements.

See Francis Trevithick, *Life of Richard Trevithick,* 2 vol. (1872); H. W. Dickinson and A. Titley, *Rzchard Trevithick: the Engineer and the Man (1934).* (AR. S.)

TRIAL: *see* PRACTICE AND PROCEDURE.

TRIAL OF ANIMALS, an ancient legal custom which persisted in Europe until relatively recent times. There is evidence that it grew out of the popular belief that animals are intelligent and consequently morally responsible for their acts. However, the old doctrine of deodand (*q.v.*), which penalized inanimate objects that had taken human life. may be germane to the concept of the responsibility of animals, in which case both must be traced to the idea underlying animism: that not only human beings, but all other entities, are endowed with volition and consciousness. An early example of legal procedure against animals is furnished by Exodus xxi, 28: "And if an ox gore a man or a woman to death, the ox shall be surely stoned." Piato, in *The Laws*, prescribed that "If a beast of burden or any other animal shall kill anyone, except while the animal is competing in the public games, the relatives of the deceased shall prosecute it for murder."

In western Europe procedure against animals was settled, both in the ecclesiastical and civil courts; in all cases they were provided with counsel, were duly summoned to appear, exceptions taken in their favour were considered, and their sentences sometimes commuted on the grounds of relative youth, exiguity of body, or a reputation for respectability: a she-ass condemned to death in France in 1750 was pardoned because of good character.

TRIANGLE. A triangle, or more precisely a plane triangle, is the geometrical figure composed of three points called the *vertices* (not lying in one straight line), and the three straight lines joining these, called the sides. Since no part of a plane can be inclosed by fewer than three straight lines, the triangle ranks as the simplest figure of its class, and plays a correspondingly important part in both practical and theoretical geometry.

Congruence Theorems.—It is important to recognize the conditions under which two triangles may be known to be *congruent;* that is, alike in all respects except position in space, so that the one triangle is merely the other moved into a new position without change of form. The most important theorems of this character have been known from very ancient times, and were handed down in the first book of Euclid's *Elements*.

Two triangles are congruent if two sides of the one are respectively equal in length to two sides of the other, and if these two sides are in each case inclined at the same angle.

Thus in figure 1, to be sure that the triangles ABC and *abc* are exactly alike, it is enough to know that $AB=ab$, $AC=ac$, and the angle at $A=$ the angle at *a*. It would *not* be enough to know that these same two pairs of sides were equal together with the angles at B and *b,* since in this case the triangle ABC might equally well have had the form of ABC' in the figure, and therefore not have agreed with *abc* in form.

Two triangles are congruent if the three sides of the one are equal respectively to the three sides of the other.

Two triangles are congruent if a side of one is equal to a side of the other, and if the angles at the ends of these equal sides are the same in both triangles.

Thus the triangles ABC and *abc* will be identical in form if $BC=bc$, the angle at $B=$ the angle at b, and the angle at $C=$ the angle at *c*.

This theorem supplies the basis for the method of triangulation. If B and C are given stations whose positions are known, the measurement of the angles ABC and ACB will determine, together with a knowledge of *BC*, the form of the triangle *ABC*, and so the position of A.

Two triangles are congruent if two angles of the one are equal

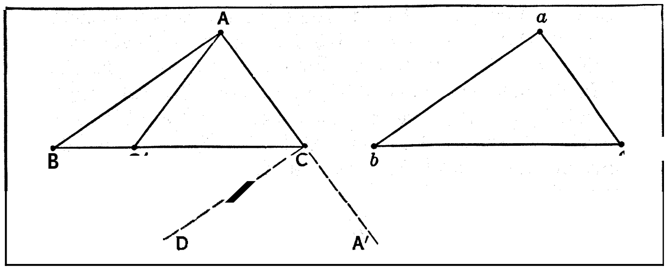

FIG. 1

to two angles of the other respectively, and if the sides opposite one of the equal pairs of angles are equal.

This theorem is readily reduced to the one before by means of the property stated at the beginning of the next section. The same consideration prepares us to accept the statement that two triangles may have the angles of one equal to the angles of the other without being congruent. In such a case the triangles are similar in shape, but may be of different sizes.

Relations Between the Parts of a Triangle.—The foregoing remarks emphasize the fact that the three sides and the three angles are not six independent magnitudes to which any values whatsoever may be given. For instance it is impossible to draw a triangle in which all the sides are equal and the angles unequal.

The simplest relation connecting the parts of a triangle in general is that *the sum of the three angles is two right angles.* This follows from the fact that, when one side is continued outside the triangle, the angle so formed on the outside is equal to the sum of the angles inside the triangle at the other two vertices. The latter relation is exhibited in figure 1 for the triangle ABC, the line CD, drawn parallel to BA, dividing the exterior angle into two parts, of which DCA' is equal to A, and DCC' to B. The relation between the three angles enables one to find the value of the third when two of the angles are known. Thus, if two of the angles are 60° and 70°, the third is 180°–60°–70° = 50°.

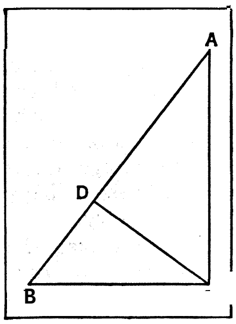

FIG. 2

It is convenient to consider here certain special forms of triangle. A triangle with two equal sides is called *isosceles.* Such a triangle has the angles opposite to these sides also equal. This is easily proved by joining the middle point of the unequal side to the opposite vertex and deducing the congruence of the two triangles so formed. The proof given by Euclid was much more elaborate, because Euclid did not permit the use of the middle point at a stage when the problem of finding it had not been taken up; and the theorem was nicknamed the *pons asinorum,* and regarded at one time as a notable obstacle to the beginner in geometry.

A right triangle is one which has one of its angles a right angle. In figure 2 the triangle ABC has a right angle at C. Evidently $CB = AB \times s$, and $AC = AB \times k$, where s and k are proper fractions depending on the angle A, and not on the size of the triangle The ratios s and k are called the sine and cosine respectively of the angle A, and their theory constitutes the science of trigonometry (*q.v.*). If CD is perpendicular to AB, by the similarity of the three triangles, $BD = CB \times s = AB \times s^2$, *and* $AD = AC \times k = AB \times k^2$. Since $AD + BD = AB$, it follows that $s^2 + k^2 = 1$. On multiplying this equation by AB^2, it is seen that $BC^2 + AC^2 = AB^2$. Here the meaning of BC^2 may be understood to be the arithmetical square of the number of units in BC. The side AB opposite the right angle is called the *hypotenuse* of the right triangle, and the result just obtained is that *the square of the hypotenuse is equal to the sum of the squares of the other two sides,* a theorem ascribed to Pythagoras (*q.v.*), and of the utmost importance in geometry.

Allusion may be made to two triangle inequalities. (1) *The sum of any two sides is greater than the third side;* (2) *the greater of two unequal sides has the greater angle opposite to it.*

As supplementing the preceding statement (2) we have the *sine formula.* In fig. 3, if CR is perpendicular to AB, the sines of A and B are respectively $\frac{RC}{AC}$ and $\frac{RC}{BC}$. These are proportional to BC and AC, so that *the sines of angles are proportional to the lengths of the opposite sides* Also $BC^2 = RB^2 + RC^2 = (AB - AR)^2 + (AC^2 - AR^2) = AB^2 + AC^2 - 2AB \cdot AR = AB^2 + AC^2 - 2AB \cdot AC \cdot k$, where k is the cosine of A. These two relations are of great importance in triangle computations.

Associated Lines and Circles.—It is only possible to quote summarily a few of the more interesting configurations that arise in connection with the triangle. The construction for the circumscribed circle (which passes through the vertices) reveals that the three straight lines drawn perpendicular to the sides through their middle points meet at a common point, the centre of the circle in question.

The centre of the inscribed circle (which touches the sides and lies between them) is the intersection of another set of concurrent

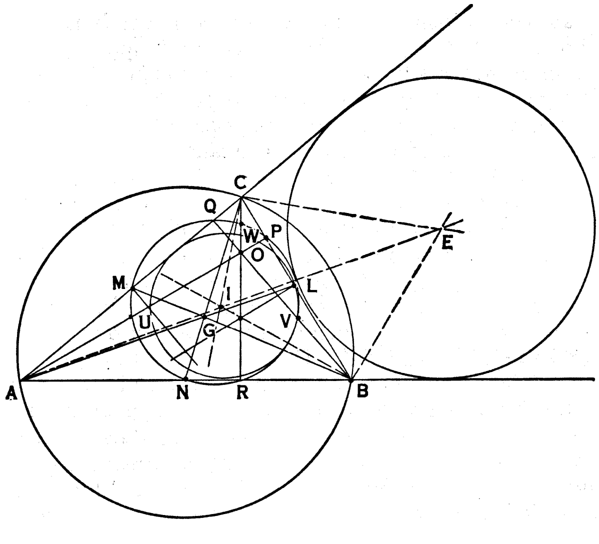

FIG. 3

lines, the three internal bisectors of the angles of the triangle.

The bisectors of two exterior angles, as BE and CE in fig. 3, meet at a point on the bisector of the interior angle at the other vertex, this point being the centre of another circle touching the three sides. Four circles in all are found to touch the sides.

The lines joining the vertices to the middle points $L,M,N,$ of the opposite sides meet in a point G called the *centroid.* The perpendiculars AP, BQ and CR meet in a point O, called the *orthocentre.*

There is the remarkable theorem that the points $L,M,N,P,$ Q,R and the middle points U,V,W of AO, BO, CO lie on a circle (the *nine-point circle*), and the still more striking result (Feuerbach's Theorem) that this circle touches the four circles touching the sides of the triangle.

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TRIANGLE, in music, an instrument of percussion of indefinite musical pitch, consisting of a rod of steel bent into the form of a triangle. Suspended by a loop, it is played by means of a short steel rod. The tone of the triangle is clear and ringing, but it should have no definite pitch.

TRIANON, TREATY OF. The treaty of peace between the Allied and Associated Powers and Hungary, after World War I, was signed at the Trianon on June 4, 1920. The Supreme council of the Conference of Paris had decided and published the frontiers with Czechoslovakia and Rumania as early as June 13. 1919; but the presentation of the treaty was delayed by the existence in Hungary of the Bolshevik regime of Béla Kun. with whom the Allies were unnilling to treat and afterward by the inability of the counterrevolutionary regime which succeeded Kun to form a stable government. (See HUNGARY: History; PARIS, CONFERENCE OF.) After the terms had been presented (on Jan. 15, 1920) to the Hungarian delegates, further delays occurred. Certain circles in France were for a time prepared to consider revising those terms against which the Hungarian delegates had protested most strongly, in return for various concessions, national and international. Counterpressure brought by rival circles in France ended these negotiations, and Hungary had to sign the original draft terms almost unaltered, although a covering letter to the treaty, signed by Alexandre Millerand, the French premier and foreign minister, held out the prospect of subsequent revision if later consideration showed this to be desirable. No noteworthy revision was in fact accorded to Hungary on the basis of this letter: although its own resistance, aided by diplomatic support from Italy, brought the concession that the Allies allowed a plebiscite in the city of Sopron (Oedenburg), originally allotted unconditionally to Austria. This vote, taken in 1921, resulted in Hungary's retaining that city.

Terms of the Treaty.— The treaty was presented to the government of Hungary, whose complete international independence was thus recognized. The treaty made no reference to Hungary's form of government: the legislation enacting the dethronement of the Habsburg (*q.v.*) dynasty was passed, under pressure from the Allies, at a later date. The territorial provisions of the treaty liquidated the ancient historic state of Hungary, which had been a multinational one. According to official Hungarian calculations: the area of the state was reduced from 282,870 sq.km. (or 325,411 if Croatia-Slavonia were included), to 92.963 sq.km., while 4,020 sq.km. were eventually assigned to Austria (*i.e.*, after the Sopron plebiscite), j89 to Poland. 61,633 to Czechoslovakia, 103,093 to Rumania. 21 to Italy and 20,551 (plus Croatia-Slavonia 42,541 sq.km.) to Yugoslavia. The census of 1910 had given the population of Hungary at that date as 18,264,533, plus 2,621,954 in Croatia-Slavonia. Calculated from these figures, Hungary retained only 7,615,117 under the treaty while 291,618 went to Austria. 23,662 to Poland. 3,517,568 to Czechoslovakia, 5,257,467 to Rumania, 49.806 to Italy and 1.509,295 plus 2,621,954 to Yugoslavia. Hungary's armed forces were limited to a lightly armed long-service force of 35,000 men, to be used exclusively for maintenance of internal order and the defense of the frontiers. Hungary was required to accept in advance the obligation to pay reparations to an unspecified total, these being made a first charge on all assets and resources. The remaining clauses of the treaty, which in general resembled that of St. Germain, concluded with Austria, call for no special description. (See ST. GERMAIN, TREATY OF.)

Reception of the Treaty.— These terms mere bitterly resented in Hungary (and also by some circles outside the country) as intolerably harsh and unjust. It was pointed out that the dismemberment of the old historic unit caused great economic hardship and dislocation and that even the ethnic principle invoked to justify this dismemberment (which the Hungarians claimed did not even correspond with the wishes of many of the non-Magyars themselves) was not honoured in its application: more than 3,000,000 persons shown by the 1910 census as Magyar by mother tongue had been allotted to successor states: Czechoslovakia having received more than 1,000,000 such persons and Rumania nearly 1,750,000. While some of these groups constituted ethnic islands in Slav or Rumania areas, in many cases large blocs of solid Magyar population, contiguous to the main central bloc left in Hungary, had been assigned to successor states for the economic or strategic benefit of the latter, or in order to facilitate their internal or mutual communications. The struggle to secure revision of the treaty dominated Hungarian policy from the day of signature until the end of World War II.

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TRIASSIC SYSTEM, a geological term designating the lowest system of the Mesozoic era (*q.v.*) as indicated on the accompanying geologic time chart. The dinosaurs had their origin in the Early Triassic, and became abundant before the end of the period. Most of the Triassic dinosaurs were small, ranging in length from 1 to 8 ft., but some fossils of the Upper Triassic are 30 ft. long. This article deals with the identification and correlation of the stages of the Triassic, the paleogeography of the period and the fossils of ammonites and other invertebrate marine animals that form the basis for the standard sequence of Triassic rocks. Separate subsections deal with the distribution of Triassic rocks in various parts of the world. For information on the evolution of life during the period see PALAEOBOTANY; PALAEONTOLOGY. See also AMPHIBIA; DINOSAURIA; FISHES; REPTILES.

Geologic Time Chart

System and Period	Series and Epoch	Distinctive Records of Life	1,000 Years
		CENOZOIC ERA	
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	
	Paleocene	First placental mammals	70,000
		MESOZOIC ERA	
Cretaceous		Extinction of dinosaurs	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
		PALEOZOIC ERA	
Permian		Reptiles developed, conifers abundant	235,000
Carboniferous			
Upper (Pennsylvanian)		First reptiles, coal forests	260,000
Lower (Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000
Ordovician		First primitive fishes	400,000
Cambrian		Marine invertebrates	500,000
		PRE-CAMBRIAN TIME	
		Few fossils	3,500,000–4,000,000

The term Trias, later modified to Triassic, was proposed by Friedrich von Alberti (1834) for a sequence of strata in central Germany lying above marine Permian (Zechstein) and below marine Jurassic (Liassic) because of the threefold division of the strata into a lower nonmarine red-bed facies (Bunter), a middle marine limestone, sandstone and shale facies (Muschelkalk), and an upper nonmarine continental facies like the lower division (Keuper). This sequence and character of facies typifies Triassic strata of northern Europe, France. Spain and north Africa; it is commonly known as the Germanic facies. In contrast to the predominantly continental Germanic facies, there are developed in the Alps, covering all of Triassic time. a complete marine fossiliferous sequence, that is commonly called the Alpine facies and that, uith the addition from southern Asia of some minor units in the lower beds, forms the primary standard sequence of stages. The standard divisions and correlation of the Germanic and Alpine units (descending from the most recent) plus the main zones, identified by ammonite fossils, are shown in Table I.

It should be noted from this chart that the French geologists define the term Keuper in more restricted fashion than do the German geologists and apply Keuper to the middle part of the German sequence (Gypskeuper), and refer the Rhaetian (Rhät) to the Jurassic and the Lettenkohle to the Middle Triassic (Muschelkalk). In the French literature the German terms have been translated in ascending order, as Grès bigarré (Bunter). Calcaire conchylien (Muschelkalk) and Marnes irisées (Keuper. restricted). An additional but minor variation is the use of Virglorian for Anisian and Werfenian for Scythian.

TRIASSIC PALEOGEOGRAPHY

The widespread orogenies uhich began during the Carboniferous period and continued intermittently until the end of the Paleozoic era brought to an end the pattern of widespread geosynclines that had characterized the Paleozoic. Thus during the later phases of the Paleozoic much of Europe north of the Alps, the Cral mountains region, eastern North America and much of Asia north of the Himalayas, which had been active geosynclinal regions were transformed into rigid continental blocks and became part of the stable portion of the respective continents. With the close of the Permian. epicontinental and geosynclinal seas retreated from most of the continents and the geography of the lands and seas must have been very similar to what it is today.

It is upon this pattern that Triassic history began. Early Triassic seas are marginal to the continents except for the Tethyan geosyncline extending from the Alps through the middle east, the Himalayas and to Indonesia. Thus one finds marine Triassic rocks in all the countries on the margins of the Pacific and marginal to the Arctic ocean. In nearly all of these cases the marine strata grade landward into continental facies. South America except for its western margin now occupied by the Andes was land area with local basins of continental deposition. Africa was also emergent except for a narrow intermittent zone in extreme north Africa. Madagascar has mainly continental sediments like those of south Africa except for a few thin marine tongues in the north. Australia was also a continental area much as today. The main central area of Eurasia was a land area with localized sedimentary basins.

It was not until the Jurassic that shallow shelf seas began to spread beyond these main geosynclinal belts and inundated parts of Eurasia, North America, etc.

TRIASSIC INVERTEBRATE MARINE LIFE

The great restrictions of epicontinental and geosynclinal seas in Late Paleozoic time led to the extinction of a large part of the marine faunas that are characteristic of the Paleozoic era. Major taxa of the corals. echinoderms. arthropods, rnollusca, bryozoa and brachiopods became extinct. This great crisis in the evolutionary history of marine animals is reflected in the composition of Triassic marine faunas. For instance, in the Lower Triassic no corals, foraminifera or bryozoa have been discovered. Brachiopods. crinoids. sponges, asteroids, ophiuroids, echinoids and ostracods are represented by few genera. The dominant marine animals in the Early Triassic seas are rnollusca, especially the ammonites. Pelecypods (Lamellibranchia). nautiloids and gastropods are fairly common but not nearly to the extent of the ammonoids. The most characteristic feature of Early Triassic faunas is their great homogeneity wherever they occur.

Table I.—Triassic System Correlation Table

Germanic facies			Series	Stage	Alpine facies Zones*
Keuper	Rät	Rhaetian	Upper Triassic	Rhaetian	*Choristoceras marshi*
	Gypskeuper	Keuper of French geologists (Marnes irisées)		Norian	*Sirenites argonautae* *Pinacoceras metternichi* *Cyrtopleurites bicrenatus* *Cladiscites ruber* *Sagenites giebeli* *Discophyllites patens*
				Karnian	*Tropites subbullatus* *Carnites floridus* *Trachyceras aonoides* *Trachyceras aon*
	Lettenkohle			Ladinian	*Protrachyceras archelaus* *Protrachyceras reitzi*
Muschelkalk (Calcaire conchylien)			Middle Triassic	Anisian (Virglorian)	*Paraceratites trinodosus* *Paraceratites binodosus* *Nicomedites osmani* *Neopopanoceras haugi*
Bunter or Bundsandstein (Grès bigarré)			Lower Triassic	Scythian (Werfenian)	*Prohungarites similis* *Columbites parisianus* *Tirolites cassianus* *Anasibirites multiformis* *Meekoceras gracilitatus* *Flenimgites flemigianus* *Koninckites volutus* *Xenodiscoides fallax* *Prionolobus rosenkrantzi* *Vishnuites decipiens* *Ophiceras commune* *Otoceras woodwardi*

*Indexed by the ammonite (*q.v.*) fossils

Chronology and correlation of Triassic marine rocks is based mainly on the sequence and distribution of ammonites. *(See also* FOSSIL: *Index Fossils.)* There are roughly 400 genera. of Triassic ammonoids, many of world-wide distribution; in the Lower Triassic alone there are 130 genera. This reflects a phenomenal evolutionary radiation of the group from a single surviving Paleozoic stock. The ammonoids underwent another period of crisis at the end of the Triassic and only a single stock survived into the Jurassic. This reflects another phase of extensive regression of the seas during the Rhaetian stage.

The great crisis of mass extinctions that affected marine invertebrate life at the end of the Paleozoic and led to such a different character of Triassic faunas did not affect the land-living animals. There are no sharp breaks or interruptions in the evolutionary history of the amphibians or reptiles. The same applies to the evolutionary development of plants.

DISTRIBUTION OF TRIASSIC ROCKS

Germanic **Facies.**—The Triassic strata of Germany are mainly clastic, that is, made up of fragments of other rocks, except for limestones and dolomites with marine fossils in the Muschelkalk. The Bunter is composed mainly of sandstones with some shale and conglomerate; divisions that are recognized are chiefly lithological. In places the upper Bunter has marine faunas and indicates the initial phases of the incursion of the Muschelkalk sea. The fauna of the Muschelkalk is characterized by peculiar endemic types that are not particularly diverse in kind but abundant in individuals. The commonest fossils are ammonites of the genus *Cerutites.* The Keuper is composed mainly of mottled red clays, containing masses of gypsum and salt and also bright coloured sandstones and thin impure limestones and dolomites. The lower division of the Keuper, the Lettenkohle, represents a regressive facies of the retreating Muschelkalk sea leaving lagoons and swamps. The sequence contains a mixture of marine, brackish water and continental facies. The overlying Gypskeuper is mainly of continental origin.

In Great Britain the Germanic facies is also present but represented by only the Bunter and Keuper, the Muschelkalk seas never reaching there. The Triassic occurs chiefly in a Y-shaped outcrop belt across central England, with outlying patches. The Bunter is represented mainly by sandstones with conglomerate bands. The Keuper is made up of marls and sandstones with thick beds of gypsum and salt.

The Triassic strata of France, Spain, Sardinia, Corsica and hlorocco are of Germanic facies. The Muschelkalk of Spain and Sardinia, however, contain some marine faunas of Alpine affinities indicating at least partial connection to the east.

Alps.—The classic area of the Triassic of the Alpine facies is in the eastern Alps where carbonate facies prevail. Because of complex facies changes and the recumbent fold (nappe) structure of the Alps (*q.v.*) only the barest. outline of Triassic history or formations can be given here.

In the northern calcareous Alps, the Lower Triassic consists of sandstones, conglomerates and shales. The Anisian'stage is represented by sandy marls and limestones with brachiopods and ammonites. The Ladinian comprises two facies, a lower shale formation with ammonites and brachiopods overlain by thick reef carbonate facies. The Karnian is a marginal shallow-water sandstone facies, but the Norian and Rhaetian are represented by thick, massive dolomite formations. In many places the Rhaetian consists of platty marls and limestones.

To the south in the Dolomite Alps the Scythian stage consists of shales, sandstones and marls with a small pelecypod fauna and rare ammonites. The Anisian is represented by a sandy cephalopod limestone, overlain by dolomites. The Ladinian is a complex of volcanic deposits, reef limestones and dolomites and cephalopod marls. Most of these facies are richly fossiliferous. The Karnian is represented also by a similar complex of facies and the Norian by massive dolomites.

Thus in the eastern Alps there is to the north a mainly shallow-water facies with ammonites common only in the Anisian limestones. In the Dolomite Alps, reefy dolomites and limestones predominate. In both regions the Lower Triassic is a shallow-water, and even lagoonal, clastic facies. Between the northern and southern areas of the eastern Alps mentioned, through the Middle and Upper Triassic are other carbonate facies, with abundant cephalopod faunas, that are thought to represent deeper water deposits. Table II summarizes the stratigraphy of the Triassic in the eastern Alps.

TABLE 11.—*Stratigraphy of Triassic in the Eastern Alps*

Stage	North	Central	South
	Bavarian nappe	Hallstatt nappe	Dolomite Alps
Rhaetian	Marls and limestones	Marls	Absent
Norian	Dolomite	Hallstatt limestone	Dolomite
Karnian	Beds with *Cardita*		Raibl beds
Ladinian	Wetterstein limestone Partnach shales	Dolomites or limestones with cephalopods	Marly facies (with tuffs), St. Cassian } Coral facies Wengen, Buchenstein } Schlern Dolomite
Anisian	Virgloria limestone Sandy marls		Dolomites Sandy limestone with cephalopods
Scythian	Sandstone, conglomerate	Werfen sandstone and shale	Sandstone and shales

Asia.—The classic area of Triassic rocks in the eastern Tethys is in the Himalaya mountains at Spiti. Garhwal, Kumaon and Kashmir. The exposures at Spiti are well developed and fossiliferous. The Lower Triassic (Scythian) consists of 50 ft. of dark coloured shales and limestones conformable to the underlying Productus shales of Permian Age. The rich ammonite fauna represents several of the Scythian ammonoid zones. The Anisian stage is represented by limestones containing an extremely diverse ammonoid fauna. The Ladinian consists of thin black limestones and shales containing Daonella, a bivalve rnollusca, and ammonoids. The whole Middle Triassic is around 400 ft. thick. The Upper Triassic is 2,800 ft. thick at Spiti, consisting of shale and limestone in the lower part and dolomite and limestone in the upper part. The lower part includes the Karnian and Norian stages and is richly fossiliferous. the upper part is generally unfossiliferous and of Rhaetian age. The Triassic of Kashmir consists mainly of limestone and dolomite facies that are generally not as fossiliferous as those of Spiti. In the region of Mount Sirban, south of Abbottabad, the Lower and Middle Triassic is represented by volcanic deposits overlain by Upper Triassic limestones.

The Salt range of Pakistan is one of the more important localities for study of the Scythian stage. The Lower Triassic strata, called the Ceratite beds, are less than zoo ft. thick and consist of limestone. sandstone and marls with an abundant and diverse fauna of ammonoids. Incomplete and poorly known Middle and Upper Triassic formations also occur in the Salt range. All the Triassic facies in the Salt range are shallow-water shelf deposits.

The Triassic rocks discussed so far for India and Pakistan are all of marine origin and part of the Tethyan geosyncline. Throughout geologic history after the Pre-Cambrian. peninsular India has been a prominent stable shield area in contrast to the highly unstable geosynclinal area of north India. Kashmir and Pakistan. The most significant depositional phase on the peninsula was from Late Carboniferous to Lower Cretaceous time when a vast thickness of continental sediments accumulated in linear, local depressions, or grabenlike basins.

This sedimentary complex makes up the Gondwana series (see INDIA: Geology: *Peninsular* India). The beds of the Triassic Age are mainly sandstones and shales.

Indonesia.— Throughout this area there is a varied complex of Triassic strata representing a highly involved depositional history. The most classic region is the island of Timor where extremely abundant and diverse Triassic faunas and facies are present. From the island of Timor about 900 species of invertebrates have been described. The Scythian stage is represented by a cephalopod limestone facies. The Anisian is a limestone facies rather similar to the Hallstatt facies of the Alps. This facies contains mainly cephalopods and some pelecypods and gastropods, there is also an Anisian brachiopod marl facies. In the Ladinian three distinct facies are recognized (1) a cephalopod limestone facies of dark, brownish-red crinoidal limestone with cephalopods and pelecypods, interbedded with a dark red limestone uithout cephalopods but filled nith *Daonella* indica; (2) the Halobia facies of brown, red claystone, clay shale, marl, radiolarian chert, siliceous limestone, siliceous shale and limestone with Halobia and Daonella; and (3) an Alpinelike flysch (*q.v.*) facies of poorly fossiliferous sandstone, calcareous sandstone and graywacke. rich in plant remains, echinoderm breccias and conglomerate.

The Karnian stage shows four distinct facies: (1) a cephalopod limestone facies in which the lowest Karnian zone is a three-foot tuffaceous limy marl. This is overlain by a seven-foot pale, reddish, manganese coated limestone which contains an extraordinarily rich fauna of 462 species of ammonites. jo species of nautiloids. 12 species of orthocerids. 20 species of belemnoids, 32 species of pelecypods. 26 species of gastropods, 2 species of brachiopods, hydrozoa, crinoid stems and segmented worms (serpulids). The ammonites are a mixture of middle and upper Yarnian and Norian elements; the clamlike mollusca Halobia facies; the flysch facies with *Halobia*,.calcareous shale and thin chert beds; and finally a reef limestone facies.

The Norian rocks reach the highest facies development. There is a cephalopod limestone facies, a Halobia facies, a flysch facies and a reef facies. The latter. called the Fatukalksteinfacies. is a massive limestone composed of coralline material, oolitic material or fine echinoderm fragments. Parts of this facies of stratified limestone contain pelecypods, brachiopods and a few ammonites. The Rhaetian is a bituminous series. In places bedded marly limestone and shale contain liquid petroleum and pelecypods and ammonites.

Australia and New Zealand.— The essential features of the tectonic framework, or crustal structure! of this continent were formed by the end of the Paleozoic era. The Tasman geosyncline which had occupied much of eastern Australia since the Cambrian had been completely consolidated. What little Triassic there is in Australia was deposited in remnants of Late Paleozoic Age coal basins or in faulted basins. Deposits of this age are known only in extreme southeastern Queensland, eastern New South Wales and eastern Tasmania. The Triassic rocks are mainly continental sandstones and shales that in places have important coal seams. Plants and vertebrates are the commonest fossils but in New South Wales some beds contain marine ostracods and foraminifera.

If rocks of the Recent and Pleistocene epochs are excepted, the New Zealand rock sequences can be divided into three parts. each forming a well-defined natural unit without major unconformities. The lower division includes the Lower Paleozoic, the middle division the Upper Paleozoic and Lower Mesozoic and the upper division the Upper Cretaceous and Cenozoic. Two distinct facies complexes are recognized in the middle division formations, the Alpine and Hokonui. Both facies are very thick graywacke, arkose, mudstone and conglomerate complexes with some volcanic rocks. Details of the stratigraphy have been poorly known because of extremely complex structure, homogeneity of facies and sparsity of fossils. The little paleontological data available shows that most stages of the Triassic are represented.

Japan.——Triassic formations are present in many widely scattered but small, restricted areas. Where present they rest unconformably on Paleozoic strata and are also unconformable to the overlying Jurassic formations. A significant unconformity within the Triassic sequence, the Akiyoshi orogenic (mountain-building) movement of Ladinian age, makes a convenient lower and upper division which show great contrast in facies and thickness. The lower (preorogenic) part generally consists of thick marine fine-grained clastic sediments. The upper part consists, on the one hand, of thin sediments formed on a neritic shelf, that is, not more than 600 ft. deep (see MARINE BIOLOGY), to the east of the orogenic zone and, on the other, of conglomerates, sandstones and shales of mixed marine, lacustrine and continental origin. This latter facies is thought to have been laid down within the orogenic zone. All of the above facies are predominantly clastic; limestones are rare and volcanic rocks unknown. In addition to these facies there are in extreme southeastern Japan thick fine-grained sediments which contain much chert, but little limestone and almost no conglomerate. This series is thought to represent a continuous depositional series from Permian through Jurassic. The unconformities noted above did not affect this area.

The Triassic occurrences may be classified into those of the Kitakami mountain land, of the inner side of southwestern Japan and of the outer side of the southwestern Japan.

Kitakami Mountain Land. — Resting unconformably on Permian Toyoma series are 9,800 ft. of sandy shale, sandstone, a little limestone and conglomerates of the Inai group. The lower part of this group has yielded Scythian fossils and the upper part Anisian fossils. An unconformity exists in the middle of the Inai group.

Unconformably overlying the Inai group are 650 ft. of sandstone, shale and conglomerate of the 'Saragai group which contain pelecypods of Norian age (Entomonotis ochotica, etc.).

Inner Side of Southwestern Japan. — This region is characterized by scattered occurrences of clastic sediments deposited within the orogenic area. Marine. continental and brackish water facies are represented. Most of these formations are of Upper Triassic age. Both marine invertebrates and land plant fossils are present.

Outer Side of Southwestern Japan. — This is an area of extremely complicated structure. Various beds of Early to Late Triassic Age are identified from their fossils but their stratigraphical relations are much in doubt. On the island of Shikoku are many areas of clastic rocks that have yielded Middle and Upper Triassic pelecypods and a few ammonites.

Africa. — The Triassic in south Africa comprises the major part of the Karroo system, a thick sedimentary complex of continental origin spanning Upper Carboniferous to Lower Jurassic time (see also AFRICA: Geology). The Triassic rocks are divided into a Beaufort series overlain by the Stormberg series. The sequence is as follows:

Stormberg series	Drakensberg volcanics	Lower Jurassic
	Cave Sandstone	Triassic
	Red beds	
	Molteno beds	
Beaufort series	Upper	
	Middle	
	Lower	
		Upper Permian

The Beaufort series consists of highly coloured shales, mudstones and intercalated sandstone beds. The series is especially known for the rich and varied fauna of fossil reptiles it has yielded. Aside from the reptiles, plant fossils of the *Glossopteris* flora are also fairly common. The Molteno beds are dull coloured sandstones and shales with some workable coal seams; the Red beds are highly coloured sandstones and shales conformable to the underlying Molteno beds; the Cave Sandstone is a light coloured, fine grained massive rock primarily of aeolian origin; the Drakensberg volcanics are a thick succession of lavas, in places 4,000 ft. thick, which are thought by some authorities to be of Late Triassic (Rhaetian) Age. All of the formations are thickest in the Cape regions of the Union of South Africa and thin northward toward Rhodesia.

The lithologic character of the sedimentary succession of the Karroo formations and their fauna and flora have many similarities to rock successions of the same age in South America (Argentina and Brazil) and peninsular India. This similarity has led to the thesis that all of these continental areas were once connected, forming the vast continent of Gondwanaland (*q.v.*). This is a very controversial hypothesis. Few people in the northern hemisphere accept the ideas of continental connections of these southern lands during the geologic past. Most geologists in the southern hemisphere are strong supporters of the idea.

South America. — By the end of the Paleozoic, geosynclinal conditions persisted only in the region of the present Andes cordillera. The remainder of the continent was emergent and the site of continental deposition in scattered regions. Marine and continental Triassic formations crop out in the Andean mountain chain in isolated areas from Colombia southward to the southern part of Chile. These formations are everywhere unconformable upon older rocks ranging in age from Pre-Cambrian to Permian. The Triassic rocks in Colombia consist of a thick series of marine and continental formations. The marine part of this sequence (Payande formation) contains pelecypods and ammonoids of Norian age. This formation is transitional upward with a volcanic series of flows, tuffs and breccias of uppermost Triassic Age.

Limestones with Norian fossils crop out in northern and central Peru where they are respectively named the Utcubamba and Pucara formations. The key guide fossil in these areas as well as in Colombia is Entomonotis ochotica, a Norian pelecypod of circum-Pacific distribution.

Various isolated localities of marine and continental Triassic strata are known from Chile. Fossils are generally very scarce but in the marine strata a few supposed Karnian pelecypods and ammonites have been found. The continental strata have yielded Rhaetian plants.

An area of more than 800,000 sq.km. in southern Brazil, northern Argentina, Uruguay and Paraguay was the site of tremendous deposition, mainly continental, in Late Paleozoic and Early Mesozoic times. The Triassic is represented by the Santa Maria formation of red sandstone and shale containing an Upper Triassic or latest Middle Triassic vertebrate fauna; this is overlain disconformably by a thick aeolian sandstone, the Botucatu sandstone.

North America.—Geosynclinal and shelf seas were confined to the western part of the continent covering western Mexico, the Rocky mountain and Pacific coast states, western Canada and Alaska. The Arctic islands of Canada and northern and eastern Greenland were also periodically inundated by Triassic seas. Continental deposits of this age are known in the eastern United States from Florida (subsurface data) to Nova Scotia and in the western United States in Wyoming, Utah, Colorado, New Mexico and Texas.

In the geosynclinal area of western North America a highly complex and varied sequence of Triassic facies, many richly fossiliferous, are present. The western portion of this vast geosynclinal tract is characterized by presence of thick volcanic accumulations along with a varied suite of sedimentary rocks. The eastern half of this geosynclinal region has no volcanic materials and the sedimentary facies consist of shallow water limestones, sandstones and shales that grade eastward into nonmarine red bed formations. This general pattern of facies had persisted since the Early Paleozoic. At the end of the Lower Triassic the seas retreated from the eastern geosynclinal region in the United States, and through Middle and Upper Triassic time the seas were confined to a region west of a north-south line through central Nevada. The area east of this line, which formerly had been covered by geosynclinal seas, became the site of active continental deposition during the Upper Triassic and following Jurassic. To illustrate the lithologic character of the strata in the western. volcanic part of the geosyncline the region of southwestern Nevada is classic. The Lower Triassic (Candelaria formation) is represented by 3,000 ft. of marine shales and limestones with tuffaceous sandstones unconformably overlying Permian and older rocks. The Middle Triassic is represented by first a marine limestone and shale formation (Grantsville) and a volcanic sequence with some lenses of shale and limestone (Excelsior formation). This volcanic formation may be in part equivalent to the Grantsville formation. Unconformably above, the Upper Triassic consists of a varied sequence of marine shales and limestones nearly two miles thick which grade without change into the overlying Lower Jurassic.

From California north through southern Alaska no Lower or Middle Triassic is present, only Upper Triassic strata consisting of sedimentary and volcanic rocks. From northern Alaska eastward through the Arctic islands of Canada to Pearyland are many areas of Triassic rocks; poorly known except that in one place or another a nearly complete sequence of marine faunas occur.

East Greenland has various areas with marine Lower Triassic rocks of a near shore facies that have yielded an abundant ammonite fauna nearly identical with those from the classic Himalayan sections.

Continental Triassic deposits are exposed along the Atlantic coast and in the Rocky mountain — Colorado plateau region. The exposures in eastern North America are confined to a series of isolated troughs from Nova Scotia south to North Carolina. This is the area of the former Appalachian geosyncline which underwent its final orogenesis in the Late Paleozoic. After the orogenic phase a series of downwarped and faulted troughs developed within this new mountain system. Sediments from the adjoining highlands poured into the troughs, forming thick deposits of sandstones, shales and conglomerates representing fan, stream and lake deposits. Associated with the sedimentary deposits are igneous rocks in the form of flows, sills and dikes. These Triassic deposits are known as the Newark group and are all Upper Triassic in age. No marine fossils are known from the Newark group but land plants, fresh-water fish and dinosaur tracks are fairly abundant.

A sequence of terrestrial or marginal clastic rocks tentatively classified as Triassic was penetrated in 12 scattered oil-test wells in southeast Alabama, southwest Georgia and north-central Florida. Lithologically, the subsurface sedimentary rocks are closely similar to rocks of the Triassic Newark group, that crop out at various localities along the Atlantic seaboard from Massachusetts to North Carolina; also. like the Newark group, intrusions and flows of diabase and basalt cut the Triassic (?) strata in several wells.

In the Colorado plateau area Lower Triassic deposits are termed the Moenkopi formation; to the west and north these grade into marine formations. The Moenkopi consists of dark-red sandstone, siltstone, interbedded gypsum and some marine limestones in its more western exposures. The vertebrate fauna contained in these beds resembles that of the Early Triassic of Spitzbergen and the Bunter of Germany. Unconformably overlying the hloenkopi and overlapping it extensively to the east is the Chinle formation, with a basal sandstone or conglomerate often separately recognized as the Shinarump. In eastern New Mexico and western Texas equivalents of the Chinle are termed the Dockum group. From the Wind River mountains of Wyoming east into South Dakota extensive Triassic red beds are designated as the Chugwater and Spearfish formations. All of these formations are Upper Triassic in age and contain only fair fossil faunas of reptiles, amphibians and fish. Konmarine formations of Rhaetian age (Wingate sandstone. Moenave formation; and possibly the Kayenta formation) are widespread in southwestern United States.

Arctic Region. — The continental areas marginal to the Arctic ocean have extensive development of Triassic formations. Besides those on the northern margin of North America that have already been mentioned, marine formations of the Triassic Age are known from Spitzbergen, Bear Island. New Siberian islands, and the coast of Siberia off the Laptev and East Siberian seas.

The best known of these regions is Spitzbergen where a thick fossiliferous sequence is fairly well known. The lowest Triassic formations consist of sandstones. calcareous sandstones and marly limestones. poor in fossils: resting unconformably on 'the underlying Permian. The higher strata of the Lower Triassic and the Middle Triassic are represented by black and gray sandy marls and shales rich in the fossil remains of reptiles, fish, ammonites and pelecypods. Toward the close of the Middle Triassic there was a general regression of the seas and a mixed succession of marine and nonmarine formations was formed. The nonmarine formations frequently contain coal beds. With the advent of the Cpper Triassic another general inundation took place and an alternating sequence of fossiliferous marine calcareous and arenaceous beds accumulated. During the Rhaetian the seas again retreated from Spitzbergen.

See also geology sections of articles on continents and countries, as ASIA; UNITED STATES (OF AMERICA), THE, etc.

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(B. KL.)

TRIBALLI, in ancient geography, a Thracian people whose earliest home was near the junction of the Angrus and Brongus (the east and west Morava), and included toward the south "the Triballian plain" (Herodotus iv, 49), which corresponds to the plain of Kossovo in Turkey.,

In 424 B.C. they were attacked by Sitalces, king of the Odrysae, who was defeated and lost his life in the engagement. On the other hand they were overcome by the Autariatae. an Illyrian tribe; the date of this event is uncertain (Strabo vii, 317). In 376 B.C. a large band of Triballi crossed Mt. Haemus, and were preparing to besiege Xbdera when Chabrias appeared off the coast with the Athenian fleet and compelled them to retire. In 339 B.C. when Philip II of Macedon was returning from his expedition against the Scythians, the Triballi refused to allow him to pass the Haemus unless they received a share of the booty. Hostilities took place, in which Philip was defeated (Justin ix, 3), but the Triballi appear to have been subsequently subdued by him. After the death of Philip, Alexander the Great in 334 crossed the Haemus and drove the Triballi to the junction of the Lyginus with the Danube. Their king Syrmus took refuge in Peuce, an island in the Danube, whither Alexander was unable to follow him. The punishment, however. inflicted by him upon the Getae (*q.v.*) induced the Triballi to sue for peace. In spite, however, of misfortunes at the hands of the Gauls, they continued (135–84 B.C.) to cause trouble to the Roman governors of Macedonia. Under Tiberius mention is made of Triballia in Moesia, and the Emperor Maximin (A.D. 235–237) had been commander of a squadron of Triballi.

TRIBE. W. H. R. Rivers defined a tribe as "a social group of a simple kind, the members of which speak a common dialect, have a single government, and act together for such common purposes as warfare." Other typical characteristics include a common name, a contiguous territory, a relatively uniform culture or way of life and a tradition of common descent. Tribes are usually composed of a number of local communities, *e.g.*, bands, villages or neighbourhoods, and are often aggregated in clusters of a higher order called nations. The term is seldom applied to societies that have achieved a strictly territorial organization in large states but is usually confined to groups whose unity is based primarily upon a sense of extended kinship ties. It is no longer used for kin groups in the strict sense, such as clans.

All the elements in the above definition are subject to exceptions. Thus the Amba of Uganda are considered one tribe though they speak two mutually unintelligible languages; the Zuiii "tribe" comprises only a single community; the Kiowa Apache constitute one band of the larger Kiowa tribe; the Dorobo tribe of Kenya live scattered among the Kandi and blasai for whom they hunt and perform ritual services. The criterion of political integration. in particular, is inapplicable to many primitive peoples. *e.g.*, of Australia. Melanesia, Amazonia and western North America, among whom each community may be politically autonomous. Anthropologists, nevertheless, are accustomed to divide such peoples into "tribes" on the basis of linguistic and cultural resemblances. Sometimes a cluster of independent local groups forms an intermarrying unit or maintains peaceful trade relations or is unified by a common cult or age-grade organization, despite the lack of political integration, but oftentimes all that distinguishes it from other clusters is a common dialect and culture. For this reason there has been a discernible recent trend toward employing the term tribe for any group that can be isolated as the carrier of a distinctive culture, at least in the absence of territorial states.

Where the latter have developed, the term nation is preferred to designate the comparable but larger culture-bearing groups. *See* also Index references under "Tribe" in the Index volume

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TRIBONIAN (TRIBONIANUS) (d. *c.* A.D. 545), Justinian's legal adviser and minister, chiefly responsible for the codification of the law, was probably born in Pamphylia in the late 5th century. He practised as an advocate at Constantinople, where he attracted the attention of Justinian and thereafter enjoyed imperial favour. He was appointed *magister officiorum* (A.D. 528) and *quaestor sacri palatii* (A.D. 530), a minister not unlike the late medieval English chancellor. From this office Justinian removed him in A.D. 532, yielding to the mob in the Kika riot, but Tribonian was restored in A.D. 534 and apparently remained *quaestor* until his death, about A.D. 545. Tribonian's personal character was attacked by the contemporary author Procopius, who accused him of venality and religious unorthodoxy, but the charges are not necessarily reliable and may be, in part, misconceived. Tribonian was a versatile man and his interest in philosophy, astronomy and the calendar may be the source of the charge of atheism.

His great interest, however, was the law, and it is as the principal agent of the codification which distinguished Justinian's reign that Tribonian is renowned. It may be, indeed, that he was in large measure its instigator. He appears first as a member of the commission which produced the first *Codex* of imperial legislation in A.D. 529. In A.D. 530 he was president of the commission compiling the *Digest,* excerpting extracts from the works of the great jurists of earlier times, and Justinian himself acknowledged the benefit derived by the commission from Tribonian's own private library of older legal works. It was again to Tribonian (with two others) that the emperor entrusted the preparation of an elementary handbook, the *Institutes,* published before the *Digest* at the end of A.D. 533. Finally, Tribonian was president of the commission which, in A.D. 534, produced a completely revised *Codex.* In the codification, the various commissions were empowered to amend and alter the texts they used where they felt such course necessary. It is a measure of Tribonian's pre-eminence that scholars designate such alterations *emblemata Triboniani.* After the second *Codex,* Tribonian remained Justinian's legal adviser and was doubtless responsible for the earlier *Novellae,* enactments subsequent to the codification. It is noticeable that Justinian legislated less after Tribonian's death. *See* also JUSTINIAN I.

See B. Kübler, *Acta Congressus Iuridici Internationalis, vol.* i, 18 ff. (1935). (J. A. C. T.)

TRIBUNE (Lat. *tribunus,* connected with *tribus,* "tribe"). a name assigned to officers of different descriptions in ancient Rome.

Military Tribunes. — The original tribunes were the commanders of the contingents of cavalry and infantry supplied to the Roman army by the early tribes: the Tities, the Ramnes, and the Luceres. The *tribuni celerum,* or commanders of the horsemen, no longer existed in the later times of the republic. So long as the monarchy lasted these tribunes were nominated by the king as commander in chief; and the nomination passed over to his successors, the consuls. From 362 B.C. six tribunes were annually nominated by popular vote, in 311 B.C. the number was raised to 16, and in 207 B.C. to 24, at which figure it remained. The rights of the assembly passed to the emperors, and "the military tribunes of Augustus" were still contrasted with those nominated in the camp by the actual commanders. (For *Tribuni aerarii, see* AERARIUM.)

Tribunes of the Plebs. — The most important tribunes were the tribunes of the *plebs (tribuni plebis).* These were the outcome of the struggle between the patrician and the plebeian orders. When in 494 B.C. the plebeian legionaries met on the Sacred Mount, it was determined that the plebeians should by themselves annually appoint executive officers, two tribunes to confront the two consuls and two helpers, called *aediles,* to balance the *quaestors,* and that the persons of the tribunes and aediles should be regarded as inviolable. The ancient traditions concerning the revolution are extremely confused and contradictory. It must have ended in something which was deemed by both the contending bodies to be a binding compact, although the lapse of time has blotted out its terms. This is necessary to explain the "sacrosanct" character always attached to the tribunate. There must have been a formal acceptance by the patricians of the plebeian conditions; probably the oath which was first sworn by the insurgents was afterward taken by the whole community, and the "sacrosanctity" of the plebeian officials became a part of the constitution. There must also have been some constitutional definition of the powers of the tribunes. These rested at first on an extension of the power of veto which the republic had introduced. Just as one consul could invalidate an order of his colleague, so a tribune could invalidate an order of a consul, or of any officer inferior to him. There was, no doubt, a vague understanding that only orders which sinned against the just and established practice of the constitution should be annulled, and then only in cases affecting definite individuals.

Development of the Tribunate.—Although the revolution of 494 B.C. gave the tribunes a foothold in the constitution, it left them with no very definite resources against breaches of compact by the patricians. The traditional history of the tribunate from 494 to 451 B.C. is obscure; we hear of attacks by patricians on the newly won privileges, even of the assassination of a tribune, and of attempts on the part of the plebeians to bring patrician offenders to justice. The plebeians attempted to set up a criminal jurisdiction for their own assembly parallel to that practised by the older centuriate assembly. Furthermore, the *plebs* attempted something like legislation; it passed resolutions which it hoped to force the patrician body to accept as valid. As to details, only a few are worth notice. In the first place, the number of tribunes was raised to ten; how we do not know, but apparently some constitutional recognition of the increase was obtained. Then an alteration is made in the mode of election. As to the original mode, the authorities are hopelessly at variance. It was in accordance with the Roman spirit of order that the tribunes, in summoning their assemblies, should ask the plebeians to organize their supporters in bands. The *curia* was certainly a territorial district, and the tribunes may have originally used it as the basis of their organization. If tribunes were elected by plebeians massed *curiatim,* such a meeting would easily be mistaken in later times for the *comitia curiata.* A change was introduced in 471 B.C. by the Publilian Law of Volero, which directed that the tribunes should be chosen in an assembly organized on the basis of the Servian tribe, instead of the *curia.* This assembly was the germ of the *comitia tribute.* The question by what authority the Law of Volero was sanctioned is difficult to answer. Possibly the law was a mere resolution of the plebeians with which the patricians did not interfere, because they did not consider that the mode of election was any concern of theirs. Whatever view may be taken of the movement which led to the decemvirate, an important element in it was the agitation carried on by the tribunes for the reduction of the law of Rome to a written code. Until they obtained this, it was impossible for them to protect those who appealed against harsh treatment by the consuls in their capacity of judges.

During the decemvirate the tribunate was in abeyance. It was called into life again by the revolution of 449 B.C., which gave the tribunes a considerably stronger position. Their personal privileges and those of the aediles were renewed. The road was opened up to legislation by the tribunes through an assembly summoned by them on the tribe-basis *(concilium plebis),* but subject to the control of the senate. The growth of the influence of this assembly over legislation belongs rather to the history of the *comitia* (*q.v.*) than to that of the tribunate. After the Hortensian Law of 287 B.C., down to the end of the republic, the legislation of Rome was mainly in the hands of the tribunes. The details of the history of the tribunate in its second period, from 449 to 367 B.C., are hardly less obscure than those which belong to the earlier time. There was, however, on the whole, undoubtedly an advance in dignity and importance. Gradually a right was acquired of watching and interfering with the proceedings of the senate, and even with legislation. Whether the absolute right of veto had been achieved before 367 B.C. may well be doubted. But the original auxilium, or right of protecting individuals, was, during this period, undergoing a very remarkable expansion. From forbidding a single act of a magistrate in relation to a single person, the tribunes advanced to forbidding by anticipation all acts of a certain class, whoever the persons affected by these restrictions might prove to be. It therefore became useless for the senate or the comitia to pass ordinances if a tribune was ready to forbid the magistrates to carry them out. Ultimately, the mere announcement of such intention by a tribune was sufficient to cause the obnoxious project to drop; that is, the tribunes acquired a right to stop all business alike in the deliberative assembly, the senate, and in the legislative assemblies, or comitia. The technical name for this right of veto is intercessio. The two main objects of the tribunes were the opening of the consulate to plebeians, and the regulation of the state domain in the interests of the whole community. Both were attained by the Licinio-Sextian laws of 367 B.C.

Then a considerable change came over the tribunate. From being an opposition weapon it became an important wheel in the regular machine of state. As the senate became more and more plebeian, the old friction between senate and tribunes disappeared. It was found that the tribunate served to fill some gaps in the constitution, and its power was placed by common consent on a solid constitutional basis. From 367 to 134 B.C. (when Tiberius Gracchus became tribune) the tribunate was for the most part a mere organ of senatorial government.

Qualifications and Powers.—Even after the difference between patrician and plebeian birth had ceased to be of much consequence, the plebeian character was a necessity for the tribune. When the patricians P. Sulpicius Rufus and, later, P. Clodius (the antagonist of Cicero) desired to enter on a demagogic course, they were compelled to divest themselves of their patrician quality by a peculiar legal process. The other necessary qualifications were such as attached to the other Roman magistracies: complete citizenship, absence of certain conditions regarded as disgraceful, and fulfilment of military duties. The election took place in a purely plebeian assembly, ranged by tribes, under the presidency of a tribune selected by lot. The tribune was bound by law to see a complete set of ten tribunes appointed. Technically, the tribunes were reckoned, not as magistrates of the Roman people, but as magistrates of the Roman plebs; they therefore had no special robe of office, no lictors, but only messengers (viatores), no official chair, like the curule seat, but only benches (subsellia). Their right to summon the plebs together, whether for the purpose of listening to a speech or for passing ordinances, was rendered absolute by the "laws under sacred sanction" (leges sacratae), which had been incorporated with the constitution on the abolition of the decemvirate. The right to summon the senate and to lay business before it was acquired soon after 367 B.C., but was seldom exercised, as the tribunes had abundant means of securing what they wanted by pressure applied to the ordinary presidents, the consuls or the praetor. When an interregnum came about and there were no "magistrates of the Roman people," the plebeian tribunes became the presidents of the senate and conductors of state business. At the end of the republic there were interregna of several months' duration, when the tribunes held a position of more than usual importance.

The Right of Veto.—The real kernel of the tribune's power consisted in his intercessio, or right of invalidating ordinances, whether framed by the senate or proposed by a magistrate to the comitia, or issued by a magistrate in pursuance of his office. From 367 B.C. down to the time of the Gracchi the power of veto in public matters was, on the whole, used in the interests of the governing families to check opposition arising in their own ranks. A recalcitrant consul was most readily brought to obedience by an exercise of tribunician power. The tribunes found a field for constant activity in watching the administration of justice, and in rendering assistance to those who had received harsh treatment from the magistrates. The tribunes were, in fact, primarily legal functionaries, and constituted in a way a court of appeal. It was to this end that they were forbidden to pass a whole night away from the city, except during the Latin festival on the Alban Mount, and that they were expected to keep their doors open to suppliants by night as well as by day. They held court by day in the Forum and frequently made elaborate legal inquiries into cases where their help was sought. We hear of this not infrequently in Cicero's speeches, and in other writings which deal with legal matters. According to the general principle of the constitution, magistrates could forbid the acts of magistrates equal to or inferior to themselves. For this purpose, the tribunes were deemed superior to all other officers. If a tribune exercised his veto no other tribune could annul it, for the veto could not be itself vetoed, but it was possible for another tribune to protect a definite individual from the consequences of disobedience. The number of the tribunes made it always possible that one might baulk the action of another, except at times when popular feeling was strongly roused. The veto was not, however, absolute in all directions. In some it was limited by statute; thus, the law passed by Gaius Gracchus about the consular provinces did not permit a tribune to veto the annual decree of the senate concerning them. When there was a dictator at the head of the state, the veto was of no avail against him. One of the important political functions of the tribunes was to conduct prosecutions of state offenders, particularly ex-magistrates. These prosecutions began with a sentence pronounced by the tribune upon the culprit; whereupon, exercising the right given him by the XII. Tables, the culprit appealed. If the tribune sought to inflict punishment on the culprit's person, the appeal was to the assembly of the centuries; if he wished for a fine, the appeal was to the assembly of the tribes.

The Late Republic and Empire.—It is commonly stated that a great change passed over the tribunate at the time of the Gracchi, and that from their day to the end of the republic it was used as an instrument for setting on foot political agitation and for inducing revolutionary changes. This view is an inversion of the facts. The tribunate did not create the agitation and the revolutions, but these found vent through the tribunate, which gave to the democratic leaders the hope that acknowledged evils might be cured by constitutional means, and in the desperate struggle to realize it the best democratic tribunes strained the powers of their office to their ruin. For the bad tribunes did not hesitate to use for bad ends the powers which had been strained in the attempt to secure what was good. But the tribunate only fared like all other parts of the republican constitution in its last period. The consuls and the senate were at least as guilty as the tribunes. After a severe restriction of its powers by Sulla and a restoration by Pompeius, which gave a twenty years' respite, the essential force of the tribunate was merged in the imperial constitution, of which indeed it became the principal constituent on the civil side. The ten tribunes remained, with very restricted functions. The emperors did not become tribunes, but took up into their privileges the essence of the office, the "tribunician authority" (*tribunicia potestas*). This distinction between the principle of the office and the actual tenure of the office was a creation of the late republic. Pompeius, for example, when he went to the east, was not made proconsul of all the eastern provinces, but he exercised in them a "proconsular authority," which was the germ of the imperial authority on its military side. Similarly the emperor, as civil governor, without being tribune, exercised powers of like quality with the powers of the tribune, though of superior force. By virtue of his tribunitian authority he acquired a veto on legislation, became the supreme court of appeal for the empire, and to his person was attached the ancient sacrosanctity. Augustus showed the highest statesmanship in founding his power upon a metamorphosed tribunate rather than upon a metamorphosed dictatorship, upon democratic rather than aristocratic traditions.

Rienzi.—The name "tribune" was once again illuminated by a passing glory when assumed by Cola di Rienzi (*q.v.*). The movement which he headed was in many respects extremely like the early movements of the plebeians against the patricians, and his scheme for uniting Italy in one free republic was strangely parallel with the greatest dream of the Gracchi.

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TRICAMERON, BATTLE OF (A.D. 533). This battle, the second major engagement in the campaign led by Belisarius to restore Vandal Africa to the power of Justinian (see JUSTINIAN I), completed the defeat of the Vandal king Gelimer (Geilimir), Tzazo his brother and the whole Vandal army. The Roman provincials had no love for their Vandal masters and favoured the Byzantine army, advancing professedly as liberators. Gelimer could prevent neither the Byzantine victory at Ad Decimum on Sept. 13, 533 nor the capture of Carthage, his capital, but his remaining army was still much more numerous than that of Belisarius. The final clash came at Tricameron, about 20 mi. W.S.W. of Carthage, in the middle of December. It was a notable battle, because the Byzantines, with cavalry only, attacked and routed a much larger force of horsemen and infantry. According to the account of Procopius the Vandals were drawn up on the bank of a shallow river, with tribunes commanding the wings and Tzazo the centre. Gelimer rode hither and thither haranguing his troops and commanding that the Vandals (as distinguished from the federate horsemen on their wings) should use no throwing weapon but only their swords—a defensive measure. Belisarius, arriving hastily with the cavalry and in advance of his infantry, would not wait to give battle but drew up his line with his federates on the wings and the Byzantine general John with the praetorian standard in the centre. At his order John and his small cavalry force crossed the river and attacked. The Vandals repulsed them, but could not cross the river themselves, not being on horseback. Twice more John crossed the river and attacked, the third time advancing with the whole army and the praetorian standard, whereupon the Vandal centre broke, Tzazo was killed, and Gelimer fled. (M. DY.)

TRICERATOPS, the best-known member of the horned dinosaur group (Ceratopsia) of the Upper Cretaceous. This was a four-footed dinosaur about 20 ft. long. Its head bore a pair of long brow horns and a smaller horn over the nose; a large bony frill protected the neck. (See DINOSAURIA.) (A. S. RR.)

TRICHINOPOLY (TIRUCHIRAPALLI), a city and district of Madras state, Republic of India. The city is on the right bank of the Cauvery river, 180 mi. by rail S.W. of Madras. Pop. (1951) 218.921. The fort which forms the nucleus of the city measures about 1 mi. by ½ mi.; its defenses have been removed. Within it rises, 273 ft. above the city, the isolated Trichinopoly rock, upon which is a temple reached by a covered stone staircase, entered by a carved gateway and profusely ornamented. Trichinopoly is an important trading centre and railway junction. Its industries are goldsmiths' work and modelling in pith, silk weaving, cigar and soap making. Trichinopoly and its neighbourhood was the scene of much hard fighting between the English and the French during the Carnatic wars between 1749 and 1761.

The DISTRICT OF TRICHINOPOLY has an area of 5,514 sq.mi. Pop. (1951) 2,943,882. It is a flat plain bisected by the Cauvery river, but there are a few rocky heights in the south and southwest. The chief crop is paddy, a little sugar cane is also grown. There are large deposits of gypsum, phosphate rock and limestone. In March 1948 the princely state of Pudukkottai was merged into the district. (S. GL.)

TRICHINOSIS (TRICHINIASIS), a disease in man and other animals caused by infection with the parasite Trichinella *spiralis*. The parasite was named by Sir Richard Owen on the basis of encysted trichinae discovered in human muscle by Sir James Paget in 1835. The larvae were first found in the muscle tissue of swine by Joseph Leidy in 1846. The complete life cycle was elucidated in 1859 by Rudolf Leuckart and Rudolf Virchow, who, working independently, found the adult worms in the intestinal tract. The clinical character of the acute disease caused by the invasion of the parasite was demonstrated by Friedrich von Zenker in 1860. Following Zenker's discovery, severe outbreaks of the disease were recognized in Prussia and other parts of Germany. (W. H. WT.)

Trichinosis is acquired by eating uncooked or inadequately cooked flesh containing infective encysted larvae, which, after release from their cysts, migrate from the stomach to the small intestine, in the wall of which they embed themselves. There the male and female worms rapidly develop to maturity, reaching lengths of approximately $\frac{1}{16}$ and $\frac{1}{6}$ in., respectively. After mating, birth of minute living young may take place for six weeks or longer. These larvae enter the lymph spaces in the intestinal wall and are carried to the heart, from which they reach the general circulation. They penetrate into many tissues. but further growth occurs only in voluntary muscle fibres. Within approximately 30 days the larvae reach a length of $\frac{1}{25}$ in., and are spirally coiled. They are gradually enclosed in cysts, and may remain alive for many years, or may die and be absorbed, or become calcified. Trichinae become infective after approximately 14 days' development in muscle; when they are ingested alive by another animal, the cycle described above is repeated.

Symptoms. — The clinical manifestations of trichinosis are in general related to the number of worms developing in a particular infection, the most severe illness usually being associated with large numbers of organisms. Persons contracting light infections may show no evidence of ill-health. Diagnosis of sporadic cases is difficult because the symptoms simulate closely those of many other conditions. Nausea, vomiting, diarrhea and abdominal pain may appear within 24 to 48 hours, related to development of worms in the intestine. Such symptoms may be absent, but those arising from the migration of larvae through the body may be detected between one and three weeks after infection. They include weakness, fatigue, headache and fever accompanied by chills and sweats; some patients have sore throat or laryngitis with cough. Swelling around the eyes and face is a common symptom. A rash may be present on the trunk and upper extremities.

When the larvae begin to reach the muscles, pronounced muscle pain and stiffness of the joints are experienced. Symptoms of heart disease may be present, and pneumonia is not an unusual complication. The larvae may invade the spinal cord and brain and give rise to symptoms simulating meningitis. encephalitis or poliomyelitis. The acute phase of the disease lasts from two to three days in mild cases and up to three to four weeks in more severely infected persons. If complications ensue, the course may be prolonged.

After recovery, the muscle pain gradually disappears, and in most cases there are no residual symptoms. The mortality rate of clinically recognized cases is fairly low; in the United States between 1930 and 1938, for example, it was approximately 6%.

Diagnosis and Treatment. — Diagnosis may be aided by laboratory findings. Blood examinations generally reveal an increased white cell count, and increase in eosinophiles is usually but not invariably present. A biopsy of muscle tissue may disclose the larvae. Skin and blood tests are of value but, like the biopsy, are generally not positive until after the larvae have reached the muscles.

Unfortunately, there is no drug of specific value, and treatment is mainly symptomatic. Adrenocorticotropic hormone (ACTH) and cortisone are of considerable benefit in alleviating symptoms during the acute stage.

Incidence and Prevention. — Despite the fact that Trichinella is widespread in many hosts, such as rats, dogs and cats, man, because of his food habits, acquires trichinosis primarily from the consumption of pork. Occasional epidemics have occurred from the ingestion of bear, smoked dog and walrus meat.

It is estimated that approximately 28,000,000 persons throughout the world are infected with Trichinella, and that 21,000,000 of them live in the United States. Probably 350,000 new infections develop in the U.S. each year. The majority of these persons have only light infections and seemingly never suffer ill-health as a result. Only an average of about 300 cases exhibiting clinical symptoms are actually recognized and reported each year. Outbreaks have occurred in most European countries, but incidence of the parasite in England, elsewhere in Europe, Canada and Australia at mid-20th century was only a small fraction of that in the U.S.

Prevention lies in reducing or eliminating the infection in hogs and in the thorough cooking of pork. As a general rule, all pork should be cooked until the pink colour has completely disappeared

(137° F. throughout). In the United States, where feeding of raw garbage to swine is a common practice, approximately 6% of the animals maintained on such food are infected. Undoubtedly, infection is carried through pork scraps in the garbage. The incidence in grain-fed hogs is less than 1%. In European countries for which data are available, only a fraction of 1% of swine carry the parasites; many of these countries require the microscopic examination of pork. Infection in hogs is equally low in England, which requires the cooking of garbage fed to swine. In the United States. federal meat-inspection regulations require processing for the destruction of trichinae of all pork products customarily eaten without cooking (frankfurters, salami, mettwurst, cervelat, etc.); these products are potent sources of infection unless processed to kill the parasite. Protection extends only to such products; there is no federal inspection or treatment of fresh pork or other types of pork products for trichinosis. See also PARASITIC DISEASES. (P. P. W.)

TRICHOPTERA, an order of usually somberly coloured insects commonly known as caddis flies, though they are not true flies (Diptera). See CADDIS FLY.

TRICHUR, a town and district of Kerala, India. The town, formerly in Cochin state and now headquarters of the district, lies 12 mi. inland at the head of an extensive system of backwaters or lagoons within the Malabar coast (*q.v.*), 37 mi. N. of Ernakulam. Pop. (1951) 69,515. It is considered to be the oldest town on the west coast, its origin being ascribed to the legendary Parashurama; its name signifies "a small sacred place." The town is built around a hillock surmounted by the temple of Vatakkuntha ("the god of the north"). Its site off the western spurs of the Anaimalai hills is important, as the north-south traffic in Kerala must pass there.

The Southern railway to the interior and Madras through the gap at Palghat, and the good road connections, much assisted Trichur's development; Trichur is both a commercial and a cultural centre. There is some cotton spinning and weaving and the town contains a museum, a zoological garden and five colleges affiliated to Kerala university.

TRICHUR DISTRICT was constituted from the components of the former princely state of Cochin (*q.v.*). Area 1,149 sq.mi. Pop, (1961) 1,634,251. It is essentially a lowland coastal area broken along the-coast by numerous lagoons, and ridged on the .east by laterite hills and knolls. The chief crops are rice and coconuts, The district is much industrialized, with factories making glass, aluminum, fertilizers and caustic soda at Alwaye. Cranganore, the ancient capital of the Chera kings, lies in the southwest. (V. V. B.; P. B. D.; M. S. H.)

TRICLINIUS, DEMETRIUS (14th century A.D.), the foremost Byzantine scholar of the Palaeologan era, devoted his energies to editing the Greek poets, mainly the tragedians, with metrical and exegetical scholia. These incorporated, beside his own, notes by Thomas Magister and Manuel Moschopoulos, as well as scholia taken from older traditions. Triclinius was the first Byzantine scholar to examine closely the metrical structure of the lyrics of Attic plays; but striving to apply the rules of Hephaestion and misled by his own unsatisfactory views of Greek prosody he often tampered with the text. Most of Triclinius' textual changes have now been discarded, but this does not detract from the importance of his scholarly achievement in its own time.

His text of Aeschylus (Codex *Farnesianus* I.E. 5) survives, probably in his own handwriting, as does his transcript of Hesiod (*Codex Marcianus* Graecus 464); his text of Sophocles (represented in the so-called libri *Tricliniani*) printed by A. Turnebus (1553) became the vulgate of this author until it was superseded by R. F. P. Brunck's edition (1786). Triclinius also wrote scholia to Euripides, Pindar, Aristophanes and Theocritus.

See K. Krumbacher, *Geschichte der Byzantinischen Litteratur*, 2nd ed. (1897) ; A. Turyn, *Studies in the Manuscript Tradition of the Tragedies of Sophocles* (1952). (S. J. PA.)

TRICONODONTA, a group of small, extinct, carnivorous mammals of the Jurassic Age, characterized by the condition of their molar teeth, which typically bore three cusps arranged in a line, the long axis fore-and-aft. They left no descendants. *See* MAMMALIA; MULTITUBERCULATE; PALAEONTOLOGY.

TRICOUPIS (TRICOUPI, TRIKOUPIS), **CHARILAOS** (1832–1896), Greek prime minister, was born at Nauplia in 1832 and studied law and literature in Athens and Paris. After serving in the Greek diplomatic service, he entered the chamber of deputies in 1865 and in the following year was made foreign minister. In 1875 he became prime minister for a few months, but he had no opportunity to begin carrying out his policy—to develop the resources of the country and create an army and navy. In 1882 he became prime minister for the third time (his second period of office, two years earlier, had lasted only a few months) and at once set about the task of putting Greek finance upon a firmer basis and of increasing the prosperity of the country by making roads, railways and harbours. He was defeated in the general election of 1885, but in the following year resumed office.

His difficulties were now increased by the large expenditures which had been incurred for military preparations while he had been out of office (see GREECE: Modern History). Tricoupis, nevertheless, believed that he could raise the value of Greek paper currency to par in a few years, and based his calculations upon that assumption. His dexterity in finance was generally admired, and his schemes for the construction of roads and railways met with a certain amount of success. But Greece could not meet its obligations, and Tricoupis failed in his attempts to make terms with the creditors of the country.

In Jan. 1895 he resigned. At the general election four months later, he and his party were defeated. He retired from public life and died at Cannes, France, on April 11. 1896.

Although Tricoupis has been criticized for being excessively ambitious and far too optimistic, he was regarded, even during his lifetime, as the foremost Greek statesman of his time. By nature he was reserved—his nickname was "the Englishman"—and he had no sympathy with the arts of the demagogue. Both in the ranks of his party and by the country at large, however, his abilities and character were unquestioned. Unfortunately the circumstances of the time did not allow his wide schemes for the benefit of the country to be carried into effect.

TRIDYMITE, a rare mineral consisting of silicon oxide or silica, SiO_2, but differing from quartz in crystalline form. The crystals are small, thin hexagonal plates or scales, which are usually twinned together in groups of three; hence the name, from Greek. meaning "triplet." The apparent hexagonal plates are themselves pseudosymmetric twins of optically biaxial material, but at a temperature of 117° C. these optical anomalies disappear and the plates are then truly hexagonal (β-tridymite). The specific gravity is 2.28 (that of quartz being 2.65). Unlike quartz, tridymite is soluble in a boiling solution of sodium carbonate; it occurs in the cavities of acid volcanic rocks (rhyolite, trachyte and andesite), but in most instances the crystals are replaced by a fine granular aggregate of quartz. Tridymite also is found in meteorites. At 870° C. quartz passes over into β-tridymite with a considerable increase in volume; and this change has an important bearing on siliceous refractory materials used for furnace linings and silica bricks. At a still higher temperature (1,470° C.) tridymite itself passes over into another modification of silica known as cristobalite.

See SILICA; METEORITES.

TRIER (French TRÈVES; sometimes in English TREVES; Lat. AUGUSTA TREVERORUM), the oldest town in Germany, founded by the Romans about 15 B.C. and later nicknamed "Roma secunda" or "Roma transalpina." It was formerly the capital of an archbishopric and electorate of the empire, and is now the seat of a Roman Catholic bishop and chief town of a governmental department in Rhineland-Palatinate. Pop. (1959 est.) 85,431. It is on the Moselle, about 6 mi. from the Luxembourg frontier and 69 mi. S.W. of Coblenz by rail on the Coblenz-Metz and Cologne-Saarbrücken lines. Trier is the centre of the Moselle wine trade, and manufactures textiles, machinery, leather and tobacco products. The well-preserved amphitheatre just outside the modern town to the southeast was probably built in the reign of Trajan or Hadrian. It accommodated about 30,000 spectators. The most remarkable Roman building is the Porta Nigra, the fortified north gate of the city, 118 ft. long, 98 ft. high and 75 ft. deep, built of sandstone blocks. This building may date from the 3rd to 4th century A.D. It is also called the Simeonstor, after a Greek hermit who inhabited it. In 1035 Archbishop Poppo converted the gate into two churches, one above the other, but all the additions except the apse have been removed. In the southeast of the city are ruins of 4th-century Roman baths (Imperial thermae) and near the old Roman bridge substructures of the 2nd-century Roman baths (Barbara thermae), 660 ft. long. On the Constantinsplatz stands the brick basilica, probably of the age of Constantine. Converted into a palace for the Frankish kings and their deputies, it passed in 1197 to the archbishops, and was restored (1846–56) and turned into a Protestant church. Near the basilica are the electoral palace (1757–61) and the palace garden. Another Roman basilica forms the nucleus of the cathedral. Built under the emperors Valentinian I and Gratian as a quadrilateral hall, it was converted into a church about the close of the 4th century, and restored by Bishop Nicetius about 550. Archbishop Poppo and his successors in the 11th and 12th centuries extended the cathedral and added an apse at each end. The vaulting of the nave and aisles and the cloisters were added in the 13th century. The most famous relic preserved is the "Holy Coat of Trier," believed by the devout to be the seamless robe of the Saviour, and said to have been discovered and presented to the city by the empress Helena. The cloisters connect the cathedral with the Church of Our Lady, a building in the form of a circle intersected by a cross, with a vault, built 1235–70 and said to be the oldest Gothic church in Germany. St. Matthias in the south, now represented by a 12th-century building, has a Christian cemetery of the Roman age. A market cross dates from 958, and a beautiful Renaissance fountain, the Petersbrunnen, was erected in 1595. Close by are the Steipe or Rotes Haus, formerly the town hall, of the mid-16th century, and the Frankenturm or *propugnaculum*, of the 11th century. Built on a Roman burial ground north of the Porta Nigra is the church of St. Paulinus (1732–57), by Balthasar Neumann, a masterpiece of the baroque period. The Landesmuseum (1885–89) contains many Roman and mediaeval antiquities. Among the Stadtbibliothek's most treasured manuscripts are the codex aureus, a copy of the gospels presented to the abbey of St. Maximin by Ada, a reputed sister of Charlemagne, and the codex Egberti of the 10th century. At Igel is a remarkable Roman column, 72 ft. high. It dates from the 2nd century, and was the family monument of the Secundini.

History. — The Treveri were among the most powerful tribes of the Belgae, and according to Julius Caesar, who conquered them in 56 B.C., possessed the best cavalry in Gaul. The Roman city, Augusta Treverorum, was probably fortified by Augustus about 15 B.C., and organized as a colony about A.D. 50, in the reign of Claudius, but is not mentioned before the war of Civilis in 69 (Tacitus, *Hist.*, iv). At first the Treveri resisted the appeal of Claudius Civilis and his Batavi to join the revolt, and built a defensive wall from Trier to Andernach, but soon afterward the two Treverans, Julius Tutor and Julius Classicus, led their fellow tribesmen, aided by the Lingones (Langres), in the attempt to set up a "Gallic empire." After a brief struggle the rebels were overthrown at Trier by Petillius Cerealis (70). Mainly on account of its strategic position, Diocletian, on his reorganization of the empire, made Trier the capital not only of Belgica Prima, but of the whole "diocese" of Gaul. Constantine the Great, who generally resided there from 306 to 331, and his successors, beautified the city.

The Franks, who had three times previously sacked the city, gained permanent possession of it about 455. The city was included in Lothair's kingdom (Lotharingia) in 843, and in the East Frankish kingdom in 870. Archbishop Hetti, who occupied the see from 814 to 847, is said to have been the first archbishop of Trier, and Archbishop Radbod acquired the temporal rights of the counts of Trier in 898. In the 10th century Archbishop Dietrich I obtained the primacy over Gaul and Germany.

The temporal power of the archbishops was not gained without opposition. The German kings Otto IV and Conrad IV granted charters to the city, which, however, admitted the jurisdiction of its archbishop, Baldwin of Luxembourg, in 1308. This prince, a brother of the emperor Henry VII, ruled from 1307 to 1354 and was the real founder of the power of Trier. He raised it to great prosperity by his foresight, and enlarged his dominions almost to their ultimate extent. He assumed the title of arch-chancellor of Gaul and Arles (or Burgundy), and thenceforward the elector of Trier held the third place in the electoral college. After Baldwin's death the prosperity of Trier was checked by wars and disputes between rival claimants to the see, and in 1456 the estates united for the purpose of restoring order and secured the right of electing their archbishops.

Throughout the middle ages the sancta civitas Trevirorum was a great seat of monastic learning. The university, founded in 1473, existed until 1797.

The last elector and archbishop, Clement Wenceslaus (1768–1812), granted toleration to the Protestants in 1782, established his residence at Coblenz in 1786, and fled from the French in 1794. In 1815 nearly the whole of the former electoral dominions were given to Prussia. A bishopric was again founded in 1821, but it was placed under Cologne.

After World War I Trier was occupied by the 3rd U.S. army from Nov. 1918 to the spring of 1923. In World War II the town suffered damage by bombing. It was taken by Gen. G. S. Patton's 3rd U.S. army on March 13, 1945. Later in the year it became part of the French zone of occupation.

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TRIESTE (Slovene and Serbo-Croatian TRST), a port of Italy situated at the northeastern angle of the Adriatic sea, 70 mi. E.N.E. of Venice. Under Roman control about 177 B.C., made into a *colonia* by Julius Caesar and mentioned in his De *bello gallico* as Tergeste, the city attracted the attention of Octavian (Augustus) in 33 B.C. He ordered a harbour to be built there and the city to be surrounded by walls. After the breakup of the Roman empire Trieste shared the general fortunes of Istria. In 948 it received from Lothair II, king of Italy, independence under its count-bishops. It was captured by the Venetians in 1202 but constantly agitated for autonomy. In 1382 it placed itself under the protection of Leopold III of Habsburg whose overlordship gradually developed into actual Austrian possession. As part of the Austrian dominions Triest, as the Germans called it, was a small city built on and around Monte Giusto. The castle (1470–1680), which now houses a medieval museum, is believed to occupy the site of the Roman capitol. The Romanesque cathedral of S. Giusto was formed in the 14th century by the union of an early Christian baptistery with two adjacent 6th-century churches; the campanile of the cathedral (1337) incorporates part of a Roman temple. When the emperor Charles VI proclaimed it an imperial free port in 1719 Trieste had 5,700 inhabitants. In 1891, when it was deprived of this privilege, it had 156,000 inhabitants. A new town was built on the flat land adjoining the crescent-shaped bay, partly on ground that had been reclaimed from the sea. This modern town, with its broad streets and handsome squares, has typical 18th-century baroque and 19th-century neoclassical architecture, the church of S. Antonio, the Verdi theatre and the Exchange being the best examples of the latter. About 4 mi. N.W. of the city centre Archduke Maximilian, the ill-fated emperor of Mexico, built for himself in 1854–56, on the very edge of the sea, the neo-Gothic castle of Miramare.

On the eve of World War I Trieste was a prosperous city. It was the main port of the Austro-Hungarian empire, and its seaborne trade in 1913 amounted to 6,200,000 metric tons of merchandise loaded and unloaded. It was the headquarters of the Austrian Lloyd Steam Navigation company and of a few other companies formed mainly by local shipowners who were of Croatian origin but Italians by assimilation. The total tonnage of shipping registered in Trieste in 1914 was 720,000 tons.

The Austrian census of 1910 showed that the city of Trieste had a population of 229,510, including 118,959 Italians, 59,319

Slovenes and Croats, 12,635 other Austrian subjects (including 9.600 Germans) and 38.597 foreigners (including 29,439 Italian subjects). Among the Italians who were Austrian subjects there were some Italianized Croats and Italian-speaking Jews. Other Jews gave German as their mother tongue. Nevertheless. the Italians (Austrian and Italian subjects together) composed nearly tuo-thirds of the population of the city. That was the ground on nhich. in the secret treaty of London signed on April 26. 1915, the U.K., France and Russia agreed to give the city to Italy at the peace settlement. Trieste was occupied by Italian troops on Nov. 4, 1918.

As part of Italy and cut off by a political frontier from its natural hinterland, the port of Trieste lost most of its maritime trade. The volume of merchandise loaded and unloaded fell in 1930–34 to 2.200.000 metric tons; but Italy also inherited the flourishing shipbuilding industries, steel mills, oil refineries and an important insurance business. A11 this was maintained and, with government subsidies, even developed, industrialization being the only way to keep the population of the city employed. A university was founded in 1938. But the population stopped increasing: in 1913 it was estimated at 247.000; in 1936 it amounted to 237.717.

In Sept. 1943 the Germans occupied Trieste. not hiding their intention of keeping it as one of the southern outlets to the sea of the Grossdeutsches Reich. On April 30. 1945, Marshal Tito's Yugoslav troops, having liberated Dalmatia and Istria, entered Trieste and claimed its incorporation into Yugoslavia. The peace treaty with Italy signed in Paris on Feb. 10, 1947, created instead the Free Territory of Trieste which was to be a small independent state, demilitarized and neutral, whose integrity and independence were to be guaranteed by the Security council of the UN. Temporarily it was divided into two zones, zone A, with the city of Trieste, under British-U.S. military administration and zone B under Yugoslav administration.

The statute of the Free Territory of Trieste was as unworkable as that of the Free City of Danzig. The deadlock in Trieste came about immediately after the ratification of the Italian peace treaty. On March 20, 1948, the U.S., G.K. and French governments proposed the inclusion of the free territory in Italy. a solution refused by both the U.S.S.R. and Yugoslavia. On Oct. 8, 1953. the U.S. and U.K. suggested the partition of the free territory and the handing over of zone A to Italy and zone B to Yugoslavia. This nas opposed by Yugoslavia. mainly on the ground that it had not been consulted beforehand. In Feb. 1954 the U.S. and U.K. started in London negotiations for a solution with the two powers directly interested. This move was successful and an agreement was concluded on Oct. 5, 1954. It provided for the partition of the free territory between Italy and Yugoslavia with a small addition of about 5 sq.mi. in the latter's favour. Italy agreed to maintain Trieste as a free port and received 91 sq.mi. with a population of about 310.000, including 63.000 Slovenes, while the Yugoslav part covered an area of 202 sq.mi. with a population of about 73,000, including 30,000 Italians. The Italian and Yugoslav governments agreed to a special statute regulating the rights of national minorities left on both sides of the demarcation line of the former free territory. On Oct. 26, 1954. Italian troops re-entered the city after an absence of over 11 years. On the same day the last units of the U.S.and British occupation troops left zone A.

By 1961 the population of the territory attributed to Italy was 299,187. including about 283.000 for the city of Trieste.

The port's sea-borne trade steadily improved after 1954 and in the early 1960s exceeded 5,000.000 metric tons of goods annually. about one-fifth of the total being in coastal traffic.

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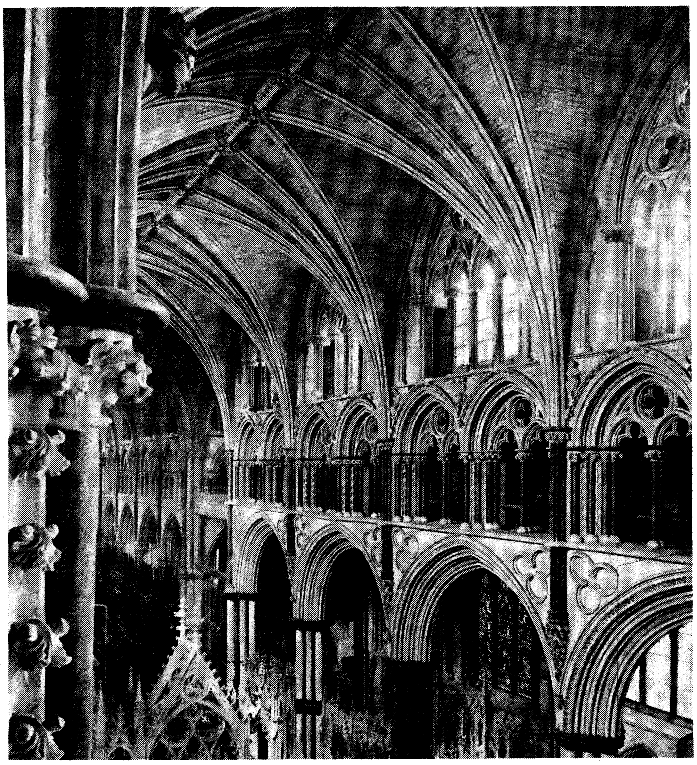
TRIFOLIUM, the generic name of the plants commonly called clover (*q.v.*), from the Latin *tres*, "three," and *folium*, "a leaf."

TRIFORIUM, in architecture, is the space in a church above the nave arcade, below the clerestory and extending over the vaults or ceilings of the side aisles. The usage of the term is loose; by some it is limited to an arcaded gallery in that level. In other cases it is applied to any second-floor gallery opening onto a higher nave by means of arcades or colonnades, Like the galleries in some pagan Roman basilicas or in Byzantine churches. The triforium became an integral part of interior design during the Romanesque period, sometimes as a series of openings to



A F KERSTING

ANGEL CHOIR, LATE 13TH-CENTURY TRIFORIUM, LINCOLN CATHEDRAL, ENGLAND

light and ventilate the roof space and sometimes as an open gallery. Often it was covered with a quarter-circle vault and served to partially transmit the thrust of the nave vaults, although originating below their springing, to the outer walls (St. Sernin, Toulouse, begun 1096). With the development of the Gothic vaulting system in France, the triforium diminished in size and importance. Reims (begun 1220) and Amiens (1220–47) both have triforia of little relative height but with rich arcading. By the end of the 13th century the triforium was usually replaced by greatly heightened clerestory windows.

The more horizontal English Gothic architecture shows an important development of the triforium gallery as a decorative element. It is relatively much higher than in similar work in France, often almost equaling the pier arcades. The richest, most characteristic example is in the Angel choir, Lincoln cathedral (completed 1282). In the 15th century the tendency toward height of pier arcade and clerestory window led to the reduction in importance and final disappearance of the triforium. *See* GOTHIC ARCHITECTURE. (*E.* B. MACD.)

TRIGONOMETRY. The desire to compute numerically angles and distances for which geometry would require diagrams plotted to scale led to the development of the science of trigonometry. This science is concerned with the definitions, properties and relations of certain functions of angles. Application of the science to problems requiring the determination of unknown angles and distances from known or measured angles and distances, occurring in a figure lying wholly in one plane, is the subject matter of plane trigonometry. Applications to similar problems whose diagrams lie in more than one plane of three-dimensional space are comprised in spherical trigonometry. Their relation to the sphere is shown below.

TRIGONOMETRIC FUNCTIONS

For the purpose of trigonometry, a somewhat more general concept of angle is required than that used in geometry. An angle A with vertex at V, whose initial side is VP and whose terminal side is VQ, is indicated in fig. 1 by the solid circular arc. This angle is said to be generated by the continuous counterclockwise rotation of a line segment about the point V from the position VP to the position VQ. A second angle A' with the same initial and terminal sides, indicated in fig. 1 by the dotted circular arc, is generated by the clockwise rotation of the line segment about the point V from the position VP to the position VQ. Angles are considered positive when generated by counterclockwise rotations, negative when generated by clockwise rotations. The positive angle A and the negative angle A' in fig. 1 are generated by less than one complete rotation of the line segment about the point V. All other positive and negative angles with the same initial and terminal sides are obtained by rotating the line segment counterclockwise or clockwise about the point V one or more complete turns before coming to rest at VQ.

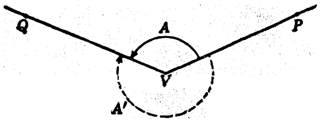


FIG 1.—GENERAL ANGLE (see TEXT FOR FURTHER EXPLANATION)

Numerical values can be assigned to angles by selecting a unit of measure for angles. Besides the complete revolution and the right angle, the units commonly used are the degree (minutes. seconds) and the radian. The degree is $\frac{1}{90}$ of a right angle. There are 60' in a degree and 60″ in a minute. In theoretical work, the radian is the most convenient unit. It is the angle at the centre of a circle which intercepts an arc equal in length to the radius. From these definitions, it follows that

$$1 \text{ revolution} = 4 \text{ right angles} = 360° = 2\pi \text{ radians}$$

Equal angles are angles nith the same measure; *i.e.*, they have the same sign and the same number of degrees. The angle $-A$ has the same number of degrees as A but is of opposite sign. Hence its measure is the negative of the measure of A. If the angles A and B have the initial sides VP, VQ and the terminal sides VQ, VR, respectively, then the angle $A + B$ has the initial

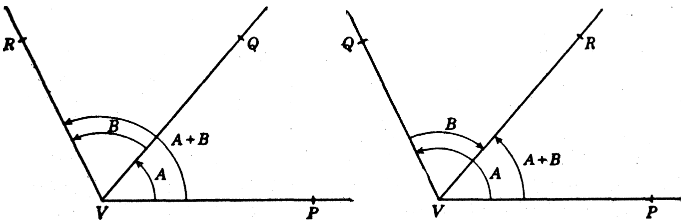


FIG. 2.— ADDITION OF ANGLES (see TEXT.)

and terminal sides VP, VR, respectively. The angle $A + B$ is called the sum of the angles A and B and its relation to A and B when A is positive and B is positive or negative is illustrated in fig. 2. The sum $A + B$ is the angle whose measure is the algebraic sum of the measures of A and B. The difference $A - B$ is the sum of A and $-B$. Thus all angles coterminal with angle A (*i.e.*, nith the same initial and terminal sides as angle A) are given by $A \pm 360\,n$, where $360\,n$ is an angle of n complete revolutions. The angles $180 - A$ and $90 - A$ are the supplement and complement of angle A respectively.

Trigonometric Functions of an Angle.—There are six functions of an angle commonly used in trigonometry. Their names and abbreviations are sine (sin), cosine (cos), tangent (tan), cotangent (ctn), secant (sec), cosecant (csc). To define these functions for any angle A, the angle is placed in standard position on a rectangular co-ordinate system (see ANALYTIC GEOMETRY); *i.e.*, with the vertex of A at the origin and the initial side of A along the positive x-axis. Let r (positive) be the distance from V to any point Q on the terminal side of A dnd let (x,y) be the rectangular

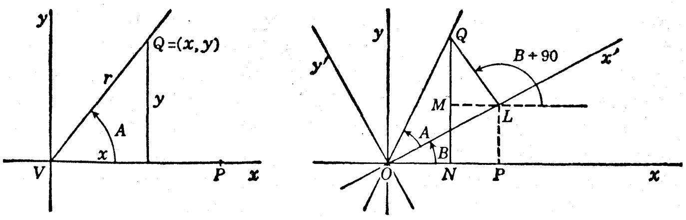


FIG. 3.— (LEFT) ANGLE IN STANDARD POSITION. (RIGHT) ROTATION OF AXES

co-ordinates of Q. The six functions of A are then defined by six ratios as follows:

$$\begin{array}{ll} \sin A = y/r, & \operatorname{ctn} A = x/y \\ \cos A = x/r, & \sec A = r/x \\ \tan A = y/x, & \csc A = r/y \end{array} \qquad (1)$$

Since division by zero is not allowed, the tangent and secant are not defined for angles whose terminal side falls on the y-axis, and the cotangent and cosecant are undefined for angles whose terminal side falls on the x-axis.

From these definitions, follow the three reciprocal relations:

$$\operatorname{ctn} A = 1/\tan A \quad \sec A = 1/\cos A \quad \csc A = 1/\sin A \qquad (2)$$

and also the quotient identities:

$$\tan A = \sin A/\cos A \qquad \operatorname{ctn} A = \cos A/\sin A \qquad (3)$$

When the Pythagorean equality $x^2 + y^2 = r^2$ is divided in turn by r^2, x^2, y^2, the three square relations

$$\cos^2 A + \sin^2 A = 1 \quad 1 + \tan^2 A = \sec^2 A \quad \operatorname{ctn}^2 A + 1 = \csc^2 A \qquad (4)$$

are obtained.

If the point Q on the terminal side of angle A in standard position has co-ordinates (x,y), this point will have co-ordinates $(x,-y)$ nhen on the terminal side of $-A$ in standard position. From this fact and the definitions are obtained the identities:

$$\begin{array}{ll} \sin(-A) = -\sin A & \operatorname{ctn}(-A) = -\operatorname{ctn} A \\ \cos(-rl) = \cos A & \sec(-A) = \sec A \\ \tan(-A) = -\tan A & \csc(-A) = -\csc A \end{array} \qquad (5)$$

These relations may also be stated briefly by saying that cosine and secant are even functions whereas the other four are odd functions.

It is immediately evident that a trigonometric function has the same value for all coterminal angles. Hence. when n is an integer,

$$\sin(A \pm 360\,n) = \sin A \qquad (6)$$

with similar relations for the other five functions. These results may be expressed by saying that the trigonometric functions are periodic and have a period of 360°.

When Q on the terminal side of A has co-ordinates (x,y), it has co-ordinates $(-x,-y)$ on the terminal side of $A \pm 180$ and consequently

$$\begin{array}{ll} \sin(A \pm 180) = -\sin A & \operatorname{ctn}(A \pm 180) = \operatorname{ctn} A \\ \cos(A \pm 180) = -\cos A & \sec(A \pm 180) = -\sec A \\ \tan(A \pm 180) = \tan A & \csc(A \mp 180) = -\csc A \end{array} \qquad (7)$$

These relations show that tangent and cotangent have the smaller period of 180°. In fact, this is the smallest period for these two functions. the other four having 360° for their minimum period. The relations (7) also show that an angle and its supplement have the same sine and the same cosecant whereas for each of the other four functions the value for the supplement is the negative of the value for the angle.

When Q on the terminal side of A in standard position has co-ordinates (x,y), it has co-ordinates $(-y,x)$ and $(y,-x)$ on the terminal side of $A + 90$ and $A - 90$ in standard position respectively and consequently

$$\begin{array}{ll} \sin(A \pm 90) = \pm \cos A & \operatorname{ctn}(A \pm 90) = - \tan A \\ \cos(A \pm 90) = \mp \sin A & \sec(A \pm 90) = \mp \csc A \\ \tan(A \pm 90) = - \operatorname{ctn} A & \csc(A \pm 90) = \pm \sec A \end{array} \qquad (8)$$

Thus a function of the complement of A is equal to the corresponding cofunction of A.

Of fundamental importance for the science of trigonometry are the addition formulas:

$$\cos (A \pm B) = \cos A \cos B \mp \sin A \sin B \qquad (9)$$
$$\sin (A \pm B) = \sin A \cos B \pm \cos A \sin B$$

These relations may be derived from the formulas

$$x = x' \cos B - y' \sin B \qquad (10)$$
$$y = x' \sin B + y' \cos B$$

for the rotation of the co-ordinate axes through the angle B about the origin, and these formulas are evident from fig. 3 (right) since

$$x = ON = OP + LM = OL \cos B + LQ \cos (B + 90)$$
$$= x' \cos B - y' \sin B$$

and

$$y = NQ = PL + MQ = OL \sin B + LQ \sin (B + 90)$$
$$= x' \sin B + y' \cos B$$

To obtain the addition formulas (9), it is only necessary to divide each equation in (10) by $r = OQ$ and use the definitions of sine and cosine.

From the addition formulas are derived the double-angle and half-angle formulas:

$$\sin (2A) = 2 \sin A \cos A$$
$$\cos (2A) = \cos^2 A - \sin^2 A = 2 \cos^2 A - 1 = 1 - 2 \sin^2 A \qquad (11)$$
$$\sin^2 (A/2) = (1 - \cos A)/2$$
$$\cos^2 (A/2) = (1 + \cos A)/2$$

Numerous examples of the various identities of lesser importance that can be derived from the above basic identities may be found in any standard textbook on trigonometry.

Historically the trigonometric functions were lines associated with arcs. For example, half of a chord of a circle was called the sine of half of the arc subtended by the chord. The presentation of the science was greatly simplified by the substitution of angle for half arc and ratio for half chord. However, for convenience in spherical trigonometry, sine of the arc is still written for the sine of the central angle intercepting the arc.

Tables of Natural Functions.— To be of practical use, the values of the functions must be readily available for any given angle. The identities (6), (7) and (8) show that the values of the functions for all angles can readily be found from their values for angles from 0° to 45°. For this reason, it suffices to list in a table the values of sine, cosine, tangent, cotangent of all angles from 0° to 45° that are integral multiples of some convenient unit (commonly 1'). Such tables are called tables of natural trigonometric functions. For angles that are not integral multiples of the unit. the values of the functions are found by the usual methods of interpolation (*q.v.*). Since the values of the functions are in general irrational numbers, they are entered in the table as decimals, rounded off at some convenient place. For almost all purposes. four or five decimal places are sufficient and tables of this accuracy appear in most texts. Most scientific libraries have available tables of greater accuracy (see A. Fletcher et al., Index of Mathematical Tables, 1946). A method of computing the entries in the tables is explained below. However, simple geometrical facts alone suffice to determine the values of the trigonometric functions for the angles 0°, 30°, 45°, 60° and 90°. These values are listed in the table, which also illustrates the arrangement used in larger tables.

Functions of 0°, 30°, 45°, 60° and 90°

	sin	cos	tan	ctn	
0	0	1	0	—	90
30	$\frac{1}{2}$	$\frac{1}{2}\sqrt{3}$	$\frac{1}{3}\sqrt{3}$	$\sqrt{3}$	60
45	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}\sqrt{2}$	1	1	45
	cos	sin	ctn	tan	

The names at the head of the table are used for angles less than 45°, listed in the left-hand column, whereas the names at the foot of the table are used for the complementary angles larger than 45°, listed in the right-hand column. For example, from the table $\cos 30 = \frac{1}{2}\sqrt{3}$ and $\text{ctn } 60 = \frac{1}{3}\sqrt{3}$.

PLANE TRIGONOMETRY

To conduct a survey of a plane region, the surveyor inspects the terrain and then sets up stakes at points which the inspection indicates will be convenient for his purpose. The surveyor then measures uith a transit enough of the angles between the lines joining pairs of stakes so that, when two points are arbitrarily selected on a plat to represent two of the stakes, all points that represent the other stakes can be located as the intersections of lines drawn on the plat in the directions determined by the measured angles; *i.e.*, the angles measured suffice to completely determine the plat except for scale. The scale of the plat is found by measuring the distance with a steel tape between one pair of stakes and comparing this distance with the distance between the corresponding points on the plat. With the scale determined, the distance between any two stakes can be found approximately by measuring the distance between the corresponding points of the plat and multiplying by the scale factor. When greater accuracy is required, the unknown distances are computed by means of the trigonometric functions. Enough of the points of the plat are first joined by lines to divide the region of the plat into triangles and each triangle is solved; *i.e.*, the lengths of its sides. the size of its angles and its area are computed. Triangles can be solved by the law of sines and the law of cosines. To secure symmetry in the writing of these laws, the angles of the triangle are lettered A, B and C and the lengths of the opposite sides are lettered a, b and c respectively as shown in fig. 4.

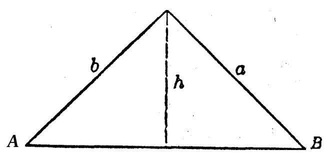


FIG. 4.—STANDARD LETTERING OF A TRIANGLE (see TEXT)

The law of sines or sine theorem is

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \qquad (12)$$

and the law of cosines or cosine theorem is

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc} \qquad (13)$$

with similar expressions for cos B and cos C, obtained by cyclic permutation of the three letters. In fig. 4, $b \sin A = h = a \sin B$, from which the first equality in (12) follows. The second is shown by drawing a perpendicular from A to the opposite side of the triangle. Also $c = b \cos A + a \cos B$ and likewise $b = a \cos C + c \cos A$, $a = c \cos B + b \cos C$. When these three equations are multiplied by c, b, $-a$, respectively, and added, the result is $c^2 + b^2 - a^2 = 2bc \cos A$, which when divided by $2bc$ becomes (13). To solve a triangle, we substitute in formulas (12) and (13) all the known values and solve the equations for the unknown values. The law of sines is effective when two angles and a side are known or when two sides and an angle opposite one are known. The law of cosines is effective when two sides and an included angle are known or three sides are known. The area of the triangle may be found from

$$\text{area} = \tfrac{1}{2}bc \sin A \qquad (14)$$

This formula is derived from the relations area $= \frac{1}{2}ch$ and $h = b \sin A$ in fig. 4.

Texts on trigonometry derive other formulas for solving triangles and for checking the solution. especially those suited to logarithmic calculation (see LOGARITHMS). The most important among these are the law of tangents or tangent theorem and the half-angle formulas. However, with the advent of mechanical calculators, computation by logarithms has lost some of its advantage, and it is no longer so necessary to adapt formulas to logarithmic computation when machines are available.

SPHERICAL TRIGONOMETRY

The fundamental configuration of space to which the formulas of spherical trigonometry apply is the trihedral angle formed by three rays—half lines—radiating from a point. The point is the vertex, the rays are the three edges, the planes and angles determined by the rays taken in pairs are the three faces and the three face angles α, β, γ of the trihedral angle. The faces in pairs form three dihedral angles A, B, C opposite respectively to the face angles α, β, γ. The formulas of spherical trigonometry relate the trigonometric functions of these six angles.

For a trihedral angle, there is the law of sines

$$\frac{\sin \alpha}{\sin A} = \frac{\sin \beta}{\sin B} = \frac{\sin \gamma}{\sin C} \tag{15}$$

which may be derived from fig. 5 (left) in which the planes PQS and PRS are perpendicular to the edges VQ and VR, respectively. The first equality in (15) is a result of the relations

$$\begin{aligned} \overline{PS} &= \overline{QP} \sin B = \overline{VP} \sin \alpha \sin B \\ &= \overline{RP} \sin A = \overline{VP} \sin \beta \sin A \end{aligned}$$

The second equality may be proved in like manner.

A first law of cosines for the trihedral is

$$\cos \alpha = \cos \beta \cos \gamma + \sin \beta \sin \gamma \cos A \tag{16}$$

with similar expressions for $\cos \beta$ and $\cos \gamma$ obtained by cyclic permutation of the letters. In fig. 5 (right), the plane PQR is perpendicular to the edge VP. The law of cosines applied to the plane triangles PQR and VQR gives

$$\begin{aligned} \overline{QR}^2 &= \overline{PQ}^2 + \overline{PR}^2 - 2\,\overline{PQ}\,\overline{PR} \cos A \\ &= \overline{VQ}^2 + \overline{VR}^2 - 2\,\overline{VQ}\,\overline{VR} \cos \alpha \end{aligned}$$

Hence, after transposing and using the Pythagorean theorem,

$$2\,\overline{VQ}\,\overline{VR} \cos \alpha = 2\,\overline{VP}^2 + 2\,\overline{PQ}\,\overline{PR} \cos A$$

This relation when divided by $2\,\overline{VQ}\,\overline{VR}$ becomes (16) after using the definitions of the trigonometric functions.

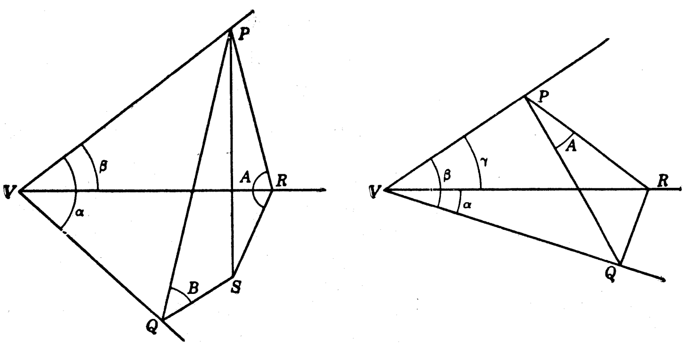


FIG. 5.—TRIHEDRAL ANGLES FOR DERIVATION OF THE LAWS OF (LEFT) SINES AND (RIGHT) COSINES

If at the vertex of a trihedral three rays are drawn perpendicular to the three inner faces of the trihedral, a second trihedral is obtained called the polar trihedral of the first. The first is also the polar of the second. The face angles α', β', γ' of the polar trihedral are the supplements of the dihedral angles A, B, C of the given trihedral and hence the face angles α, β, γ of the given trihedral are the supplements of the dihedral angles A', B', C' of the polar trihedral.

The first law of cosines when applied to the polar trihedral and simplified by the relations $\cos \alpha' = \cos (180 - A) = -\cos A$, etc., yields the formula

$$\cos A = -\cos B \cos C + \sin B \sin C \cos \alpha \tag{17}$$

and two additional relations for $\cos B$ and $\cos C$, obtained by cyclic permutation of the letters, which are called the second law of cosines for the given trihedral.

Spherical Triangles.—When the vertices of a spherical triangle are joined to the centre of the sphere, there is formed a trihedral angle with vertex at the centre (fig. 6).

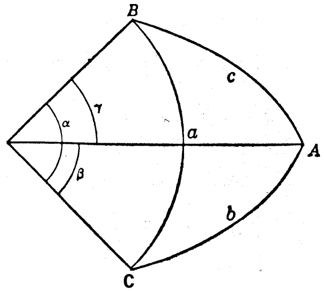


FIG. 6.— SPHERICAL TRIANGLE AND TRIHEDRAL

The sides a, b, c of the spherical triangle are the great circle arcs intercepted by the face angles α, β, γ, and the angles of the spherical triangle are the dihedral angles A, B, C of the trihedral. The faces of the polar trihedral intersect the sphere in the polar triangle of the given spherical triangle. Since a trigonometric function of a central angle and of the intercepted arc have the same value, the law of sines (15) yields a law of sines for spherical triangles:

$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C} \tag{18}$$

Similarly, the first law of cosines (16) gives a law of cosines for the sides of the spherical triangle:

$$\begin{aligned} \cos a &= \cos b \cos c + \sin b \sin c \cos A \\ \cos b &= \cos c \cos a + \sin c \sin a \cos B \\ \cos c &= \cos a \cos b + \sin a \sin b \cos C \end{aligned} \tag{19}$$

and the second law of cosines (17) furnishes a law of cosines for the angles of a spherical triangle:

$$\begin{aligned} \cos A &= -\cos B \cos C + \sin B \sin C \cos a \\ \cos B &= -\cos C \cos A + \sin C \sin A \cos b \\ \cos C &= -\cos A \cos B + \sin A \sin B \cos c \end{aligned} \tag{20}$$

To solve a spherical triangle, the known values are substituted in formulas (18), (19) and (20) and the resulting equations solved for the unknowns. When three sides or two sides and the included angle are given, (19) is effective, and (20) may be used when three angles or two angles and an included side are given. If two sides and an angle opposite one side or two angles and a side opposite one angle are given. (18) is applied first and the solution is finished by the use of a pair of equations one each from (19) and (20). The area of the spherical triangle is given by

$$\text{area} = E\, r^2 \tag{21}$$

where r is the radius of the sphere and E is the excess of $A + B + C$ over two right angles measured in radians. Observe that a solution of a spherical triangle yields a solution of the polar triangle.

Other relations between the sides and angles of a spherical triangle are derived in texts on spherical trigonometry. In particular, John Napier's analogies are formulas relating the half angles and half sides. Each formula contains five of the six parts and is well suited to logarithmic solutions of a spherical triangle. Other formulas of a similar character are the half-angle formulas, the half-side formulas and the analogies of Gauss-Delambre.

When angle C is 90°, the triangle is a right spherical triangle. Since $\sin C = 1$ and $\cos C = 0$, the relations in (18), (19), (20) yield the following formulas for the right spherical triangle:

$$\begin{aligned} \sin a &= \sin c \sin A = \tan b \operatorname{ctn} B \\ \sin b &= \sin c \sin B = \tan a \operatorname{ctn} A \\ \cos c &= \cos a \cos b = \operatorname{ctn} A \operatorname{ctn} B \\ \cos A &= \cos a \sin B = \tan b \operatorname{ctn} c \\ \cos B &= \cos b \sin A = \tan a \operatorname{ctn} c \end{aligned} \tag{22}$$

Napier's rules of circular parts given in texts is a mnemonic for these ten relations.

ANALYTIC TRIGONOMETRY

Trigonometric functions of a real variable x are defined by means of the trigonometric functions of an angle. For example, $\sin x$ where x is real is defined to have the value of the sine of the angle containing x radians. Similar definitions are made for the other five trigonometric functions of the real variable x. These functions satisfy the relations (2)–(9) and (11) with A, B, 90, 180. 360 replaced by x, y, $\pi/2$, π, 2π, respectively. Thus the minimum period of $\tan x$ and $\operatorname{ctn} x$ is π, and of the other four functions is 2π.

In the calculus it is shown that sin x and cos x are sums of power series:

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots \tag{23}$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \dots$$

These series may be used to compute the sine and cosine of any angle. For example, to compute the sine of 10°, it is necessary to find the value of $\sin \pi/18$ since 10° is the angle containing $\pi/18$ radians. When $\pi/18$ is substituted in the series for sin x, it is found that the first two terms give ,17365, which is correct to five decimals for the sine of 10°. By taking enough terms of the series, any number of decimal places can be correctly obtained.

Tables of the functions may be used to sketch the graphs of the functions, shown in fig. 7.

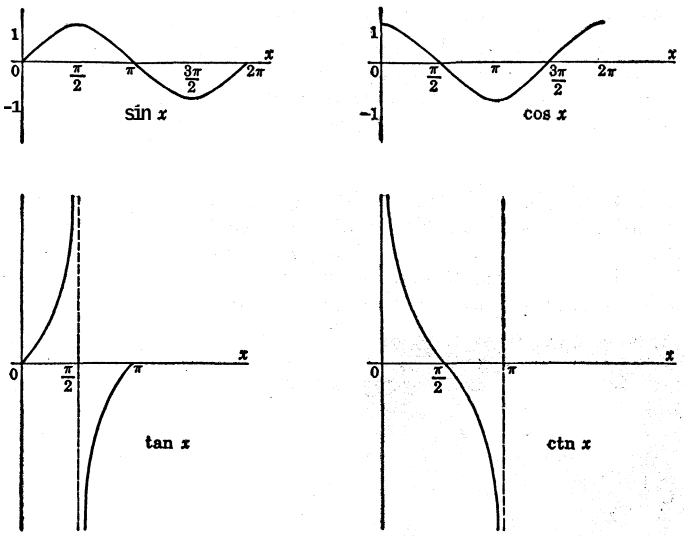


FIG. 7.— GRAPHS OF TRIGONOMETRIC FUNCTIONS

The diagrams give the graph of each function for one period. To obtain the complete graph in each figure it is only necessary to extend the curve indefinitely in both directions by repetitions of the piece of graph shown in the figure.

Trigonometric Functions of a Complex Variable.—Since the series in (23) converge for all complex numbers, they can be used to define trigonometric functions sin z and cos z of the complex variable z. The functions tan z and ctn z are then defined by the quotient identities (3), and sec z and csc z by the reciprocal relations (2). Since all trigonometric identities are derivable from the series (23), these functions of the complex variable z satisfy the same identities as the corresponding functions of the real variable x.

In the realm of complex numbers, the trigonometric functions are closely related to the exponential function. From the series expression for these functions, the relations

$$\begin{aligned} e^{iz} &= \cos z + i \sin z \\ e^{-iz} &= \cos z - i \sin z \end{aligned} \tag{24}$$

are readily derived. Hence

$$\begin{aligned} \sin z &= (e^{iz} - e^{-iz})/2i \\ \cos z &= (e^{iz} + e^{-iz})/2 \end{aligned} \tag{25}$$

Some interesting relations follow easily from these formulas among which is DeMoivre's theorem,

$$(\cos z + i \sin z)^n = \cos n z + i \sin n z \tag{26}$$

This is shown by raising both members of (24) to the power n and then using (24) with z replaced by $n z$.

Each of the six trigonometric functions has an inverse. For example, the inverse of sin z is written arcsin z and is the function (multiple-valued) for which sin (arcsin z) = z is an identity in z. Thus w = arcsin z is the solution of sin w = z for w as a function of z.

Trigonometric Polynomials and Series.—The graph of the function

$$M \sin (wx + \alpha) = A \cos wx + B \sin wx$$

where $A = M \sin \alpha$, $B = M \cos \alpha$ and M and w are positive is called a sine wave. It may be obtained from the graph of sin x in fig. 7 by a change of the scales on the two co-ordinate axes and a horizontal shift of the origin. The length of the wave is the period $2\pi/w$ of this function, its amplitude is the maximum value M of the function and α is its phase. Sine waves occur in the study of wave motion, simple harmonic motion, alternating electric currents, light, sound and other periodic phenomena where the tone is pure.

The absence of purity of tone may be due to the presence of overtones. Such phenomena may be successfully studied by trigonometric polynomials.

$$\tfrac{1}{2}A_0 + A \cos wx + B \sin wx + \dots + A_n \cos nwx + B_n \sin nwx$$

where the constant term is added to allow for a vertical shift of origin. There is, in fact, a theorem that every continuous periodic function can be approximated as nearly as desired by a trigonometric polynomial. showing that all phenomena representable by a continuous periodic function differ arbitrarily little from a suitably chosen fundamental with its overtones, combined with properly selected amplitudes and phases.

It is natural to pass from trigonometric polynomials to infinite trigonometric series

$$\tfrac{1}{2}A_0 + A_1 \cos x + B_1 \sin x + A_2 \cos 2x + B_2 \sin 2x + \dots$$

where it is usual to select the scale on the x-axis so that $w = 1$. These series (see FOURIER SERIES) have occupied the attention of mathematicians for more than a century and have played a central role in the development of modern analysis. The most important trigonometric series are the Fourier series in which the coefficients have the special form

$$A_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(t) \cos (nt)\, dt,\ B_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(t) \sin (nt)\, dt$$

where f(x) is a given function integrable on the interval $(-\pi, a)$. These series were first introduced by Joseph Fourier (1768–1830) in studies on the flow of heat when boundary temperatures are maintained. For a very large class of continuous periodic functions f(x), the corresponding Fourier series converges to f(x).

HISTORY

Trigonometry among the early mathematicians was essentially a computational science based on geometrical theorems. The simplicity of the modern science was brought about by the perfection of the number system, originating with the Hindus about the 5th or 6th century A.D., and of highly developed algebraic symbolism with its complete system of rules of operation, largely developed by Europeans of the Renaissance and later.

What is now embodied in a formula earlier had to be described by words as a succession of computational steps each justified by the citation of an appropriate geometrical theorem. The absence of negative numbers (first systematically used in the early 17th century) made necessary the discussion of many more cases in the solution of triangles. One or more steps in a solution was the passage from the length of an arc to the length of its chord (Greek) or the length of half the chord of the double arc (Hindu) or vice versa, a feat accomplished by means of a table. In the 12th century the Arabic word for the half chord of the double arc was confused with another word and translated sinus (sine). The difficulty of making tables with irrational entries without decimals (first systematically introduced into arithmetic late in the 16th century) was met by selecting a circle so large that when the chords used were computed to the nearest integer the desired accuracy was attained. This unfortunately introduced into the arguments supporting the solutions the added complexity of proportionality between similar figures.

Trigonometry, uniting as it did aspects of the three sciences of arithmetic, algebra and geometry, progressed more slowly than did geometry. However, astronomy, the first love of the early Hindus and Arabs, required as a tool the solution of spherical triangles, a fact which drove them to master this art. It is accordingly not surprising that the development of spherical trigonometry preceded that of plane trigonometry. Not until about the 13th century did trigonometry divorce itself from astronomy and become an independent science.

In the extant mathematical literature of the civilizations preceding the Greeks occur a few calculations suggestive of trigonometric calculations but no further evidence of the science. The early Greek writers appear to have advanced a step further by making calculations based on the proportionality of similar triangles. In the determination of a height by comparison of its shadow with the shadow of a known height can be seen the germ of the tangent function. Greek writers of the 4th century make Hipparchus the originator of the science of trigonometry. He was reputed to have calculated a table of chords in 12 books about the middle of the 2nd century B.C. To what extent he may have developed the uses of the table is unknown since the complete work is lost. Menelaus was also reputed to have produced about the end of the 1st century a treatment of the trigonometry of chords in six books, but this is also lost. An extant work contains the important lemma of Menelaus and the corresponding theorem for the sphere *regula* sex *quantitatum* upon which later writers based their work on trigonometry.

The first extant work on trigonometry is contained in the *Almagesf*, a work on astronomy in 13 books, produced by Ptolemy of Alexandria around the middle of the 2nd century. In one section is a table of chords at intervals of 30' accurate to at least five places, and the method of computing the tables is explained. Another section is devoted to the solution of triangles, particularly spherical. Theorems concerning chords are proved which involve implicitly the equivalence of the addition formulas, the half-angle formulas and the lam of sines.

There is no work of the Hindus extant, but it is known they made tables of sines, the half chord of the double arc, at intervals of 3° 45' using the equivalent of $\sin^2 a + \cos^2 a = 1$, $\cos a = \sin (90 - a)$ and $1 - \cos 2a = 2 \sin^2 a$ only. These tables were used to solve right triangles: plane and spherical. This work was translated into Arabic about the last quarter of the 8th century.

In the late 9th century the Arab al-Battani added the law of cosines for oblique spherical triangles and introduced the sine for the chord into the work of Ptolemy and also into his tables. He brought into use the tangent and cotangent functions and constructed a table for them at intervals of 1°.

Abul Wefa in the last half of the 10th century gave a more accurate method for computing sines and established the complete generality of the sine law for spherical triangles. He introduced the secant and cosecant and studied the interrelations of the six trigonometric lines associated with an arc. Credit for establishing the general sine law for plane triangles is given to the Persian al-Biruni (973–1048).

Jabir of Seville, in the second half of the 11th century, added to the four formulas of Ptolemy the equivalent of the fifth formula for right spherical triangles. The systematization of plane and spherical trigonometry as a science independent of astronomy was finally achieved by the great Persian mathematician Nasir ad-din at-Tusi in the second half of the 13th century. Essentially, the same work was done for the western world independently by Regiomontanus (1436–76), the science of the Arabic world having filtered into Europe over several centuries, that of the east coming much later than that from Spain. The development of arithmetic and algebra allowed the successors of Regiomontanus in Europe to unify and simplify the trigonometry of the triangle by substituting the angle for arc and ratios for the trigonometric lines, and by abstracting from the cumbersome treatment of Regiomontanus the essential formulas convenient for calculations. The cosine law for plane triangles appears for the first time in the work of François Vieta (1540–1603).

The invention of logarithms by Napier (1550–1617) stimulated the development of formulas suitable to their use. The law of tangents appears in the writings of Vieta and the half-angle formulas in the works of Rhaeticus (1568) and William Oughtred (1657). Napier's analogies appeared in 1619, while the Gauss-Delambre and Mollweide relations came later (1807–09). Abraham de Moivre (1667–1754) artd Leonhard Euler (1707–83) were among the first to open the field of analytic trigonometry. The work of Fourier on trigonometric series appeared in 1807.

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TRIKKALA (anc. Tricca), a town of Thessaly (Thessalia), Greece, capital of department of Trikkala, 35 mi. W. of Larissa. In winter, when great numbers of Vlach herdsmen settle in the town, its population exceeds that of Larissa. It has the appearance of a Moslem town because of the mosques built there and is a centre of trade in wheat, maize: tobacco and cocoons. In ancient times it was a seat of the worship of Aesculapius. Pop. (1951) 24,131, department (1961) 142,450.

Occupied by Axis troops in April 1941, it was bombed during World War II.

TRILLIUM (alluding to the three leaves), a genus of beautiful plants of the lily family (Liliaceae, *q.v.*), comprising about 30 species, natives of North America and eastern Asia. The plant is a smooth low perennial, having a rhizome from which proceeds a simple stem bearing at the top a whorl of three leaves and a single, erect or nodding, conspicuous flower consisting of three green sepals, three showy petals: six stamens and a three-celled ovary; the fruit is a many-seeded berry. About 18 species occur in the United States and Canada; these include many handsome spring wild flowers, known as wake-robin and birthroot. Well-known eastern species are the great white trillium (*T. grandiflorum*), the purple trillium (*T. erectum*), the painted wake-robin (*T. undulatum*) and, in the southeastern states, the mountain wake-robin (*T. stylosum* or *nervosum*, as it is also called). The only yellow trillium is *T.* sessile *luteum* from the southern Appalachians west to Arkansas and hlissouri. Of all these the finest and most easily grown in the wild garden, needing shade and woodsy soil, is *T. grandiflorum*, its large white flower being very showy in late spring. (N. TR.)

ROCHE
(TRILLIUM GRANDIFLORUM) GREAT WHITE TRILLIUM

TRILOBITA, a group of extinct. Arthropoda of which the fossil remains are found in the rocks of the Palaeozoic era. Many species are found in the Lower Cambrian, among the earliest known fossils. They are abundant in the Ordovician and Silurian when they begin to decline and only three genera survive in the Permian.

A typical trilobite has a segmented body roughly resembling that of a wood louse, with the dorsal surface marked by two longitudinal furrows which divide it into the three lobes alluded to in the name of the group. In the head-region the middle lobe is the glabella and usually shows transverse grooves marking the five segments of which the head is composed. On either side of the head are plates, the "free cheeks," divided from the central part of the head by the "facial sutures" and bearing the compound eyes. In some trilobites, however, the eyes are reduced or absent. Behind the head a number of the body-segments, from two to 44, are freely movable, and they are followed by a tail-shield or "pygidium" which often shows, by transverse furrows, that it is composed of a number, sometimes a large number, of segments. Most trilobites, after the Cambrian, could roll up into a ball like many wood-lice and are often found in this condition.

For long no definite traces of the limbs of trilobites could be discovered and their nature was the subject of much speculation. They have now been described in several genera by C. D. Walcott, C. E. Beecher and P. E. Raymond. The structure is most fully known in *Triarthrus,* investigated by Beecher and by Raymond. The appendages of the first pair, placed at the sides of the fore-lip (hypostoma) which underhangs the mouth, are long, slender, many-jointed antennae. The remaining appendages are all similar in structure and are attached, four pairs to the head and one pair each to the somites of the body whether free or coalesced into the pygidium. They are two-branched, the inner branch (endopodite) being a jointed leg, while the outer (exopodite) bears a fringe of what seem to be stiff flattened bristles. The two branches spring from a single basal segment drawn out on the inner side as a jaw-lobe (gnathobase) which served, no doubt, to seize food and pass it forward to the mouth. Towards the hinder end of the body the appendages become smaller and the inner edge of the endopodite is lobed in a way recalling the appendages of the Branchiopod Crustacea. In *Neolenus* another point of resemblance to certain Branchiopoda is provided by a pair of long thread-like tail-filaments. Walcott believed the structure of the limbs to be more complex, certain genera possessing, in addition to the parts mentioned, two or three "epipodites," but the presence of these awaits confirmation. Still less probable is Walcott's conclusion that *Calymmene* and *Ceraurus* possessed corkscrew-like gills.

The development of various species has been traced. Starting with a minute larva with only indications of head and pygidium, segments appear between these regions in order from behind forwards, the new segments being set free in succession from the front edge of the pygidium. The relationships of trilobites to the various groups of Arthropoda now living have been the subject of much discussion but the elucidation of their appendages leaves no doubt that their main affinities are with the Crustacea (*q.v.*). The five pairs of appendages on the head-region are directly comparable with those of Crustacea, since the second pair or antennae of Crustacea are still postoral and biramous and carry a masticatory process or gnathobase in the nauplius larva as in the trilobites. The biramous form of all the postoral limbs is also a weighty argument in favour of crustacean affinity. On the other hand, there is no trace of the characteristic crustacean shell-fold or carapace. In the uniformity of the postoral appendages, however, the trilobites are more primitive than any living crustacean. The view that trilobites are phylogenetically connected with Arachnida (*q.v.*) has less to support it, but it is possible that connecting links may yet be proved to exist in the imperfectly known Cambrian *Limulava* of Walcott.

The trilobites were all marine and lived, some on sandy or muddy bottoms, some on coral reefs, and some, perhaps, in the deep sea. They were distributed all over the world and in some localities were in such abundance that rock strata are crowded with their remains. A very large number of genera and species are known. Their range of size is from a quarter of an inch to 27 in. in length, but most species are between one and three inches long. (W. T. C.)

TRIM, a market town and the county town of Co. Meath, Ire., on the upper waters of the Boyne, 28 mi. N.W. of Dublin by road. Pop. (1956) 1,342. Monthly fairs are held, and there is considerable trade in corn and flour, The town was the seat of a very early bishopric. A Norman tower, called the Yellow Steeple, is supposed to mark the site of St. Patrick's Abbey of St. Mary. Two gates remain from the old town walls. King John's castle mas originally founded by Hugh de Lacy in 1173, but a later date is assignable to the greater part of the building. Other castles are Talbot's and Scurlogstown castles; the former erected by Sir John Talbot, lord lieutenant of Ireland in 1415, the latter dating from 1180. At Newtown Trim, about a mile east of the town, the ruins of the abbey of St. Peter and St. Paul. founded in 1206 by Simon Rochfort, occupy both banks of the river. These include the Transitional-Norman cathedral on the north bank, and a castle guarding the crossing of the river on the south, together with a chapel and other remains. North of the town, ruins may be seen of a 13th-century Dominican friary. The tower of the old parish church dates from 1449. Several Irish parliaments met at the castle until the middle of the 15th century, and a mint was established in 1469. The town was incorporated by Edward III.

TRIMONTIUM, according to Ptolemy (ii. 3, 6) a "city" in the territory of the Selgovae, was probably the name of the Roman fort at Newstead, near Melrose, Scotland, close under the three Eildon Hills (whence the name *trium montium*). It was an advanced post of the Romans towards Scotland from about A.D. 80 onwards, and again (after an interval of evacuation) from about A.D. 140–180. Excavations carried out between 1907 and 1911 yielded finds of almost unique importance, These included the foundations of several successive forts, one above the other, which throw much light on the character of the Roman military post, an unparalleled collection of Roman armour, notably ornate helmets, and a good series of coins and datable pottery. The whole illustrate the history of the Roman army and that of Roman Scotland very remarkably and to an extent equalled by no other Scottish site as yet explored.

See James Curle, *A Roman Frontier Post and its People* (Glasgow, 1911).

TRINCOMALEE, a town and former naval station on the northeast coast of Ceylon, 100 m. N.E. by N. of Kandy. Pop. (1953) 28,236. It is built on the north side of the bay of Trincomalee, on the neck of a bold peninsula separating the inner from the outer harbour. The annual average rainfall is 64.8 inches and the average temperature 81.2° F.

The town was one of the first Tamil settlements in Ceylon. Their temple, dedicated to Konatha, or Konasir, on a height at the extremity of the peninsula, was known as the "temple of a thousand columns." The building was destroyed in 1622 by the Portuguese. The town was successively held by the Dutch (1639), the French (1673), the Dutch (1674), the French (1782), and the Dutch (1783). It surrendered to the British fleet in 1795, and with other Dutch possessions in Ceylon was ceded to Great Britain by the Treaty of Amiens in 1802.

With its magnificent harbour--one of the five or six greatest natural harbours in the world—it used to be the headquarters of the admiral commanding on the East Indian station and had a military garrison. Pearl oysters are found in the lagoon of Tambalagam to the west of the bay. Some tobacco, rice, and coco-nuts are grown in the district.

Rice and general merchandise are imported while paddy, timber, dried fish, tobacco, deer horns and skins are exported. The merchant anchorage in the harbour is in 4 to 8 fathoms about 4 cable lengths from the wharf. The harbour can accommodate the largest vessels.

TRING, a market town and urban district in the Hemel Hempstead parliamentary division of Hertfordshire, Eng., 32 mi. N.W. of London by road. Pop. (1951) 5,017. Area 6.9 sq mi. It lies on the western slope of the Chiltern hills. The Rothschild museum contains an extensive natural history collection. The museum stands near an entrance to Tring park with its magnificent beech woods. Tring reservoirs, which supply the Grand Union canal. were leased as a nature reserve in 1955 to protect the wintering duck and migratory birds.

TRINIDAD, a town near the southern coast of Cuba, in Las Villas province, about 45 mi. southeast of Cienfuegos, and 3 mi. from its seaport, Casilda. which lies due south. Pop. (1953) 21,605. There is a local railway. connected with the central trunk line of the island. The city lies on the slope of La Vigia hill (goo ft.) amid higher mountains, and on the banks of the Jayoba (San Juan) river. Casilda has a land-locked, shallow harbour; but Masio bay, a trifle farther distant, accommodates larger craft; and there are excellent deep-water anchorages among the quays off the coast. The Manatí river is navigable for about 7 mi. inland and is used as an outlet for sugar and molasses crops. These and honey are the chief exports; tobacco and various vegetables and fruits are of minor importance. Trinidad is one of the seven original cities of Cuba established by Diego Velásquez. It was founded in 1514 on the coast, but after being attacked by pirates was removed inland. It was thrice sacked by English buccaneers—in 1642, 1654 and 1702. The late 18th century witnessed the development of sugar in this area on a scale that led Trinidad to become by the middle of the 19th century Cuba's fifth city. with more than 14,000 inhabitants. But it did not recover from the civil war and the shift of the sugar industry to other areas. Its traditional architecture makes it one of the most interesting tourist centres in Cuba.

TRINIDAD, the most southerly and, next to Jamaica, was the largest territory of the former West Indies federation. Politically. Trinidad and Tobago (*q.v.*), which was amalgamated with it in 1888, constitute a single colony. Trinidad is 16 mi. east of the coast of Venezuela, between 10° 3' and 10° 50' N. and 60° 55' and 61° 56' W. Average length, 50 mi.; breadth, 37 mi.; area, 1,864 sq.mi. Geographically it is a part of South America, from which it is separated by the Gulf of Paria. Off the northwest coast of Trinidad lie several islands, of which Chacachacare, Huevos, Monos and Gaspar Grande are the most important; Patos. westernmost of the islands, was ceded to Venezuela in 1942. Cnder its "destroyer bases" agreement with Great Britain in 1940, the United States acquired 99-yr. lease rights for naval and air bases in Trinidad. Several areas were taken over and occupied beginning in 1941, but by 1950 all of these had been relinquished except the naval base at Chaquaramas, although the United States retained full rights to re-establish bases in the event of war or grave emergency. An agreement signed April 14, 1953, demarcated the submarine boundaries in the Gulf of Paria between Trinidad and Venezuela.

Both in the north and south of Trinidad there are ranges of hills running east and west, prolongations of the Venezuelan coast ranges. Of these, the northern is the more elevated, its highest point being Mt. Aripo (3,085 ft.). A small ridge runs through the centre of the island, from Manzanilla point to San Fernando, with the isolated Mt. Tamana (1,009 ft.). All hills are densely wooded. There are four mineral springs and several mud volcanoes, but the two most striking natural features are the Maracas falls and Pitch lake. The Maracas falls, 312 ft. high, are situated at the head of a valley of the same name, to the northeast of Port-of-Spain. Pitch lake lies about 38 mi. S.E. of the capital, by water, in the ward of La Brea. It is circular in form. about 2 mi. in circumference, and 148 ac. in extent. The asphalt wells up in low bulging masses, separated from one another by narrow channels. in which the rain forms pools. Near the centre of the lake the pitch is always liquid and can be observed bubbling up. When the sun is hot the lightest footfall leaves an impression, and the pitch emits a strong odour. The soil of the surrounding district is charged with asphalt, but is very fertile, while the road to the neighbouring port of La Brea, running over a bed of asphalt, moves slowly toward the sea like a glacier. The lake is worked by a company which exports the asphalt to the United States, paying royalty to the local government. Asphalt production in 1954 was 142,101 tons, of which 81,529 tons were exported.

The mountain range which runs along the north coast is formed of clay slates, micaceous and talcose schists and crystalline and compact limestones, constituting the group of unknown age called the Caribbean series. The rest of the island is composed of Cretaceous, Tertiary and Quaternary strata. The Cretaceous beds rise to the surface in the centre and are flanked to north and south by later deposits. The relations of the various divisions of the Tertiary formation ate still somewhat obscure. but they are grouped by J. B. Harrison into (1) Nariva and San Fernando beds = Eocene and Oligocene; (2) Naparima marls = Miocene; and (3) Moruga series = Pliocene and Pleistocene. The Naparima marls consist of a lower division containing Globigerina and an upper division with Radiolaria and diatoms and are clearly of deep-sea origin. The bitumen of the Pliocene and Pleistocene deposits appears to have been formed by the decomposition of vegetable matter. Salses or mud volcanoes occur upon the island.

Trinidad's seasons are regular, wet from May to January except for a short break in October, and dry from late January to mid-May. The temperature varies only slightly—daylight average 84° F.. night average 64° F. Annual rainfall averages 64 in. at Port-of-Spain and from 50 in. to 120 in. elsewhere.

Trinidad was discovered by Columbus in 1498. A Spanish governor was appointed in 1532, and before the end of the 16th century San José de Oruna (site of the modern town of St. Joseph), 7 mi. inland from Port-of-Spain, became the capital. San Jose de Oruna was burned by Sir Walter Raleigh in 1595, and the island was raided by the Dutch in 1640 and by the French in 1677 and 1690. Foreigners of all nations were encouraged to settle in Trinidad by advantages offered in 1783, and a large influx of people included many French families driven from Haiti and elsewhere by events of the French Revolution. In 1797, during mar between Great Britain and Spain. a British expedition under Sir Ralph Abercromby sailed from Martinique to reduce the island. Trinidad capitulated without a fight on Feb. 18, 1797, and it was formally ceded to Great Britain by the treaty of Amiens in 1802.

The 1960 census showed the entire population to be 827.957, a 26.9% increase in 15 yr. In 1960 the population of Trinidad was 786.434. General health conditions are excellent. A mass B.C.G. inoculation campaign against tuberculosis was carried out in 1952–53. One-third of the inhabitants are of East Indian extraction. constituting the largest unit of that racial element in the western hemisphere. The population in 1946 was made up as follows: Negro 46.8%; East Indian 35.1%; mixed 14.1%; white 2.8%; Chinese 1.0%; Syrian 0.2%. English is spoken generally; some French patois, Hindi and Spanish are still in use. Port-of-Spain (1960 pop., 91,596), the capital, is on the west coast. It is the leading port of The West Indies and handles virtually all the island's external trade. King's wharf and King's wharf extension provide six berths for discharging and loading of bulk and general cargoes to and from six transit sheds and eight annexes. There is also a seventh berth used mainly by vessels engaged in the mineral trade and two small berths capable of accommodating lighters and small vessels trading within the Caribbean. The eastern portion of King's wharf extension also provides berthing facilities for passenger vessels and royal navy ships. The wharf is well equipped mechanically and there is a 24-hr. service which enables vessels to enter and leave at any time. Pilotage is compulsory for vessels moving between the outer anchorage and the quay side. The government operates two passenger and freight-carrying steamers connecting Port-of-Spain with Scarborough, Tobago, where the wharf was reconstructed in 1953 to enable berthing of the steamers alongside. A new 1,800-ton slipway was opened in 1946. In addition to the city of Port-of-Spain there are two other municipalities, both of them rated as boroughs: San Fernando (pop. 38,587), on the Gulf of Paria about 30 mi. from Port-of-Spain. and Arima (pop. 10,941), 16 mi. inland and east of Port-of-Spain.

Elementary education is free, but is compulsory only in Port-of-Spain, San Fernando and San Juan. In 1955 there were 559 primary and 8 intermediate schools, total enrolment 154,127. Most of these schools are denominational, including Moslem and Hindu, receiving government subsidies. Of the primary schools 65 were government, 311 government-assisted and 153 private. There were 2 government intermediate schools and 2 assisted. Fees are charged at the intermediate and secondary schools. Colleges for training teachers for elementary schools comprised government and Roman Catholic institutions at Port-of-Spain and the Naparima training college at San Fernando. Several high schools in Trinidad. and one in Tobago, were affiliated with the Queen's Royal college at Port-of-Spain.

The government awarded annually three four-year scholarships to universities overseas. A government technical training institute was opened at San Fernando in 1953; also an eastern Caribbean farm training institute in Feb. 1954. In 1921 the Imperial College of Tropical Agriculture was established at St. Augustine, about 8 mi. E. of Port-of-Spain; it was incorporated by royal charter in 1926. Its purposes are to provide training in the science and practice of tropical agriculture for students intending to become planters, agricultural administrators or specialists in agricultural science and technology. It also conducts research relating to a wide range of tropical crops. and advises other British possessions in the Caribbean area with respect to agricultural problems. The college was enlarged in 1951 by two new research laboratories.

Under the constitution of 1956 a governor was appointed by the crown. There was a legislative body consisting of an executive council of 11 (8 chosen by members of the legislative council from among their own number) and a legislative council of 5 appointed by the governor, 2 ex-officio and 24 members elected by universal suffrage. A chief minister was elected by the legislature. There are three municipalities and seven county councils: the latter were given executive powers by statute effective Feb. 2, 1953.

In 1958 the colony of Trinidad and Tobago became a member of The West Indies federation. A constitution scheduled to go into effect in 1962 provided for a bicameral legislature of nominated senators and elective representatives, and terminated the governor's reserved executive powers.

Trinidad has a rich soil well adapted to the cultivation of tropical products For many years cacao was the most important crop. but sugar eventually supplanted it. By the 1960s sugar production had risen to about 200,000 tons annually. About 23,000 tons annually is consumed locally, the rest is exported. Sugar and its by-products have an annual value of more than W.I. $20,-000.000. Coconuts are third in agricultural importance. Coffee, tonka beans, citrus fruits and bananas are raised. The manufacture of Angostura bitters is important.

Petroleum accounts for about 75% of all export values, with sugar and sugar products second. By the 1960s imports and exports had reached a value of more than W.I. $400,000,000 each, not including re-exports. An important ship supply trade usually accounts for more than 15% of export values. The heaviest trade is normally with the following countries. *Exports:* United Kingdom, Brazil, Canada and Newfoundland, The West Indies federation. *Imports:* United Kingdom, Venezuela, United States, Canada and Newfoundland.

Trinidad is the third largest producer of petroleum in the British commonwealth. The first well was drilled at Aripero in 1867, but no shipments were made until 1911. Much of this oil is refined by the island's two refineries, which are also refining an increasing volume of crude oil from Colombia and Venezuela. The average depth of oil wells exceeds 4,500 ft.

A government railway system of 108 mi, links Port-of-Spain with other parts of the island. There are 1,091 mi. of main roads and 1,318 mi. of secondary roads. The island is served by British, Canadian, United States, Venezuelan, Dutch, Brazilian, Argentine, Colombian and Spanish air lines. In an average year, between 4,000 and 5,000 ships touch at Trinidad ports.

The official monetary unit is the West Indian (W.I.) dollar, valued at W.I. $4.80 to the pound sterling. Prior to 1960 this monetary unit was called the British West Indian (B.W.I.) dollar.

The colony's revenues usually exceed expenditures. They were estimated at W.I. $169,968,000 and W.I. $167,640,000, respectively, in 1959.

In 1955 a five-year economic program, which called for W.I. $38,885,275 expenditure on public works, was completed. The largest single outlay was $14.000.000 toward completion of an island-wide water scheme, eventually to cost an estimated $23,-724,000. Other projects included highways, slum clearance an3 erection of schools.

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(L. W. BE.; H. E. CN.)

TRINITARIANS, a religious order founded in 1198 by St. John of Matha and St. Felix of Valois, for the liberation of Christian prisoners and slaves from captivity under the Moors and Saracens. The two founders went to Rome and there obtained the approbation of Innocent III, 1198. The rule was the Augustinian, supplemented by regulations of an austere character. The habit was white, with a red and blue cross on the breast. The Trinitarians are canons regular, but in England they were often spoken of as friars. The first to go on the special mission of the order were two Englishmen, who in 1200 went to Morocco and returned thence to France with 186 liberated Christian captives. Vast sums of money were collected by the Trinitarians; but they were called upon, if other means failed, to offer themselves in exchange for Christian captives. Many thousands were liberated by their efforts. In the 17th century a reform called the Barefooted Trinitarians was initiated, which became a distinct order and is the only one that survives. There are now less than 500 members. Their headquarters are at San Crisogono in Rome. They devote themselves to the ransoming of negro slaves, especially children, and a great district in Somaliland has been since 1904 entrusted to them as a field for missionary work.

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TRINITY. The Christian doctrine of the Trinity can be best expressed in the words '(The Father is God, the Son is God, and the Holy Ghost is God, and yet they are not three Gods but one God . . . for like as we are compelled by the Christian verity to acknowledge every Person by himself (*singillatim*) to be God and Lord, so we are forbidden by the Catholic religion to say that there be three Gods or three Lords" *(Quicunque vult)*. Though this doctrine was one of the first to be dealt with by modern methods of "comparative religion" (as long ago as when Gibbon wrote, "300 B.C., The Logos taught in Alexandria, A.D. 97. Revealed by St. John") — and though it is natural to ask its relation to certain triple arrangements of Pagan deities, to Jewish doctrines of "Wisdom" and the "Word," to the Hegelian triad "The Idea: Nature: Spirit" — it is probably less well adapted to this treatment than other Christian doctrines. At any rate the first step is to discover what, in using this *prima facie* paradoxical language, the Christian Church believed itself to be asserting.

Here a common misunderstanding must be cleared away. "The Creed"—it has been suggested (see *Hibbert Journal,* xxiv. No. *1*) —"means that there is only one being that can, with strict theological correctness, be called 'God,' viz., the Trinity as a whole; but each of the three persons can be called 'God' in a looser sense." This suggestion is offered as a short method of "rendering consistent" the statements of the Creed. But the paradox is not thus lightly to be got rid of. Plainly the Church did not regard itself as lowering the conception of the Father, so that He should become merely one Component of a Divine Whole. "The Father," says St. Thomas Aquinas, "is as great as the whole Trinity," and explains that in such matters "greatness signifies perfection of nature and pertains to essence" *(Summa Theol.* i., xxx. *1*, xlii. *4)*.

Fundamental Conceptions. — This conception of the Trinity is systematically developed by theologians, Greek, Latin and Protestant. "The whole perfection of the. Divine nature is in each of the persons. The essence and dignity of the Father and the Son is the same, but is in the Father according to the relation of Giver, in the Son according to the relation of Receiver" *(S.T.* i., xlii. *4)*. Writers in the 4th and 5th centuries had compared the relation of the Father to the Son with the relation of the "flame to its light," of the "spring to the stream," of the "seal" to its "impress." "Think," says St. Augustine *(Sermo ad Catechumenos,* sec. *8)* "of fire as a father, light as a son. See: we have found coevals: and it is easy to see which begets which." The meaning of these comparisons is plain. They teach that the whole Divine nature or essence is in each of the Three Persons. The impress, for example, is a *full* reproduction of the character of the seal. They teach also that the Divine persons are inseparable. We are dealing both with a "generical" and a "numerical" unity (cf. Aug., F. *and S.,* sec. 4; *Modern Churchman,* vol. xv. 12, 675–7; Webb; *God and Personality,* 69n).

Thus, side by side with language declaring that Father and Son are each in the full sense God, there is other language — not intended. to be inconsistent with the former — which implies that the Son is "necessary to the completeness of the Godhead." The Son, we are told, is not "external" to the Father (Athan., *Discourse I.,* ch. v.), does not "accrue" to the Father from without, but is "of the Substance of the Father." If the Son, it is argued, were not eternal, the Father would not always be Father, and this absence of fatherhood, it is implied, would be a defect (*cf.* the words *consortium, solitarius,* S.T. i., xxxi., 2 and 3). What is the value of these speculations? They cannot be understood apart from a knowledge of the context in which they grew up. This context may be summed up in a sentence. Christians, who were willing to die for Monotheism, deliberately held Jesus to be worthy of full Divine worship; and offered the phrase *Consubstantialem patri* as the intellectual justification of this attitude. In contact with the "Spirit" (who was held to speak in the heart of the individual Christian) they believed themselves to be in contact with God. In contact with Jesus as Master, they likewise found themselves in contact with God; but with no divided allegiance, since they conceived the Universe—in spite of its manifest evils—as the work of the Father of Jesus Christ, and so the embodiment of the same Holy Will which expressed itself most clearly in Jesus and in the Holy Spirit.

The doctrine, then, is primarily religious; and if we define God—as in practice religion does—as "That which has an absolute claim upon our obedience" or as "the Supreme Object of our reverence," the paradoxical element in the doctrine is at least diminished. The ultimate Object of the Christian's reverence is—as reflection will show—the Christian ideal of holiness. A being who fell short of this standard, however omnipotent or self-existent he might be, would not receive the Christian's worship. Conversely, this standard would have an equal claim upon our reverence—since its claim to our obedience is conceived as being absolute—whether or not it were embodied in a person. Jesus is worshipped because the Christian "identifies" Him with His Call—His Law. Reverence and subjection to Him are reverence and subjection to it (John xiv. 21, etc.). Is there, then, any insuperable difficulty in the notion of a threefold personal embodiment of the one Divine Will and Character, an embodiment so complete in each case that contact with the Divine Person is contact with God?

Claims of Unity.—The answer to the foregoing question turns upon the claims of unity. The unity of the world is sometimes represented as based upon its presence to, and its existence in, a single Divine Mind. Religion, however, is interested primarily in the unity of the moral ideal, of the ideal of perfection generally. "The Monotheism of Israel," it has been well said, "was primarily moral seriousness." Religion is concerned also with a faith—which is the basis of its trust and hope—in the necessity of the complete realization of the good in the universe as seen in God; with a faith in that "perfection of the Universe" which St. Thomas regarded as God's chief purpose in creation (i. 50, 3). A Universe which has unity as the complete realization of this single ideal, has the unity which chiefly concerns religion. This ultimate unity of subordination to a single principle is not necessarily identical with the unity which comes from being included within the mind of a single Divine Being. Nor is it obviously identical with the theologian's "numerical unity of substance" (see *e.g.*, Tanqueray, Syn. *Theol.* Dog., ii. 575–576). The Unity, then, of the Object of our supreme reverence and trust is not plainly inconsistent with the existence of personal distinctions (in the modern sense of the word) within the Godhead. It was probably an afterthought to regard the doctrine of the Trinity as providing a more satisfactory conception of "personality in God" than could grow up under a "unipersonal" theology. Yet Trinitarianism has some points of superiority over a theory which may compel us to conceive God as waking up at the Creation from "an eternity of idleness" (Shelley, Queen Mab, vii. *cf.* Journal of Theol. Studies, iv. 376). Love—it may be argued—can only be at its highest perfection in the "love of God for God"—in a love in which He that loves and He that is loved are wholly adequate to one another. A faith in God's perfection would thus tend to a belief in the "plurality of persons in the Godhead."

Amplifying Conceptions.—It has been similarly argued that in conceiving the "not-self with which God contrasts Himself" as "wholly internal to His essence" while the unity (the Holy Spirit) "within which the relation of the. two falls is not, as in us, a dark mystery at the back of our life but something which 'proceeds from both' " we have "the best notion that we can frame of Being at its highest" (Webb, *J.T.S.,* Oct. 1900). Such an argument leads not merely to a plurality but to a trinity of Divine persons, and supports the Western doctrine of the procession of the Spirit from the Father and the Son, tanquam ab *uno principio* et *unica spiratione* (Council of 1274). It agrees also with the conception of the mutual indwelling of the Three Persons (Tanqueray, S.T.D., ii., 664–665). Again, the argument—if joined with the belief that "whatever we conceive the Divine life to be, our life cannot be outside it"—is in accordance with the Scriptural conception that mankind is within the Eternal Son, that the Church is His "body" or His "fulness." Such a conception would lead us beyond any mere "trinity of manifestation"; since it implies that, though in knowing each Person of the Trinity we are knowing God, yet to know God as Trinity is a real addition to our knowledge, and further, that the personal relations within the Trinity are necessary to His full glory, since they make possible to God something better than mere self-contemplation.

The doctrine, then, we may conclude, arose primarily from the conviction that worship of Jesus is consistent with Monotheism. But if, secondarily, the doctrine when formed is defended as offering the best attainable conception of the Divine perfection, it follows that our sense of what is good and fitting, our aesthetic and religious instinct for perfection, and likewise those qualities in the doctrine which moved Dante (*Parad.,* x. 1–6) to give it poetic expression, are all relevant to its discussion. (See PANTHEISM, ATHEISM.) (C. J. SH.)

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TRINITY HOUSE, CORPORATION OF. A fraternity of seamen connected from early times with the river Thames and described in the charter of incorporation granted in the name of the Holy Trinity by King Henry VIII on May 20, 1514, as the Shipmen of Mariners of England. Its present charter, granted by King James II on July 8, 1685, describes it as the "Guild, Fraternity, or Brotherhood of the Most Glorious and Undivided Trinity and of St. Clement in the Parish of Deptford Stronde in the County of Kent." The first master appointed was the founder of the corporation, Sir Thomas Spert, Controller of the Navy to King Henry VIII. Deptford having been made a royal dockyard by Henry VIII, and being the station where outgoing ships were supplied with pilots, the corporation rapidly developed. By an Act of Parliament, 8. Queen Elizabeth, the corporation was granted power to erect seamarks at its own costs, and in 1594 it received the very valuable grants of ballastage in the river Thames, and the rights to erect and place beacons and buoys up to that time held by the Great Admiral of England. The charter was regranted by successive sovereigns; King James I made considerable changes and added a number of "Elder Brethren" as distinct from the remaining brethren who were designated "Younger Brethren", whose sole rights consisted of having a vote in the election of the master and wardens.

During the Commonwealth the constitution of the corporation was suspended and the work was conducted by nominees of Parliament, but on the restoration the charter was given back but subsequently surrendered to King Charles II towards the end of his reign, and a new charter was granted by King James II under which the corporation now functions.

The original home of the corporation was at Deptford, but in the seventeenth century it was moved to Water Lane, London, where it remained until 1795 when it was transferred to its House on Tower Hill where it still remains. The corporation by virtue of letters patent granted by the Crown from time to time had erected lighthouses and established light vessels and buoys, for the maintenance of which it was empowered to collect tolls, and in 1836 Parliament passed an Act giving the corporation power to purchase from the Crown, as well as from sundry private proprietors, all their interests in certain principal coast lights. From the earliest days the maintenance of the lights, buoys, etc., was met out of the tolls levied on shipping, any surplus being devoted to the relief of old and indigent mariners and their families, but in 1853 the control of the light dues or tolls was transferred to the Board of Trade, and the corporation was left with only its private and charitable income.

The corporation is now the general lighthouse authority for England and Wales, the Channel Islands and Gibraltar; it is also the principal pilotage authority for England and Wales, and its functions in both these respects are controlled by statute. The Elder Brethren act as nautical assessors in the House of Lords, the Admiralty Division of the High Court of Justice, and the Court of Session in Scotland. Other Trinity Houses established under ancient charters exist at Hull, Newcastle and Leith.

See W. H. Mayo, *Trinity House, London, Past and Present* (1905); C. R. B. Barrett, *The Trinity House of Deptford Strond* (1893).

TRINITY SUNDAY, the Sunday next after U'hitsunday. A festival in honour of the Trinity had been celebrated locally at various dates for many centuries before Pope John XXII (1316–1334) ordered its general observance on the octave of Whitsunday. From Trinity Sunday onward all Sundays until the close of the ecclesiastical year are reckoned in the Church of England as "after Trinity," in the Roman Church as "after Pentecost."

TRINOVANTES, commonly Trinobantes, a powerful British tribe about 50 B.C.–A.D. 50 dwelling north and northeast of London, rivals and neighbours of the Catuvellauni. When Gaius Julius Caesar invaded Britain 54 B.C. they joined him against their domestic rivals. They were conquered by Rome in A.D. 43 and joined in Boadicea's revolt in 61. In the tribal division of Roman Britain given by Ptolemy their land included Camulodunum (Colchester), but nothing more is known of them. Their name plays a part in mediaeval legends and romances. There it was interpreted as Troy Novant, the "new Troy," and connected with the names of the Trojans Brutus and Corineus who were reputed to have given their names to Britain and Cornwall.

(F. J. H.)

TRIOLET, one of the fixed forms of verse invented in medieval France, and preserved in the practice of many modern literatures. It consists of eight short lines on two rhymes, arranged a b a *a a* b a b, and in French usually begins on the masculine rhyme. The first line reappears as the fourth line, and the seventh and eighth lines repeat the opening couplet; the first line, therefore. is repeated three times. and hence the name. No more typical specimen of the triolet could be found than the following, by Jacques Ranchin (c. 1690):

Le premier jour du mois de mai
Fut le plus heureux de ma vie:
Le beau dessein que je formais,
Le premier jour du mois de mail
Je vous vis et je vous aimais
Si ce dessein vous plut, Sylvie,
Le premier jour du mois de mai
Fut le plus heureux de ma vie.

This poem was styled by Gilles Ménage "the king of triolets." The great art of the triolet consists in using the refrain line with such naturalness and ease that it should seem inevitable, and yet in each repetition slightly altering its meaning, or at least its relation to the rest of the poem. The triolet seems to have been invented in the 13th century. The earliest example known occurs in the *Cléomadés* of Adenès-le-Roi (1258–97). The medieval triolet was usually written in lines of ten syllables, and the lightness of touch in the modern specimens was unknown to these perfectly serious examples. One of the best-known is that of Jean Froissart, "Mon coeur s'ebât en odorant la rose." The rules are laid down in the Art *et* Science de Rhethorique (1493) of Henry de Croi, who quotes a triolet written in words of one syllable. According to Jean Sarasin, who introduces the triolet as a mourner m his *Pompe funèbre* de Voiture, it was Froissart who brought back into fashion the ancient precise forms of verse by his ballades, his triolets and his rondeaus, which after his death (1645) returned to their former disrepute. N. Boileau-Despreaux threw scorn upon the delicate art of these pieces, but they continued to be written in France, though not by poets of much pretension, until the middle of the 19th century, when there was a great revival of their use. There are delightful examples by Theodore de Banville.

The earliest triolets in English are those of a devotional nature composed in 1651 by Patrick Carey, a Benedictine monk at Douai, where he probably had become acquainted with what Voiture had made a fashionable French pastime. The triolet was reintroduced into English by Robert Bridges, in 1873, with his

When first we met, we did not guess
That Love would prove so hard a master;
Of more than common friendliness
When first we met we did not guess.
Who could foretell this sore distress,
This irretrievable disaster,
When first we met?—we did not guess
That Love would prove so hard a master.

Since then the triolet has been cultivated very widely in English, most successfully by Austin Dobson, whose "Rose kissed me today," "I intended an Ode" and "In the School of Coquettes" are masterpieces of ingenuity and easy grace.

In French literature, triolets are innumerable; perhaps the most graceful cycle of them is "Les Prunes," attached by Alphonse Daudet to his Les Amoureuses in 1858. In Germany the triolet has attracted much attention. Those which had been written before his day were collected by Friedrich Rassmann in 1815 and 1817. But as early as 1795 an anthology of triolets had been published at Halberstadt and another at Brunswick in 1796. Rassmann distinguished three species of triolet: the legitimate form (which has been described above), the loose triolet, which only approximately abides by the rules as to number of rhymes and lines and single-strophe poems which more or less accidentally approach the true triolet in character. The true triolet was employed by W. Schlegel, F. Hagedorn, F. Riickert, A. Platen and other romantic poets of the early 19th century. In many languages the triolet has come into frequent use to give point and brightness to a brief stroke of satire; the French newspapers are full of examples of this. The triolet has laboured under a suspicion of frivolity, but in the hands of a genuine poet the form possesses a delicate charm. (E. G.; G. W. A.)

TRIPOD, in classical antiquities, any "three-footed" utensil or article of furniture. The name is specially applied to: (1) a seat or table with three legs; (2) a stand for a cauldron in cooking. or for a camera, compass. theodolite, etc.; (3) a sacrificial tripod or altar, the most famous of which was the Delphic tripod, on which the Pythian priestess took her seat to deliver the oracles of the god. the seat being formed by a circular slab on the top, on which a branch of laurel was deposited when it was unoccupied by the priestess. Another well-known tripod was the "Plataean," made from a tenth part of the spoils taken from the Persian army after the battle of Plataea. This consisted of a golden basin, supported by a bronze serpent with three heads (or three serpents intertwined), with a list of the states that had taken part in the war inscribed on the coils of the serpent. The golden bowl was carried off by the Phocians during the Sacred War; the stand was removed by the emperor Constantine to Constantinople. Tripods have been given since Homer's time as prizes in athletic games and as gifts.

TRIPOLI, a city in Lebanon and the seat of administration of the sanjak of Yorth Lebanon in French mandated territory until 1941, mod. Tarabulus. It is situated about 2 mi. inland from its port. El-Mina, to which it is joined by a streetcar line. Pop. (1956 est.) 80,000. The city is the 'terminal of railroads connecting with Turkey and Egypt, has a modern port for seaplanes and is the terminal of one of the two pipelines of Mosul oil. The chief industries are soap manufacture. sponge fishing, tobacco cultivation and fruitgrowing. It has an export trade in fruit (especially oranges). eggs and cotton.

History. — Tripoli is known only by its Greek name. Founded after 700 B.C., it became in the Persian period the capital for the Phoenician triple federation — Sidon, Tyre and Aradus. Each of the three had its own district in the "triple town," which at that time stood on the El-hlina peninsula. The Seleucids and Romans extended and embellished the city. The Moslems took possession in A.D. 638. In 1109 it surrendered to Raymond of St. Gilles, after a five-year siege. A great library founded by Ammar, the ruling family, and consisting, it is said, of 100,000 volumes, was consigned to the flames. When Sultan Kala'un of Egypt took the town in 1289 it was destroyed: and a new city arose on the present site. Tripoli was often a disputed possession of the rival princes of Aleppo and Acre. In 1834, during the Egyptian conquest of Syria, it was made a centre of administration. The British occupied it Oct. 13, 1918. It was incorporated in the state of Grand Liban on Aug. 31, 1920. In 1941 it was occupied by the British and Fighting French and became part of the independent republic of Lebanon on Nov. 26 of that year. (E. Ro.; X.)

TRIPOLI, one of the two capitals (the other being Benghazi) of the united kingdom of Libya, and its chief port, is situated on the north African coast on a promontory stretching out into the Mediterranean. Pop. (1954) 130,238, including the European and American populations. Mass emigration to Israel has reduced the Jewish element.

The oasis of Tripoli is very fertile and beautiful. The desert almost touches the western side of the city, while to the east is the oasis of Mechia, where the tombs of the Karamanlian sultanas are to be seen. Tripoli has a brief winter (lasting from November to January) which is also the rainy season. Night temperatures may drop as low as 32° F. The summer is hot and at times uncomfortably humid. The winter is inclined to be windy, but the spring is frequently accompanied by the ghibli, a hot, rapidly moving sandstorm which may take a day or two to pass.

Tripoli, seen from the sea: is a picturesque city dominated by the ancient Spanish castle dating from the first half of the 16th century. Stretching along the whole length of the bay are the sea wall and a wide boulevard shaded by palm trees. Many of the brightly coloured houses have beautiful gardens.

The city was originally surrounded by walls, now no longer in existence. They dated from Roman times, but the earliest parts actually preserved belong to the Byzantine period, and the greater part to the 16th century. The old city is quite distinct from the new and is characterized by its bazaars, Arab coffee shops and narrow streets, some of which are completely roofed over. Certain streets are associated with special trades, the street of brass-workers being particularly well known where brass and copper trays, bowls, lamps and ornaments are fashioned. Silver articles are also made. In the street of dyers, cobblers and tailors there are many mosques. Of these the largest is the Gurgi mosque and the most famous the Karamanli mosque with its octagonal minaret. Near the harbour is the Marcus Aurelius arch, a Roman triumphal arch, made entirely of white marble and richly embellished with sculpture. It was erected in A.D. 163. In the Turkish quarter the minarets and cupolas of numerous mosques are clearly silhouetted above the flat-roofed and whitewashed houses.

The modern part of the city to the southwest of the old town is more spaciously planned and includes a garden-city residential area. At the centre of the city is the Roman Catholic cathedral. The English church is on the outskirts. Most of the city's streets have been renamed and given Libyan names with one main exception; the boulevard along the sea front (formerly the Lungomare Conte Volpi) has been named Adrian Pelt avenue in honour of the Dutch representative, of the United Nations in Tripoli when Libya acquired its independence. Many of the city's official buildings, theatres and hotels are on this boulevard. The King's palace, white and domed and with a Moorish façade, stands in beautiful grounds; a royal guard of Libyan troops is mounted at the gates.

Communications and Industry. — The coastal road linking Tunis with Benghazi passes through Tripoli; westward toward the Tunisian frontier the road passes the ancient city of Sabratha and, toward the Egyptian border, east of Homs, passes Leptis Magna. Other roads lead south from Tripoli to el Azizia, Gharyan and Jefren. The local rail service runs to a few of the smaller towns, to Zuara, 68 mi. to the west, and Homs, 70 mi. to the east, both of which are on the coastal road. There is an airport at Idris el Awal, 21 mi. S. of the city, which serves several main airlines. At Wheelus Field there is a U.S. military air base.

Agriculture, animal husbandry and fishing form the basis of the local economy. Tunny fishing is particularly important but can only take place for a very short period, when the fish approach the coast. With the aid of Italian experts the fish are prepared and tinned for export. There is a little sponge fishing. Along the shore large salt pans have been dug in which sea water is evaporated; a certain amount of the salt is exported, but most of that produced is used in the drying and preserving of hides and skins. Small local industries include the culture of tobacco and manufacture of cigarettes, and the weaving of carpets and rugs.

The principal exports are esparto grass, tunny fish, peanuts and olive oil, sheep and cattle, hides and skins, and fresh, mainly citrus, fruits. Goods imported include sugar, clothes and general foodstuffs, cars and agricultural machinery, and crude and refined oil. In 1958 a number of European and American companies were prospecting for oil in Libya; a supply of natural gas was discovered a few years previously 40 mi. W. of Tripoli.

The Port. — In addition to a busy transshipment trade, Tripoli handles most of the imports and exports of the kingdom of Libya. The main quays accommodate vessels with a draft of 24 ft. and the Karamanli oil quay can with pontoons accommodate oil tankers of 24–27 ft. draft. The harbour is enclosed by two breakwaters, the Spanish mole and Rasel Zur. The entrance is 310 ft. wide; the buoyed channel, which is 250 ft. wide, has a depth of 29 ft. and there is deeper water in the harbour. The docks are well equipped with mobile cranes, lighters and tugs, and there is a good supply of fresh water.

History. — Tripoli, the ancient Oea, is the only city which has survived of the three — Oea, Leptis Magna (*q.v.*) and Sabratha (*q.v.*)—that formed Tripolitania between 700 B.C. and 146 B.C. It was probably founded by Phoenicians from Sicily, but was under Roman occupation from 146 B.C. until A.D. 450. Invasion by the Vandals followed and conquest by the Byzantines (A.D. 533–643). During the Arab invasions in the 11th century Sabratha and Leptis were destroyed and as a result Tripoli grew in importance. In 1146 it was overrun by the Normans from Sicily and in 1510 it was taken by the Spaniards. It fell to the Turks in 1551 and was in their hands until 1911. They made it the capital of the vilayet of Tripoli. During the first century of the Turkish period Tripoli was a pirates! stronghold. The Italians occupied it from 1911 until Jan. 23, 1943, when British forces entered the city. From 1911 it served as the capital of the Italian colony, and from 1939 it was the capital of the Italian province of Tripolitania. Prior to the establishment of an independent kingdom on Dec. 24, 1951, Tripoli was under British administration. (A. J. Bn.)

TRIPOLI is a porous, friable, microcrystalline silica rock of sedimentary origin comprised chiefly of chalcedony and microcrystalline quartz. It does not include diatomite, although the name was chosen because of its superficial resemblance to tripolite, a diatomite from Tripolitania in north Africa. Some tripoli is a coherent residuum from leached limestone, dolomite or chert; other is probably leached, flocculated colloidal silica which has partly recrystallized. The friable variety is more typical. The chemical composition is usually more than 95% silica, SiO_2, but the impurities may impart beneficial, desirable physical properties. Tripoli is used mainly as a polishing or buffing abrasive, wherein it excels because of its physical properties (particle shape and porosity), and also as a foundry facing. Commercial tripoli powder is finely pulverized, much of it being reduced below ten microns in diameter.

Production in the U.S. is chiefly from Missouri and Illinois, less from Arkansas, Georgia and the Tennessee valley. Besides domestic consumption, large exports go to England chiefly and to other European, Asian and South American countries. (W. D. Kr.)

TRIPOLITANIA, the western part of the kingdom of Libya, has an area of about 348,000 sq.mi. (only 96,471 if the desert hinterland of the Fezzan be excluded) and is bounded on the east by Cyrenaica, on the north by the Mediterranean sea, on the west by Tunisia and, beyond the Fezzan, by Algeria and on the south, likewise beyond the Fezzan, by French West Africa and by French Equatorial Africa. The population in 1951 was estimated as follows: Moslems 753,240; Italians 46,838; Jews 8,000; others, mainly Maltese and Greeks, 3,800; total 811,878. The chief towns, both coastal, are Tripoli (*q.v.;* pop., 1951 est., 119,000) and Misurata (pop., 1951 est., 48,000).

Physical **Features.**—Tripolitania is essentially an undulating plateau, forming a northern part of the central Sahara desert. The surface rises generally southward, where, at the extreme southern frontier, it merges into the Ahaggar, Timmu and Tibesti uplands of the central Sahara. In the northeast, between Misurata and the Gulf of Sirte, the land rises gradually from sea level without much discontinuity; but westward there is first a coastal plain, known as the Jefara, that is backed to the south by a line of northward-facing scarps, successively from east to west the Jabal Misurata, Jabal Tahuna, Jabal Garian and Jabal Nefusa. This latter feature, formed by subsidence along fracture lines trending from east to west with downthrow to the north, is often referred to simply as the Jabal. It does not run parallel to the coast but strikes inland from the coast due westward between Misurata and Homs (Khums), giving the Jefara a triangular shape, with its broadest, part in the west.

The Jabal reaches a general elevation of 2,000 ft. and is marked in places by outpourings of lava (*e.g.,* at Takut, due south of Tripoli). Beyond the crest of the Jabal lies the Hammada al-Hamra (Red desert), a stony plateau about 1,700 ft. above sea level, that covers 40,000 sq.mi. The Hammada is uninhabited, but the presence of numerous well-developed and now dry river valleys indicates that climatic conditions were once very different. There are a few ridges running east-west, the most imposing being the Jabal as-Suda (Black mountain), about 1,000 ft. higher than the plateau. About 400 mi. S. of the Mediterranean coast, the Hammada gives place abruptly to a series of depressions aligned east-west, which form the basin of the Fezzan. There water can be tapped at three distinct levels below ground—at 20 ft., 70 ft. and 200 ft.—and settlements occur in three main districts, Murzuk (the capital), Gatrun (south) and Sebha-Ubari (north). Away from these oases, there is the same alternation of seas of soft sand, gravel desert and volcanic masses. Two isolated oases lie in the extreme west of Tripolitania: Ghadames, an ancient centre 350 mi. S.W. of Tripoli; and Ghat, a much newer settlement 250 mi. S.W. of Murzuk. Both centres command trade routes skirting the main Hammada on the west and continuing southward between the Ahaggar and Timmu ranges toward the Niger and Lake Chad. For several decades previous to 1920 the only caravan routes from the Niger to Tripoli used the track via Ghat, disturbances in Bornu and the Tuareg country farther east having closed all others. The importance of both places has greatly declined.

Because of its open topography, with few screening hills, Tripolitania is affected by unmodified influences alternately from the Mediterranean and from the Sahara. Hence the climate is somewhat unstable, with rapid changes in temperature and unreliable. sporadic rainfall. Temperatures are generally high, with modification caused by the sea near the coast and by altitude in the Jabal. Day maxima in summer frequently exceed 100° F. or even 110° inland. Typical mean conditions for the different regions are: coldest month 54" F. (coast), 52° (Jefara), 47° (Jabal) and 51° (Hammada); warmest month 80° F. (coast), 86" (Jefara), 81° (Jabal) and 84" (Hammada). In summer, the whole of Tripolitania falls under the influence of the Azores anticyclone, and there is no appreciable rainfall. In winter, the northern half of the country is affected from time to time by small depressions that move eastward over the Mediterranean sea; but the northward-jutting promontory of Tunisia shelters Tripolitania from the main rain-bearing northwesterly winds, so that most of the country has only eight inches or less of annual rainfall. The Tripoli area and the Jabal lying to the south and east may receive 10 in. to 15 in. Figures of average rainfall can, however, be misleading, as rain may be entirely restricted to a few weeks, or even days, in each year. Severe droughts occur roughly at ten-year intervals, with, at times, successive seasons of drought. A special feature is the *ghibli,* a violent dusty wind from the south that can suddenly raise temperatures to more than 105° F. and cause enormous damage to growing crops.

The flora of Tripolitania is mainly Saharan, with the date palm and tamarisk highly characteristic. Acacia, asphodel, sapanwood and mastic are found in the wadies, and wormwood forms clusters in the Hammada. Near the coast laurel, myrtle, oak and other evergreens are common, with rarer patches of cypress, pine and carob. Among the commoner animals are the hare, rabbit, hyena, fox, jackal and marmot, while reptiles include the horned viper and gecko. Birds include the vulture, hoopoe, wood pigeon and dove. (W. B. FR.)

History.—Tripolitania, also commonly called Tripoli simply, was originally a Phoenician colony. The wars between the Libyans and the ancient Egyptians do not come properly into its history. (See EGYPT.) Before the colonization of the neighbouring territory to the east by the Greeks (see CYRENAICA) the Phoenicians appear to have founded the cities of Sabratha, Oea and Leptis. Oea, which stood between the other cities, became the capital of the country and was named Tripolis (the "Three Cities"). These towns commanded the trade of the central Sudan, and caravans regularly crossed the Sahara, there at its narrowest. The early history of Tripolitania was similar to that of Cyrenaica: Cyrenaica passed from the Greeks to the Ptolemies and from them to the Romans; Tripolitania, adjoining Carthaginian territory on its west, fell under the sway of Carthage and, following its fortunes, became eventually a Roman province.

In the 5th century A.D. both Tripolitania and Cyrenaica were conquered by the Vandals, whose power was destroyed in the 6th century by the Byzantine general Belisarius. In the middle of the 7th century North Africa was overrun by the Arabs, and Christianity gave place to Islam. From this period dates the decay of a civilization which had lasted about 1,000 years. Tripolitania became subject to the successive rulers of Tunisia. It was pillaged in 1146 by the Normans of Sicily. In 1321 the Beni Ammar established an independent dynasty, which lasted, with an interval during which two sovereigns of the Beni Mekki reigned (1354–69), until 1401, when Tripolitania was reconquered by the Tunisians. In 1510 Ferdinand the Catholic of Spain took the city of Tripoli, and in 1530 it was given to the Knights of St. John, who were expelled in 1551 by the Turkish corsairs Dragut and Sinan. Thus the country fell to the Turks, though after the death of Dragut the connection with Constantinople seems to have weakened. The Tripolitan pirates soon became the scourge of the Mediterranean; half the states of Europe seem at one time or other to have sent fleets to bombard the capital of the country, nor was piracy stopped until after the French occupation of Algiers in 1830. In 1714 Ahmed Pasha Karamanli achieved practical independence. He and his descendants governed the country as a regency, the claims of the Porte being recognized by the payment of tribute, or "presents."

In the early part of the 19th century the regency was twice involved in war with the United States. In May 1801 the pasha demanded from the U.S. an increase in the tribute ($83,000) which the government had paid' since 1796 for the protection of its commerce from piracy. The demand was refused and a naval force was sent from the U.S. to blockade Tripoli. The war dragged on for four years, and the Americans in 1803 lost the frigate "Philadelphia," Capt. William Bainbridge and the whole crew being made prisoners. The expedition undertaken by William Eaton (*q.v.*) had the object of enthroning an exiled pasha, elder brother of the reigning sovereign, who had promised to accede to all the wishes of the United States. Eaton, at the head of a motley assembly of 500 men, marched across the desert from Alexandria and with the aid of U.S. ships took Derna. Soon afterward (June 3, 1805) peace was concluded, the reigning pasha relinquishing his demands but receiving $60,000 (about £12,000) as ransom for the "Philadelphia" prisoners. In 1815, in consequence of further outrages, Captains Bainbridge and Stephen Decatur again visited Tripoli with a squadron and forced the pasha to comply with the U.S. demands.

In 1835 the Turks took advantage of a civil war to reassert their direct authority. They administered the country as an ordinary vilayet (province) under a pasha. Turkish rule was marked by occasional, spasmodic and mainly ineffective efforts to develop the country. When in 1881 the French seized Tunisia the Turks were alarmed and greatly strengthened their garrison in Tripolitania. Disputes followed as to the extent of the Tripolitanian hinterland, which the French endeavoured to circumscribe. It was not only the French that the Turks had to fear: Italy had looked upon Tunisia as its heritage and, baulked in that direction, now fixed its eyes upon Tripolitania and Cyrenaica; and understandings were reached with other European powers interested. For another generation, however, the Turks remained undisturbed and under the impetus of the pan-Islamic movement penetrated farther south, a Turkish garrison even occupying the oasis of Bilma in 1910. Meanwhile Germany was making endeavours to secure economic and, as a result, political predominance in both Tripolitania and Cyrenaica. This led to action by Italy; war was declared upon Turkey in Nov. 1911 and both Tripolitania and Cyrenaica were declared to be under the full sovereignty of Italy. (For the war see ITALO-TURKISH WAR.) However, when the first treaty of Lausanne was signed in Oct. 1912 the Italians held only the coastal region and they met with considerable opposition from the natives (Berbers and Arabs) in their occupation of the interior. But by Aug. 1914 every place of importance in the vilayet, including Fezzan, was in Italian hands. Meanwhile in the coastal districts the Italians had with great energy begun a big program of public works, while toward the Arabs and Berbers they adopted a policy of confidence and trust.

In Cyrenaica the war continued, the Turks having incited the Senussites to continue the struggle. (See SENUSSI.) In Sept. 1914 the *Fezzani*, many of whom adhered to the Senussite sect, rose in revolt. Turkish, German and Senussi propaganda was very active throughout Tripolitania, and the declaration of war by Italy upon Austria (May 28, 1915) was the signal for a general rising. After some hesitation the Italians, in view of the situation in Europe, abandoned the whole country, with the exception of the seaports of Tripoli and Homs. Another seaport, Zuwara, was reoccupied in Aug. 1916. Meanwhile a brother of the Senussi chief ruled in Fezzan; Sulaiman al-Baruni, a Berber chieftain who had given much trouble in 1912–13, reappeared (Sept. 1916) with a firman from the sultan of Turkey appointing him governor general of the vilayets of Tripoli, Tunis and Algiers; and Ramadan ash-Shitaiwi, another powerful chieftain, established a so-called republic of Tripoli and ruled at Misurata, which place became a German submarine base. There was, however, little cohesion and much jealousy among the opponents of Italy.

A campaign under the direction of the governor, Count Giuseppe Volpi, during 1922–23 restored Italian authority as far east as Misurata. It was extended southward to the Hammada al-Hamra in 1924, eastward over the Sirte desert in 1928 and southward again over the Fezzan in 1929–30. In Jan. 1935 the French government under Pierre Laval ceded to Italy a strip of territory 700 mi. long and 40–90 mi. broad along the northern margin of the Tibesti massif. On Jan. 1, 1934, Tripolitania and Cyrenaica had been united to form the colony of Libya, and this was incorporated into the metropolitan kingdom of Italy on Jan. 9, 1939.

The Italian population of Tripolitania rose from 18,000 in 1921 to 90,000 in 1940, nearly half of these living in the capital while large agricultural colonies were settled in the comparatively fertile coastal area.

With the expulsion of the axis forces from North Africa in the spring of 1943, Tripolitania came under British military administration with local Arab and Italian councils, while the southern Fezzan oases had been occupied by the Free French and remained under French administration. The political situation was more complex than in Cyrenaica because of the large Italian minority and also because the Moslem population was less united in its views, since only a minority of Tripolitanian Moslems belonged to the Senussite sect. However, on Nov. 21, 1949, the United Nations general assembly decided that Tripolitania should form part of an independent and sovereign state of Libya. Accordingly, the British and French, who had progressively transferred authority to the embryo state, completed the transfer on Dec. 24, 1951, when the emir Mohammed Idris el-Mahdi es-Senussi became King Idris I of Libya. (See LIBYA.)

See Gordon Casserly, *Tripolitania* (London, 1943); Lord Rennell of Rodd, *British Military Administration in Africa, 1941–47* (London, 1948). (F. R. C.; G. E. K.)

Economic Conditions. — Agriculture occupies at least 80% of the population, but, because of severe environmental limitations, production is low. It is estimated that only 11% of the land is potentially productive. Four-fifths of this productive land is fit only for grazing, and of the remaining fifth only 960,000 ac. are used for static agriculture, 3,950,000 ac. being partly unused, partly occupied by shifting agriculture. Barley is the chief crop, being best suited to the severe conditions (average annual production under British administration, 66,000 metric tons), and there is some wheat (7,000 tons annually) and millet. There are 3,500,000 olive trees (yielding 9,000 tons of oil in 1951), of which 2,500,000 were planted by the Italians. Dates are important, forming a staple food in the southern oases, but quality is much inferior to that of Tunisian dates. There would seem to be about 1,500,000 palms in the north and as many as 10,000,000 in the Fezzan, giving an annual production of at least 30,000 metric tons. The Italians planted 300,000 citrus trees, and 50% more were planted after 1945; quality is high, and the export of oranges and tangerines had met with some success by the end of 1951. Other crops are almonds (1,800,000 trees and 2,000 tons in 1951), figs, peaches, apricots, peanuts, castor beans, henna, tobacco, vegetables and vines. There were 20,000,000 vines (mostly Italian-owned) in 1951, yielding more than 660,000 gal. of wine annually. Animal husbandry is of great importance, and in 1950 livestock numbers were: sheep 305,000, goats 314,000, camels 63,000, donkeys 33,000, cattle 31,000, horses 5,400. Industrial activities are small, many being carried on as local crafts. . The main activity consists in the processing of agricultural and fishing products; olive- and castor-oil pressing, the canning of tunny and sardines, brewing and macaroni making. Textiles are mainly produced at home, but there are a few carpet and weaving factories in Tripoli and Misurata. Other activities are the collection of esparto grass, which grows wild in the Jabal and Jefara (18,000 tons in 1950; value £220,000), and fishing for tunny, sardines and sponges (2,500 tons of fish and 25 tons of sponges in 1950). Total exports in 1950 amounted to £2,300,000; imports to £4,600,000. An annual budgetary deficit was met by grants-in-aid from the British government during the period of British administration.

Development under the Italians.—The Fascist government (see *History,* above) spent about £20,000,000 in developing Tripolitanian agriculture. Two main types of farming grew up: concessions, which were moderately large farms financed by private firms; and demographic settlements organized on a communal basis. The concessions were a kind of small plantation, employing much Arab labour; the communal settlements were planned and subsidized by the state, and occupants (Italian immigrants) worked first as semilabourers and then as part owners and were finally to become full owners (after about 20 years) on liquidation of debt charges. No Arabs were employed. In 1949 there were still 7,400 Italians living in private concessions (covering an area of 314,000 ac.) and 11,000 in public settlements (240,000 ac.). Thus 60% of the land under static farming was in Italian hands when Tripolitania was incorporated into the predominantly Arab-Berber kingdom of Libya. The concessions were approximately self-supporting, but the settlements had depended on state subsidies.

Railways comprise 122 mi. of narrow-gauge line centred on Tripoli.

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TRIPOLITSA, officially TRIPOLIS, a town of Greece, capital of the nomarchy of Arcadia, 22 mi. S.W. of Argos. The name refers to the three ancient cities of Mantineia, Pallantium and Tegea, of which Tripolitsa is the modern representative. It does not stand on any ancient site. Before the War of Independence it was the capita1 of the Morea and the seat of a pasha, with about 20,000 inhabitants; but in 1821 it was sacked by the insurgents, and in 1825 its ruin was completed by Ibrahim Pasha. The town was later rebuilt; German troops captured it in April 1941. Pop. (1951 census) 17,585.

TRIPOLYE (KOMSOMOLYE), a town of the Ukrainian Soviet Socialist Republic, U.S.S.R., on the Dnieper river, 35 mi. south of Kiev, with which it has steamer communication. It is famous for its painted pottery of late Neolithic date; its site and others near by were explored by Chwojka and the name

Tripolye was given to the culture there represented. This highly developed civilization probably dates from about 2750 B.C. Two types of pottery have been discovered, Tripolye A, the grooved type, being the more common. Tripolye B, or painted pottery, is thought to be an imported product and both are considered to be contemporary. Tripolye is mentioned in 1093 and later was inhabited by refugees from Kiev, after the capture of that city by the Mongols. In the 17th century Tripolye was a fortress, and the remains of its walls still stand, as do two old churches built in the Ukrainian style. During the 1917–20 civil war it was the headquarters of the bandit chief Zeleny, who drowned 100 victims in the Dnieper. A battle ensued between the Communist Youth party (Komsomol) and the bandits and the town was renamed Komsomolye in memory of the Communist victims.

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TRIPTOLEMUS, an agricultural hero of Eleusis, first priest of Demeter, and founder of the Eleusinian mysteries. His name is of doubtful meaning ("he who ploughs or toils thrice"; *i.e.,* diligently?); in some legends he is the inventor of the plough. In the best known legend (Apollodorus, i) Triptolemus was the son of Celeus, king of Eleusis, and Metaneira. Demeter, during her search for her daughter Persephone, arrived at Eleusis in the form of an old woman. There she was hospitably received by Celeus, and out of gratitude would have made his son Demophon immortal by anointing him with ambrosia and destroying his mortal parts by fire; but Metaneira, happening to see what was going on, screamed out and disturbed the goddess. Demophon was burnt to death, and Demeter, to console his parents, took upon herself the care of Triptolemus, instructed him in everything connected with agriculture, and presented him with a wonderful chariot, drawn by dragons, in which he travelled all over the world, spreading the knowledge of her gifts. In another account (Hyginus, *Fab.* 147) Triptolemus is the son of Eleusinus, and takes the place of Demophon in the above narrative, but does not die. In the Homeric hymn to Demeter, Triptolemus is simply one of the nobles of Eleusis, who was instructed by the goddess in her rites and ceremonies. The Attic legend represented him as one of the judges of the underworld. He is often represented in art, and formed the subject of a play (now lost) of Sophocles. His altar and threshing floor were shown on the Rarian plain near Eleusis; hence he is sometimes called the son of Rarus.

See Preller-Robert, p. 767, vol. i, and the classical dictionaries.

TRIPTYCH: *see* ALTARPIECE.

TRIPURA, a constituent state of the republic of India, adjoining the East Pakistan district of Tippera. Area, 4,036 sq.mi.; pop. (1961) 1,141,492. Tripura comprises six parallel ranges of hills running from north to south, at an average distance of 12 mi. apart. The hills, of which the highest is 3,200 ft above sea level, are covered for the most part with forest and bamboo jungle, while the low ground abounds with trees of various kinds, canebrakes and swamps. The forests shelter wild elephants, bison, tigers, leopards and deer. The principal crop and food staple is rice. Half the population consists of Tiparas, a tribe of Mongolian origin. The capital is Agartala (pop., 1951, 42,595), where there is a college affiliated to Calcutta university.

Tripura represents the remnant of an ancient kingdom which at various times extended in the north to Kamrup and in the east to Arakan. Ralph Fitch, who travelled through the country in 1585, noted that "the king of Tippara had almost continual wars with the Arakanese." The country now included in the Tippera district of East Pakistan was conquered by the Moguls and annexed in 1733, but Tripura still remained under its own line of rulers. When the East India company obtained the ***diwani*** or financial administration of Bengal in 1765 they placed a rajah on the throne and, after 1808, each successive ruler received investiture from the British government. After the state's accession to India a chief commissioner's administration was established on Oct. 15, 1949. This led to serious disturbance for, although the maharaja's rule had been autocratic, the new administration was regarded as an attempt of non-Tripuris to dominate.

TRISECTRIX: *see* CURVES, SPECIAL.

TRISTAN or TRISTRAM, one of the most famous heroes of mediaeval romance. In one of the earlier versions of his story he is the son of Rivalîn, a prince of northwest Britain, and Blancheflor, sister of King Mark of Cornwall. Rivalîn is killed in battle and Blancheflor dies after giving birth to a son. The boy is brought up as his own by Roald or Rual, seneschal of the kingdom, who has him carefully trained in all chivalric and courtly arts. With the possible exception of Horn, Tristan is by far the most accomplished hero in the whole range of knightly romance; a finished musician, linguist and chess player, no one can rival him in more knightly arts, in horsemanship or fencing. He has, besides, the whole science of *vénerie* at his fingertips. Being kidnapped by pirates, Tristan is carried to Cornwall where he finds his way to the court of his uncle, King Mark, who is at first unaware of his identity but, on learning it, joyfully accepts him as nephew and heir. The Tristan romance proper begins at this point, and the following incidents are common to most of the early versions: Tristan defeats the Irish giant, Morholt, who comes to claim the tribute payable every third year by Cornwall, but is desperately wounded in the encounter. Set adrift in a boat, Tristan is carried by the waves to Ireland, where he is healed by the queen, sister to Morholt. Later on he returns to ask the hand of the princess Iseult for his uncle, King Mark, and, having slain a dragon which is devastating the country, succeeds in his quest. On the homeward journey Tristan and Iseult, by misadventure, drink of the love potion prepared by the queen for her daughter and King Mark. Henceforward the two are bound to each other by an imperishable love which dares all dangers and makes light of hardships, but does not destroy their sense of loyalty to the king. The greater part of the romance is occupied by plot and counterplot; Mark and the courtiers seeking to entrap the lovers, who escape the snares laid for them until finally the two are discovered under circumstances which admit of no evasion, and Tristan is obliged to flee to Brittany. There he weds Iseult of the White Hand, daughter of the duke, "for her name and her beauty," but makes her his wife only in name. Wounded by a poisoned weapon he sends to Iseult of Ireland to come and heal him. If she accedes to his request the ship on which she embarks is to have a white sail, if she refuses, a black. Actuated by jealousy, his wife, who has discovered his secret, seeing the ship approach on which Iseult is hastening to her lover's aid, tells him that it carries a black sail. Tristan, turning his face to the wall, dies, and Iseult, arriving too late to save her lover, yields up her life in a final embrace. A miracle follows their deaths: two trees grow out of their graves and intertwine their branches so that they can in no wise be sundered.

The legend of Tristan and Iseult was one of the most popular themes of mediaeval romance; it was translated into many tongues, and the episodes are preserved in miniatures, carvings and embroideries. The earliest form of the story is still a matter of debate. The name of Iseult's father, Gormond, is certainly Scandinavian, and she herself is noted for her golden hair; she may be a northern, not a Celtic, princess. The name of Tristan, on the other hand, has been referred to the Pictish Drustan, and some elements in the story are now generally admitted to be of insular origin. Since the publication of Joseph Bédier's epoch-making study it is more generally believed that there was but one poem at the root of all the varying versions of the Tristan story, and that that work, composed in the 12th century by an unknown French poet, was of such force that it determined for all time the form of the tradition. One of the adaptations of that archetype is a poem composed late in the 12th century by an Anglo-Norman named Thomas, which was translated into German, English and Old Norse. Only fragments now remain, but they are sufficient to show that the original was a work of outstanding merit. The German translation, by Gottfried von Strassburg, which seems to have followed the original closely, is one of the classics of the middle ages. But the most authentic adaptations of the archetype are those produced late in the 12th century by the Norman poet, Béroul, and the German poet. Eilhart von Oberge. Of the former only about one-third or less is extant. There also exists in two manuscripts a short poem, *La Folie Tristan,* relating how Tristan, disguised as a fool, visits the court of King Mark. This poem is valuable, as, relying upon the sufficiency of his disguise, Tristan audaciously gives a résumé of his feats and of his relations with Iseult, in this agreeing with the earliest versions. The "Gerbert" continuation of the *Perceval* contains the working over of a short *Tristan* poem, called by him the *Luite Tristan;* the latter part, probably a distinct poem, shows Tristan, in the disguise of a minstrel, visiting the court of Mark.

Finally, in consequence of the popularity of the cyclic version of the Arthurian romances, the original *Tristan* story was worked over in prose on the model of the prose *Lancelot,* and so served to swell the already unwieldy bulk of the romantic corpus. The original tragic beauty of the primitive story is here obscured by an interminable series of banal adventures. It was in this form that Thomas Malory knew it. Richard Wagner, inspired by the text of Gottfried von Strassburg, restored the story to one of its earlier forms and enshrined it in imperishable music.

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(J. L. W.; E. VR.)

TRISTAN DA CUNHA, the group name for three small volcanic islands belonging to Great Britain, situated in the South Atlantic, approximately midway between South Africa and South America in latitude 37° 5' S., longitude 12" 16' W. The population of Tristan was evacuated in 1961 after a volcanic eruption; the other two islands, Inaccessible and Nightingale, are uninhabited as is Gough Island *(see* below) which is associated with the group.

Physical Geography.—Inaccessible, the westernmost island, is about 20 mi. from Tristan. It is quadrilateral, the sides being about 2 mi. long, with cliffs about 1,000 ft. high. Its highest point (2,260 ft.) is on the west. At the base of the cliffs in some places are narrow fringes of beach, but landing is possible only in small boats in favourable weather. The small flightless land rail *Atlantisia rogersi* is a bird peculiar to this island.

Nightingale, the smallest and southernmost island, is 10 mi. from Inaccessible and 25 mi. from Tristan. Its area is not more than 1 sq.mi. and its highest point 1,200 ft. Its coasts are marked by low cliffs and rocks and landing is made, under favourable conditions, by leaping onto a rocky platform as the swell raises the boat to its level. Millions of greater shearwaters, petrels and other sea birds nest on the island. Two small islets, Stoltenhoff (325 ft.) and Middle (150 ft.), and several rocks are adjacent to the coast.

The island of Tristan da Cunha, the largest and northernmost, has an area of 40 sq.mi. It is roughly circular, having a coast line of 21 mi. and a volcanic cone 16.760 ft.) which is frequently covered by clouds. Winds are generally strong and variable. The prevailing winds are westerly; cloud forms with northerly winds and clear skies accompany southerly winds. The climate is mild. temperatures averaging 68° F. in summer and 55° F. in winter. There is no frost and only rarely does hail or snow fall on lower ground. Rain, however, is frequent and humidity is high.

From a distance the island presents a bleak and barren appearance, but closer approach reveals that, though the sand and rocks on the beach are black, the 2,000-ft. cliffs, which on all sides except the northwest rise sheer out of the sea, are green with many kinds of fern. grasses and the island tree *Phylica arborea.* Where the cliffsare bare, the colour of the different rocks—basalt, porphyritic basalt, augite-andesite. palagonite, volcanic tuff and ashes—enriches the austere grandeur. The island is surrounded by a broad belt of kelp beyond which visiting ships can anchor when there is sufficient lee. There is no harbour. Tides rise and fall 4 ft. and there is a westerly ocean drift. On the northwest an irregular plateau, rising from 100 to 200 ft. high and roughly half a mile wide and five miles long, is crossed by a stream and provides the only habitable site. A new volcanic cone formed at its eastern end in Oct. 1961.

History.—The islands were discovered in 1506 by the Portuguese admiral Tristão da Cunha. Attempts to form settlements were made by the Dutch in 1656 and by the East India company about 30 years later. Jonathan Lambert from Salem. Mass., settled there with two companions in 1810 but was drowned in a boat accident. In 1816 a British garrison was stationed on Tristan to prevent any attempt to rescue Napoleon from St. Helena. and the island group was formally annexed to Britain. Corporal William Glass, a Scotsman, was permitted to remain with his family when the garrison was withdrawn in 1817. They were joined by shipwrecked sailors, settlers of European extraction and women from St. Helena. By 1886 there were 97 inhabitants. During World War II a naval meteorological and radio station was established on Tristan which was commissioned as H.M.S. "Atlantic Isle"; after the war the station was taken over by the South African government. Following severe earth tremors, an eruption and lava flow on Oct. 9, 1961, threatened the settlement of Edinburgh. The inhabitants were evacuated on the following day in fishing craft to Nightingale, whence they were picked up by a liner and carried to England. The majority were resettled in the former Royal Air Force married quarters at Calshot. Hampshire. The total population at the date of evacuation was 295, of whom 264 were islanders; the latter spoke English with a Victorian cockney intonation, pronouncing w for *v*. The only settlement was the village of 60 houses on the north coast, called Edinburgh.

In 1938. Tristan, Inaccessible. Nightingale and Gough islands were made dependencies of St. Helena. In 1950 the colonial office appointed an administrator for Tristan, which had hitherto managed its own affairs with the occasional aid of a resident Anglican chaplain. A representative island council, with the headman and headwoman ex-officio members, advised the administrator, who was empowered to make bylaws.

The homes of the islanders faced the sea and resembled Scottish crofts. They were built of volcanic tuff and thatched with New Zealand flax. Wood or imported coal was used for fuel. Potatoes were grown on the plateau and some vegetables in the gardens. Apples grow wild on the east of the island.

Sea birds and their eggs and guano were collected from the other islands, and wool was carded. spun and knitted into the long white stockings worn by all of the former inhabitants. In 1949 a South African fishing company was permitted to establish an industry for catching. freezing and canning crawfish (rock lobsters) for export. In return the company was required to provide a doctor, nurse, agriculturalist, teacher and store; later these obligations were substituted by a levy on net profits. Public expenditure was further assisted by the revenue from post-office receipts and by grants from colonial development and welfare funds. Developments achieved or in progress before the evacuation included improvement of the limited pasturage, a piped water supply and a sewerage system. (X.)

Gough Island.—Gough Island or Gonçalo Alvarez lies in 40° 20' S., 9° 55' W. about 255 mi. S.S.E. of Tristan da Cunha. It is about 8 mi. long by 4 mi. broad and is of volcanic origin. The summit, Edinburgh peak (2,956 ft.), rises from a central plateau which is bordered by a series of deep valleys and craggy ridges. The island is bounded by coastal cliffs 200–1.500 ft. high, over which many streams cascade. Grassland and bog cover the uplands; the valleys are filled with dense scrub and the cliffs support tussock grasses. Several species of flowering plants and two land birds are found only on Gough; vast numbers of rock hopper penguins. petrels, and shearwaters breed there, as do three species of albatross. Fur seals are common and sea elephants occur.

Gonçalo Alvarez was found by Portuguese navigators about 1505 and rediscovered by a Captain Gough in 1731. With the Tristan group, it became a dependency of St. Helena in 1938. Sealers, castaways and scientific expeditions have visited it occasionally, and since 1949 the Tristan da Cunha Development company's ships have exploited the crawfish around Gough Island. In 1955–56 the island was studied by a scientific expedition whose base was thereafter used for a South African weather station.

(M. W. H.)

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TRITON, the Greek merman, demigod of the sea; he was the son of Poseidon and Amphitrite. According to Hesiod in his Theogony, Triton dwelt with his parents in a golden palace in the depths of the sea.

The story of the Argonauts places his home on the coast of Libya. When the "Argo" was driven ashore on the Lesser Syrtes the crew carried the vessel to Lake Tritonis, whence Triton, the local deity, guided them across to the Mediterranean. He was represented as human down to the waist, with the tail of a fish, but ancient artists portray other and more fantastic sea creatures as well.

ALINARI

ANTIQUE SCULPTURE OF TRITON ABDUCTING A NYMPH. IN THE VATICAN MUSEUM. ROME, ITALY

Triton's special attribute was a twisted seashell, on which he blew to calm or raise the waves. Various stories represent him as jealous or violent.

TRITUBERCULATA (PANTOTHERIA), a group of very small insect-eating mammals from the Jurassic rocks, characterized by the sharp-cusped lower molar teeth with a posterointernal heel (tuberculo-sectorial type).

Some of them, such as Amphitherium, are, perhaps. the ancestors of all modern mammals except the platypus and echidna (Monotremata; *q.v.*). See MAMMALIA; MULTITUBERCULATE; PALEONTOLOGY.

TRIUMPH, the highest honour bestowed in Rome upon a victorious general (Lat. triumphus). It was only granted on certain conditions, relaxed in special cases. Only those who held the office of dictator, consul, or praetor were entitled to the distinction; the war must have been brought to a definite conclusion, resulting in an extension of the boundaries of the state; the victory must have been gained over a foreign enemy. The power of granting a triumph rested with the senate. Special legislation was necessary to keep the general in possession of the *imperium* on his entry into the city. Without this, his command would expire and he would have no right to a triumph. He remained outside the city limits until the ordinance was passed; Lucullus on his return from Asia waited outside Rome three years.

The triumph, a solemn procession, starting from the Campus Martius, passed through the city to the Capitol. The streets were adorned with garlands, and the procession was greeted with shouts of *Io* triumphe. At its head were the magistrates and the senate, followed by trumpeters and then by the spoils (arms, standards, statues, etc., representations of battles, and of the towns, etc., of the conquered country). Next came the victims destined for sacrifice, especially white oxen with gilded horns. They were followed by the prisoners kept to grace the triumph.

The chariot of the victorious general (*triumphator*) was crowned with laurel and drawn by four horses. The general was attired like the Capitoline Jupiter in robes of purple and gold; in his right hand he held a laurel branch, in his left an ivory sceptre surmounted by an eagle. Above his head the golden crown of Jupiter was held by a slave, who reminded him in the midst of his glory that he was a mortal man. Last came the soldiers shouting *Io* triumphe.

On reaching the temple of Jupiter on the Capitol, the general placed the laurel branch on the lap of the image of the god, and offered the thank offerings. A feast of the magistrates and senate concluded the ceremony. Under the empire-only the emperors celebrated a triumph, because the generals commanded under the auspices of the emperors as lieutenants (*legati*); the only honour they received was the right of wearing the triumphal insignia (the robes of purple and gold and the wreath of bay leaves) on holidays.' The last triumph recorded is that of Diocletian (A.D. 302).

A naval triumph was sometimes allowed for victories at sea, the earliest being that celebrated by C. Duilius for his victory over the Carthaginians in 260 B.C.

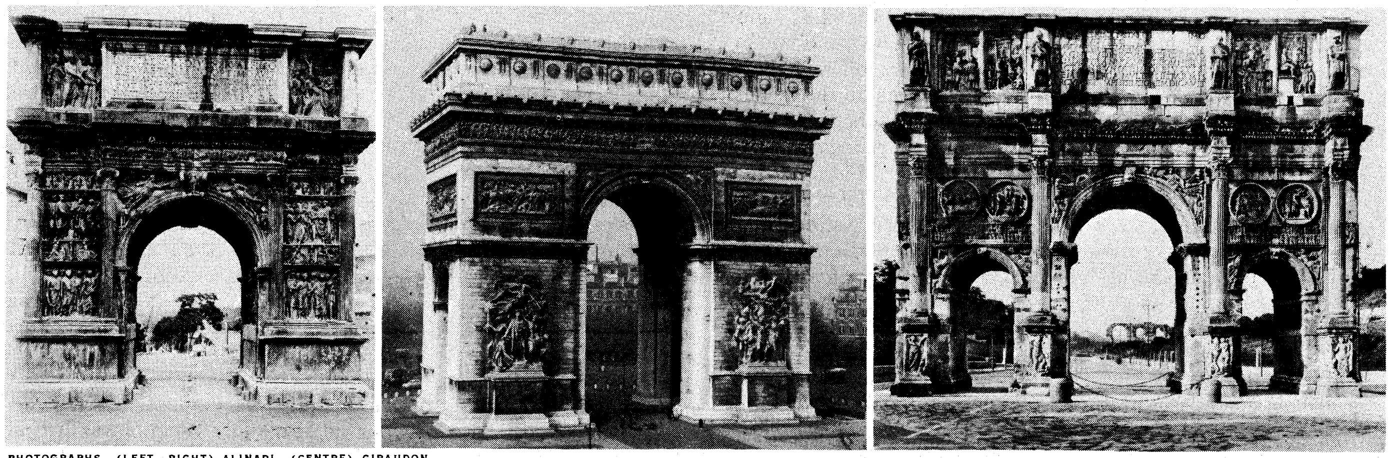
See Marquardt, *Romische Staatsverwaltung* (1884) ; Mommsen, *Ronzisches Staatsrecht* (1887) ; J. E. Sandys, *Companion to Latin Studies* (1921).

TRIUMPHAL ARCH is an arch that was built to commemorate the victory of a Roman general; in a broader sense, any monumental arch built for purely commemorative or even decorative purposes. The term is also used for the great arch between the nave and the apse of an early Christian basilica (*q.v.*) although this arch is an integral part of the interior structure of the church and has no resemblance with the Roman triumphal arch.

The origin and significance of this typically Roman form of monument is much debated. It was a separate structure, with no connection with city gates or city walls, and should not be confused with the Porta Triumphalis through which the victorious Roman army had to pass before entering the sacred city territory (*pomerium*) of Rome. Its basic form consisted of two piers connected by an arch and crowned by a superstructure, *attica,* that served as a base for statues. The arch was usually placed over a street; in Rome, preferably over a street used by the triumphal processions. The attica carried a commemorative inscription. The statuary at first usually represented the victor in his triumphal chariot; later, only the emperor was depicted. The function of the arch therefore seems to have been that of an honorary monument of unusual importance; it was so interpreted by the only ancient author who discussed it, Pliny the Elder (c. A.D. 70).

By the age of Augustus, it sometimes took the form of a triple arch with the central passage somewhat higher than the flanking ones. Few triumphal arches of the time of the republic are known. In Rome three were erected: the first, in 196 B.C. by L. Stertinius; the second by Scipio Africanus on the Capitoline hill in 190 B.C.; and the third, the first in the Forum area. by Q. Fabius Allobrogicus in 121 B.C. All carried statuary, but little is known of their architectural form.

In Augustan times and during the imperial period the triumphal arch was very popular. Early in the 4th century A.D. there were



PHOTOGRAPHS, (LEFT, RIGHT) ALINARI, (CENTRE) GIRAUDON

TYPES OF THE TRIUMPHAL ARCH

(Left) Arch of Trajan, Benevento, 2nd century; (centre) Arc de Triomphe, Paris, early 19th century; (right) Arch of Constantine, Rome, 4th century

36 such monuments in Rome. The triumphal arch of imperial times was a very articulate monument. The façade was of marble, columns and ornamental cornices were added to the piers and *attica,* and the archway and sides were adorned with sculpture in relief referring to victories and other achievements of the emperor. In Rome three triumphal arches have survived: the Arch of Titus (completed after the emperor's death in A.D 81) with representations of his triumph over Jerusalem; the Arch of Septimius Severus (203–205) commemorating his victory over the Parthians; and the Arch of Constantine (312). The latter is a composite product, decorated with reused material from the times of Domitian, Trajan and Hadrian. Outstanding examples of arches outside Rome are. those of Augustus in Susa. Aosta, Rimini and Pola; those of Trajan in Ancona and Benevento; that of Marcus Aurelius in Tripoli, and that of Septimius Severus in Leptis Magna in north Africa. *(See* also ROMAN ARCHITECTURE.)

In Castelnuovo in Naples is a marble gateway called the triumphal arch of Alfonso I (1453–70); in its decoration it was inspired by its ancient forerunners. The 17th-century Porte St. Denis and Porte St. Martin and, above all, the Arc de Triomphe by Chalgrin (1836), all in Paris, are noteworthy. The Marble arch in London, designed by John Nash in 1828 for an entrance gate to Buckingham palace and later moved to its present position, was inspired by the Arch of Constantine; the Hyde Park Corner arch from the same year was of more independent design.

The Washington arch in New York city, built to commemorate the 100th anniversary of Washington's presidential inauguration (completed 1895), is exceptional for its balanced blend of modern and ancient stylistic features. *See* also MONUMENTS AND MEMORIALS. (EK. S.)

TRIVANDRUM, city and district of Kerala state, India. The city, 2 mi. from the sea, is the state capital; pop. (1951) 186,931. It is famous for an old temple, around which the city grew. It is the seat of Travancore university.

The DISTRICT OF TRIVANDRUM is the southernmost district of India. Area 847 sq mi.; pop. (1951) 1,327,812. The climate is damp, except in the south.

The produce is mainly paddy and coconut, with some tea, rubber and coffee. Deposits of monazite and ilmenite have been found in the sands. (S. GL.)

TRIVIUM, in medieval educational systems, the curriculum which included grammar, rhetoric and logic (Lat. for "crossroad." *i.e.,* where three roads meet, from *tres,* three, and *via,* road). The trivium and the quadrivium (arithmetic. music, geometry and astronomy) together made up the seven liberal arts.

TRNAVA, a town in Bratislava. Czech., on the Trnava river, was transferred from Hungary to Czechoslovakia by the treaty of Trianon, 1920. It is a market town for a rich agricultural region. Manufactures include sugar refining, starch, beer, shoes and, oldest of all, cloth; fertilizers are also prepared.

The population in 1950 was 26.078.

TRNOVO (TIRNOVO), a city and capital of a department in Bulgaria; 124 mi. E.N.E. of Sofia, on the Yantra river, on the Trans-Balkan railway, nhich joins the Sofia-Varna line at Gorna-Orehovitsa. 8 mi N. of Trnovo. Pop. (1956) 24,751.

The city is remarkably situated. The Yantra runs in a deep gorge, doubling first left. then right, round two promontories which stand like high fortresses. surrounded by water on three sides. The first of these, the Tsarevitsa, is connected with the rest of the town by a high causeway, in part a bridge; the other, the Trapesitsa, is entirely isolated. The inhabited town covers the two sides of the rooflike ridge which terminates in the Tsarevitsa.

On the latter are a ruined tower, known as Baldwin's tower, where the Frank emperor is supposed to have been imprisoned, and, behind it, the somewhat unimposing remains of the palace of the Asens (*q.v.*). Few of these ruins have been excavated. The Trapesitsa contains the fragments of several medieval churches in the Byzantine style.

Trnovo is believed to have been a Roman fortress; it was the birthplace of Tsar Sisman, and the home of the second Bulgar empire, proclaimed there in 1185 by the brothers Peter and Ivan Asen, who were boyars of the Tsarevitsa and Trapesitsa. It was capital of Bulgaria 1186–1394, when it was adorned with great splendour; most of the relics were destroyed in the earthquake of 1911. It was the seat of the Bulgarian patriarchate from 1232 to its abolition in 1767.

Trnovo was taken by the Turks on July 17, 1394. It remained, however, a commercial centre. It nas captured by Russia in 1877. Prince Alexander of Battenberg was there proclaimed Bulgarian prince (1879). There the Bulgarian constituent assembly sat and the independent kingdom of Bulgaria was proclaimed in the Church of the Forty Martyrs (Oct. 5, 1908) *(see* BULGARIA: *Hzstory).* (C. A. M.)

TROAD: *see* TROY AND TROAD.

TROCHEE (CHOREE), literally the "running" or "dancing" foot (– ⏑) (Gr. *Trechein,* "to run," and *Choros,* "a band of dancers"). Classical trochaic metre is of several kinds, usually described by the number of *metra,* or groups of two trochees, which they contain. In example, the dimeter:

Rōmă Rōmă, | cērnĕ quāntă
Cōmrădes, leave mĕ | hēre ă lĭttlĕ

consists of two *metra* or four trochees. The commonest form, especially in ancient drama, is the *tetrameter catalectic* or *septenarius* (four *metra* or eight trochees, lacking the final syllable), as

~om: ~om:,- | cērne quāntă | sīt dĕūm bĕn|īgnĭtās
Cōmrădes, leave mĕ | hēre ă lĭttlĕ, | while as yet 'tĭs | ēarly mŏrn.

Trochaic metre in English accentual verse, a stressed syllable followed by an unstressed, has an especially lilting. buoyant effect, but it is less flexible than the iambic. Completely regular trochaic verse is usually monotonous. as Longfellow's blank trochees in *Hiawatha* prove, or Tennyson's in "Locksley Hall."

It was not used extensively until the 19th century, but then with frequent iambic substitutions and omissions of the unstressed syllable at the end of the line, thus permitting masculine rhyme (*q.v.*).

See METRE; VERSE. (G. W. A.)

TROCHOPHORE (TROCHOSPHERE), the names applied to the free-swimming larval form of the segmented worms or Annelida (*q.v.*) and to the very similar (first) larval stage of the Lamellibranchia (bivalves) and Gastropoda (univalves) (*q.v.*) among the Mollusca (*q.v.*).

TROCHU, LOUIS JULES (1815–1896), French general, was born at Palais, Belle-Ile-en-Mer, on March 12, 181j. He served as a captain in Algeria and as a colonel throughout the Crimean campaign. He commanded a division in the Italian campaign of 1859.

In 1866 he was employed at the ministry of war in the preparation of army reorganization schemes, and he published anonymously in the following year *L'Armée française en 1867,* a work inspired with Orléanist sentiment! which brought him into bad odour at court. He left the war office on half pay, and was refused a command in the field at the outbreak of the Franco-German War.

After the earlier disasters in 1870, he was appointed by the emperor first commandant of the troops of Châlons camp, and soon afterward (Aug. 17) governor of Paris and commander in chief of all the forces destined for the defense of the capital, including about 120,000 regular troops, 80,000 mobiles and 330,000 national guards. He put Paris in a state of defense, and showed himself a master of the passive defensive. At the revolution of Sept. 4 he became president of the government of national defense. His "plan" for defending the city failed; the successive sorties were unsuccessful, and when capitulation became inevitable he resigned the governorship of Paris on Jan. 22, 1871, to General Vinoy, retaining the presidency of the government until after the armistice in February.

He was elected to the national assembly by eight departments, and sat for Morbihan. In July 1872 he retired from political life, and in 1873 from the army. He published in 1873 *Pour la vérité et pour la justice,* in justification of the government of national defense, and in 1879 *L'Armée française en 1879, par un officier en retraite.*

He died at Tours on Oct. 7, 1896.

TROELSTRA, PIETER JELLES (1860–1930), Dutch Socialist leader, was born at Leeuwarden and educated for the legal profession at the University of Groningen, but early abandoned it for politics and journalism. He adopted Socialist opinions and, becoming dissatisfied with the leadership of Domela Nieurenhuis, under whom Dutch Socialism had assumed an extremist complexion bordering on anarchism, he founded the Social Democratic Workers' party in 1894 for the constitutional achievement of Socialism.

In 1913, the Liberal party offered the Socialists three seats in a government which would include in its program universal suffrage and old-age pensions. This Troelstra refused, on the assumption that the entrance of the Socialists into the government would strengthen the opposition to universal suffrage. His point of view was approved by the conference of the party. At the elections of 1918, as a result of the introduction of universal suffrage. the Socialists scored important gains, and under the influence of the German revolution. Troelstra, in a remarkable speech in the chamber, called upon the government to resign with a view to the formation of a socialist state. The leading members of his party repudiated his tactics but pressure was brought to bear upon the government, which resulted in the eight-hour day and other reforms.

Thenceforward Troelstra's influence with the proletariat increased steadily, until in 1925, because of failing health. he retired from politics.

TROELTSCH, ERNST (1865–1923), German liberal Protestant theologian and historian, was born in Haunstetten near Augsburg on Feb. 17, 1365. From 1894 to 1914 he was professor of theology and from 1910 to 1914 also professor of philosophy at Heidelberg; from 1915 to 1923 he was professor of philosophy at Berlin. Troeltsch also served as undersecretary for Protestant affairs in the Prussian ministry of public worship and education (1919–21). He died at Berlin on Feb. 1, 1923.

The bulk of Troeltsch's writings were historical studies dealing with philosophy of religion, philosophy of history, Christian theology and social ethics, and with the broad periods and movements of western history. Two underlying philosophical concerns determined these and his other studies: the significance of the modern historical consciousness for understanding and evaluating western religion and culture, and the problem of relating the living power of historical Christianity to the needs growing out of the cultural situation and the religious unrest of his time. As a Neo-Kantian, and in opposition to the Marxists, he insisted, in the name of "the religious a priori," upon the independence of religion in its relation to and influence upon society; at the same time, as a sociologist of religion, he investigated the ways in which social factors have influenced the development of religion and its institutions. Under the influence of A. Ritschl he emphasized the decisive concern of Christianity with the enhancement of the human personality, the personality of Jesus being assumed as the unifying element in all forms of Christian faith. In contrast to Ritschl, however, he stressed the autonomous role of reason and intuition in religion and the sole right of historical method in theology; he demanded also a comparative study of the world's religions.

In his view of history Troeltsch, like W. Windelband and H. Rickert, stressed the differences between nature and history, viewing the latter in terms of individuality, unique development and (provisional) creative synthesis. Each religion, in his view, is closely bound up with its local culture. With a strong inclination to nominalism and relativism, he rejected the claim of any religion to absoluteness.

In his interpretation of the history of Christian social ethics Troeltsch gave prominent place to the various formulations of (ethical and legal) natural law theory. He severely criticized Luther and Lutheranism for the social conservatism issuing from a dualism between the church and the world and between Gospel and Law. Like Max Weber, he examined the relations between Calvinism and capitalism. He went beyond Weber in discriminating three types of Christian group in history—the church type, the sect type and the mystical type.

The Neo-Reformation theologians (*e.g.,* Karl Barth and Emil Brunner) have viewed Troeltsch as a major misinterpreter of Christian faith and of the Reformation. Among the philosophical theologians of existentialism, Paul Tillich and H. Richard Niebuhr in qualified ways have acknowledged special indebtedness to him, as did also the Roman Catholic theologian Friedrich von Hügel.

Many of Troeltsch's writings have been assembled in *Gesammelte Schriften,* 4 vol. (1912–25). The most influential of his books are *Die Absolutheit des Christentums und die Religionsgeschichte* (1902 and later ed.); *Die Bedeutung des Protestantismus für die Entstehung der modernen Welt* (1906 and later ed.; Eng. trans., *Protestantism and Progress,* 1912); *Die Soziallehren der christlichen Kirchen und Gruppen* (1912; Eng. trans., *The Social Teaching of the Christian Churches,* 1931); *Der Historismus und seine Probleme* (1922); and *Der Historismus und seine Überwindung* (1924; Eng. ed., *Christian Thought, Its History and Application,* 1923).

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TROGIR (TRAU), a seaport of Croatia, Yugos. Pop. (1953) 4,348. The town is built upon an island. The Venetian loggia is a fine specimen of a 16th-century court of justice; and the Hungarian Gothic cathedral, founded in 1200, was completed in 1450. Trau has some trade in fruit and wine, the fertile soil producing vines, figs, pomegranates and olives.

The chief industries are the weaving of *rascia,* a coarse blue serge, and metalwork.

Tragurium, by which name it was known to the Romans, was probably colonized about 380 B.C. by Syracusan Greeks from

Lissa, and its name is sometimes derived from τρώγιλος, a place near Syracuse. In 998 it submitted to Venice; but in 1105 it acknowledged the supremacy of Hungary, while retaining its municipal freedom, and receiving, in 1108, a charter which is quoted by Lucio. After being plundered by the Saracens in 1123, it was ruled for brief periods by Byzantium, Hungary and Venice. In 1242 the Tatars pursued Bela IV of Hungary to Trau, but were unable to storm the island city, which remained in the possession of Hungary till 1413. The Italians attempted to take possession of the town at the close of World War I, but were driven out by the inhabitants, 99% Slavs. After Germany's Balkan successes in World War II, Italy occupied the port (1941).

See T. G. Jackson, *Dalmatia, the Quarnero, and Istria* (Oxford. 1887); E. A. Freeman, *Sketches from the Subject and Neighbour Lands of Venice* (London, 1881); and G. Lucio, *Memorie istoriche in Tragurio, ora detto Trau* (Venice, 1673).

TROGLODYTES, "cave-dwellers," a name applied by ancient writers to different tribes in various parts of the world. Strabo speaks of them in Moesia, south of the Danube (vii. 318), in the Caucasus (xi. 506), but especially in various parts of Africa from Libya (xvii. 828) to the Red Sea. The troglodyte Ethiopians of Herodotus (iv. 183) in inner Africa, very swift of foot, living on lizards and creeping things, and with a speech like the screech of an owl, have been identified with the Tebus of Fezzan. According to Aristotle (*Hist. An* viii. 12) a dwarfish race of Troglodytes dwelt on the upper course of the Nile, who possessed horses and were in his opinion the Pygmies of fable. But the best known of these African cave-dwellers were the inhabitants of the "Troglodyte country" (Τρωγλοδυτική) on the coast of the Red Sea, as far north as the Greek port of Berenice, as recorded by Diodorus (iii. 31) and Photius (p. 454 Bekker) from Agatharchides of Cnidus, and by Artemidorus in Strabo (xvi. 776).

They were a pastoral people, living entirely on the flesh of their herds, or, in the season of fresh pasture, on mingled milk and blood. But they killed only old or sick cattle (as indeed they killed old men who could no longer follow the flock), and the butchers were called "unclean." They gave the name of parent to no man, but only to the cattle which provided their subsistence. They went almost naked; the women wore necklaces of shells as amulets. They practised circumcision or an operation of a more serious kind. The dead body, its neck and legs bound together with withies of the shrub called *paliurus,* was set up on a mound, and pelted with stones amidst the jeers of the onlookers, until its face was completely covered with them. A goat's horn was then placed above it, and the crowd dispersed with manifestations of joy.

TROGON, the name of birds forming the family Trogonidae. The trogons are birds of moderate size, the smallest hardly bigger than a thrush, the largest less bulky than a crow. The bill is wide at the gape, which is beset by recurved bristles. They seize most of their food on the wing. Their flight is short, rapid and spasmodic. Their feet are weak and of a unique structure, the second toe, which in most birds is the inner anterior one, being reverted; in all other birds that have two toes before and two behind, the outer toe is turned backward. The plumage is beautiful and characteristic, and the glory of the group culminates in the quezal (*q.v.*). The plumage is further remarkable for the absence of down and for the large size of its contour-feathers, which are extremely soft and so loosely seated as to come off in scores at a touch. The tail is a characteristic feature, the rectrices being often curiously squared at the tip. The nidification of these birds is in holes of trees, wherein are laid without any bedding two roundish eggs, generally white, but certainly in one species (quezal) tinted with bluish green.

The trogons form a very well-marked family of Coraciiform birds placed near the colies (*see* COLY) and swifts (*q.v.*). The remains of one have been found in the Miocene of France. This discovery seems to account for the remarkable distribution of the trogons at the present day. While they chiefly abound in the tropics of the New World, they occur too in the tropical parts of the Old. About sixty species are recognized, which J. Gould in the second edition of his *Monograph* of the family (1875) divides into seven genera.

TROGUS, GNAEUS POMBEIUS, Roman historian from the country of Vocontii in Gallia Narbonensis, nearly contemporary with Livy, flourished during the age of Augustus. The name Pompeius was adopted by his grandfather, who received the citizenship from Pompey. Trogus' books on natural history are frequently quoted by Pliny; his principal work, however, was *Historiae Philippicae* in 44 books, so called because the Macedonian empire founded by Philip is the central theme of the narrative. This was a general history of the world, or rather of those portions of it which came under the sway of Alexander and his successors. Of this great work, we possess only the epitome by Justin, the *prologi* or summaries of the 44 books, and fragments. But even in its present mutilated state it is often an important authority for the ancient history of the East. Ethnographical and geographical excursuses are a special feature of the work.

Fragments edit. by A. Bielowski (1853); *see* also, A. H. L. Heeren, *De Trogi P. fontibus et auctoritate* (prefixed to C. H. Frotscher's edition of Justin); A. Enmann on the authorities used by Trogus for Greek and Sicilian history (1880); A. von Gutschmid, *Dber die Fragmente des Pompeius Trogus* (1857); M. Schanz, *Geschichte der römischen Litteratur* (2nd ed., 1899), ii., where all that is known of Timagenes is given; and article JUSTIN.

TROILUS, in Greek legend, son of Priam (or Apollo) and Hecuba. In the *Iliad* (xxiv., 257) he is already slain before the action of the poem commences. According to a non-Homeric tradition (*e.g.,* Virgil *Aen.* i. 4743, when a mere boy he fell by the hand of Achilles. In another account he was dragged to death by his own horses. His death formed the subject. of a lost tragedy hy Sophocles.

The story of Troilus and Cressida (Caxton, Chaucer, Shakespeare, etc.) is entirely medieval.

TROIS-RIVIÈRES (THREE RIVERS), a city and port at the confluence of the St. Maurice and St. Lawrence rivers in Quebec, Can., 100 mi. from Montreal and 78 mi. from Quebec city. Founded in 1634 by order of Samuel de Champlain and named after the St. Maurice, which flows into the St. Lawrence by three channels or three rivers, it is one of the oldest settlements of Canada. In 1857 it was incorporated as a city. Ironwares were manufactured as early as the 17th century at the St. Maurice forges located several miles from the city. At the turn of the 20th century the development of cheap hydroelectric power on the St. Maurice and the availability of vast forest reserves of pulpwood in the immediate area occasioned a great industrial and commercial development. Trois-Rivikres is one of the largest newsprint-manufacturing centres in the world. Ironworks, textiles, clothing and electrical equipment are also manufactured. Trade is carried on in lumber, grain, asbestos and chemical products; its port handles an annual traffic of over 3,000,000 tons of commodities. Trois-Rivières is the commercial centre of an urban area comprising more than 135.000 inhabitants within a 25-mi. radius and including such cities as Shawinigan (*q.v.*), Grand'Mère and Cap de la hfadeleine. The city is the seat of a Roman Catholic bishopric and the county seat of St. Maurice. Ferryboats cross the St. Lawrence the year around, giving access to the south shore area. Pop. (1961) 53,477. More than 95% of the population is French Canadian.

(P. CA.)

TROITSKOSAVSK, a town of the Buryat Autonomous Soviet Socialist Republic, Russian Soviet Federated Socialist Republic. U.S.R.R., in 51° 28' N., 106" E., on the Kyakhta river near its junction with the navigable Selenga, which forms a waterway from Asiatic Russia to the Mongolian People's Republic. Two miles south of it is Kyakhta, on the frontier, which adjoins Maim''-Chen, a walled town with a large market place. and 10 mi. N., at the confluence of the Kyakhta and Selenga, is Ust-Kyakhta. It was formerly the great route by which Chinese tea entered Russia; and its December fair, when Russian leather, furs and wool were exchanged for tea. was very important.

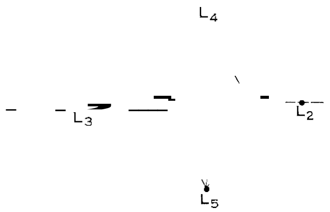
From 1689 to 1727 the trade was a government monopoly, but from then till 1860 trade was thrown open to private merchants, and as all trade across the Chinese border was by law compelled to pass through it, the town increased greatly in importance.

In 1860. however, the whole frontier was declared open, and Kyakhta declined; the Transbaikal railway further diminished its importance.

Gold and osmiridium are found in the district. The town was a storm centre in the post-1917 period, and nas the scene of the massacre of 800 Bolshevik prisoners in 1920 by order of the Cossack ataman Semyonov.

TROJAN PLANETS, a group of asteroids or minor planets, named for characters in Homer's *Iliad,* revolving around the sun in the same period as Jupiter. Achilles, the first member of the group, was discovered by Max Wolf in 1906, and subsequently the number of known members was increased to 13.

The orbit of Achilles was calculated by Adolf Berberich, who found that its period was almost exactly that of Jupiter Thereupon C. V. L. Charlier, noting that Achilles was about 55° in front of Jupiter, as seen from the sun, suggested that it was an example of one of the particular cases of planetary motion deduced by Joseph Louis Lagrange in 1772. Until 1906 these results had been of mathematical interest only.



SCHEMATIC REPRESENTATION OF GENERAL PROBLEM OF THREE CELESTIAL BODIES (*see* TEXT)

Lagrange's work dealt nith the general problem of three bodies, a simplified case being that in which the sun and Jupiter are the only bodies with sensible masses, the orbit of Jupiter being considered circular. The figure represents schematically a co-ordinate system rotating with Jupiter's period in which the sun, S, and Jupiter, J, will occupy fixed positions. A minor planet located in any of the three points L_1, L_2 or L_3 on the line joining S and J, or at either of the points L_4 or L_5, which form equilateral triangles with S and J, if started with an appropriate velocity. would then continue to occupy the same position relative to the sun and Jupiter. The straight line solutions are of little practical importance, honever, since slight disturbances would cause the minor planet to move away from the Lagrangian points. The greater practical significance of the equilateral solutions is due to the fact that these solutions are stable in the sense that small oscillations about these positions exist. The oscillations about the triangular points fall into two classes: (1) an oscillation, called the libration, nith a period of about 148 years for small amplitudes, increasing with the amplitude; (2) oscillations aith approximately the same period as that of Jupiter's revolution. about 11.86 years. Oscillations of this second type correspond to the eccentricity and inclination of the asteroid. In the case of Achilles these are approximately 0.15° and 11°, respectively.

Of the 13 known members, 8 asteroids—588 Achilles, 624 Hector. 659 Nestor, 911 Agamemnon, 1143 Odysseus, 1404 Ajax, 1437 Diomedes and 1583 Antilochus—are in the neighbourhood of the triangular point L_4, which is 60° ahead of Jupiter (greater longitude).

Five asteroids—617 Patroclus. 884 Priamus, 1172 Aeneas. 1173 Anchises and 1208 Troilus—are about 60° behind Jupiter.

As a group they belong among the fainter known asteroids. However, their faintness is due to the fact that they are much more distant than the typical asteroid located betneen Mars and Jupiter. The known Trojans undoubtedly rank among the larger asteroids. There are probably many smaller and even fainter members as yet undiscovered. The mathematical theory of the motions of the Trojans has attracted the interest of a number of astronomers and mathematicians, and sequences of possible orbits have been obtained under certain simplifying hypotheses. However, the limiting cases (*see* fig.) present great difficulties in analytical treatment.

No certain information exists concerning the possibility that the action of other planets may cause a Trojan to change into a non-Trojan or, conversely, change an orbit circling around the sun or Jupiter, or both, into a Trojan type.

(D. BR.; D. L. H.)

See also ASTEROIDS: *Statistics of the Asteroid Ring.*

TROJAN WAR: *see* TROY AND TROAD.

TROLLE, HERLUF (1516–1565), Danish naval hero, was born on Jan. 14, 1516, at Lillö. At the age of nineteen Trolle went to *Vor Frue Skole* at Copenhagen, subsequently completing his studies at Wittenberg, where he adopted the views of Melanchthon, with whom he was in intimate correspondence for some years. His marriage with Brigitte, the daughter of Lord Treasurer Mogens Gjoe, brought him a rich inheritance, and in 1557 he took his seat in the senate. Both Christian III. and Frederick II. had a very high opinion of Trolle's trustworthiness and ability and employed him in various diplomatic missions. Trolle was, indeed, richly endowed by nature, and his handsome face and lively nature made him popular everywhere. His one enemy was his wife's nephew, Peder Oxe, the subsequently distinguished finance minister, whose narrow, grasping ways, especially as the two men were near neighbours, did not contribute towards family harmony. In 1559 Trolle was appointed admiral and inspector of the fleet, and in 1563 he superseded the aged Peder Skram as admiral in chief. On May 10 he put to sea with twenty-one ships of the line and five smaller vessels and, after uniting with a Liibeck squadron of six liners, encountered, off the isle of Öland, a superior Swedish fleet of thirty-eight ships under Jacob Bagge. Supported by two other Danish ships Trolle attacked the Swedish flagship "Makalös" (Matchless), then the largest flagship in northern waters, but was beaten off at nightfall. The fight was renewed at six o'clock the following morning, when the "Makalös" was again attacked and forced to surrender, but blew up immediately afterwards, no fewer than 300 Liibeck and Danish sailors perishing with her. The Swedish admiral was captured, and the remnant of the Swedish fleet took refuge at Stockholm. Despite the damage done to his own fleet and flagship "Fortuna" by this victory, Trolle, on Aug. 14, fought another but indecisive action with a second Swedish fleet under Klas Horn, and kept the sea till Oct. 13. Trolle spent the winter partly at his castle of Herlufsholm completing his long cherished plan of establishing a school for all classes, and partly at Copenhagen equipping a new fleet for the ensuing campaign. On June 1, 1565, he set sail with twenty-eight liners, which were reinforced off Femern by five Lubeck vessels. Klas Horn had put to sea still earlier with a superior fleet and the two admirals encountered off Fehmarn on June 4. The fight was severe but indecisive, and both commanders finally separated to repair their ships. Trolle was severely wounded in the thigh and shoulder, but he insisted on being the last to receive the surgeon's attention. He died of his wounds at Copenhagen on June 25.

TROLLHATTAN, a town of Sweden in the district (*län*) of Älvsborg, 45 mi. by rail N. by E. of Gothenburg. Pop. (1950) 24,157. It lies on the left (east) bank of the Gota at the point where that river descends 108 ft. in the course of nearly a mile by the famous falls of Trollhättan (six in number) and several rapids. The scenic setting of the falls is not striking, but the great volume of water, nearly 18,000 cu.ft. per second, makes the falls imposing. The narrowed river here surrounds several islands, on either side of one of which (Toppö) are the first falls of the series, Toppo and Tjuf. These are 42 ft. in height. The water-po er is used in rolling-mills, a cellulose factory and other works. The electric works supply power to Gothenburg and other Swedish towns. (*See* GÖTA.)

TROLLOPE, ANTHONY (1815–1882), English novelist, was born in London, April 24, 1815. He came of a family which engaged in literary pursuits. His father, THOMAS ANTHONY TROLLOPE (1774–183j) was a learned but unbusinesslike barrister, who spent much time on an *Encyclopedia Ecclesiastica* and gave up law for farming, with ruin as the result. His mother, FRANCES MILTON TROLLOPE (1780–1863) went with her husband to Cincinnati to retrieve their fortunes by running a fancy-goods shop, and coming back disappointed achieved notoriety and roused violent resentment by her caustic book, *Domestic Manners of the Americans* (1832). She aftenvards wrote some fifty novels and books of travel, and maintained the family by her literary earnings, her best novel being *The Vicar of Wrexhill* (1837) and *The Widow Barnaby* (1839), a fair second. (See *Frances Trollope, her Life and Literary Work,* 1895, by her daughter-in-law.) Her eldest son, THOMAS ADOLPHUS TROLLOPE (1810–92), was a popular writer of novels and miscellaneous works, largely on Italian subjects, his adopted home being in Florence. His second wife, FRANCES ELEANOR TROLLOPE, also a novelist, collaborated with him in *Homes and Haunts of Italian Poets* (1881).

Anthony, who was the third son, gave an unvarnished account of his unhappy youth in his *Autobiography* (which was edited by his son Henry M. Trollope in 1883), an extraordinarily candid book that had a disillusioning effect on too fervid admirers by giving away the secrets of his workshop. It probably caused the long eclipse of his fame, which has recently been followed by a striking renewal. During the family impecuniosity, he was a day-boy at Winchester and Harrow, and suffered pangs through his shabby and dirty appearance, and the unpopularity and general discouragement which were the result. He reached the verge of manhood almost as ignorant as if he had had no schooling at all, yet he tried to start in life by taking the post of classical usher in a private school in Brussels. But he received the offer of a clerkship in the General Post Office, London, and after a farcical pretence at an examination was appointed (1834). For the seven years of his service here, his salary was small, he was in debt, troubled with awkward love-affairs, and often in hot water with his superiors. Then he was transferred to Ireland (1841) as a surveyor's clerk, with a moderate salary but liberal allowances and the duties of a sort of travelling inspector. The change brought out a business capacity hitherto unsuspected. He enjoyed a comfortable income, he had time in spite of a busy life to indulge freely in hunting, he consorted with people of all classes and began to stock his memory for the long-cherished purpose of trying his hand at fiction, and in 1844 he married an English lady, Rose Heseltine, whom he had met in Ireland, and established himself in a house at Clonmel.

Trollope's first two novels, *The Macdermots of Ballycloran* (1847) and *The Kellys and the O'Kellys* (1848), failures though they proved, are examples of his thoroughness in making himself acquainted with a given sphere of life, as he was afterwards to do with clerical society, political life, and legal affairs, and also of his aptitude for developing a good story casually heard. The first is dark and pathetic, the second has many sparkling scenes; neither is the work of a Carleton or Banim, but both steer clear of the mere stage Irishman of Lever and Lover. Trollope persevered, but a historical novel, *La Vendée* (1850) deservedly fell flat.

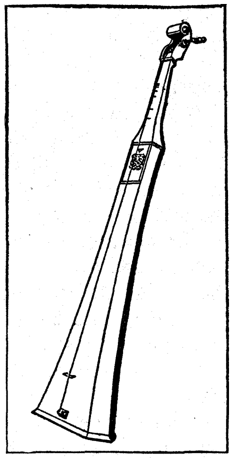
A chance visit to Salisbury Close gave him his idea for *The Warden* (1855), the simple, touching, but humorous story of a precentor in a cathedral town, who out of sensitiveness to public criticism resigns the well-paid office of warden to an ancient charity. Mr. Harding and his blustering son-in-law Archdeacon Grantly reappear, with other clerical dignitaries, their wives, families and friends, including the famous "Bishopess," Mrs. Proudie, the unctuous and pushful Mr. Slope, and the epicurean Dr. Stanhope and his disreputable children, in *Barchester Towers* (1857). The "Barsetshire Chronicles" were thus launched, bringing their author praise and, in due time, substantial profit. Trollope was now inspector of rural deliveries for the south-west of Ireland, with a roving commission that suited his tastes, scope for improvements on which he prided himself, and plenty of time for hunting. He is said to have been the inventor of the pillar-box. His ability and his experience of Post Office business led to his being sent on a mission to the West Indies (1858), which gave him material for a travel-book, *The West Indies and the Spanish Main* (1859). Other official journeys took him to Egypt (1858), the United States (1862), Australia and New Zealand (1871–72), and South Africa (1878), and resulted in further gossipy narratives and several tales. He got himself transferred to England (1859), taking charge of the eastern postal district and settling in a house at Waltham Cross. He retired from the Post Office (1867), out of annoyance at being passed over for promotion. Trollope was instrumental in starting the *Fortnightly Review* (1865), edited the *St. Paul's Magazine* (1868), rather disastrously, and was a contributor to *Cornhill, Blackwood* and other periodicals. He stood for Beverley (1868), but only acquired useful experience for future novels of political life.

All this time he was steadily writing fiction. The first of his books to bring him remuneration was *The Three Clerks* (1858), a poor novel of the Civil Service which sold for £250. But before long, he tells us in the *Autobiography*, he was earning on the average £4,500 a year, and in one instance he received £3,525 for a single book. An enormous output—for, besides more than fifty novels he wrote much else, and believed that no writer had made a larger contribution to letters in an equal space of time—was rendered possible by a methodical apportionment of the 24 hours. He rose regularly at 5.30 A.M., wrote steadily for two hours and a half, at the rate of 250 words every quarter of an hour, and thus calculated each book as so many days' work, which was carefully checked off as it proceeded. Yet he found leisure to hunt three times a week during the season, played whist daily, and had plenty of time for social enjoyments. He lived in London for about eight years (1872–80), and then removed to the village of Harting, under the Sussex Downs. He was staying in town when he died of paralysis, Dec. 6, 1882.

Trollope was a big, bluff, vociferous person, whose blustering and overbearing ways offended some, but whose John Bull philistinism did not conceal an essential honesty and good nature and a tender heart. He thought *Pride and Prejudice* the greatest novel in the language, and he idolized Thackeray; but he was as far from the exquisite art of the one writer as from the perfect mastery and irony of the other. With perhaps too much fidelity to the usual and commonplace, he depicted the great middle class as it was in mid-Victorian times. He was a "character-monger" of first-rate quality, who showed his personages moving in their own little spheres, and as he widened his circle of characters took in a larger sweep until he embraced almost as large and diversified a world as that surveyed by Thackeray. Among the characters that stand out, along with the two or three already mentioned, Mr. Crawley, the grimly pathetic hero of *The Last Chronicle of Barset,* the wicked but delightful Signora Neroni, Lucy Robarts, the best of many admirable heroines (unless Lady Glencora be preferred to that place), her husband, Mr. Plantagenet Palliser, afterwards Duke of Omnium, Lady Lufton, and that shrewd and downright person Miss Dunstable, with such different examples of the unattractive in life turned to artistic account as Mr. Sowerby and Mr. Chaffanbrass—these make a notable gallery and are only a selection from the catalogue. Other characters show uncertainty of touch and a failure of motivation. Trollope was best at a sort of coarse or at any rate very broad comedy, but he also had a command of real pathos. Tragedy was outside his scope. He revelled in mankind's idiosyncrasies, but shirked the closer scrutiny into the byways of conscience, just as he was shy of the spiritual questions which must, surely, have played some part in the lives of his clerical personages. George Eliot, his contemporary, would have dealt with Mr. Harding and Mr. Crawley in a totally different way.

Besides *The Warden* and *Barchester Towers,* the Barchester series comprises:—*Dr. Thorne* (1858), *Framley Parsonage* (1864), *The Small House at Allington* (1864), and *The Last Chronicle of Barset* (1867). The best of Trollope outside that series, besides such as are named above, are probably *Orley Farm* (1862), *Can You Forgive Her* (1864), *Phineas Finn* (1869) and its sequel *Phineas Redux* (1874), *The Claverings* (1867), *The Belton Estate* (1866), *He Knew He was Right* (1869), *The Vicar of Bullhampton* (1870), *The Eustace Diamonds* (1873), *The Way We Live Now* (1875), *The American Senator* (1877), *The Duke's Children* (1880), *Ayala's Angel* (1881) and *Mr. Scarborough's Family* (1883). Trollope's *Autobiography* was edited by his son (1883). The best biography is T. H. S. Escott's *Anthony Trollope, His Work, Associates and Literary Originals* (1913) which may be supplemented by Michael Sadleir's *Trollope, a Commentary* (1927), H. Walpole's *Trollope* ("English Men of Letters," 1928), Leslie Stephen's *Studies of a Biographer, IV.* (1902), Henry James's *Partial Portraits* (1888), and Professor Saintsbury's "Trollope Revisited" (*Essays and Studies by members of the English Association,* VI., 1920). (E. A. BA.)

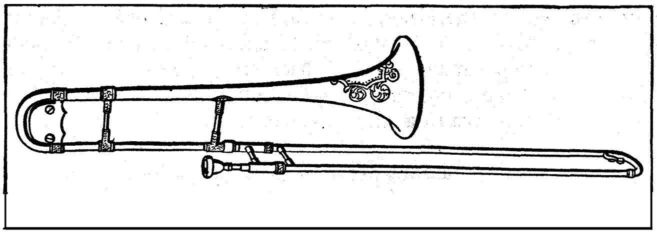
TROMBA MARINA or **MARINE TRUMPET,** an obsolete bowed instrument about 6ft. in length, with an outline somewhat recalling that of an elongated cricket bat. It consisted of a body and neck in the shape of a truncated cone resting on a triangular base. In the days of Michael Praetorius (1618), its length was 7ft. 3in. and the three sides at the base measured 7in., tapering to 2in. at the neck. These measurements varied considerably, as did also the shape of the body and the number of strings. The bridge had the curious feature that a portion of its foot was left loose so that it vibrated against the belly with every movement of the bow, producing a trumpet-like timbre. It is to this feature, in conjunction with its general resemblance in contour to the marine speaking-trumpet of the middle ages, that the name of the instrument is doubtless due, though other derivations have been suggested. In Germany, at the time when the trumpet was extensively used in the churches, nuns often substituted the tromba marina, whence the name *Nonnengeige.* The instrument, whose tone was not beautiful. fell into disuse during the first half of the 18th century.



FROM GALPIN, "OLD MUSICAL INSTRUMENTS"
THE TROMBA MARINA, AN OBSOLETE STRING INSTRUMENT

TROMBONE, an important member of the brass wind family of musical instruments formerly known as sackbut (*q.v.*). The trombone is characterized by the slide, consisting of two parallel cylindrical tubes, over which two other cylindrical tubes, communicating at their lower extremities by means of a short semicircular pipe, slips without loss of air. The outer tube, therefore, slides upon the inner, thereby altering the total length of tube and so modifying the pitch. When the slide is closed the instrument is at its highest pitch. To the upper end of one of the inner tubes is fastened the cup-shaped mouthpiece and to the end of the other tube is fixed the bell-joint, on the proper proportions of which depend the acoustic properties of the instrument.

Sound is produced on the trombone, as on the horn, by means of the lips stretched like a vibrating reed across the cup mouthpiece from rim to rim; the acoustic principles involved are the same for both instruments. By overblowing, *i.e.,* by the varying tension of the lips and pressure of breath, the harmonic series is obtained, which is effective between the second and the tenth harmonics, the fundamental being but rarely of practical use. There are seven positions of the slide on the trombone, each giving a theoretical fundamental tone and its upper partials a semitone lower than the last, and corresponding to the seven shifts on the violin and to the seven positions on valve instruments. These seven positions, which give a complete chromatic compass of two octaves and a sixth, are found by drawing out the slide a little more for each one.



BY COURTESY OF BOOSEY & CO., LONDON
THE TROMBONE, FORMERLY KNOWN AS THE SACKBUT, CHARACTERIZED BY ITS SLIDING TUBES

The quality of tone varies greatly in the different instruments and registers. The alto trombone has neither power nor richness of tone, but sounds hard and has a timbre between that of a trumpet and a French horn. The tenor and bass have a full rich quality suitable for heroic, majestic music. The contra-bass trombone, formerly little in request in the concert hall, is required for some modern orchestral music.

Besides the slide trombone, which is most largely used, there are the valve trombones, and the double-slide trombones. The former in which the slide is replaced by three pistons permit more brilliant execution than the slide instruments, but their tone is inferior. In the double-slide trombone the sliding branches are doubled and their length accordingly halved, thereby making the instrument more compact and lessening the length of the shifts, though demanding greater nicety in the adjustment of the slide.

The evolution of the trombone from the buccina is referred to in the article on the sackbut (*q.v.*), the name by which the earliest draw or slide trumpets, and subsequently the trombones, were known in England.

Of all wind instruments the trombone has perhaps been least modified in form; changes have occasionally been attempted, but for the most part with only trifling success. The application of ventils or pistons was made for the first time in 1818, in Germany, but instruments of this kind, though extensively used, have never superseded the original sliding type.

TROMP, the name of two famous Dutch admirals.

1. MARTIN HARPERTZOON TROMP (1597–1653) was born at Brielle, South Holland. At the age of eight he made a voyage to the East Indies in a merchantman. but was made prisoner and spent several years on board an English cruiser. On making his escape to Holland he entered the navy in 1624, and in 1637 was made lieutenant-admiral. In February 1639 he surprised, off the Flemish coast near Gravelines, a large Spanish fleet, which he completely destroyed, and in the following September he defeated the combined fleets of Spain and Portugal off the English coast—achievements which placed him in the first rank of Dutch naval commanders. On the outbreak of war with England Tromp appeared in the Downs in command of a large fleet and anchored off Dover. On the approach of Blake he weighed anchor and stood over towards France, but suddenly altered his course and bore down on the English fleet, which was much inferior to his in numbers. In the engagement which followed (May 19, 1652) he had rather the worst of it and drew off with the loss of two ships. In November he again appeared in command of eighty ships of war, and a convoy of 300 merchantmen, which he had undertaken to guard past the English coast. Blake resolved to attack him, and, the two fleets coming to close quarters near Dungeness on Nov. 30, the English, after severe losses, drew off in the darkness and anchored off Dover, retiring next day to the Downs, while Tromp anchored off Boulogne till the Dutch merchantmen had all passed beyond danger. The statement that he sailed up the Channel with a broom at his masthead in token of his ability to sweep the seas is probably mythical. In the following February (1653), while in charge of a large convoy of merchantmen, he maintained a running fight with the combined English fleets under Blake, Penn and Monk off Portland to the sands of Calais, and, though baffling to some extent the purposes of the English, had the worst of the encounter, losing nine ships of war and 30 or 40 merchantmen. On June 3, he fought an indecisive battle with the English fleet under Richard Dean in the Channel, but the arrival of reinforcements under Blake on the following day enabled the English to turn the scale against him and he retired to the Texel with the loss of seventeen ships. Greatly discouraged by the results of the battle, the Dutch sent commissioners to Cromwell to treat for peace, but the proposal was so coldly received that war was immediately renewed, Tromp again appearing in the Channel towards the end of July 1653. In the hotly contested conflict which followed with the English under Monk on the 29th Tromp was shot by a musket bullet through the heart. He was buried with great pomp at Delft, where there is a monument to his memory.

2. CORNELIUS VAN TROMP (1629–1691), the second son of the preceding, was born at Rotterdam on Sept. 9, 1629. At the age of 19 he commanded a small squadron charged to pursue the Barbary pirates. In 1652 and 1653 he served in Van Galen's fleet in the Mediterranean, and after the action with the English fleet off Leghorn on March 13, 1653, in which Van Galen was killed, Tromp was promoted to be rear-admiral. On July 13, 1665 his squadron was, by a hard stroke of ill-fortune, defeated by the English under the duke of York. In the following year Tromp served under De Ruyter, and on account of De Ruyter's complaints of his negligence in the action of Aug. 5, he was deprived of his command. He was, however, reinstated in 1673 by the stadtholder William, afterward king of England. and in the actions of June 7 and 14, against the allied fleets of England and France, manifested a skill

and bravery which completely justified his reappointment. In 1675 he visited England, where he was received with honour by King Charles II. In the following year he was named lieutenant-admiral of the United Provinces. He died at Amsterdam on May 29, 1691, shortly after he had been appointed to the command of a fleet against France. Like his father he was buried at Delft.

TRONDHEIM (TRONDHJEM), a city and seaport of Norway; chief town of the diocese of Trondheim and the county of Sør-Trøndelag, 384 mi. by rail N. of Oslo. Pop. (1950) 55,522. It lies on the Trondheim fiord on a peninsula between the fiord and the Nid river. The cathedral is the finest church in Norway, and the scene of coronation of the Norwegian kings Building was begun in the 11th century and continued through the 12th and 13th centuries. Repeatedly the church was burned, but as often restored. In the 20th century it was expanded and enriched with Vigeland sculptures. The port trades chiefly in timber. wood pulp, oil, fish and copper. In the town are shipbuilding, fish-curing, sawmills and machine works. Olaf Tryggvesson founded the town of Nidaros there in 996, building a church and a royal residence. (For a brief time from 1930 the town was renamed Nidaros.) It became an archbishopric (1182) and was the capital to 1380. It was an important pilgrimage centre, but suffered many sieges. Declining after the Reformation period, its commerce and population grew rapidly again in the 20th century, aided by new port facilities and the railway from Oslo (1921). The Norwegian Institute of Technology is there.

TROON, a small burgh of Ayrshire, Scot., on a spit of land on the coast of the Firth of Clyde, 30 mi. S.W. of Glasgow by road. Pop. (1951) 10,063. It is a popular holiday resort, with sandy beaches and extensive golf courses. Troon is also a coal port, and industries include shipbuilding, engineering and railway equipment repair work. Lady Isle, a bird sanctuary, lies about 4 mi. out at sea.

TROPAEOLACEAE, the nasturtium or tropaeolum family of plants, consisting of one genus, *Tropaeolum,* with about 65 species of mostly climbing or sprawling herbs. The often peltate leaves are simple but sometimes deeply lobed. The showy, spurred flowers have five sepals; five entire or lobed, often fringed, petals; eight stamens; and a three-celled ovary. The fruit separates into three one-seeded sections. Species of *Tropaeolum* are native from Mexico to southern Chile and Argentina, mostly in mountainous regions. Perhaps 20 species are knonn in cultivation, the most familiar being T *majus,* the garden nasturtium, and T. *peregrinum,* the canary-bird vine. The añu, T. *tuberosum,* is cultivated in Andean highlands for its edible tubers. See also NASTURTIUM.

(J. W. TT.)

TROPHY. In ancient Greece, a memorial of victory set up on the field of battle at the spot where the enemy had been routed. It consisted of captured arms and standards hung upon a tree (preferably an olive or an oak) and booty heaped up at its foot, dedicated to the god to whom the victory was attributed. In the case of a naval victory the trophy, composed of the beaks of ships, was set up on the nearest beach and consecrated to Poseidon The Romans showed a preference for setting up the memorials of victory in Rome rather than on the field of battle. In imperial times their place was taken by columns or triumphal arches. See ROMAN ARCHITECTURE; TRIUMPHAL ARCH.

TROPICAL AGRICULTURE. About one-quarter of the land surface of the earth lies between the Tropic of Cancer and the Tropic of Capricorn, and almost one-third of the world's population lives within this intertropical zone. In all intertropical countries most of the people are cultivators. Tropical agriculture may be taken to mean all the varieties of agriculture practised within the tropics, including animal husbandry. In many instances, seas and deserts so isolate the areas of cultivation in the intertropical zone from those in higher latitudes that there is little difficulty in distinguishing tropical agriculture from other kinds. In countries like Brazil, China and India, however, such sharp physical boundaries are absent, and it is less easy in these cases to say where tropical agriculture ceases and another sort begins. Many of the crops, as well as forms of organization and techniques, characteristic of tropical agriculture also occur widely in extra-tropical areas.

Tropical Environments.—The intertropical milieu offers, on the whole, uniquely favourable conditions for plant and animal life. The variety and luxuriance of plant growth in the tropics are paralleled nowhere else, and tropical animal life is similarly rich and populous. Climatic and soil conditions, however, limit the kinds of crops that can be grown in any area, and ecological factors seriously interfere with agriculture.

Agriculture in the intertropical zone is little hindered by temperature conditions because a suitable temperature can be found at some altitude for almost any crop known. In many tropical countries different altitudinal levels are recognized (tierra *fría, tierra templade* and tierra celiente in Latin America), to each of which corresponds a distinctive group of crops; temperatures in the higher (tierra *fría*) elevations often are suitable for standard northern European crops. Relatively little land in the tropics is high enough to be too cold for crops, although here and there are found glaciated mountains (e g., in New Guinea, east Africa and the Andes) and barren cold plateaus (upland Peru and Bolivia). Throughout most of the intertropical zone frosts are unknown.

Tropical temperature conditions are but slightly variable from one month to another; the range may be only a few degrees Fahrenheit during the year. Often the range of temperatures during a single day is greater than the difference between any two monthly means. This equable climate means a year-round growing season if sufficient water is present. For some crops, however, the absence of strong seasonal rhythms prolongs vegetative growth and defers, or even prevents, flowering, fruiting and other desired phases of the plant life cycle. The nearly uniform intensity of sunlight and the even length of the daylight period throughout the year affect plants similarly.

Rainfall in tropical areas is either continuous throughout the year or sharply interrupted for a period of some months. The total precipitation during the year usually is high, so that soils are heavily leached of minerals, leaving behind a dense clay of low nutrient value. Abundant rainfall and high temperatures favour bacterial decay, so that in lands of moderate elevation organic wastes are quickly decomposed and little humus accumulates in the soil.

Despite poor surface soils, where there is rain throughout the year a luxuriant vegetation may develop, composed of as many as five or six different stories of trees, the tallest of which may be over 300 ft. This rich tropical rain forest depends on deep roots to furnish it with minerals from the unleached lower layers of the soil. Where the moisture supply is interrupted for three or more months, the vegetation ranges from less dense forest of deciduous trees where the dry season is relatively short, through open woodland and spiny shrub, to impoverished short-grass steppe and ultimately to deserts where rainfall is rare or even altogether lacking in most years (as in coastal Peru, Somaliland and northwestern Mexico). The savannah soils of drier regions have impermeable hardpans that cause ponding of water on the surface in the wet season and deep fissuring and desiccation of the soil in the dry period.

The soils of mountainous areas in the tropics are also impoverished as a rule and are rapidly washed and eroded on the steeper slopes. As temperature decreases with elevation, total yearly precipitation and relative humidity of the atmosphere usually increase for some distance upslope. The higher lands are, therefore, usually characterized by cooler, wetter conditions than the lowlands. The vegetation of highlands with year-round rain grades off from the tropical rain forest, growing progressively lower and finally stunted at higher elevations, but remaining lush and dense. A fantastic dwarf forest with curious forms and aerial growths occurs at certain elevations where the slopes are constantly bathed by clouds. Where a marked dry season occurs, the forests tend to become richer with altitude, but are usually deciduous.

Land Use.—The luxuriance of the tropical rain forest is no assurance that agriculture can flourish where it grows. In all the great rain forest regions (the Amazon and Congo basins, the Guinea coast, Mozambique, Madagascar, the Caribbean, southeast Asia, Indonesia, New Guinea) agriculture has indeed invaded the primeval forest, but it has suffered considerable handicaps. Crop plants, except for a few tree crops like rubber, kapok, oil palm and cacao, are not equipped to reach down into the deeper layers of the soil for nutrients, and most crops do poorly after the first year on heavily leached rain forest soils; this is not a favourable environment for small annual plants. Furthermore, the forest is a great reservoir of animal and plant pests. Certain mild plant species especially adapted to colonize clearings become weeds in cultivated land. Harmful microorganisms flourishing under high temperatures and abundant moisture readily attack the struggling crop or unadapted domestic animal. Weeds, plant diseases and raiding animals are a constant menace to crops, and predators threaten domestic stock. Under these conditions, agriculture can succeed only when it is possible to invest heavily in control measures (as on plantations) or to move from deteriorated lands to new sites (shifting cultivation).

In the seasonally dry areas most of these same handicaps apply, but without the advantage of a year-round groning season. The moisture regime restricts agriculture mostly to the rainy months. Here, too, the soil is usually poor, and the hosts of pests are still present. It is often simply not found worthwhile to confront these difficulties for the meagre return that can be expected, and vast expanses of the drier areas are left uncultivated. For this reason much tropical land is used for cattle raising. Livestock, however. suffer greatly from pests and are sometimes unable to withstand them (*e.g.,* in the tsetse-fly areas of Africa). On the whole, livestock raising is economically inefficient on most tropical lands, except where high investment makes possible the use of improved breeding stock, artificial pastures, good fences and pest and disease control measures; even then there often is no suitable market for the product.

In higher altitudes. rainfall patterns and temperature usually are conducive to successful agriculture, but soil erosion is the frequent consequence of most farming practices. The areas suitable for agriculture in the highlands are very limited in total extent, and population often is crowded, resulting in overintensive use and ultimate ruin of the land.

Wherever conditions of soil. temperature and moisture are suitable for use under existing local practices, tropical lands are intensively exploited. Land well suited to cultivation is scarce, however, and much of the cultivated land is found in scattered mountain valleys (*e.g.,* in Mexico, the northern Andes, the south Asiatic mainland from Assam to Laos, interior New Guinea and Ethiopia). Elsewhere coastal lands are well tilled, against a solid backdrop of primitive forest (as in Caribbean Central America, the Malabar Coast, Mozambique and Borneo). Much of the agricultural population of the tropics, especially in Asia, inhabits alluvial lowlands and deltas (those of the Ganges-Brahmaputra in India and Pakistan, and the Irrawaddy, Chao Phraya [Nenam], Mekong and Red [Song-Coil rivers in southeast Asia).

Parts of the Amazon basin, central Africa and many of the islands of Indonesia and beyond are still occupied by wandering hunters and gatherers or isolated subsistence farmers. Most of the people of the tropics, however, are peasants, low in income, producing some or most of the goods they use, but also raising crops for market or working for wages. In most of tropical America, tropical Africa. upland southeast Asia and the more easterly islands of Indonesia and Oceania, the cultivators live in small villages or on isolated homesteads: in coastal south Asia and western Indonesia the population is densely concentrated in gardenlike lowlands where tillage and settlement are continuous.

Techniques. — Everywhere in the tropics permanent plantings of varied crops, often surrounded by fruit or shade trees. are maintained the year round. The garden usually is planted mostly from cuttings rather than seeds, and the plants are tended individually with hand tools. There is no single harvest, but food is available throughout the year. Such plants as bananas, ginger and other spices. gourds and yams are found as garden crops throughout the tropics.

In hilly tropical lands upland rice. corn (Indian corn or maize), millets, various kinds of beans and some root crops like taro, yam and sweet potato are groan in clearings made by cutting off all or most woody growth and burning the plot clean. Crops are planted and cared for with a simple digging stick or hoe and few other tools are used. This so-called shifting agriculture, using the slash-and-burn technique, seldom succeeds for more than a few years in one spot because of erosion, declining soil fertility and rapid increase of weeds and pests. This technique is widespread throughout the tropics. where it is known under several names (roy, *rastrojo, kaingining, ladang, tavy,* etc.); in the past it was also common in higher latitudes. (See AGRICULTURE, PRIMITIVE.)

Asian and Indonesian lowland peasants, as well as some Africans, employ the plow with domestic animal traction and raise seed crops on permanent farm plots. Heavy use of organic fertilizers and the skilled management of water supply, as well as intensive hand labour, characterize the very productive rice agriculture of the Asiatic tropics and the nearby far east. In Africa and the Americas. plow agriculture is commonly associated with market crops, and often with irrigation, but corn, millets, manioc, peanuts, beans, cotton and other field crops of these areas also are grown without the plow.

Tropical Crops. — In the tropical regions, supremely rich in species and long inhabited by man, many domestic plants have originated. Throughout the tropical American. African and Asiatic-Oceanian realms, two classes of crops occur, one reproduced from seed, the other vegetatively. Of the seed-grown tropical cereals, corn originated in the Americas, rice in Asia and various millets in Africa. Lesser cereal crops (amaranths. quinoa, Job's-tears and others), as well as distinctive kinds of beans and seed-propagated vegetables came out of each region (*e.g.,* from America, tomato, squash. pumpkin and chili pepper; from Africa, okra; and from Asia, cucumber). Examples of vegetatively propagated root or tuber crops are the arrowroot, yautia (Xanthosoma), sweet potato and manioc (cassava) from the lowlands of America and the potato, oca (*Oxalis*) and potatolike ulluco and arracacha from the American highlands; various yams from Africa; and taro, ginger and other yams from Asia and Oceania. In each region numerous fruit trees were developed — the guava, papaya and hog plum in South America, the mango. citrus fruit and breadfruit in Asia-Oceania, the karite (the shea-butter tree) and some annonas in Africa. There are domestic plants serving many other uses in each area (*e.g.,* cotton for textiles in Asia and America; drug plants like the South American coca, Asiatic betel and African kola; sources of beverages like Asiatic tea, African coffee, American cacao).

Plants like the banana, sugar cane and coconut, of Asiatic-Oceanian origin, spread to Africa and perhaps even to America before the period of European expansion. Others like the sweet potato and cotton may represent some sort of pre-Columbian borrowing betneen America and the old world. After 1500 there took place a wholesale exchange of domestic plants among tropical countries, and the lowland crop plants, of America and Asia especially, were spread everywhere through the tropics and well intermixed. Some tropical highland crops like the potato have become established in middle latitudes as well. In turn, some crop plants of higher latitudes invaded the tropics, but are confined chiefly to highland areas (*e.g.,* wheat).

The plantation system is old in the tropics. Spice plantations have long been characteristic of the Malabar Coast and Indonesia, and the early European colonies in the Caribbean and elsewhere developed great sugar plantations. Coffee, tea, rubber, cacao, oil palm, coconut, abaci, banana, vanilla, pineapple, sugar cane, pepper, cloves, cinnamon, ginger and many other spices, medicinals and insecticides, and textile, lumber, food and oil plants are grown on tropical plantations for the world market. Incorporating high investment capital and skilled management with choice but difficult environments and low-cost labour, the plantations occupy a relatively small total area in the tropics, but produce a large proportion of all tropical goods entering world commerce. (See also FRUIT FARMING; OIL PLANTS.)

Animal Husbandry. — Most species of domestic animals and practically all forms of animal husbandry occur somewhere in the tropics. The pig infests native settlements from Polynesia to the southern Sudan and Guinea — except where proscribed for religious reasons—and in the new world. In Melanesia, pigs are important in ritual. Everywhere the pig acts as a village scavenger, and its flesh is eaten. The animals are allowed to shift for themselves, but are sometimes fed on coconuts. garden crops and wild fruits. The sale of live pigs is an important source of cash income in many tropical countries. Pork products, however, are difficult to process and preserve in tropical climates.

Domestic fowl are common in settlements throughout the tropics, and in the new world turkeys are often kept. Fowl are allowed to forage for themselves, and sometimes are fed on fruit or grain. Live fowl and eggs constitute another chief source of cash for people and furnish a major part of the scant protein consumed by many in the tropics.

Goats are raised in many drier tropical areas for their meat, milk, hair and hides. Sheep are found at the higher elevations and in the arid lands of Arabia and Africa where nomads wander.

The horse is not common as a riding animal in the tropics, except in the Americas and in Moslem countries. Horses are rarely used for ploning in tropical lands. The ass is a common beast of burden in dry areas of Africa and the Americas.

Horned cattle and the closely related buffalo or carabao are the draft animals of tropical Asia, the Arab lands and America; draft animals are seldom used in Negro Africa. Cattle are kept for prestige by many peoples in Africa and Madagascar; some of these folk also subsist almost entirely on their products. Vast numbers of cattle are found in India. where they are venerated and their slaughter is forbidden by the dominant religion. Open-range cattle are vastly more numerous in the American and African tropics than those raised on improved pasture or fodder crops. In Asia, the buffalo is a village animal fed on garden products and plant refuse. Improved races of meat or dairy cattle are rare in tropical countries, and commercial meat production is sufficient only for local needs. Numerous diseases and parasites and periodic drought afflict the herds. Facilities for shipping animals and milk products are poorly developed, and packing and processing plants are few. Native animal husbandry is traditionally oriented and grossly undercapitalized for commercial production. *See* also BANANA, COFFEE, PINEAPPLE, etc.

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TROPICAL FISH, a term popularly applied to numerous small, brightly coloured fish kept in home aquariums. *See* AQUARIUM: *Aquariums in the Home*.

TROPICAL MEDICINE. The peoples of the tropics, numbering almost half the population of the world, made little cultural or material progress during centuries of colonial rule and extractive economy. After World War II, with the emergence of a score of self-governing nations, they entered upon a period of vigorous self-development, In this enterprise, tropical medicine assumed enormous importance, since the prevalence of disease was a barrier to development and, in the age of air transportation, a threat to the world.

Diseases of tropical climates reach their highest incidence and present the greatest problems where high temperatures and heavy rainfall prevail at all seasons. Such conditions favour the multiplication and longevity of man's enemies and competitors—rodents, insect species that transmit disease, parasitic worms with free-living stages in the soil, and infective organisms that pass part of their lives outside the body of the host. The tropics also are characterized by the prevalence of diseases spread by filth and overcrowding, insanitary habits and lack of sanitation—marks of a low socioeconomic status. In this they reveal the characteristics of the so-called underdeveloped regions: low standard of living, illiteracy, high incidence of disease and short life expectancy, an unending cycle of poverty, ignorance and disease. In fact, the economist's "underdeveloped areas" virtually coincide geographically with the tropics, suggesting a causal relationship between tropical environment and slow economic progress.

Certainly a combination of climatic and social factors has fastened upon the tropics such chronic and debilitating diseases as malaria, hookworm and yaws. which throughout history have undermined the physical, economic and social vitality of whole peoples. Life expectancy is an index of the economic burden of disease, and in many countries less than half the children reach the productive age of 15; these premature deaths have undoubtedly been one of the chief limiting factors on productivity.

History.—It was not until Louis Pasteur's revelation in the 1870s of the world of microorganisms that it was possible to identify the causal agents and understand the modes of transmission of infectious diseases. This was accomplished for most of the important tropical diseases in the following half century. Malaria presented the most serious problem and Alphonse Laveran's observation of the parasites of malaria in the blood of man (1880) was a signal event. Seventeen years later the mystery of its transmission was solved by Ronald Ross in India. Spurred by Sir Patrick Manson, whose observations in China had led him to suspect the transmission of tropical elephantiasis by mosquitoes, Ross in 1897 observed the human malaria parasite in *Anopheles* mosquitoes and in 1898 infected birds with malaria by the bites of *Culex* mosquitoes, a discovery completed by G. B. Grassi in Italy in transmission experiments on human beings. Walter Reed in Havana in 1900 demonstrated the mosquito transmission of yellow fever (*q.v.*), which led to its control by W. C. Gorgas in Panama beginning in 1904 and made possible the construction of the Panama canal. Within a few years the roles of the tsetse fly as vector of African sleeping sickness, the sand fly of kala azar, the tick of relapsing fever, the rat flea of plague, the body louse of typhus fever and the snail of schistosomiasis were all clarified. These and other discoveries opened the way to rational and scientific treatment, prevention and control of tropical disease. Tropical medicine had evolved from a clinical specialty in exotic diseases into a public health movement to protect and improve the health of native populations. The establishment of schools and research institutions accompanied this evolution. The London and Liverpool schools of tropical medicine were opened in 1899. followed by others in the colonial nations of Europe and in a score of tropical countries around the globe. The U.S. government supports tropical research laboratories in the National Institutes of Health and in Panamá. International collaboration in disease control, in the strengthening of health services and training of personnel has been invaluable, beginning with the International Health division of the Rockefeller foundation in 1914 and later offered by the World Health organization (WHO) and by the International Cooperation administration (ICA) of the U.S. government.

Biological and pharmaceutical laboratories contributed signally to the success of the efforts to bring tropical diseases under control, producing powerful new drugs without which it is conceivable that many projects would have failed or might not even have been attempted. The proposed eradication of malaria and smallpox and the co-ordinated attacks on yaws, syphilis and tuberculosis would not have been deemed possible without the antibiotics, synthetic drugs, vaccines and insecticides made available during and after World War II in a burst of technological achievement. Meanwhile, a handful of stubborn diseases remain uncontrolled, a stimulus to research: amoebic dysentery, the schistosomal, filarial and leptospiral worm infections, leprosy and the sleeping sickness of Africa.

Tropical Diseases.—The term tropical disease is accepted to mean any disease that is prevalent chiefly in the tropics, though not necessarily limited to those areas. Very few diseases are thus restricted, the only important ones being African sleeping sickness, filariasis of several types, yaws and yellow fever. The first two have not been effectively controlled with either drugs or insecticides. Yaws is spread by contact among crowded and dirty people, but it is rapidly cured by penicillin and its eradication by mass treatment is a major objective of countries where it occurs, aided by WHO and the United Nations Children's fund (UNICEF).

Yellow fever is limited to the tropics because its vector mosquitoes do not survive northern winters. In summer, ship-borne from the tropics, they once caused devastating epidemics in North America and Europe, but the species has been eradicated in all tropical ports and is on the road to extinction throughout the western hemisphere. The virus persists as jungle yellow fever in the monkeys of the American and African tropics, transmitted by forest mosquitoes. An effective vaccine exists to protect person's who may be exposed; the major hazard is that an infectious case may by plane reach the orient. where yellow fever is unknown but where the vector mosquito abounds.

Most of the diseases that flourish in the tropics were once widespread as well in the temperate zones, where they have been controlled or eradicated. For example, such pestilences as cholera, plague and smallpox no longer sweep the earth; they can persist only where water supplies are constahtly polluted, environmental sanitation is neglected and populations go unvaccinated. Such conditions now exist mainly in the tropics.

More important in their long-term effects on health and prosperity are six chronic diseases strongly entrenched in the tropics. Malaria, first in importance, a scourge of rural populations and a killer of children, can be eliminated from any stable community by insecticides and drugs. but over vast areas it is still the major health problem. Tuberculosis. when introduced in areas of tropical climate, runs through populations like an acute infection, but it too is susceptible of control with modern drugs and mass vaccination. Schistosomiasis, caused by a parasitic worm, afflicts millions of farmers. Larval forms of the worm, which infest irrigation water. require the snail as intermediate host. The disease is an unsolved problem since neither an effective drug nor a method of snail eradication is known. Hookworm disease, caused by an intestinal bloodsucking parasite, occurs everywhere in the wet tropics. It causes profound anemia and stunts the growth of children. It could be eradicated by preventing pollution of the soil with human feces, but this requires an educational effort continued over generations. Leprosy; almost eliminated in economically advanced countries, is prevalent in every part of the tropics where segregation of infected persons is impracticable. Continued treatment with the sulfone drugs arrests or retards most cases, but search for an even more effective drug continues. Finally, nutritional deficiencies are almost universal among tropical agricultural peoples. The cause is low food production resulting from climate. poor soils and farming methods. hookworm and malaria. conservatism or custom. Beriberi, pellagra and scurvy are only extreme forms of a general malnutrition (*q.v.*), but more important is kwashiorkor; highly fatal, after weaning, to children whose diet is grossly deficient in protein and protective substances. Several international agencies have attacked the problem in collaboration : WHO deals with the nature, prevalence and prevention of malnutrition; the Food and Agriculture organization (FAO) and UNICEF with the production, improvement and distribution of food; the Institute of Nutrition of Central America and Panama (INCAP) with research and education.

Control of disease, resulting in a greatly lowered death rate without a corresponding decrease in birth rate, raises a spectre of future calamity that has alarmed many persons. In spite of international aid and better distribution of food, living standards have actually fallen in many areas as a result of uninhibited population growth. In Ceylon, for example, control of malaria reduced the death rate by half and doubled the life expectancy, resulting in a rate of increase of the population that threatens to nullify the benefits obtained unless positive steps are taken to restrict fertility. A few believe. on the other hand, that scientific agriculture can produce the required food until urbanization, industrialization and "modernization" automatically, though gradually, bring birth rates and death rates into balance.

The **White Man** in the Tropics.—The health of the white dweller in the tropics, unlike that of persons native to those regions, depends on how fully his physiology can adapt to the unaccustomed heat, humidity and solar radiation and on his ecologic adjustment—his relations with the physical and biological world around him, including his fellow man. The newcomer relies on acclimatization, which is little understood, and on modification of his indoor environment by air conditioning, which he finds necessary partly because of his unwillingness to discard the usages and paraphernalia of his own culture—housing, clothes, food, ways of life—and adopt those appropriate to the climate.

His ecologic adjustment begins with an exchange of diseases; he falls victim to malaria, viral infections and dysentery, and gives to the native peoples tuberculosis, "children's diseases" and venereal infections. Whether the white man can carve a permanent niche for himself and retain his faculties and stamina over generations is still a moot question even after centuries of colonization. The answer awaits further experience under modern conditions and physiological research carried out in the tropical setting.

See also separate articles on diseases, as: BERIBERI; MALARIA; RELAPSING FEVER; etc. *See* also ENTOMOLOGY: *Medical* and *Veterinary Entomology;* PARASITIC DISEASES; PUBLIC HEALTH.

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(L. W. H.)

TROPICAL STORM. Severe cyclonic disturbances of the atmosphere in low latitudes are called tropical storms. In the western Atlantic they are known regionally as hurricanes and in the western Pacific as typhoons. It is the fury of the weather associated with tropical storms that distinguishes them from the many minor weather disturbances that more commonly produce periods of greater than normal rainfall in the tropics. They are, roughly. 50 to 500 mi. in diameter.

Description.—Tropical storms frequent the tropical oceans between latitudes of approximately 5° and 30° of both hemispheres. Their characteristics are not entirely uniform, but depend somewhat on age, size and latitude of the storms. They are cyclonic whirls. *(See* CYCLONE.) The winds near the centre form an almost circular vortex, with a slight inward motion toward the centre near the ocean surface.

As a result of the effect of the earth's rotation, the rotation of the vortex is clockwise in the southern hemisphere and counterclockwise in the northern.

A cyclonic whirl is called a hurricane or typhoon if the surface winds exceed 75 m.p.h. (Beaufort force 12). The area covered by such high winds may have a diameter of only 10 mi. when the storm is in its early stage. In fully grown storms the diameter is rarely less than 50 mi. and may attain 150 mi. The diameter of the entire area affected in some measure by a large storm may exceed 500 mi. Even the largest tropical storms, however. have an area which is less than the area covered by strong cyclones of middle and high latitudes.

An outline of the wind and weather distribution connected with a mature storm is given in fig. 1.

Winds.—While the areal extent of tropical cyclones is small compared with storms outside the tropics, the violence of the weather within the disturbed zone is usually far greater. This is the most spectacular feature of tropical storms. Sustained winds in excess of 100 m.p.h. are common near the centre, and winds as high as 200 m.p.h. have occurred. Since mature storms usually lie within the broad easterly trade winds, the distribution of the hurricane winds around the centre tends to be asymmetrical.

On the poleward side of the cyclones the trade winds reinforce the wind field produced by the disturbances themselves; on the equatorward side they counter this wind field. Thus. the high winds around centres located in the trades extend a far greater distance poleward than equatorward. In a mature storm of the northern hemisphere, for instance, hurricane winds may extend for only 30 to 40 mi. south of the centre but they will occur for twice that distance to the north.

Eye of the Storm.—Within the region of hurricane winds, the wind speed rises toward the innermost portion of the storm. Very close to the centre of mature cyclones, however, the winds drop abruptly from their extreme maximum to light breezes or even to complete calm. Clear skies or only thin clouds prevail. The central circular calm area bears the name "eye of the storm." The diameter of the eye is variable, but it is about 15 mi., on the average. Within the eye. the roar of the surrounding storm is often audible in the distance. Everyone who has passed from the outer ring of hurricane winds into the eye has commented on the sudden drop of the violence of the elements as a most remarkable experience. The eye figures prominently in many works of fiction. Outstanding among them is Joseph Conrad's Typhoon.

Pressure.—Coincident with the rise of wind speed from the, edge of the storm inward, the atmospheric pressure as measured by the barometer drops. Tropical storms are low-pressure centres, and the lowest sea-level pressures observed on earth occur in or near the eye of hurricanes. Up to 1957, the lowest official pressure on record was registered at Key West. Fla.. on Sept. 2. 1935, with a reading of 26.35 in. of mercury. This low pressure existed in a storm of small diameter, indicating that the intensity of a tropical storm does not depend on its areal extent. There are many other instances to substantiate this conclusion. The drop of the barometer can be exceedingly rapid as the winds increase to hurricane strength. and its rise after passage tends to be equally rapid.

Clouds and Ruinfall.—The interior of a tropical storm contains a great mass of cumulo-nimbus clouds (see CLOUD) from which heavy rain is falling. Only in the eye is there a lightening of the clouds; here many times the sky is even entirely clear. The distribution of the rainfall around the central core often is not symmetrical. As revealed by radar observations, the large clouds gather in a series of narrow bands, often only a few miles wide, that spiral cyclonically from the outside toward the centre. The length of a band may be 100 mi. and more; as many as ten bands may be encountered in a large storm. In a fully developed cyclone located in the trade-wind stream, the heaviest rain is concentrated on the poleward side, while on the equatorward margin the bad weather ceases just as quickly as the winds.

The amount of rainfall received on tropical islands and coastal areas of continents during the passage of a storm is dependent on the speed. size and intensity of the rain-producing centre and on the topography of the land. Several small storms in the stage of development have given less than five inches of rain over Puerto Rico in the West Indies. A great storm passing over the same island in 1928 produced 10 to 15 in. of rain near the coast and up to double that amount in the mountainous interior. Precipitation in excess of 20 in. in one day has occurred on several occasions along the southern coast of the United States and in various parts of the tropics. At Baguio in the Philippines 42 in. fell within 24 hours in 1911. For a general estimate, a rainfall of 10 to 1j in. should be expected during the passage of a fully developed cyclone over coastal regions.

Dangers to Flying.—The dangers caused by turbulence as well as other dangers to flying in and near tropical storms are not quite so prohibitive in most instances as was supposed prior to 1940. After 1944, military aircraft carried out regular reconnaissance flights in tropical cyclones at heights from 500 to 20,000 ft. Most missions succeeded in flying through and around the centres, spending at times several hours in the zone of very rough weather. Others have flown over hurricanes at great heights. It appears that most dangerous clouds can be topped at 40,000 ft.

Sequence of Events at Fixed Location.—Young, developing disturbances will give little or no advance indication of their arrival, except to the meteorologist who has wind measurements from the upper parts of the atmosphere at his disposal.

A mature cyclone is preceded by a distinct ocean swell with a frequency two to four times less than that of normal waves. In the Gulf of Mexico, for example, waves normally reach the shore about every four to five seconds. The presence of a hurricane may be suspected if they arrive only every 12 to 1j sec. and if the swell is correspondingly higher. At sea, moreover, the direction of the swell indicates the direction in which the storm is located, since the swell travels outward from the central area. It can precede the centre by 500 mi. and more. a great distance compared with the diameter of the hurricane winds.

The drop of the barometer often does not begin until 12 hr. before the arrival of the storm centre. Appearance of a sheet of cirrus clouds (see CLOUD). gradually thickening, frequently supplies an earlier warning. In addition. the inhabitants of the tropics often rely on other abnormalities of the local weather, such as brilliant red sunsets and winds from unusual directions, as precursory signs of a cyclone. Kone of these indications is entirely reliable, however, and may fail badly. On Sept. 13, 1945, a hurricane of great intensity was approaching the southeastern Bahamas. Nevertheless, the fishermen of South Caicos Island went out in their boats. They did not believe that there was a hurricane because the usual warning signs were missing. More than 50 of them drowned.

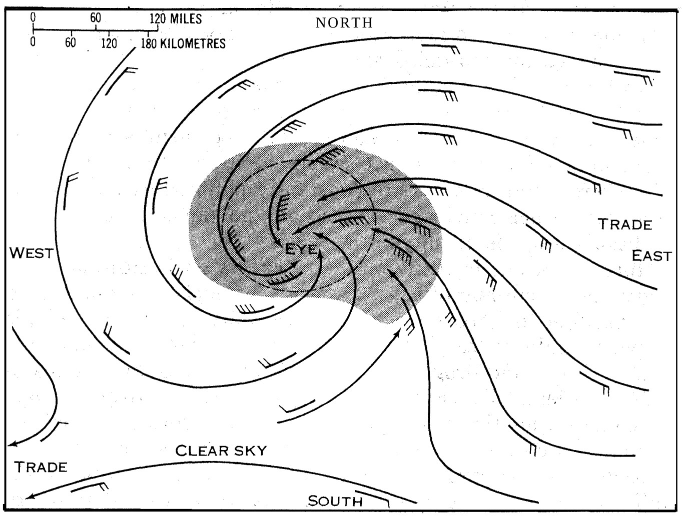

FIG. I.—DISTRIBUTION OF WIND AND WEATHER AROUND MATURE TROPICAL STORMS OF THE NORTHERN HEMISPHERE. MOVING WEST-NORTHWESTWARD IN THE TRADE WIND ZONE. STREAMLINES GIVE SURFACE WIND DIRECTION. WIND ARROWS FLY WITH THE WIND. EACH BARB REPRESENTS TWO BEAUFORT FORCES. DASHED LINE SURROUNDS AREA WITH WINDS HIGHER THAN BEAUFORT FORCE 12. SHADED AREA OUTLINES REGION OF HEAVY RAINFALL

The arrival of the storm area itself begins with a gradual picking up of the wind and increasing gustiness, followed by a thickening of low clouds in the sky and intermittent squally showers. Sometimes the main wall of cumulo-nimbus clouds can be seen approaching in the distance. It is called the bar of the storm.

When a storm is observed from a point that is not on the path of the centre itself, it will be noted that the hurricane winds gradually change direction. They will not let up materially, however, until the cyclone passes. Should the eye travel over the observation point, however, it will be noted that the winds drop from hurricane strength to light breezes within a few minutes. At the same time the rain ceases and the clouds lighten. After passage of the eye the winds and the precipitation resume with full force, but the winds come from the opposite direction.

The duration of the hurricane winds depends on the size of the storm and its rate of movement. If the high winds extend over 100 mi. and the storm moves 10 m.p.h., then the gales will last for ten hours If the cyclone advances at 15 m.p.h., the winds will last for less than seven hours. The same consideration applies to the eye. The central calm may remain for only a few minutes or stay for one to two hours.

Origin.—The development and maintenance of any vortex of the dimension of a tropical storm depend on the effect of the earth's rotation (see METEOROLOGY). As the component of this rotation is zero on the equator, tropical cyclones cannot develop in its immediate vicinity. Areas of strong squalliness and heavy rainfall appear near the equator, but few tropical storms have been observed between latitudes 5° N. and S. On the poleward margin of the tropics, conditions favourable for the development of tropical cyclones occasionally exist even beyond latitude 30°. Formation between latitudes 20° and 30° is fairly common. especially in the western Atlantic ocean and in the Gulf of Mexico.

All tropical storms develop over water. Long before the turn of the 20th century some authors drew attention to the fact that most of them develop along a narrow zone of air convergence, where the trades of both hemispheres meet This zone. which girdles the globe. has been variously called doldrums, intertropical front and equatorial low-pressure trough. It is not of uniform strength around the globe, and it changes its position and intensity with the seasons of the year, following the sun with a lag of two to three months. The equatorial trough penetrates to about latitude 15° N. between July and October and to latitude 10° to 15° S. from January to March or April. These months, then, represent the principal cyclone seasons of the respective hemispheres. In the northern hemisphere, the peak month of activity usually is September.

The distance by nhich the equatorial trough moves away from the equator in the course of a year is not uniform around the globe but is greatest in the regions indicated in fig. 2. The formation of tropical storms is most frequent in those places where the zone deviates far from the equator. Where there is little or no seasonal variation of its position cyclonic developments are rare or nonexistent. The zone appears in the transition periods between summer and minter in the Arabian sea and the western part of the Caribbean sea. Over those parts of the tropical oceans, therefore, the cyclone frequency is greatest about June and October, with a lull in midsummer. There is also a tendency toward two peaks of cyclone activity in the Bay of Bengal.

Tropical storms can develop also in the absence of the equatorial trough, although they do so less frequently. The storms of the western North Atlantic and the Gulf of Mexico are the outstanding examples of formation without equatorial trough. However, cyclonic development will net take place near the equatorial trough or near other disturbances of the tropics unless a broad-scale atmospheric circulation pattern is present in the low and high atmosphere that is favourable for formation. The high-atmospheric observations taken over the oceans during World War II have shown that tropical aeather is greatly dependent on the atmospheric flow in middle latitudes. In order to predict the formation of a tropical storm in the West Indies region, for instance, a weather forecaster must have knowledge of weather conditions over all of the North Atlantic ocean and the United States, besides the information as to conditions over the tropics themselves.

Those regions of the earth where tropical storms form principally are shaded in fig. 2. The greatest frequency should be found over those parts of the tropical oceans where the equatorial trough is strong and has large seasonal departures from its average position and where, moreover, sea surface temperatures are high and the average atmospheric flow in middle and high latitudes is favourable. In the western North Pacific ocean these conditions are fulfilled to a higher degree than anywhere else. On the average, about 20 tropical storms form in that area each year. Although statistics are lacking, the cyclone frequency of the South Indian ocean is thought to be almost as high. Compared with these large figures, other hurricane areas of the world have few storms. In the western North Atlantic, the Caribbean and the Gulf of Mexico the mean annual frequency is about six. The deviations from this average, however, are very large. In 1933, 21 tropical cyclones appeared in the area just mentioned; in 1929 and 1930 there were only 2 each. The South Atlantic is the only ocean where tropical storms are unknown. The equatorial trough does not penetrate far enough southward.

Movement. — Within the tropics, storms that have attained maturity usually drift westward with the prevailing trade wind. While the speed of the winds within the disturbances frequently exceeds 100 m.p h., the rate of movement of the disturbances themselves is about 15 m.p.h. on the average. It may deviate, however, by 5 m.p.h. or more from this mean figure in individual cases. Besides the westward movement there is also a tendency for most storms to approach the poleward limit of the tropics gradually. When they reach this limit near latitude 30°, they leave the tropical easterlies and come under the influence of the prevailing westerlies of higher latitudes. Their direction of motion then reverses and they are said to recurve. After the recurvature they drift eastward while continuing to approach the high-latitude regions. During the recurvature the speed of the cyclones is lowest, and they frequently become almost stationary for 12 to 24 hours. After recurving, their speed increases rapidly and they may be moving at 50 to 60 m.p.h. when they reach the polar zone.

The general path of tropical storms just outlined has a large number of exceptions because of constant changes of the broad-scale atmospheric currents and their effect on the tropics. Weather observation networks extending over large portions of the globe and experienced forecasters are necessary to predict the path of individual storms. These predictions become especially difficult when a storm lies between the broad-scale easterlies and westerlies (see WINDS, GENERAL CIRCULATION OF) so that it is temporarily controlled by neither of these currents.

End of Storms. — Dissipation of tropical storms over the tropical oceans is rare. Most disturbances eventually enter the middle and high latitudes where they are absorbed into the prevailing westerly circulation of those regions. Tropical storms normally lose intensity when striking land, irrespective of latitude. Even passage over smaller islands of the tropics can result in great reductions of their strength. Within 24 hr. after striking land, the winds of a severe hurricane may have been reduced to 20 to 30 m.p.h. Over flat ground, such as Florida, the dissipation is far slower than over rugged country. It should be noted, however, that tropical storms passing into the temperate zone occasionally encounter conditions favourable for regeneration as strong extra-tropical cyclones. In these cases, which are fairly rare, the winds at first lose intensity when the hurricane reaches land, and the eye disappears. Later the circulation again increases, even over a continent, but the strongest winds then are found at a distance of about 200 mi. from the centre.

Damages. — The loss of life and property on tropical islands and coastal areas of continents is caused by the direct and indirect effects of the high winds and the excessive rains.

Winds. — The pressure exerted by the air on solid objects, for instance houses, is proportional to the square of the wind speed. Thus an increase of the wind from 40 to 50 m.p.h. produces far

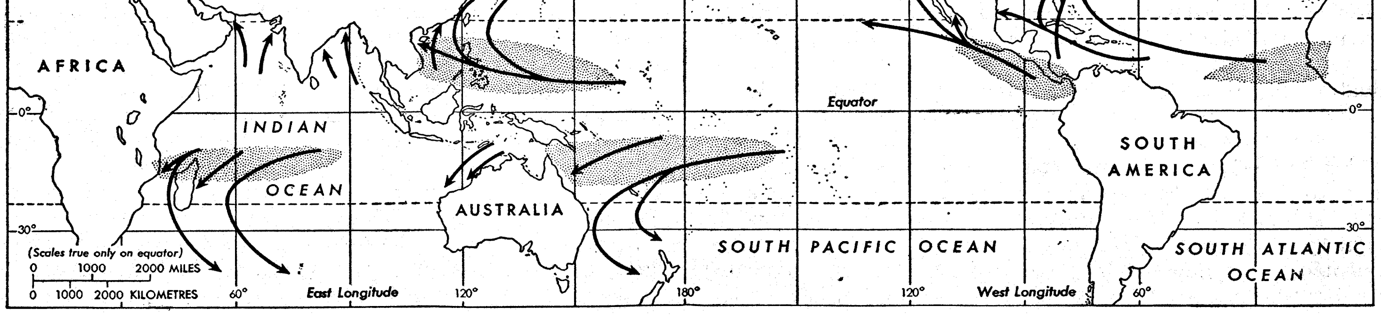

FIG. 2. — TYPICALTRACKS OF TROPICAL STORMS THROUGHOUT THE WORlD AND REGIONS OF GREATEST DEPARTURE OF THE EQUATORIAL FRONT FROM ITS MEAN POSITION

less added danger to buildings than a rise from 90 to 100 m.p.h. Moreover, the resistance capacity of many structures appears to become exhausted rapidly when the winds exceed 75 to 80 m.p.h. In industrial and city areas, danger to industrial and electrical installations is great. Short circuits in the midst of a raging storm and the explosion of gasoline tanks have led to uncontrollable fires. Much damage also results from the impact of flying debris.

Storm Waves.—Some of the most disastrous losses of life and property have been caused by a sudden rising of the ocean and widespread inundations of low-lying, poorly protected coastal areas. The abrupt increase of the water level, referred to as the storm wave, is caused by the action of the wind on the water The storm wave appears so quickly and is carried with tremendous force so far inland that often there is no time for the coastal inhabitants to rescue themselves or their belongings.

Rainfall.—The heavy rainfall often accompanying tropical storms frequently causes landslides in mountainous and hilly areas. Because of the great and sustained intensity of the precipitation, the runoff of the water is extreme and produces rapid and excessive rises of the water level of the rivers along which the human settlements and valuable agricultural activities are concentrated.

The damaging power of tropical storms is not confined to the tropics. Occasionally, storms moving up against Japan, China and the northeastern coast of the United States have struck with a violence equal to that of storms within the lower latitudes.

Storm **Warning** Services.—Forecasting of the appearance of tropical storms was attempted long before the start of the 20th century. These activities were begun largely by the Society of Jesus whose members developed a high forecasting standard notably in the West Indies and the Philippines. With the gradual expansion of governmental weather services after 1900, the forecasting work passed more and more into official hands, aided also by the military weather services during World War II. From 1935, for instance, the United States weather bureau has maintained special hurricane forecast centres which advise the public concerning the position, the intensity and the probable movement of hurricanes and indicate what type of precautions are necessary.

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TROPIC BIRD, a genus (Phaethon) of sea birds of the order Steganopodes with webbed feet and long forked tails. The flight is by rapid strokes of the wing. The yellow-billed tropic bird (P. *flavirastris*) has the widest range, inhabiting the Atlantic, Indian and Pacific oceans, and breeding on trees in various islands, including the Bermudas. It lays a single pinkish-white egg, mottled with brownish-purple. The plumage is white, with black patches. P. aethereus is larger and lacks the yellow bill. It does not occur in the western part of the Indian ocean. P. *rubricauda* is still larger and has a red tail and a roseate tinge to the rest of the plumage. It is confined to the Pacific and Indian oceans. The tropic birds form the family Phaethonidae.

TROPINE (TROPANOL), the amino-alcohol portion formed, together with tropic acid, when the ester linkage in atropine or hyoscyamine is hydrolyzed with acids or alkalies. It forms white, hygroscopic crystals melting at 63° C. and does not rotate the plane of polarized light (see STEREOCHEMISTRY). Its synthesis (Richard Willstatter, 1901) furnished proof of the structure of the parent alkaloids. Tropine has no medical uses but is employed in the manufacture of homatropine and similar agents used in dilating the pupil of the eye. Tropine is closely related to ecgonine, the basic portion of cocaine. See also ATROPINE; COCAINE; HYOSCYAMINE (L. F. SL.; V. E.)

TROPISM, a term introduced by plant physiologists by 1835, grew to designate the bending of a plant in relation to some definite stimulus like that furnished by gravity (geotropism) or light (phototropism). The turning continues until the plant is so oriented that symmetrically placed parts are equally stimulated. As outlined in ANIMAL BEHAVIOUR (*q.v.*), tropism has retained essentially this same meaning except that it also includes the orientation of sessile animals. Jacques Loeb initiated and developed the transfer of concepts centring about tropisms from plant physiology to animal behaviour. He believed that, despite the more complicated reaction system of animals, plants and animals behave fundamentally alike. The tropism theory of orientation as applied to higher animals postulates that these bilaterally symmetrical organisms give a quantitatively different reaction of the locomotor appendages or tissues on opposing sides in direct proportion to the strength of stimuli received by the corresponding receptors. After being oriented, a motile organism is held on its path by balanced thrusts of its locomotor apparatus, much as a rudderless boat is guided and propelled by laterally operated oars or by a tail-like sculling oar at the stern. This tropism theory of oriented response—also called the muscle-tonus theory—is an incomplete explanation of oriented behaviour. The term tropism has been expanded to include all aspects of unlearned, reflex actions of whole organisms that appear to result from the direct interaction of physical forces in the environment with physiological processes within the organism. Taxes (taxis, singular), as well as tropisms in the restricted sense, were called tropisms with the implication that the reacting organism is mechanically forced to behave as it does. Loeb skilfully developed this mechanistic conception of behaviour; after 30 yr. of study he wrote (1918): "Motions caused by light or other agencies appear to the layman as expressions of will and purpose on the part of the animal, whereas in reality, the animal is forced to go where carried by its legs. For the conduct of animals consists of forced movements." (Jacques Loeb, Forced Movements, Tropisms, and Animal Conduct, J. B. Lippincott Co., 1918.) According to this theory, behaviour is not primarily adaptive; the male moth is not trying to find a mate, and fishes do not will to swim upstream; they are mechanically forced to do so. Loeb applied this interpretation very widely and (1918) suggested that, with the enlargement resulting from memory, the tropism theory might include human conduct. Largely because of its close association with unproved theories, some students avoid the word tropism entirely; others use it descriptively, without theoretical implications, for orientation reflexes of sessile organisms.

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TROPOSPHERE, the lowest region of the earth's atmosphere. It is characterized by turbulent mixing, cloud formation and, generally, a decrease in temperature with altitude. The upper boundary, called the tropopause, has an altitude of 25,000 to 55,000 ft. See ATMOSPHERE.

TROPPAU: see OPAVA.

TROPPAU, CONGRESS OF, a conference of the allied sovereigns or their representatives to discuss a concerted policy with regard to the questions raised by the revolution in Naples of July 1820. At this congress, which met on Oct. 20, 1820, the emperors Alexander I of Russia and Francis I of Austria were present in person; King Frederick William III of Prussia was represented by the crown prince (afterward Frederick William IV). The three eastern powers were further represented by the ministers responsible for their foreign policy: Austria by Prince Metternich, Russia by Count Capo d'Istria, Prussia by Prince Hardenberg. Great Britain, on the other hand, which objected on principle to the suggested concerted action against the Neapolitan Liberals, sent no plenipotentiary, but was represented by Lord Stewart, ambassador in Vienna. France, too, had given no plenary powers to her representatives.

In a series of conferences—to which the representatives of Great Britain and France were not admitted, on the excuse that they were only empowered to "report," not to "decide"—was drawn up the famous preliminary protocol signed by Austria, Russia, and Prussia on Nov. 19. The main pronouncement of the "Troppau protocol" is as follows: "States which have undergone a change of government due to revolutian, the results of which threaten other States, ipso facto cease to be members of the European Alliance, and remain excluded from it until their situation gives guarantees for legal order and stability. If, owing to such alterations, immediate danger threatens other States the powers bind themselves, by peaceful means, or if need be, by arms, to bring back the guilty State into the Great Alliance"

No effort was made by the powers to give immediate effect to the principles enunciated in the protocol; and after its promulgation the conferences were adjourned, it being decided to resume them at Laibach in the following January (*see* LAIBACH, CONGRESS OF).

TROSSACHS, THE (Gaelic, "the bristled country," an allusion to its rich, wild vegetation), a defile in the southvest of Perthshire. Scot. It is a narrow, beautifully wooded glen. of no great depth, extending from Loch Achray to Loch Katrine. and continued thence by a strip on the northeastern shore to a point above the now submerged Silver Strand opposite to Ellen's Isle—a total distance of $2\frac{1}{2}$ mi. It is situated about 7 mi. N.N.W of Aberfoyle, between the steep green slopes of Ben Venue (2,393 ft.) on the southwest and the precipitous crags of Ben A'an (1,750 ft.) on the northeast. The Trossachs region has been famous for its beautiful scenery since the appearance of Sir Walter Scott's *The Lady of the Lake* and *Rob Roy*, with their vivid descriptive passages.

TROTSKY, LEV DAVIDOVICH (1879–1940), Russian politician, whose real name was Bronstein, was born near Elizavetgrad, the son of middle-class Jews. He was educated at the Peter and Paul *Real Schule* in Odessa and at the university of that town. He was arrested as a revolutionary in 1898. and soon after exiled to eastern Siberia. In 1902 he escaped to England by means of a forged passport in the name of Trotsky (which name he used thenceforward). In London, despite his youth, he soon became an important member of the small body of social democrats which included Plekhanov and Lenin. He collaborated with the latter and others in the publication of *Iskra* (Spark), the most famous of the Russian revolutionary newspapers. In 1905 he returned to Russia, was elected a member of the St. Petersburg Soviet of Workers' Deputies and was chairman of the meeting at which the whole soviet was arrested. He was exiled to Tobolsk but escaped immediately on his arrival in Siberia and went to Vienna, where he worked for the *Arbeiter Zeitung* and the *Pravda*. He also worked in a chemical factory. In 1910 he attended the Social Democratic congress at Copenhagen, defending a position of his own, midway between that of the bolshevists and that of the menshevists. In 1913 he was in Constantinople as a war correspondent. The following year found him in Zurich and Paris, taking part in the publication of a revolutionary paper. He wrote a book on the origins of World War I, published in German, and was sentenced to eight months' imprisonment. But he opposed the War not only in Germany but in the Allied countries, and in 1916 was expelled from France. He was arrested by the Spanish authorities on crossing their frontier but was allowed to leave for America, where he edited the Russian revolutionary ***Novy Mir*** (The New World).

When the revolution broke out in March 1917 Trotsky's friends and subscribers to the paper collected the money for his journey to Russia. He was, however, arrested by the British authorities and taken ashore at Halifax, where he was interned until the Russian Provisional government asked for his release. He arrived in Petrograd soon after Lenin. He was the leader of a small party of social democrats and soon joined the Bolsheviks but did not actually become a member of the Bolshevik party until July 1917, when he was arrested for being concerned in the rising which took place in that month. He played a part hardly less important than that of Lenin in organizing the Bolshevik revolution in 1917 and became People's Commissar for foreign affairs in the new Soviet Government.

Trotsky was the most important figure in the Russian delegation during the negotiation of the Brest-Litovsk peace treaty. Believing that the moral effect of the revolution had already been such that the Germans would be unable to force their troops to move against Russia, he met the oppressive German demands with the statement that Russia would not sign a treaty on such terms but that she considered the War to be at an end and would demobilize her troops. The Germans thereupon continued their advance. Lenin had disagreed with Trotsky, considering that the risk was too great since at that time the Germans could easily have taken Petrograd. After a series of debates, Trotsky announced that he now sided with Lenin and by a majority of one it was decided to sign an even more unfavourable treaty than that previously refused. Trotsky was replaced by Chicherin as Commissar for foreign affairs and took over the Commissariat of war. In spite of opposition he made great use of officers of the old régime in organizing a new Red army. The results obtained were used to justify the employment of "bourgeois" technical experts in the factories. When he had made a new army that showed itself superior to those of the Whites his energies were used in preventing the complete collapse of the railways. In 1920 he organized as "labour armies" the troops that were not needed for war.

Until the introduction of the new economic policy Trotsky urged industrial conscription, but wholeheartedly accepted the new policy which made such measures impossible. During the Polish war of 1920, he opposed the disastrous advance on Warsaw but was overruled by Lenin. In the autumn of 1923 he adopted a position that made it possible for the "old guard" of the Communist leaders to accuse him of canvassing for the support of the younger men. He was violently attacked by Stalin, Zinoviev and others. Many of his friends were shifted from their posts and he himself was on the way to the Caucasus to take a cure, when Lenin died. Throughout the revolution the names of Lenin and Trotsky had been coupled and the death of the one seemed to leave the other alone in the field. This was not really so. Seniority counts for much in the Communist party and the older leaders never forgot that Trotsky had only joined the party in 1917. The campaign to discredit him was continued. He lost his post as Commissar of war. When he returned from the Caucasus he was given work of small political significance, being made head of the committee for the development of electric power in Russia. In 1925 he resigned from this post and was made head of the Central Committee for Concessions. In Nov 1927 he was expelled from the Communist party for his anti-party activities, and in Jan. 1928 he was exiled to Viernie in Turkestan. He was subsequently banished and went to Constantinople (1929).

In 1936 he made his home in Norway; in Jan. 1937 he went to live in Mexico. He was (1936) accused of joining Zinoviev and Kamenev in a plot to murder Stalin but emphatically repudiated the charge. On Aug. 20, 1940 he was attacked in his suburban home at Mexico city by a "friend" whom the exile's intimates described as a Stalinist agent. He died the next day.

(A. RA.; X.)

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TROTZENDORFF (or TROCEDORFIUS), **VALENTIN FRIEDLAND** (1490–1556), German educationist, called Trotzendorff from his birthplace, near Gorlitz, in Prussian Silesia, was born on Feb. 14, 1490, of parents so poor that they could not keep him at school. Nevertheless he was sent to study at Görlitz, and became a schoolmaster there. He resigned presently to study under Luther and Melanchthon, supporting himself meanwhile by private teaching. He then became master in the school at Goldberg in Silesia, and in 1524 rector. There he remained three years, when he was sent to Liegnitz. He returned to Goldberg in 1531 and began that career which has made him the typical German schoolmaster of the Reformation period. He made his best elder scholars the teachers of the younger classes, and insisted that the way to learn was to teach. He organized the school in such a way that the whole ordinary discipline was in the hands of the boys themselves. Every month a "consul," twelve "senators" and two "censors" were chosen from the pupils, and over all Trotzendorff ruled as "dictator perpetuus." One hour a day was spent in going over the lessons of the previous day. The lessons were repeatedly recalled by examinations, which were conducted on the plan of academical disputations. Every week each pupil had to write two "exercitia styli," one in prose and the other in verse, and Trotzendorff took pains to see that the subject of each exercise was something interesting. The fame of the Goldberg School extended over all Protestant Germany, and a large number of the more famous men of the following generation were taught by Trotzendorff. He died on April 20, 1556.

TROUBADOURS, poets of southern France, northern Spain and northern Italy who wrote in the *langue d'oc* (*see* PROVENÇAL LANGUAGE) from the end of the 11th century to the last decade of the 13th. The word *troubadour* is a French form of the Occitanian *trobador*, accusative singular of *trobaire*, "poet," from *trobar*, "to find," "to invent"; *cf.* Fr. *trouvère, trouver*. A troubadour, then, was one who invented new poems, finding new verse forms for his elaborate lyrics; he might be a great prince, such as Richard Coeur de Lion, or a wandering adventurer who made song his profession.

The social influence exercised by the troubadours was unprecedented in the history of medieval poetry. They had great freedom of speech. they entered into questions of politics and above all they created around the ladies of the court an atmosphere of cultivation and amenity which nothing had hitherto approached. The troubadour was occasionally accompanied by an apprentice or servant, called a *joglar*, who provided a musical setting for his words and sometimes sang his songs. About 400 troubadours were recognized in the 200 years in which they flourished.

The efficient cause of the decadence and ruin of the troubadours was the struggle between Rome and the Albigensian heretics (*see* CATHARI). This broke out into actual war in 1209, when the barons of northern France, responding with alacrity to Pope Innocent III's invitation to a crusade, fell upon the rich dominions of the count of Toulouse. Most of the protectors of the troubadours had been. if not heretics, at least liberally disposed toward the heretical party, in whose downfall they consequently found themselves involved. As the desolation of Languedoc became more and more entire, the darkness gathered round patrons and poets alike. Thus it was that Guiraut Riquier at the end of the 13th century was already speaking to the wind. He was in a decayed world. the mourner of one of the most brilliant poetical schools that ever flourished; an eminently creative school from which proceeded all the new European lyrism.

Literary Forms.—A considerable number of specimens, if not the greater part, of the work of the troubadours is extant, having been preserved in the manuscripts known as *chansonniers* ("song books"); and the rules of their art are formulated in the *Leys d'amors* (1340). The verse form most frequently employed by the troubadours was the *canzo*, consisting of five or six *coblas* ("stanzas") with a *tornada* ("envoy"). When the *canzo* was of a political or satirical nature, it was called a *sirventés*. The troubadours also used the *hnlada* or *dansa*, which was a dance song with a refrain; the *pastorela*, illustrating the love request of a knight to a shepherdess; the *alba* or morning song, one of the most exquisite of their forms, in which lovers are warned by the *gaita*, ("watchman") that day is close at hand and that *el gilos*, the jealous husband, may surprise them (there were also, however, *albas* of a religious sort). Corresponding to the *alba*, was the *serena* or evening song, a later invention. Particularly interesting were the *tenson* and the *partimen* or *joc partit*, which were lyrical conversations between two or more persons discussing, as a rule. some point of amorous casuistry or matters of a religious, metaphysical or satirical character. Though some of them wrote other kinds of poems. the troubadours were essentially lyrical.

For an account of the troubadours' importance in the literature of the Midi *see* PROVENÇAL LITERATURE.

Lives of the Troubadours.— Information on the careers of 111 of the 400 troubadours can be gathered from the several manuscript collections of biographies of these poets. The principal collection, made by various hands toward the middle of the 13th century, includes contributions by Uc de Saint Circ (*c.* 1200–40), himself a troubadour. The *Vies des plus célèbres et anciens poètes provensaux*, published by Jehan de Nostredame (or Nostradamus) in 157j. is another source, but unreliable.

Even the numerous genuine biographies. however, are often embroidered with statements that make a severe demand on a modern reader's credulity; and a major task of research in the 19th and 20th centuries has been to disentangle the true from the fanciful in these writings.

Something must be said of a few of the most notable troubadours.

GUILHEM VII, count of Poitiers (William IX, duke of Aquitaine), who was born in 1071 and reigned as count-duke from 1086 to his death in 1127, was the first troubadour to come to renown. He is still regarded both as the patron and earliest poet of the school. Some of his songs are rather licentious; in another he makes a pathetic farewell to the world.

Second on the ordinary list of great troubadours is JAUFRÉ RUDEL of Blaye (fl. 1130–50), whose heart burned like the disc of a sunflower toward his "far-away love." Little else than the famous adventure of the Lady of Tripoli (dramatized by Edmond Rostand in *La Princesse lointaine*) is told about this troubadour, whose stanzas, inspired either by the Church of Christ or by the Lady of Tripoli herself, have a simple and pathetic accent.

Another of the early troubadours, the Gascon MARCABRUN (fl. *c.* 1130–48), from whose pen 45 poems survive, was an innovator and a reformer. To him the severity of the classical troubadour's style is mainly due, and he was one of the first to make use of the complex form known as the *trobar clus*. He posed as a violent misogynist: "I never loved any lady, and no lady ever loved me." Several of his songs are of a rough beauty.

More famous is the name of BERTRAN DE BORN (*c.* 1140–1215), the warrior poet, viscount of Hautefort in Périgord. Dante met Bertran de Born in hell, carrying his severed head before him like a lantern and comparing himself with Xchitophel, who incited Absalom to rebellion against David (*Inferno*, xxviii, 112 ff.). This was because of Bertran's part in promoting the rebellion of "the young king," Prince Henry of England, against his father, Henry II. The death of Prince Henry (1183) moved Bertran to two beautiful *planhs* ("laments"). The poet was immediately afterward besieged in his castle of Hautefort by Richard Coeur de Lion, to whom he became reconciled and accompanied to Palestine. He grew devout in his old age. About 2j *sirventés* by him are extant, including some of the most colourful and vivid poems that war ever inspired.

Eleanor of Aquitaine, queen first of France and then of England, was a great patroness of the troubadours; and it was at her court that BERNART DE VENTADOUR (*c.* 1150–95) rose tb eminence. Bernart, whose name is perhaps the highest in Occitanian poetry, was the son of a kitchen scullion in the castle of Eble, viscount of Ventadour. Eble, himself a poet, early noticed the talents of his serving boy and trained him to be a poet. The beautiful wife of Eble encouraged the boy's attentions; indeed. they had secretly loved one another since childhood. The poems which this passion inspired are among the best to come down to us from the middle ages. When Eble at last discovered the intrigue and exiled him from Ventadour, Bernart took shelter at Eleanor's court. After her marriage to Henry Plantagenet (1152) he left her service and attached himself to the court of Toulouse.

The most famous adept of the *trobar clus* mas a knight of Ribérac in Périgord, ARNAUT DANIEL (fl. c. 1180–1210), who attached himself as a troubadour to the court of Richard Coeur de Lion. Arnaut owes to the repeated praise given to him by Dante in the *Purgatorio* (xxvi. 115 ff.) and elsewhere a dazzling glory that to modern readers seems somewhat excessive. To Dante he is *il miglior fabbro* ("the better craftsman") and it is evident that it was the brilliant art of the Perigourdin's elaborate verse which delighted the Florentine. Arnaut's invention of forms of verse particularly impressed Dante (*see* SESTINA).

Dante was curiously anxious to exalt Arnaut Daniel as a better artist than his immediate rival. also one of Richard Coeur de Lion's protégés, GIRACT DE BORSELH (*c.* 1165–1220), who came from the vicinity of Excideuil, between Périgueux and Limoges. Modern taste. however, is inclined to reverse Dante's verdict. Giraut indeed, besides some pieces no less laboured than Arnaut Daniel's, left an *alba* of incomparable freshness, the *Reis glorios* imitated by Ezra Pound in his *Lustra* ("Languedoc," i).

The same freshness, with a still more touching sincerity, characterizes the work of Giraut's contemporary ARNAUT DE MAREUIL, another Perigourdin, who is credited with having introduced the amatory epistle (*salut*) and the short didactic poem (*ensenhumen*) into Occitanian poetry. Attached to the court of Béziers, he was driven from it by Alphonso II of Aragon, who wanted his mistress.

GAUCELM FAIDIT (*c.* 1185–1215) came from Uzerche in the Limousin. He seems to have been a wandering minstrel of gay and reckless habits and to have been accompanied by a loose woman, Guilhelma Monja, who was the object of much satire and ridicule. Homesick, he found deep and moving notes to speak of his native Limousin.

RIGAUT DE BARBEZIEUX (*c.* 1170–1200), a poet of Saintonge, equally famous for his love affairs, was another example of the naïveté and tenderness so frequent among the troubadours.

In Provence proper flourished BEATRIX, countess of Die, whose career was inextricably interwoven with that of another noble troubadour, RAIMBAUT III (fl. *c.* 1150–73), count of Orange, who held his court at Courthézon, a few miles south of Orange. Raimbaut said that since Adam ate the apple no poet had been born who could compete in skill with himself, but his surviving lyrics have neither the tenderness nor the ingenuity of those of Beatrix, who appears to have been much in love with him.

The greatest troubadour of Provence, however, is undoubtedly RAIMBAUT DE VAQUEYRAS (fl. *c.* 1155–1207), who passed the greater part of his life at the court of Montferrat. There he devoted himself to the lady Beatrix, sister of the marquis Boniface. One of the most moving poems of the age commemorates her death. He had earlier made himself famous by a *descort* in five languages and by his lively "War of the Ladies."

PEIRE VIDAL (*c.* 1175–1206) of Toulouse, was the prototype of the reckless and scatterbrained troubadour. His biographer says that he was "the maddest man in all the world." His early life was a series of bewildering excursions through France and Spain. He is said to have stolen a kiss from Alazaïs (the wife of his patron and friend Barral viscount of Marseilles) thereby incurring her dangerous resentment. He committed a thousand follies; for instance. being in love with Loba de Penautier, he dressed himself as a wolf (*lop;* "she-wolf," *loba*) and was hunted by a pack of hounds in front of her castle in the hills of Cabaret.

FOLQUET DE MARSEILLA (*c.* 1161–1231) was the son of a Genoese merchant In the latter part of his life he became bishop of Toulouse (*c.* 1202), in which capacity he engaged in the persecution of the Albigenses Dante met him in paradise (*Paradiso*, ix, 82 ff.) and gives an interesting notice of him. It is in the *sirventés* of Folquet that critics have seen the earliest signs of that decadence which was so rapidly to destroy Provencal poetry.

Auvergne had already produced one of the first troubadours, the not very remarkable poet of Clermont known as PEIRE D'ALVERNHA. The same country was represented later by two typical troubadours: the MONK OF MONTAUDON (fl. *c.* 1180–1213), famous for his truculent *tensons* with God on the duties of monks and on ladies' rouge (*c.* 1200); and PEIRE CARDENAL (d. *c.* 1272) of Le Puy. Cardenal, a poet of the first rank, was a protégé of James I of Aragon, having apparently fled from Narbonne and then from Toulouse to escape the armies of Simon de Montfort. He was the inventor of the moral or ethical *sirventés* and the author of singularly outspoken satires against the clergy. In a score of *sirventés* he proves himself the most unorthodox spirit and the most transcendental satirist of the Midi in the middle ages.

The chief of Italian troubadours was SORDELLO (d. *c.* 1270), born at Mantua early in the 13th century, who by his barbaric *planh* for the lord Blacatz (whose heart he desired the princes of western Europe to eat, so as to ingest his qualities) achieved a fame to which Dante (*Purgatorio*, vi–ix) and Robert Browning added by the use they made of his name.

It is to the class of unfortunate lovers rather than to that of great troubadours that legend assigns GUILHEM DE CABESTANH. Guilhem is said to have made love to Seremonda, wife of Raymund of Castel-Roussillon, and to have been killed by the jealous husband. who then cut out his heart and had it delicately cooked and served to his wife at dinner. When Seremonda had eaten it, Raymund told her what she had done, whereupon she threw herself out of the window, to her death. Historical research has raised serious doubts about this story since Guilhem seems to have been alive in 1212, and Ramon de Castell-Rossello predeceased his wife Saurimonde de Perclada (between 1212 and 1221).

Another troubadour of this time was GUILHEM FIGUEIRA (*c.* 1215–50), the son of a tailor of Toulouse, an open heretic who attacked the papacy with extraordinary vigour, supported and protected by the emperor Frederick II. But the end was already in sight. After him the ruin of the southern courts, to which their fortune was attached, precipitated the decline of the troubadours.

GUIRAUT RIQUIER (1230–94), the last of the troubadours, was born in Narbonne and found protection at the court of Alphonso the wise of Castile. Guiraut, in a *sirventés* of c. 1285, gives expression of his sense of the gathering darkness, which makes it useless and almost unbecoming for a troubadour to practise his art, while of himself he mournfully confesses, "Song should express joy, but sorrow oppresses me, and I have come into the world too late." He left no successor, unless one should call troubadours the academical poets of the Gay Saber who in Toulouse remained faithful for a time to the decaying rule of the *Leys d'amors*.

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(A. A. F. B.)

TROUBETZKOY, AMÉLIE, PRINCESS (1863–1945), U.S. author whose first novel, *The Quick or the Dead?* (1888), dealing with a widow's attachment to a new lover, created a sensation and established her as a popular novelist. Born on Aug. 23, 1863, in Richmond, Va., the granddaughter of William Cabell Rives (*q.v.*), U.S. senator and minister to France. she inherited his estate.

She wrote essays, poems and plays as well as novels. Her works include the novels *Virginia of Virginia* (1889), *The Golden Rose* (1908), *Pan's Mountain* (1910), *Hidden House* (1911), *The World's-End* (1914), *The Queerness of Celia* (1926) and *Fire-damp* (1930); *Augustine the Man* (1906) is a blank verse tragedy. Prince Pierre Troubetzkoy was her second husband. She died in Charlottesville, Va., on June 15, 1945.

TROUPIAL, a collective name suggested by Ridgway for the American family Icteridae, which includes the North American orioles, meadow larks, cowbirds, grackles and blackbirds and the Central American caciques.

TROUT. The general common name applied to certain species of the family of fishes called Salmonidae. *See* SALMON AND SALMONIDAE.

TROUT LILY, a nearly stemless plant of the lily family with yellow blossoms, native to the United States and southern Canada. It is one of the dog's-tooth violets (*q.v.*).

TROUVÈRE, the name given to the medieval poets of northern and central France, who wrote in the *langue d'oil* or *langue d'oui*. The trouvères flourished abundantly in the 12th and

13th centuries. They were court poets who devoted themselves almost exclusively to the composition and recitation of aparticular kind of poetry, the subject of which was some refinement of love.

The first appearance of trouvkres seems to date from 1137, when Eleanor of Aquitaine, herself the granddaughter of an illustrious troubadour, arrived in the court of France as the queen of Louis VII, speaking the Poitiers dialect of the *langue d'oc.* She was queen for 15 years (1137–52), the period during which the southern influence was strongest in the literature of northern France, and the successive crusades tended to produce relations between the two sections of poetical literature. The northern poets rarely approach the grace and delicacy of the troubadours, while their verse shows less ingenuity and less variety. The earliest trouvhres, like Conon de Béthune and Hugues de Berze, in writing their amatory lyrics, were, however, certainly influenced by what troubadours had written.

The poetical forms adopted by the trouvbres bore curious and obscure names, the signification of which is still in some cases dubious. The *rotruenge* was a song with a refrain; the *serventois* was, in spite of its name, quite unlike the sirventes of the troubadours and had a more ribald character; the estrabot was allied to the *strambotto* of the Italians, and was a strophic form "composed of a front part which was symmetrical, and of a tail which could be varied at will" (Gaston Paris).

The court poetry of the trouvhres particularly flourished under the protection of three royal ladies. Marie, the regent of Champagne, was the practical ruler of that country from 1181 to 1197, and she encouraged the minstrels in the highest degree and discussed the art of verse with Chrktien of Troyes. Her sister, Aélis or Alice, welcomed the trouvkres to Blois; she was the protector of Gautier d'Arras and of Le Châtelain de Coucy. Another Aélis, who became the second queen of Louis VII in 1160, received Conon de Béthune in Paris, and reproved him for the Picard accent with which he recited his poetry. At the end of the 12th century the refinement and elegance of the court poets was recognized in the north of France by those who were responsible for the education of princes. A trouvkre, Gui de Ponthieu, was appointed tutor to William III of Macon, and another, Philippe of Flanders, to Philippe Auguste. The vogue of the trouvkres began during the third crusade; it rose to its greatest height during the fourth crusade and the attack upon the Albigenses. The first 40 years of the 13th century was the period during which the courtly lyrical poetry was cultivated with most assiduity. At first it was a purely aristocratic pastime, and among the principal trouvères were princes such as Thibaut IV of Navarre, Louis of Blois and John, king of Jerusalem. About 1230 the taste for court poetry spread to the wealthy bourgeoisie, especially in Picardy, Artois and Flanders. Before its final decline, and after the courts of Paris and Blois had ceased to be its patrons, the poetry of the trouvkres found its centre at Arras, where some of the most skilful of all the trouvères, such as Jacques Bretel and Adam de la Halle, exercised their art. About 1280 the poetical system suddenly disappeared.

The poet was invariably a lover, devoted to a married lady who was not his wife, and to whose caprices he was bound to submit blindly and patiently. The progress of this conventional courtship was laid down according to certain strict rules of ceremonial; love became a science and a religion, practised by the laws of precise etiquette. The *rondel* of Adam de la Halle (published in E. de Coussemaker's edition, 1872) beginning

"A Dieu comant amouretes,
Car je m'en vois
Souspirant en tere estrange!"

marks perhaps the highest point to which the delicate, frosty art of the trouvkres attained. Music took a prominent place in all their performances, but little is known of the melodies which they used. But enough has been discovered to justify the general statement of Tiersot that "we may conclude that the musical movement of the age of the trouvères was derived directly from the most ancient form of popular French melody." A precious ms. in the Faculty of Medicine of Montpellier contains the music of no fewer than 345 part-songs attributed to trouvhres.

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TROUVILLE, a seaside town of northwestern France, in the *département* of Calvados, on the English channel, 34 mi. N.E. of Caen by rail. Pop. (1954) 6,213. Trouville stands at the mouth of the Touques on its right bank opposite Deauville. Its fine stretches of sand and excellent bathing make it the most frequented French resort on the channel. Deauville is well known for its racecourse and villas. The port, shared with Deauville and formed by the Touques, is entered by a channel between jetties with a depth at high tide of $17\frac{1}{2}$ ft.; it is supplied with a half-tide dock, filled to scour the channel. and a floating dock, with average depth of 18 ft. Timber, coals and cement are imported.

TROWBRIDGE, a market and manufacturing town and urban district in the Westbury parliamentary division of Wiltshire, Eng.. 33 mi. S.W. of Swindon by road. Pop. (1951) 13,859. Area 3.5 sq.mi. The first description of the town is that of John Leland, in about 1530, who reported that its castle was in ruins. Trowbridge is the administrative centre for the county and is well known for its manufacture of fine woollen fabrics. Its prosperity is also due to brewing, light engineering, manufacture of gloves and bedding, bacon curing, creameries, printing and seed preparation. St. James's church. where the poet George Crabbe was once rector, has a 14th-century, 160-ft. spire. Sir Isaac Pitman, originator of a method of shorthand, was born in the town.

TROY, a city of eastern New York, U.S., the seat of Rensselaer county, lies on the east bank of the Hudson river at the mouth of the Mohawk a few miles from Albany. The area is designated by the census bureau as the Albany-Schenectady-Troy standard metropolitan statistical area; *see* ALBANY. Troy was originally part of the Van Rensselaer manor, one of the patroonships granted in 1629 by the Dutch West India company to encourage Dutch colonization in the Hudson valley. After the American Revolution, a town was laid out on the farm of the Van der Heyden family, who had acquired the property in 1707. In 1789 the name of Troy was adopted and in 1793 the county seat was established there. Troy was incorporated as a village by an act of the New York state legislature in March 1794 and was chartered as a city in 1816.

During the War of 1812 Troy filled large contracts for army beef, the brothers Ebenezer and Samuel Wilson being major suppliers. The latter was known locally as "Uncle Sam" and, as government purchasers stamped "U.S." on the barrels of meat being shipped, local workmen referred to it as "Uncle Sam's beef." As tradition has it, the name was picked up by soldiers and soon came into familiar usage as a nickname for the United States.

Troy has long been an important industrial and commercial city. At one time it was the steel centre of the United States but was doomed in 1873 when Andrew Carnegie set up his mills near Pittsburgh, Pa. It is a principal centre in the United States for the manufacture of men's shirts and other garments. The clothing industry dates from 1819 when Hannah Montague of Troy had the ingenious idea of making separate collars for her husband's shirts. The idea spread, and in 1829 Ebenezer Brown. a local merchant, had collars made to sell in his store. After the introduction of the sewing machine in 1852 the industry grew rapidly, reaching its peak about the time of World War I.

Among the educational institutions in the city are the Rensselaer Polytechnic institute, founded in 1824 by Stephen van Rensselaer of Albany, one of the oldest institutions in any English-speaking city continuously offering instruction and research in science and engineering; and Russell Sage college, a private liberal arts college for women, established in 1916 Emma Willard, famous feminist and leader in educational opportunities for women, founded Troy Female seminary in 1821, later known as the Emma Willard school, which still provides college preparatory training for girls.

The population in 1960 was 67,492. For comparative population figures *see* table in NEW YORK: *Population.* (P. F. W.)

TROY, a city of western Ohio, U.S., about 20 mi. N. of Dayton on the Great Miami river; the seat of Miami county. Settled about 1807. Troy was incorporated in 1818 and chartered as a city in 1890. From its earliest days Troy was a river port for the loading of farm products on flatboats for delivery to Cincinnati and beyond. With the completion of the Miami and Erie canal (1845; destroyed by flood in 1913) the town began to develop industrially. Manufactures include welding and food preparation machinery, electric motors and generators, aircraft parts and paper products. For comparative population figures *see* table in OHIO: *Population.*

TROY and **TROAD.** The Troad (*ἡ τρῳάς*), or land of Troy, is the north-west promontory of Asia Minor, between the valleys of the Caicus on the south and the Aesepus flowing into Propontis on the east. The eastern limit was variously defined by ancient writers. Geographically, it is undoubtedly (as Strabo says) the range of Ida, which, from the north shore of the Adramyttian gulf, sends its north-western spurs nearly to the coast of the Propontis. The greatest length of the Troad from north-west at Cape Sigeum (Yeni Shehr), to the south-west at Cape Lectum (Babā Kale), is about 40 m.; the breadth, not much greater. The central area is drained by the Menderes (anc. *Scamander*), which rises in Ida and reaches the Hellespont east of Cape Sigeum.

Timber is supplied by pine forests on Mt. Ida. But the plains and hills are fairly wooded. Besides valonia oak, there are elm, willow, cypress and tamarisk, with lotus, galingale and reeds, as in Homeric days, about the streams. The vine is cultivated; watermelons are abundant; cotton, wheat and maize are grown. Even under Turkish rule, the natural advantages of the land mitigated the poverty of its inhabitants; in antiquity it was fertile and populous.

Early History.—In Greek legend, Priam of Troy ruled all that is bounded by "Lesbos, Phrygia and the Hellespont" (*Il.* xxiv. 544). The Achaeans under Agamemnon destroyed Troy, and overthrew Priam's dynasty. But there is Homeric prophecy that Aeneas and his descendants shall still rule over the Troes, in a passage probably later than the bulk of the book, and it is certain that in the 7th or 6th century B.C. reputed descendants reigned somewhere in the Troad. Thracian tribes, including Bithynians and Treres, swept into Asia Minor from Europe in the 7th century *B.C.*, and the Ionian poet, Callinus, recorded the terror which they caused.

Greek Settlements.—The earliest and most important of the Greek settlements were Aeolic, mainly from Lesbos and Cyme in Aeolis; some may have been as early as the 13th century B.C. About 620 B.C. Athenians occupied Sigeum, and were resisted by Aeolic colonists from Mytilene, already established in that neighbourhood.

Chief Greek towns in the Troad were Ilium in the north, Assus (*q.v.*) in the south, and Alexandria Troas (*q.v.*) in the west. The site of the Greek Ilium is marked by the low mound of Hissarlik (Turk. "place of fortresses") in the Trojan plain, about 3 m. from the Hellespont, the traditional site of Homer's "Troy." When Xerxes visited the Trojan plain, he "went up to the Pergamon of Priam," and sacrificed to the Ilian Athena. Ilium yielded to Dercyllidas in 399 B.C., and was captured by Charidemus in 359 B.C., but was evidently still of small importance when, in 334 B.C., Alexander visited it on landing in the Troad. In their temple of Athena the Ilians showed him arms which had served in the Trojan war, including the shield of Achilles. Either then or after the battle of Granicus, Alexander enlarged the town to be a "city," with political independence and exemption from tribute. Lysimachus executed the intentions of Alexander when north-west Asia Minor fell to him in 301 B.C., building a wall 5 m. in circumference, incorporating decayed towns of the neighbourhood, and building a temple of Athena. In the 3rd century B.C. Ilium was the head of a federal league of free Greek towns, from Lampsacus on the Hellespont to Gargara on the Adramyttian gulf. In 278 B.C. the Gauls, under Lutarius, occupied Ilium, but abandoned it. Forty years later (218 B.C.) other Gauls brought by Attalus I. for his war against Achaeus, deserted his standard. pillaged the towns on the Hellespont, and besieged Ilium, from which, however, they were driven off by the troops of Alexandria Troas. In the 2nd century B.C. Ilium was in decay; as Demetrius of Scepsis says, the houses "had not even roofs of tiles." The temple of Ilian Athena, however, retained its prestige; in 192 B.C. Antiochus the Great visited it before sailing to the aid of the Aetolians. In 190 B.C., before the battle of Magnesia, Romans and Ilians were alike eager to recall the legend of Roman descent from Aeneas; Lucius Scipio offered sacrifice to the Ilian Athena; and after the defeat of Antiochus the Romans annexed Rhoeteum and Gergis to Ilium, "not so much in reward of recent services, as in memory of the source from which their nation sprang." The later history of Ilium is a catalogue of Roman benefactions, though, in 85 B.C., when Fimbria took it, he left it in ruins; Sulla, however, was careful to rebuild it; Augustus confirmed its ancient privileges and gave it new territory; Caracalla (A.D. 211–217), like Alexander, paid honours to the tomb of Achilles. In the 4th century, the Ilians were attracting tourists by their pseudo-Trojan memorials. After the 4th century the place is lost to view.

Of the other ancient cities, *Neandria* seems to be rightly fixed at Mt. Chigri, not far from Alexandria Troas, remarkable for its fine view of the whole Troad. *Cebrene* has been located in the eastern part of the plain of Bairamich; *Palaeoscepsis,* farther east, on Ida, while the new *Scepsis* was near Bairamich. At Kulakli, south of the mouth of the Tuzla, Corinthian columns mark the temple of Apollo Smintheus (excavated in 1866 by Pullan) and (approximately) the Homeric *Chryse. Colonae* was on the coast opposite Tenedos. *Scamandria* was at Eneh, in the plain of Bairamich, and *Cenchreae* probably some way north of it. The shrine of Palamedes, *Polymedium,* has been discovered by J. T. Clarke between Assus and Cape Lectum; the sacred enclosure and the statue of Palamedes were on the acropolis. Clarke also found very ancient walls on Gargarus, the highest peak of Ida.

The Site of Troy.—The traditional site, at the Hellenistic Ilium, is the mound of Hissarlik, on a spur between the main Scamander valley and its last tributary from the east (anc. *Simois),* about $3\frac{1}{2}$ m. from the Hellespont and from the Aegean shore, north of Besika bay. The famous academic dispute concerning the site, which began about A.D. 160 with Demetrius of Scepsis, may be regarded as settled by the discovery, made in 1893, of a fortress on the mound of Hissarlik, contemporary with the great period of Mycenae, and overlying the smaller and the earlier acropolis first identified by Schliemann in 1872. The rival ruins of a small hill fort on the Bali Dagh which, with another on an opposite crag, commanded the gorge where the Scamander descends into the plain neither accord with Homeric description nor challenge the remains at Hissarlik in importance.

No site in the Troad accords completely with all the topographical clues ingeniously derived from the text of Homer. The hot and cold springs that lay just without the gate of "Troy" are no more to be identified with Bunarbashi, which wells out more than a mile from the Bali Dagh ruins, than with the choked conduits south of Hissarlik, opened by Schliemann in 1882. But the broader topography is recognizable in the modern plain of the Menderes. The old bed of that river is the Scamander, and its little tributary, the Dumbrek Su, is the Simois. In their fork lies Hissarlik or Troy. In sight of it are, on the one side, the peak of Samothrace (Il. xiii. 11–14); on the other Mt. Ida (Kaz Dagh; viii. 52). Hissarlik lies in the plain (xx. 216), easily reached by foes from the shore, or left and regained in a night by a Trojan visiting the Achaean camp (vii. 381–421).

Archaeological Investigation of Troy.—Schliemann's excavations at Hissarlik in 1872–74, supplemented and confirmed by W. Dörpfeld in 1891–94, established the existence of nine superposed settlements, as follows:—

1. On the virgin soil of the natural hillock a small village of the late Aegean Neolithic period, at the dawn of the Bronze age, contemporary with the upper part of the Cnossian Neolithic bed, includes what were supposed by Schliemann to be two primitive settlements. Thin walls of rough stones, bonded with

mud, reveal no house-plans, nor traces of fortress wall. Implements in obsidian and various kinds of stone, clay whorls, a little worked ivory, accompany dark monochrome pottery, hand-polished, with simple geometric decoration, incised and often filled with white.

2. Superposed and comprehending a larger area, lies the "second city," better constructed and preserved, and twice rebuilt. Its massive fortress wall of rudely squared "Cyclopean" masonry suffered several restorations and eventual destruction, except on the south. Double gates at south-east and south-west are well-preserved. The most complete and most important structures within are a *megaron* and vestibule of the type familiar in "Mycenaean" palaces, with one or more smaller replicas alongside it, like the "women's quarters" at Tiryns (q v.) and Phylakopi. *(See* AEGEAN CIVILIZATION.) This is the fortress proclaimed by Schliemann in 1873 to be the "Pergamos" of Troy, mainly because it perished by fire. But this second stratum belongs to a primitive stage of local civilization preceding the "Mycenaean," which is the earliest recalled by the Homeric poems. The pottery now shows the first rare use of paint, and of technique and fantastic forms parallel to those of the pre-Mycenaean Cyclades. Trough-spouted vases are characteristic, and rude reproductions of human features are common in this ware, which seems all native. Bronze had come into use for implements, weapons and vessels; a hoarded treasure found in the ruins of the fortification wall includes much gold and silver. But the forms are primitive and the workmanship very rude. Personal ornaments are cut out of thin plate gold or built of coiled wire. But some of the discs, bracelets and pendants, with advanced spiral ornament, found in 1878 and ascribed to this stratum, belong undoubtedly to the sixth or "Mycenaean." Rough fiddle-shaped idols, whorls, a little worked ivory and some lead make up a find, of whose early period (probably about 2000 B.C.) comparison of objects found elsewhere leaves no doubt. This treasure is now deposited in Berlin with the bulk of Schliemann's collection.

3, 4, 5. After the burning of the "second city," Hissarlik ceased for a time to have any considerable population. Three small village settlements have left their traces superposed and show only slight advances of material culture.

6. The mound, however, occupied too important a site, in relation to the plain and the sea, to remain desolate, and it was occupied in the 14th or 13th century by a great fortress, while a city not yet explored, spread below. This "sixth city" was first distinguished clearly by Dorpfeld in 1882, but Schliemann's drastic methods confused its commoner pottery and metal objects with those of lower strata; and some grey ware, to which Schliemann gave the name "Lydian" was alone referred to this sixth or "Lydian" city, in his *Troja* (1884). This ware has been compared with the "Minyan" fabric at Orchomenus, but also resembles the "Lausitz" pottery, which originated on the middle Danube, and was intruded into Macedonia at the close of the 12th century. For years this "sixth city" was neglected.

In 1893, however, excavations in hitherto undisturbed ground outside the earlier fortress, exposed a wall of massive ashlar masonry resembling the fortifications of Mycenae itself, and "Mycenaean" walls at Phylakopi in Melos. With this wall occurred not only the grey ware, but painted potsherds unmistakably "Mycenaean"; and further search showed that such sherds were characteristic of "sixth city" deposits. The inevitable inference is that this city imported contemporary "Mycenaean" ware to supplement its own ruder products. The area of its citadel is larger than the "second city," its buildings, which include a large *megaron*, are of finer construction. This was the most important city yet built on the mound. It belonged to the "Mycenaean" age, which precedes the composition of the Homeric poems, and is reflected by them. Therefore this is Homer's Troy.

Its remains, however, having been obliterated on the crown of Hissarlik, almost escaped recognition, for when, long afterwards, the Hellenistic Ilium was built, the top of the mound was cut away and the uppermost strata vanished, Thus we find them now on the southern slope of the mound only, but have no difficulty in estimating their original extent. Tombs and the outer quarters of this city will doubtless be found eventually.

7. The "sixth," or "Mycenaean" Troy, perished by violence like the "second city," but its inhabitants reoccupied its ruins, until, in early Hellenic times, the small unfortified settlement was established which maintained itself till the Homeric enthusiasm of Alexander the Great called a city again into being on Hissarlik.

8. The Hellenistic Ilium, however, has left comparatively little trace; fortifications erected by Lysimachus are visible on the acropolis and in the plain. A small Doric temple belongs to this city, and a larger one, probably dedicated to Athena, seems to be of Pergamene age. Fragments remain of its metopes, representing Helios and a Gigantomachia. Coins of this city show Athena on both faces, and inscriptions prove that Hellenistic Ilium was of some importance.

9. Lastly, about the Christian era, the Graeco-Roman city built a theatre and an ornate gateway on the south-east slope, a large building on the south-west and others to north-east. This city seems to have decayed in the 5th century A.D.

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The Legend of Troy.—In Greek legend, the oldest town in the Troad was that founded by Teucer, who was a son of the Scamander (a Cretan stream, according to Tzetzes) and the nymph Idaea. In his reign, Dardanus, son of Zeus and the nymph Electra, daughter of Atlas, in consequence of a deluge, drifted from Samothrace to the Troad, where he received land from Teucer, married his daughter Batea, and founded Dardania, at the foot of Mt. Ida. On the death of Teucer, Dardanus succeeded him, and called the whole land Dardania. He begat Erichthonius, who begat Tros by Astyoche, daughter of Simois. Tros called the country Troy and the people Troes (Trojans). By Callirrhoe, daughter of Scamander, Tros had three sons—Ilus, Assaracus and Ganymede. From Ilus and Assaracus sprang two separate lines; Ilus, Laomedon, Priam, Hector; and Assaracus, Capys, Anchises, Aeneas. Ilus went to Phrygia, where he received, as a wrestling prize from the king of Phrygia, a spotted cow, with an injunction to found a city where she lay down. The cow lay down on the hill of the Phrygian Atē; here Ilus founded Ilion; and Dardania, Troy and Ilion became one city. Desiring a sign from Zeus, Ilus prayed and found lying before his tent the Palladium, a wooden statue of Pallas, for which he built a temple. By Eurydice, daughter of Adrastus, he had a son, Laomedon, who married Strymo, daughter of Scamander (or Placia, daughter of Atreus or of Leucippus). In his reign, Poseidon and Apollo (or Poseidon alone), built the walls of Troy, but Laomedon withheld their reward. In his reign also, Heracles besieged and took the city, slaying Laomedon and his children, except one daughter, Hesione, and one son, Podarces. The life of Podarces was granted at the request of Hesione, on condition that Podarces first be a slave and then be redeemed by Hesione; she gave her veil for him; hence his name of Priam (Gr. πριάσθαι, to buy). Priam married first Arisbe and afterwards Hecuba, and had 50 sons and 12 daughters. Among the sons were Hector and Paris, and among the daughters Polyxena and Cassandra. Paris, betrothed to Oenone, awarded the golden "apple of strife" to Aphrodite (who promised him the love of the fairest of women) and brought upon Troy the resentment of Hera and Athena. Thereafter, Paris, visiting Sparta, found favour with Helen, heiress of

Tyndareus and wife of Menelaus, son of Atreus, and carried her to Troy. To recover Helen, the Achaeans under Agamemnon, brother of Menelaus, besieged Troy for ten years. In the tenth pear Hector was killed by Achilles, and he by Paris. At last a wooden horse was contrived in whose hollow many Achaean heroes hid themselves. Their army and fleet then withdrew to Tenedos, feigning to have raised the siege. The Trojans conveyed the wooden horse into Troy; in the night the Greeks stole out, opened the gates to their friends, and Troy was taken. See also HOMERIC POEMS.

See Homer, *Il.* vii. 452 seq, xx. 215 *seq.,* xxi. *446 seq.;* Apollodorus ii. 6, 4, iii. 12; Diodorus iv. 75, v. 48; Tzetzes, *Schol. on Lycophron, 29,* 72, 1302; Conon, Narrat. 21; Dionysius Halicarn., *Antiq. Rom.* i. *68 seq.* The *Iliad* deals with a period of 51 days in the tenth year of the war: the *Odyssey* with the wanderings and homecoming of an Achaean leader, Odysseus. For the wooden horse *see* Homer, *Od.* iv. 271 *seq.;* Virgil, *Aen.* ii. **13** *seq.*

The Historical Background of the Trojan War.—The "Tale of Troy," with legends of heroes who "fought in the war," was popular when the Odyssey (see HOMER) was composed; wherein minstrels sing lays about it, and the Sirens boast that they "know it all." From the 7th century B.c., at least. it supplied subjects to vase painters and other craftsmen, and in the 5th, to the sculptors of the Aegina pediments (see GREEK ART), and to Athenian dramatists. (See DRAMA: Greek) Herodotus and Thucydides, like ancient writers generally, accepted the Trojan war as historical, though they criticized epic statements in detail, and Herodotus noted discrepancy between the *Cypria* and the *Iliad.* Ephorus, and afterwards Strabo, marshalled geographical learning as commentary on the Achaean and Trojan "catalogues" in *Il.* ii.; the scholars of Alexandria elucidated Homeric antiquities. those of Pergamum their topographical and historical background; Demetrius of Scepsis in the Troad, misdouhted. on geological grounds, the reputed site of Troy. Traditional genealogies, collated by Hecataeus (see HECATAEUS OF MILETUS) and others, enabled Eratosthenes (*q.v.*) to date the "Fall of Troy" to 1194 B.C., in the third generation before the "coming of the Dorians" and in the second after Laomedon's foundation. Homeric references to Egypt (where Thebes, not Memphis, is the capital) and to Phoenicia (where Sidon is known, but not Tyre) supply a historical background for the war. not later than the 12th century; but the names of Egyptian kings (*Thôs, Thuôris*) in epic and classical tradition, are not identified: Pliny (36.64) alludes to a Rameses "in whose time Troy fell." Egyptian references, however, to repeated sea-raids into the Levant. between 1230 and 1190 B.C., depict a situation closely resembling Homeric descriptions; and the *Aquaiusha* (*Akhaywasha*), *Danauna, Tikkara* (*Tzakarai*) and probably other participants in these raids may be safely recognized as Achaeans, Danaans, and Teucrians in Greek tradition. Hittite documents confirm the existence of an oversea régime called Akkhayawa, aggressive against south-west Asia Minor, one of whose leaders, Attarissyas, active in Caria and north Syria about 1230, was a contemporary, if not namesake. of Atreus, father of Agamemnon. Consequently, 19th century doubts as to the historical content of epic tradition, and attempts to discover "solar" and other mythological allegories in the personages and events of the war, are being superseded by recognition of a social and political régime historically assignable to the 13–12th centuries, of which the following are turning-points: (1) The establishment of the Trojans, with other Thraco-Phrygian peoples, in north-west Asia Minor before 1260 B C. fully justifying the defensive alliance between the Hittite king and Rameses II. in 1271 B.C. (2) The consolidation of a dominion, of which the "sixth city" at Hissarlik was an important centre; the geographical range of Priam's vassals, from the Axius river to the Xanthus, and the memory of a great fight "on the Sangarius river" far inland, are instructive. (3) The overthrow of Hittite dominion by this new régime, about 1200 B C., followed by the land-and-sea-raids of 1197–94 as far as south Palestine, where they were stopped by Rameses III. (4) The counterparts, west of the Aegean, of the dynasty Laomedon-Priam-Hector, are the "divine born" kingships (Pelops-Atreus-Agamemnon, Aeacus-Peleus-Achilles. and the like) established by adventurers of unknown antecedents, and foreign names, from Ithaca and Aetolia to Crete and Rhodes, and as far north as Thessaly; their distribution closely covering that of the "Late Mycenaean" settlements, which are surely dated archaeologically to these generations, in Egypt, Cyprus and Palestine. (5) Whether the destruction of the "sixth city" resulted from an attack of this "Achaean" confederacy of the south-west Aegean on the Hellespontine citadel of its Thraco-Phrygian cousins, or directly from those Danubian representatives of the "Lausitz" culture which characterizes the "seventh city," and is recognizable as a disturbing factor in Macedonia also, later in the 12th century, cannot at present be determined, nor the value of the synchronism between the attack on Troy and the great sea-and-land-raids towards Egypt, of which the tale of Tithonus and Memnon may preserve echoes. (6) Traditions of the establishment of settlements, eventually Greek, round the margins of the Late Mycenaean world, are so numerous, and coherent both with Homeric and with archaeological evidence, that they may be accepted as an essentially historical counterpart of the situation described in the Odyssey; which, however, was transformed as profoundly by the "coming of the Dorians" as the Mycenaean world had been by the irruption of the "divine born" adventurers five generations before. Between those two crises lies the "Heroic Age" of the Aegean; of its central episodes one is the struggle between Argos and Thebes, ended by the tragic fall of the Cadmeian dynasty; the other is the Trojan war, as disastrous to the victors as to the conquered. (J. L. MY.)

The Mediaeval Legend of Troy.—The mediaeval *Roman* de Troie, exercised greater influence in its day and for centuries after its appearance than any other work of the same class. Just as the chansons de geste of the 10th century were the direct ancestors of the prose romances which afterwards spread throughout Europe, so, even before Heliodorus and Achilles Tatius, there were quasi-histories, which reproduced in prose, with more or less exactness, the narratives of epic poetry. The Ἡρωικός of Flavius Philostratus (*fl.* 3rd century A.D.) is a discourse on 26 heroes of the war. A fictitious journal (Ephemeris), professing to give the chief incidents of the siege, and said to have been written by Dictys of Crete, a follower of Idomeneus, is mentioned by Suidas, and was largely used by John Malalas and other Byzantine chroniclers. This was abridged in Latin prose, probably in the 4th century, under the title of *Dictys Cretensis de bello Trojano libri* VI. It is prefaced by an introductory letter from a certain L. Septimius to Q. Aradius Rufinus, in which it is stated that the diary of Dictys had been found in his tomb at Knossos in Crete, written in the Greek language, but in Phoenician characters. The narrative begins with the rape of Helen, and includes the adventures of the Greek princes on the return voyage. With Dictys is always associated Dares, a pseudo-historian of more recent date. Old Greek writers mention an account of the destruction of the city earlier than the Homeric poems, and in the time of Aelian (and century A.D.) this *Iliad* of Dares, priest of Hephaestus at Troy, was believed to be still in existence. Nothing has since been heard of it; but an unknown Latin writer, living between 400 and 600, took advantage of the tradition to compile *Daretis* Phrygii de *excidio* Trojae historia, which begins with the voyage of the Argo. It is in prose and professes to be translated from an old Greek manuscript. Of the two works that of Dares is the later, and is inferior to Dictys. The matter-of-fact form of narration recalls the poem of Quintus Smyrnaeus. In both compilations the gods and everything supernatural are suppressed; even the heroes are degraded. The permanent success, however, of the two works distinguishes them among apocryphal writings, and through them the Troy legend was diffused throughout western Europe. The Byzantine writers, from the 7th to the 12th century, exalted Dictps as a first-class authority, with whom Homer was only to be contrasted as an inventor of fables. Western people preferred Dares, because his history was shorter, and because, favouring the Trojans, he flattered the vanity of those who believed that people to have been their ancestors. Many mss. of both writers were contained in old libraries; and they were translated into nearly every language and turned into verse.

In the case of both works, scholars were long undecided whether a Greek original ever existed but fragments of the Greek text of Dictys have been recovered. (*See* DICTYS CRETENSIS.) The Byzantine grammarian, Joannes Tzetzes (*fl.* 12th century), wrote a Greek hexameter poem *Iliaca* on the subject. In 1272, a monk of Corbie translated "sans rime *L'Estoire de Troiens et de Troie* (de Dares) du Latin en Roumans mot à mot" because the *Roman de Troie* was too long. Geoffrey of Waterford put Dares into French prose; and the British Museum has three Welsh mss. translations of the same author, of a much later period.

For a thousand years the myth of descent from the dispersed heroes of the conquered Trojan race was a sacred literary tradition throughout western Europe. The first Franco-Latin chroniclers traced their history to the same origin as that of Rome, as told by the Latin poets of the Augustan era; and in the middle of the 7th century Fredegarius Scholasticus (*Rcr. gall. script.* ii. 461) relates how one party of the Trojans settled between the Rhine, the Danube and the sea. In a charter of Dagobert occurs the statement, "ex nobilissimo et antiquo Trojanorum reliquiarum sanguine nati." This statement is repeated by chroniclers and panegyrical writers, who also considered the *History of Troy* by Dares to be the first of national books. Succeeding kings imitated their predecessors in giving official sanction to their legendary origin; Charles the Bald, in a charter, uses almost the same words as Dagobert, "ex praeclaro et antiquo trojanorum sanguine nati." In England a similar tradition had been early formulated, as appears from Nennius's *Historia Britonum* and Geoffrey of Monmouth. The epic founder of Britain was Brutus, son, or in another tradition, great-grandson, of Aeneas, in any case of the royal house of Troy. The tradition, repeated in Wace's version of Geoffrey, by Matthew Paris and others, persisted to the time of Shakespeare. Brutus found Albion uninhabited except by a few giants. He founded his capital on the banks of the Thames, and called it New Troy. Otto Frisingensis (12th century) and other German chroniclers repent similar myths. About 1050 a monk named Bernard wrote De *excidio Trojae,* and in the middle of the 12th century Simon Chèvre d'Or, canon of the abbey of Saint-Victor, Paris, followed with another poem in leonine elegiacs on the fall of the city and the adventures of Aeneas, in which the Homeric and Virgilian records were blended.

About the year 1184 Benoît de Sainte-More (*q.v.*) composed a poem of 30.000 lines entitled *Roman de Troie* He derived his information chiefly from the pseudo-annals of Dictys and Dares, but we may justly consider the *Roman de Troie* as an original work. From this source subsequent writers drew their notions of Troy, mostly without naming their authority and generally without even knowing his name. This is the masterpiece of the pseudo-classical cycle of romances: and in the Latin version of Guido delle Colonne it passed through every country of Europe.

The *De bello trojano* of Joseph of Exeter, in six books, a genuine poem of no little merit. was written soon after Benoît's work or about the years 1187–88. At first ascribed to Dares Phrygius and Cornelius Nepos, it was not published as Joseph's until 1620, at Frankfurt. It was directly drawn from the pseudo-annalists, but the influence of Benoît was considerable Of the same kind was the *Troilus* of Albert of Stade (1249), a version of Dares, in verse, characterized by the old severity and affected realism. But these Latin works can only be associated indirectly with Benoît, who had closer imitators in Germany at an early period. Herbort of Fritzlar reproduced the French text in his Lied *von Troye* (early 13th century), as did also Konrad von Würzburg (d. 1287) in his *Buch von Troye* of 40,000 verses, which he himself compared to the "boundless ocean." It was completed by an anonymous poet. To the like source may be traced a poem of 30,000 verses on the same subject by Wolfram von Eschenbach; and Jacques van Maerlant reproduced Benoît's narrative in Flemish. The Norse or Icelandic *Trojumanna saga* repeats the tale with some variations

In Italy, Guido delle Colonne, a Sicilian, began in 1270 and finished in 1287 a prose *Historza trojana,* in which he reproduced the *Roman de Troie* of Benoît, and so closely as to copy the errors of the latter. The vivacity and poetry of the Anglo-Norman trouvère disappear in a dry version. The immense popularity of Guido's work is shown by the large number of existing manuscripts. In the 14th and the commencement of the 15th century four versions appeared in England and Scotland. The best known is the *Troy Book*, written between 1414 and 1420, of John Lydgate, who had both French and Latin texts before him. An earlier and anonymous rendering exists at Oxford (Bodleian ms. Laud Misc. 595). There is the *Gest Hystoriale of the Destruction of Troy* (Early Eng. Text Soc., 1869–1874), written in a northern dialect about 1390; a Scottish version (1jth century) by a certain Barbour, not the poet, John Barbour; and *The Seege of Troy,* a version of Dares (Harl. ms. 525 Brit. Mus.). The invention of printing gave fresh impetus to the spread of Guido's work. The first book printed in English was *The Recuyell of the Hystoryes of Troye,* a translation by Caxton from the French of Raoul Lefèvre.

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TROYES, a town of France, capital of the department of Aube, 104 mi. E.S.E. of Paris on the Eastern railway to Belfort. Pop. (1946) 58,805. The town stands in the wide alluvial plain watered by the Seine, the main stream of which skirts it on the east. It is traversed by several small arms of the river, and the Canal de la Haute-Seine divides it into an upper town, on the left bank, and a lower town, on the right bank. The churches of the town are numerous, and especially rich in stained glass of the Renaissance period. St. Pierre, the cathedral, 13th to 16th centuries, consists of an apse with seven apse chapels, a choir with double aisles, on the right of which are the treasury and sacristy, a transept without aisles, a nave with double aisles and side chapels and a vestibule. There are stained glass windows of the 15th and 16th centuries. The treasury contains some fine enamel work and lace. The church of St. Urban has windows dating for the most part from the years 1265–80. Most of the old houses of Troyes are of wood, but some are of stone of the 16th century, notably the hôtels de Vauluisant. de Mauroy and de Marisy. The prefecture occupies the buildings of the old abbey of Notre-Dame-aux-Nonnains; the *hôtel de ville* dates from the 17th century.

Troyes is the seat of a bishop and a court of assize. Its public institutions include a tribunal of first instance. a tribunal of commerce, a board of trade arbitrators and a chamber of commerce. It has a school of hosiery. The dominant industries in Troyes are the manufacture of cotton, woollen and silk hosiery, printing and dyeing of fabrics.

History.—At the beginning of the Roman period Troyes was the principal settlement of the Trecassi, from whom it derives its name. In the first half of the 4th century its bishopric was created as a suffragan of Sens St Loup, the most illustrious bishop of Troyes, occupied the episcopal seat from 426 to 479. In the early middle ages the bishops were supreme in Troyes, but in the 10th century this supremacy was transferred to the counts of Troyes (*see* below), who from the 11th century were known as the counts of Champagne. Under their rule the city attained great prosperity. Its fairs, which had already made it a prominent commercial centre, flourished under their patronage, while the canals constructed at their expense aided its industrial development. The union of Champagne with the domains of the king of France in 1304 was disastrous to the city, since one of the first measures of Louis le Hutin was to forbid the Flemish merchants to attend its fairs. For a short time (1419–25), during the Hundred Years' War, the town was the seat of the royal Government, and in 1420 the signing of the Treaty of Troyes was followed by the marriage of Henry V. of England with Catherine, daughter of Charles VI. in the church of St. Jean. In 1429 the town capitulated to Joan of Arc. The next 100 years was a period of prosperity, marred by the destruction of half the town by the fire of 1524. In the 16th century Protestantism made some progress in Troyes, but in 1562, after a short occupation, the Calvinist troops were forced to retire, and in 1572 fifty Protestants were put to death. The revocation of the Edict of Nantes in 1685 was a severe blow to the commerce of Troyes, which was not revived by the re-establishment of the former fairs in 1697. The population fell from 40,000 to 24,000 between the beginning of the 16th century and that of the 19th century.

See T. Boutiot, *Histoire de Troyes et de la Champagne méridionale* (4 vols. Troyes, 1870–80); R. Koechlin and J. J. Marquet de Vasselot, *La Sculpture à Troyes et dans la Champagne méridionale au seizième sitcle* (1900).

TROYON, CONSTANT (1810–1865), French painter of the Barbizon school, an animal painter of the first rank, was born on Aug. 28, 1810, at Sèvres, near Paris, where his father was connected with the porcelain factory. Until he was 20 he laboured at porcelain ornamentation, but by the time he reached 21 he was traveling the country as an artist, painting landscapes. Troyon was a pupil of Camille Roqueplan, who introduced him to Théodore Rousseau, Jules Dupré and the other Barbizon painters. In 1847 Troyon went to The Hague, where he saw Paul Potter's famous "Young Bull." From the studies he made of this picture, of Albert Cuyp's sunny landscapes and of Rembrandt's masterpieces he evolved a new method of painting, and it is only in works produced after this time that Troyon's true individuality is revealed. He died at Paris on Feb. 21, 1865.

All Troyon's famous pictures are dated between 1850 and 1864. In the Wallace gallery in London are "Watering Cattle" and "Cattle in Stormy Weather"; the Louvre contains his famous "Oxen Going to Their Work" and "Returning to the Farm"; "Cattle" may be seen in the Isabella Stewart Gardner museum, Boston, Mass., "Drinking Place" in the Corcoran Gallery of Art. Washington. D.C., and "Return From Market" in the Art Institute of Chicago, Ill. Other examples are found in many public collections in the United States and Europe.

TRUCE OF GOD, an attempt of the Church in the middle ages to alleviate the evils of private warfare. The two measures which were adopted by the Church to remedy this evil—the *pax ecclesiae* or *Dei* and the *treuga* or *treva* Dei—are usually both referred to as the Truce of God, but they are distinct in character. The latter was a development of the former.

The *pax ecclesiae* is first heard of in the year ggo at three synods held in different parts of southern and central France—at Charroux, Narbonne and Puy. It enlisted the immediate support of the regular clergy, particularly the vigorous congregation of Cluny, and of William V. of Aquitaine, the most powerful lord of southem France, who urged its adoption at the councils of Limoges (994) and Poitiers (999). The peace decrees of these various synods differed considerably in detail, but in general they forbade, under pain of excommunication, every act of private warfare or violence against ecclesiastical buildings and their environs, and against certain persons, such as clerics, pilgrims, merchants, women and peasants, and against cattle and agricultural implements. With the opening of the 11th century, the *pax ecclesiae* spread over northern France and Burgundy, and diocesan leagues began to be organized for its maintenance. The bishop, or count, on whose lands the peace was violated was vested with judicial power, and was directed, in case he was himself unable to execute sentence, to summon to his assistance the laymen and even the clerics of the diocese, all of whom were required to take a solemn oath to observe and enforce the peace. At the council of Bourges (1038), the archbishop decreed that every Christian 15 years and over should take such an oath and enter the diocesan militia. The idea that peace is a divine institution seems to have given rise to a new name for the peace, the *pax Dei,* or peace of God.

The *treuga* or *treva Dei,* the prohibition of every act of private warfare during certain days, goes back at least to the Synod of Elne (1027) which suspended all warfare from Saturday night till prime on Monday. Like the *pax ecclesiae* it found ardent champions in the regular clergy, especially in Odilo (962–1049), the fifth abbot of Cluny, and soon spread over all France. It penetrated Piedmont and Lombardy in 1041 and Normandy in 1042. By this time the truce extended from the Wednesday evening to the Monday morning in every week and also, in most places, lasted during the seasons of Lent and Advent, the three great vigils and feasts of the Blessed Virgin, and those of the 12 apostles and a few other saints. The *treuga Dei* was decreed for Flanders at the Synod of Thérouanne (1063) and was instituted in southern Italy in 1089, probably through Norman influence. The bishop of Liége introduced it in Germany in 1082, and three years later a synod held at Mainz in the presence of the emperor Henry IV. extended it to the whole empire. It did not extend to England, where the strength of the monarchy made it unnecessary. The popes took its direction into their own hands towards the end of the 11th century; and the first decree of the Council of Clermont (1095), at which Urban II. preached the first crusade, proclaimed a weekly truce for all Christendom, adding a guarantee of safety to all who might take refuge at a wayside cross or at the plough. The Truce of God was reaffirmed by many councils, such as that held at Reims by Calixtus II. in 1119, and the Lateran councils of 1123, 1139 and 1179. When the *treuga Dei* reached its most extended form, scarcely one-fourth of the year remained for fighting, and even then the older canons relating to the *pax ecclesiae* remained in force. The means employed for its enforcement remained practically the same: spiritual penalties, such as excommunication, special ecclesiastical tribunals, sworn leagues of peace, and assistance from the temporal power. The Council of Clermont prescribed that the oath of adherence to the truce be taken every three years by all men above the age of 12, whether noble, burgess, villein or serf. The results of these peace efforts were perhaps surprisingly mediocre, but it must be borne in mind that not only was the military organization of the dioceses always very imperfect, but Continental feudalism, so long as it retained political power, was inherently hostile to the principle and practice of private peace. The Truce of God was most powerful in the 12th century, but with the 13th its influence waned as the kings gradually gained control over the nobles and substituted the king's peace for that of the Church.

See Du Cange, *Glossarium, s.v. Treuga;* A. Kluckhohn, *Geschichte des Gottesfriedens* (Leipzig, 1857); J. Fehr, *Der Gottesfriede und die katholische Kircke des Mittelalters* (Augsburg, 1861); E. Sémichon, *La Paix et la trève de Dieu* (2nd ed. 1869); L. Huberti, *Studien zur Recktsgeschickte des Gottesfrieden und Landfrieden,* Bd. i. *Die Friedens-Ordnungen in Frankreich* (Ansbach, 1892); E. Mayer, *Deutsche und französische Verfassungsgeschichte* (1899), vol. i.; A. Luchaire, "La Paix et la trève de Dieu," in E. Lavisse's *Histoire de France,* II. *a,* pp. 133–138 (1901). (C. H. H.)

TRUCK SYSTEM. The payment of the wages of workmen in *kind,* or in any other way than the unconditional payment of money, a practice known as the "truck system." Sometimes the workman was paid with "portion of that which he has helped to produce," but the more usual form was to give the workman the whole or part of his wages in the shape of commodities suited to his needs. There was also a practice of paying in money, but with an express or tacit understanding that the workman should resort for such goods as he required to shops or stores kept by his employer. The truck system led in many cases to grave abuses and was made illegal in Great Britain by the Truck Acts, under which wages must be paid in current coin of the realm, without any stipulations as to the manner in which the same shall be expended. (See LABOUR LAW.)

TRUFFLE, an edible, subterranean type of fungus of the class Ascomycetes. *(See* FUNGI.) Truffles have been prized as a delicacy from classical times. Pliny thought that they were among the most wonderful of all things springing up as they do and living without a root. Caelius Apicius gave six recipes for cooking them.

The subterranean Ascomycetes are usually placed in two main groups, the Tuberales and the Plectascales, depending upon the possession of fruit bodies with or without an opening to the exterior during development. The suggestion is that these have arisen along parallel lines.

The best-known genus of the Tuberales is *Tuber,* which is mainly native to temperate regions. The different species range in size from a pea to an orange. A section of a young specimen shows a whitish homogeneous flesh that, as maturity is approached, becomes a rich dark colour showing a lighter "marbling." The spores of *Tuber* are large and from one to four may be seen in an ascus. These were the first ascospores to be observed; J. P. de Tournefort described them in 1710–11. Truffles flourish in open woodland on calcareous soil. They are saprophytes, usually associated with the roots of trees and are possibly mycorhizal fungi, *i.e.*, living symbiotically with roots of higher plants (*see* MYCORHIZA).

The most valued truffle in French cookery is the Périgord (T. *melanosporum*), which is said to have first gained favour toward the end of the 15th century. It is brown or black, rounded and covered with polygonal warts having a depression at their summit; the flesh (gleba) is first white, then brown or gray, and when mature becomes black with white veins having a brown margin. The odour is well marked and not unpleasant. The main French *truffières* (truffle grounds) are in Périgord and the *département* of Vaucluse, though truffles are gathered throughout a large part of France. The truffle industry is an important one and about one-third of the gatherings are exported. The French government undertook the reforesting of many large and barren areas, for many of the best truffle regions become productive by the planting of trees, particularly oaks. As the truffles often occur at the depth of a foot it is difficult to detect them unaided. Truffles, when occurring near the surface of the ground, crack it as they reach full size and experienced gatherers are thereby enabled to locate them. Further, many species of fly live on truffles and in the morning and evening columns of small yellow flies (*Helomiza lineata*, etc.) may be seen hovering over a colony. Occasionally man is sufficiently susceptible to the scent of truffles to locate them but truffle hunting is usually carried on with the aid of pigs and dogs.

Direct cultivation is difficult. Calcareous ground is dug over and acorns or seedlings planted. Soil from truffle areas is usually spread about and the ground is kept in condition by light plowing and harrowing. After three years clearings are made and the trees are pruned. If they are to appear, the plants do so only after five years or so; gathering begins then but it hardly pays until eight or ten years have passed. The yield is at its maximum from 5 to 25 years later. Tuber *melanosporum* has not been recorded for England.

The English truffle is T. *aestivum*, which is found principally in beech woods. It is bluish black, rounded and covered with coarse polygonal warts; the gleba is white when immature, then ochreous and finally brown with white, branched, labyrinthine markings. Truffles are so rare in North America that few people have collected them in any quantity. They are found most often in Oregon and California. (J. RM.; AR. H. S.)

TRUJILLO, a province in southern Dominican Republic (pop. [1960] 249,776; area 1,445 sq.mi.), is mostly mountainous, occupying a section of the Cordillera Central (to 3,265 ft.) in the northern part, and an outlying range in the southwestern part. It is a significant producer of rice, sugar, cacao and coffee. The province was established in 1934 when the coastal plain around Ciudad Trujillo (Santo Domingo) was set aside as the federal district of Santo Domingo. The capital, San Cristóbal (1960) 15,525, was founded in 1575. The name of the province was changed to San Cristóbal in 1961. (D. R. D.)

TRUJILLO, a city in the coastal desert of northern Peru and capital of the department of Libertad, is approximately 300 mi. N.N.W. of Lima, at an elevation of about 200 ft. above sea level. It is 8 mi. from its port, Salaverry, with which it is connected by rail. Pop. (1958 est.) 59,265. The climate is cool and dry with temperatures averaging between 63° F. in June and 74.3° F. in March. The coolness of the air, in spite of its tropical location, is due to the cold Peruvian current. The figure generally quoted for the average annual rainfall (1.2 in.) is misleading, for in most years there is no rain. Trujillo is the commercial and industrial centre of the department, and is one of the important cities of Peru. The irrigated lands around the city produce sugar cane and rice, sugar being exported in large quantity. Trujillo serves two important mining communities in the northern Andes: Quiruvilca (copper) and Milluachaqui (gold and silver). Transport facilities include railroads, the Inter-American highway, an all-weather highway to the highland mines, an airport and a seaport. It has a considerable industrial development and its products include foods (rice, noodles, chocolate, confectionery), beer, leather, cocaine, soap, wax, candles, textiles and machinery.

The city was founded in 1534 by Diego de Almagro, and is Peru's second oldest Spanish city (the oldest is Piura). During the colonial period it enjoyed little prosperity for most of the wealth was concentrated in Lima. In 1617 a wall was built around the city as a defense against the attacks of English pirates, and traces of this wall could still be seen in the second half of the 20th century. The city was partially destroyed by earthquakes in the 17th century and again in the 18th century. Its modern growth followed British investments in sugar-cane plantations during the latter part of the 19th century. Trujillo remains essentially a city of old churches and has a cathedral and also several colonial mansions. The University of La Libertad is there. Four miles west are the pre-Inca ruins of Chan Chan (*q.v.*). (P. E. J.)

TRUJILLO VALDEZ, a province in southern Dominican Republic. Pop. (1960) 106,736; area, 626 sq.mi. It is largely mountainous, being bounded on the north by the Cordillera Central and crossed in the central part by the Sierra de Ocoa (to 5,678 ft.). The southern coastal plain is semiarid. The province is a leading coffee producer and a significant producer of rice and peanuts. Trujillo Valdez was created in 1944 from parts of Trujillo and Azua provinces; it was renamed Peravia in 1961. The provincial capital is Bani (pop. [1960] 14,472). (D. R. D.)

TRUMAN, HARRY S. (1884–), 33rd president of the United States, was born May 8, 1884, in Lamar, Mo., the son of Martha Ellen and John Anderson Truman. Soon after his son's birth, John Truman moved to Independence, Mo., where he purchased a small farm. John Truman made a comfortable living for his family, and from his childhood Harry Truman was called on to perform his daily chores and to help on the farm. He was regarded as a bright student by his teachers and he was graduated from high school at the age of 17. Financial considerations kept him from college and nearsightedness from appointment to the U.S. military and naval academies. After finishing high school, he left the farm to go to Kansas City, Mo. Depressed after five years with the prospects of carving out a career for himself in the city, he returned to his father's farm.

The entrance of the United States into World War I in 1917, however, uprooted him from his tranquil life on the farm. Truman, who had joined the national guard while in Kansas City, was called up for service and he sailed for France with a commission as a first lieutenant with an artillery unit. Modest and shy, he made little impression on the members of his unit in the pre-combat phase of their training. But in action, he proved to be a cool and resourceful leader. He participated in the St. Mihiel and Meuse-Argonne operations in 1918 and showed great consideration for the members of his battery, an attribute which won him their affection and admiration. Truman's commanding officers also recognized his ability, and toward the end of the war he was promoted to the rank of captain.

After the Armistice and upon his return to the United States, Truman married, June 28, 1919, Bess Wallace, a childhood sweetheart. They had one daughter, Mary Margaret Truman. Unwilling to return to farming, Truman and an army comrade set up a haberdashery in Kansas City. This venture failed after the depression of 1921 and left Truman saddled with debts totalling about $20,000. He refused to file bankruptcy proceedings and insisted upon repaying his creditors penny for penny. It took him more than ten years to do this.

This was a dismal epoch in Truman's life. Searching about for a job, he looked up another comrade in arms, who introduced him to Thomas J. ("Tom") Pendergast, then entering his heyday as boss of the Democratic machine that ruled Kansas City, and later Missouri, politics with an iron hand. Pendergast, a shrewd assayer of the vote-getting potentialities of aspirants for public office, regarded Truman's Baptist, Masonic and American Legion connections and his war record as political assets. He appointed Truman to the post of overseer of highways for Jackson county. After serving one year in the highway department, Truman was picked by Pendergast to run for the post of county judge for Jackson county. He was elected and served in this post from 1922 to 1924. He was defeated when he ran for a second term in 1924, but came back in 1926 and was elected presiding judge, a post he held until he became senator. Truman was determined to measure up to his new title and although the state laws of Missouri did not require that a county judge should be a qualified lawyer, he studied law in a Kansas City night school from 1923 to 1925.

Despite his association with the Pendergast political machine, whose dishonesty and corrruption were recognized and part of the public record, Truman established a reputation for personal honesty that was never questioned.

Election as Senator. — In 1934 Truman ran for senator. Accounts differ as to how he was selected for this post. One version said he had asked Pendergast for a particular post that paid about $25,000 annually in fees. According to this story, the Missouri state boss demurred, protesting that Truman did not as yet have the qualifications for that lucrative position and offered him, instead, the candidacy for U.S. senator, an office which paid $10,000 annually. More credible is the story that Truman was urged by friends to file for the senatorship and that Pendergast, needing a respectable name on his own slate to defeat Sen. Bennett Champ Clark's candidate, agreed to support Truman.

Truman won in the primary by a plurality of about 40,000 votes. He later won the election. The machine support was extremely effective in both the primary and the final election.

In 1940, when Truman came up for re-election, his defeat was predicted by many. The Pendergast machine had collapsed. Two years before, in 1938, a grand jury convicted more than 250 persons, most of them "machine" stalwarts, who had been indicted on charges of vote fraud. Pendergast himself had been convicted of income tax evasion and was sentenced to serve a prison term. His machine was thoroughly discredited and it was believed that Truman's association with Pendergast would prove a handicap. However, Truman not only won the primary but also emerged victor in the regular election.

While his foes always made capital out of his affiliations with the Missouri machine, Truman had never tried to conceal the fact that it was with Pendergast's help that he got his political start. His views on the ethics of machine politics were frank and perhaps practical in a broad sense of the term. In an interview regarding this matter, he declared: "There was nothing wrong with my relations with the Pendergast machine. . . . Every Democratic politician including myself went to Tom Pendergast for support. . . ." After he was nominated for the vice-presidency, he steadfastly refused to heed the pleas of fellow Democrats who urged him to disown his political mentor, and he even attended Pendergast's funeral in Jan. 1945. His defenders stressed that his attitude on the necessity of machine support was perhaps no different from that of scores of other politicians. Republicans or Democrats, holding high and responsible public offices. An offshoot of Truman's view on the political machine was his belief in political patronage.

Truman's first term in the senate (1935–41) was not highlighted by any marked accomplishments. He served on Sen. Burton K. Wheeler's committee investigating railroads and made modest fame as an able investigator and cross-examiner.

Although Truman probably did not realize it at the time, his path to the White House was fixed at the start of his second senate term. As a result of letters from friends and his own investigations revealing waste and graft in many national defense projects, he introduced a resolution for creation of a senate committee to act as "watchdog" of the rearmament program. As is customary, he was named chairman because of having proposed the action.

The Truman committee did an excellent and impartial job. It exposed grafting contractors, revealed collusion between corporation agents and certain army officials, and urged more comprehensive planning for conduct of the war and for postwar reconstruction. It is estimated that the committee saved the government hundreds of millons of dollars. This investigation first made the hitherto obscure Missourian a national figure.

Vice-President and President. — As the Democratic convention assembled in 1944, the big city bosses — Edward J Flynn of New York city, Frank Hague of New Jersey, Edward J. Kelly of Chicago, Robert E. Hannegan of St. Louis — convinced Franklin D. Roosevelt that Henry A. Wallace's radical, pro-Russian sympathies would endanger the ticket in the south and in metropolitan areas. Roosevelt then wrote a letter to the convention, suggesting Truman or Justice William O. Douglas as possible vice-presidential nominees. The bosses preferred Truman, who was nominated on the second ballot.

When President Roosevelt died April 12, 1945, Truman was sworn in as chief executive, asking newspaper friends to "pray for me." He knew his limitations, especially since Roosevelt had not consulted him on major domestic or foreign problems since the election five months before. It is doubtful that any president entered the White House more unprepared than Truman. At the outset, however, he had only to preside over the final conquest of Germany and Japan, for the plan of victory had been fixed and put into effect before he took office. On April 25 axis defeat was so assured that he addressed the United Nations Conference on International Organization at San Francisco, Calif. He urged creation of a "strong and lasting" organization that would make "future peace not only possible but certain." On May 8 he announced the surrender of Germany. In July he authorized and later announced the virtual destruction of Hiroshima by the first atomic bomb. On Aug. 14 he announced Japan's capitulation.

Truman's own legislative program, which he called the Fair Deal and uhich proposed even more far-reaching domestic reforms than Roosevelt had sponsored, was first presented to congress on Sept. 6. 1945 It began the breakup of the artificial coalition which had backed Roosevelt through depression and war years and which had offered its support to Truman on the assumption that he would lean toward the conservative side. Conservative elements of both Republican and Democratic parties, the latter principally from the south, blocked enactment of Truman's domestic program, until he was eventually forced to abandon most of it. The pressure of foreign problems after 1947 (as during Roosevelt's third term) gave Truman good cause for subordinating controversial domestic issues.

Serious strikes in several heavy industries, hampering production of consumer goods, embarrassed the admittedly prolabour administration A politico-economic crisis occurred in Aug 1946, when a railroad brotherhood strike threatened to tie up national transportation. Truman asked congress for a law to draft into the armed services anyone refusing to work in industries taken over by the government. His request embittered certain labour leaders, even though congress refused to grant it.

Another significant labour event of 1946 was the government's injunction to prevent a coal strike. When John L. Lewis, head of the United Mine Workers of America, ignored the order, he and his union were assessed fines totalling more than $3,000,000 by a federal court.

The "Cold War"; Korea. — These domestic problems, however, dwindled into insignificance as Truman tried to tackle the Russian problem. In July 1945 he had met with British Prime Minister Winston Churchill and Premier Joseph Stalin of the U.S S R. at Potsdam, Ger., for a discussion of postwar problems. Prospects for mutual understanding seemed favourable at the time, but the amity did not last. As the U.S S.R. became increasingly recalcitrant and then openly hostile, Truman was forced to ask for the resignation of Henry A. Wallace as secretary of commerce On Sept. 12, 1946, Wallace had delivered a speech in New York city undermining Secretary of State James F. Byrnes's position vis-a-vis Russia at the Paris peace conference. Truman nominated W. Averell Harriman, former ambassador to Moscow, to replace Wallace. When Harold L. Ickes resigned as secretary of the interior in a dispute with the White House over oil tidelands, Truman replaced him with J. A. Krug. On the resignation of Byrnes, Truman named Gen. George C. Marshall secretary of state.

But the development which affected the Truman administration most markedly and premonitorily shifting emphasis from domestic to foreign problems, was the British government's official notice in Feb 1947 that it could no longer afford to supply military and economic aid to Greece and Turkey, key Mediterranean countries which the U.S.S.R. sought to bring into its orbit. In what became known as the Truman doctrine, the president announced that the U.S. would undertake this responsibility. This was the inauguration of an ever-widening program under which the U.S. took over the global burdens England had borne since the middle of the 18th century.

The foreign-aid program was soon expanded following an address delivered by Secretary of State Marshall at Harvard university in June 1947 in which he proposed vast U.S. financial aid to restore Europe's shattered economy. Although he included the U.S.S.R. and its satellites among the prospective beneficiaries of the Marshall plan (European Recovery program). Moscow chose to regard the offer as an "imperialistic" manoeuvre, and refused to join. Under the Marshall plan, the U.S. spent $12,000,000,000 for European recovery during 1948–51 alone.

Meanwhile a new problem had arisen in the far east, where Chinese nationalists under Chiang Kai-shek and Communists under Mao Tse-tung were warring for control. In 1946 Truman had sent General Marshall to China in an effort to negotiate an agreement between the t o factions. After more than a year of futile talks, Marshall reported no progress and recommended withdrawal of U.S. economic and military aid from the nationalists. This action, together with evidence that certain state department officials sympathized with the Communists in the belief that they were mere "agrarian reformers," led to Republican charges that the administration was responsible for the loss of China to the Reds.

Associated with this issue were charges by the house committee on un-American activities and by Sen. Joseph R. McCarthy of Wisconsin that the administration was "coddling Communists" within the government, especially in the state department. Truman angrily denounced these allegations as "a red herring." But when a federal court convicted Alger Hiss, a former state department official and Yalta conference adviser, of perjury for denying before a federal grand jury that he had relayed official documents to a Soviet agent. Truman set up a federal loyalty board to weed out subversives among government employees.

Relations with the U.S.S.R. continued to deteriorate until the two countries became engaged in what was described as the "cold war." It developed into a shooting affair on June 25, 1950, when North Korean Communists attacked South Korea. Truman acted promptly. Committing U.S. forces without prior authorization by congress, he obtained United Nations sanction for the action. Characterizing the invasion as a "direct challenge to the United Nations," he announced that the U.S. had no aggressive or imperialistic aims in China, and he requested Chiang Kai-shek, the Chinese nationalists' leader on Formosa, not to attack the mainland. Gen. Douglas MacArthur was named commander of the United Nations forces in Korea.

After initial reverses which forced the U.N. forces to withdraw into a small area around Pusan in southeast Korea, General MacArthur launched an amphibious attack at Inchon, far behind the North Korean lines. By Nov. 1950 most of Korea was under U.N. control. The whole complexion of the military scene changed later that month, however, when Chinese Communists reinforced the North Koreans and dealt a severe setback to the U.N. forces (of which about 90% were U.S.). President Truman then placed the U S on a semiwar basis, calling for a greatly expanded defense establishment, partial mobilization of industry, huge appropriations and controls of wages, prices and materials. Congress gave him almost all the authority and funds he asked in response to his warning that "our homes, our nation, and all the things we believe in, are in great danger—danger created by the rulers of the Soviet Union."

On Dec. 16, 1950, Truman proclaimed a national emergency and organized a virtual wartime cabinet. with Charles E. Wilson as director of defense mobilization. Besides imposing controls on wages, prices and material allocations, Wilson began a slow but ordered shift from civilian to military production to make the **U.S.** and its allies capable of resisting Russian attack.

As a further bulwark against the U.S.S.R. the United States inspired formation of the North Atlantic Treaty organization (NATO), consisting of the U.S., Canada, Iceland and nine western European states. On Dec. 19, 1950, the NATO council approved the appointment of Gen. Dwight D. Eisenhower, then president of Columbia university, as organizer of a western European army under NATO auspices.

On April 11, 1951, President Truman removed General MacArthur from his posts as commander of U.S. and U.N. forces in the far east. Truman justified his action on the ground that MacArthur's proposed tactical plan, which included bombing of Communist bases in North Korea and China, would have transformed a local conflict into a possible global war. Returning to the U.S., MacArthur delivered a series of speeches attacking the administration's policies in the far east.

Domestic Problems; Decision Not to Run Again.—In view of unsettled conditions at home and abroad, Truman's election in 1948 had been a minor miracle of U.S. politics. Powerful influences within the party, including political professionals and liberals, wanted to sidetrack him in favour of General Eisenhower. The election of Gov. Thomas E. Dewey of New York, the Republican nominee, was forecast by almost every public-opinion poll and political prophet. But Truman made what he called a "whistle stop" campaign, appearing before thousands of voters in every section except the south and assailing the Republicans as reactionaries and isolationists

Truman received 303 electoral votes and Dewey 189, with 39 going to the States' Rights Democrats ("Dixiecrat") ticket, which was entered in the race as a southern protest against the strong civil rights plank in the Democratic platform. The "Dixiecrat" ticket was headed by J Strom Thurmond of South Carolina with Fielding L. Wright of Mississippi the vice-presidential candidate.

Congressional revelations of corruption and maladministration in several executive agencies, notably the bureau of internal revenue, the Reconstruction Finance corporation and the department of justice. embarrassed the administration in 1950–51. After defending his appointees for almost a year, the president discharged many high government and political officials and ordered Attorney General J Howard McGrath to "clean up" venal conditions among federal officeholders.

On Nov. 1, 1950, President Truman was the object of an attempted assassination. He escaped unharmed. One assassin was killed and the other wounded; one secret service guard was killed and two others wounded. The would-be assassins, Griselio Torresola (killed) and Oscar Collazo, were Puerto Rican nationalists.

Truman's seizure of the steel industry April 8, 1952, to avoid a strike precipitated a grave constitutional issue which was settled only when the supreme court, by a vote of six to three, ruled that the seizure was unconstitutional. Truman announced March 29, 1952, that he would not run for the presidency again, although he made another "whistle stop" tour in support of the unsuccessful Democratic nominee. Adlai E. Stevenson. At the 1956 Democratic National convention. Truman supported Xverell Harriman, but Stevenson was again nominated and again defeated at the polls. The same year Truman made a tour of Europe, and he received an honorary degree from Oxford university. In 1957 the Harry S. Truman library, part of the national archives, was dedicated in Independence, Mo. His *Memoirs* were published in two volumes, 1955–56. (R. Tu.; X.)

See William Hillman (ed), ***Mr. President*** *(1952)*

TRUMAN DOCTRINE. As the union of the World War II Allies dissolved in the emerging "cold war," conflict in Greece (1944–49) between the communist-oriented National Liberation Front (EAM) and the British-supported government forces created what Pres. Harry S. Truman called a "grave situation."

Considering Greece as outside the Soviet sphere of influence since the Oct. 1944 Churchill agreement with Stalin, but unable in its economic condition to maintain its strategic commitments, the British government asked the United States for aid to save Greece and Turkey for the free world.

President Truman, in a historic about-face in U.S. foreign policy, on March 12, 1947, asked a joint session of congress to provide $400,000,000 in military and economic aid to Greece and Turkey to stop the spread of communism in the Balkans. Such aid, according to the president, did not necessarily constitute an endorsement of the governments of these countries.

The subsequent United Nations investigatory commission report of May 23, 1947, which charged that Greek guerrillas were receiving aid from across the Yugoslav, Bulgarian and Albanian frontiers, had not as yet been issued, but President Truman was sure that the spread of communism to Greece and Turkey would have a decidedly bad effect upon the middle east, Italy and western Europe. The appeal of the Greek and Turkish governments for aid on March 3, 1947, was promptly met. The president's request was passed by congress and signed on May 22, 1947. The "Truman Doctrine," thus formed, was considered by the president as "the turning point in America's foreign policy, which now declared that whenever aggression, direct or indirect, threatened the peace [and] security of the United States . . . ," action would be taken to stop that aggression. *See* also GREECE: *Modern History;* TURKEY: *The Republic.*

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TRUMBIĆ, ANTON (1863–1938), Yugoslav statesman, was born at Split. He became successively mayor of Split, and deputy for the city in the Dalmatian diet, and after 1907 deputy in the Austrian parliament. In 1905 he and his fellow Dalmatians, Pero Čingrija, Smodlaka and Supilo, as delegates of the Croat National party, worked for the renewed co-operation between Serb and Croat, which culminated in the resolutions of Fiume and Zara in 1905, and in the parallel negotiations with the Magyar coalition parties. In 1917 Trumbić and others negotiated, with the exiled Serbian government in Corfu and representatives of all the Serbian parties, the so-called "Declaration of Corfu," which provided the basis for a united Yugoslav state. Trumbić met representative Italians in Dec. 1917 and March 1918, and shared in the arrangements for the congress of oppressed nationalities held in Rome in April. In Oct. 1918 Trumbić was appointed foreign minister in the Yugoslav provisional government and peace delegate in conjunction with Pašic and Vesnić. The Yugoslavs were obliged to come to a direct agreement with Italy, and the Treaty of Rapallo was signed in Nov. 1920.

Trumbić's long absence in Paris, coupled with the policy of abstention pursued by the Croat Peasant party under Radić, placed him at a fatal disadvantage when the question of the new constitution came up in 1921. The sudden *volte face* of Radić after the elections of 1925 left Trumbić somewhat isolated, as the leader of the newly constituted "Croat Federalist Peasant party."

TRUMBULL, JOHN (1750–1831), U.S. poet known for his political satires, was born in what is now Watertown, Conn., on April 24, 1750. At the age of seven he passed the entrance examinations at Yale, but did not enter until 1763, when he was 13; he graduated in 1767, remained at the college studying, and in 1771–73 was a tutor. He spent a year in Boston in the office of John Adams, and after 1774 practised law in Connecticut. He was state's attorney in 1789, a member of the Connecticut assembly in 1792 and 1800, a judge of the superior court in 1801 and a judge in the supreme court of errors in 1808; the last two positions being held until 1819. The last six years of his life were spent in Detroit, Mich., where he died on May 11, 1831.

While studying at Yale he had contributed in 1769–70 ten essays, called "The Meddler," imitating *The Spectator,* to the *Boston Chronicle,* and in 1770 similar essays, signed "The Correspondent" to the *Connecticut Journal* and *New Haven Post Boy.* While a tutor he wrote his first satire in verse, *The Progress of Dulness* (1772–73), an attack in three parts on educational methods of his time. His great poem, which ranks him with Philip Freneau and Francis Hopkinson as an American political satirist of the period of the Revolutionary War, was *M'Fingal,* of which the first canto, "The Town Meeting," appeared in 1776 (dated 1775). This canto, about 1,500 lines, portrays a Scotch Loyalist, M'Fingal, and his Whig opponent, Honorius, apparently a portrait of John Adams. This first canto was divided into two, and with a third and a fourth canto was published in 1782 bringing the poem's total length to 3,000 lines. After the war Trumbull was a rigid Federalist, and with the "Hartford Wits," David Humphreys, Joel Barlow and Lemuel Hopkins, wrote *The Anarchiad,* a poem directed against the enemies of a firm central government.

BIBLIOGRAPHY.—V. L. Parrington, *The Connecticut Wits* (1926), *The Colonial Mind* (1927); A. Cowie, *John Trumbull: Connecticut Wit* (1936); Leon Howard, *The Connecticut Wits* (1943).

TRUMBULL, JOHN (1756–1843), U.S. patriot-artist, visual recorder of the American Revolution, author and amateur architect, was born on June 6, 1756, at Lebanon, Conn., the brilliant and erratic son of Gov. Jonathan Trumbull. A boyhood injury to his left eye made him virtually monocular, with the consequence that his small-scale work is finer than the large. He was educated locally and attended Harvard college for a year and a half, graduating in 1773, the youngest member of his class. Returning to Lebanon he taught school and prepared maps of Connecticut's western claims for his father. During the American Revolution he served with the 1st Connecticut regiment under Gen. Joseph Spencer, as an aide to General Washington (who utilized his ability as a cartographer at Boston) and with Gen. Horatio Gates at Ticonderoga, achieving a colonelcy before reaching the age of 21. Thus he unconsciously provided himself with the subject matter that was to be his lifework.

He resigned his improperly dated commission and in 1780 left for London to study under Benjamin West. There, as a reprisal for the hanging of the British agent Maj. John André (*q.v.*), he was imprisoned, improving his time the while by studying architecture at the insistence of Edmund Burke. Released, he returned home but was back in London by 1784, again working under West. Shortly thereafter he abandoned his early Copley manner of painting, when Sir Joshua Reynolds pronounced Trumbull's portrait of Jeremiah Wadsworth and his son Daniel "bent tin"; he adopted, instead, the current English mode. He was also influenced by the work of his French friends, Jacques Louis David and especially Mme. Vigée-LeBrun.

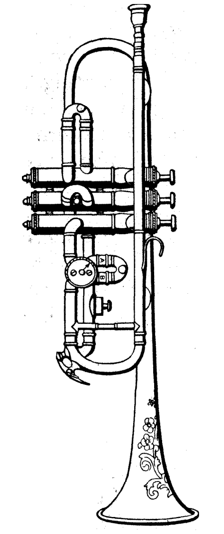
At the suggestion of West and with the encouragement of Thomas Jefferson he began his celebrated historical series. In 1789 he was back in the U.S. collecting data and soliciting subscriptions for the projected engravings to be made after the small original paintings (now at Yale university). He returned to London in 1794 as secretary to John Jay, remaining for ten years as a commissioner for the implementing of the Jay treaty—to the great detriment of his art. In 1800 he married an Englishwoman, the beautiful Sarah Hope Harvey. Once again in the U.S. (1804–08), he designed the Congregational meetinghouse at Lebanon, his only architectural work to survive, and painted panoramas of Niagara falls. In 1808 he attempted portrait painting in London with little success. From 1815 to 1837 he maintained a studio in New York city, where he executed four of the eight large pictures in the rotunda of the Capitol at Washington ("Washington Resigning His Commission," "The Surrender of Cornwallis," "The Surrender of Burgoyne" and, best known of all Trumbull's paintings, "The Declaration of Independence"). He was the dictatorial president (1817–36) of the American Academy of Fine Arts, the younger members of which seceded under S. F. B. Morse to found the National Academy of Design in 1826. In 1831 the artist gave his best work to Yale university in exchange for an annuity. The Trumbull gallery at Yale, designed by him, was founded by the scientist Benjamin Silliman, his nephew-in-law, at whose New Haven home he wrote his *Autobiography* (1841; edited and supplemented by T. Sizer, 1953). He died on Nov. 10, 1843, and according to his wish lies buried, with his wife, under the Yale Art gallery.

See Theodore Sizer, *The Works of Col. John Trumbull, Artist of the American Revolution* (1950); Mary Bartlett Cowdrey, *American Academy of Fine Arts and American Art-Union, 1816–1852,* vol. i, pp. 3–94 (1954). (T. SR.)

TRUMBULL, JONATHAN (1710–1785), American political leader, was born at Lebanon, Conn., on Oct. 12, 1710. He graduated from Harvard in 1727 and began the study of theology, but in 1731 engaged in business with his father. He next studied law, was elected to the assembly in 1773 and held public office almost continuously afterward. He served for 7 years in the assembly, being speaker for 3 years; for 17 years as county judge of Windham County; for 23 years (after 1740) as governor's assistant; for 2 years as deputy governor (1767–69); and for 3 years (1766–69) as chief justice of the colony. In 1769 he was elected governor and continued in office until his voluntary retirement in 1784. During the War of Independence he was a valued counsellor of Washington. The story that the term "Brother Jonathan," a sobriquet for the United States, originated in Washington's familiar form of addressing him seems to be without any founrlation. After the war Trumbull was a strong Federalist. He died in Lebanon on Aug. 17, 1785.

Bibliography.—His public papers have been printed in the Massachusetts Historical Society's *Collections*, 5th series, vol. ix, x (1885–88), and 7th series, vol. ii, iii (1902). See I. W. Stuart, *Life of Jonathan Trumbull*, sen. (1859).

TRUMPET, in music, a brass wind instrument with cup-shaped mouthpiece and a characteristic tone. It consists of a brass or silver tube with a narrow cylindrical bore except for the bell joint, forming from one-third to one-fourth the length, which is conical and terminates in a bell of moderate diameter. The tube of the trumpet is doubled round upon itself to form a long irregular rectangle with rounded corners. A tuning slide consisting of two U-shaped cylindrical tubes fitting into each other is interpolated between the bell joint and the long cylindrical joint to which the mouthpiece is attached.



BY COURTESY OF BOOSEY & CO., LONDON

THE TRUMPET, SHOWING THE MODERN FORM EQUIPPED WITH VALVES

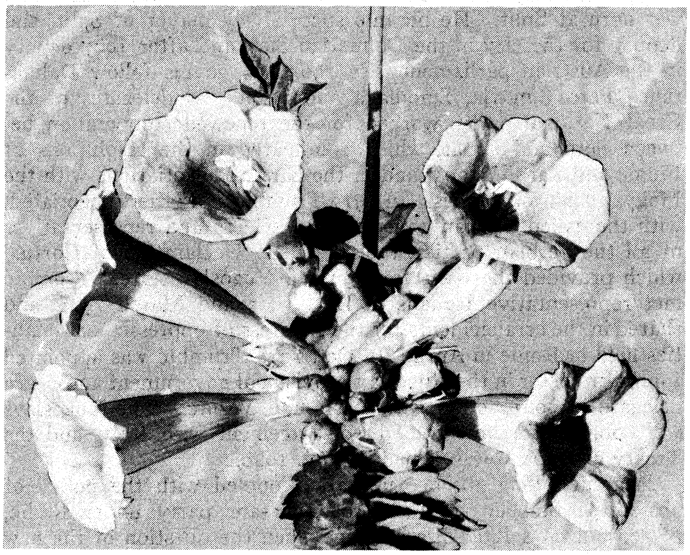
The mouthpiece consists of a hemispherical cup with a rim across which the lips stretch. The shape of the cup, and more especially of the bottom. in which is pierced a hole communicating with the main bore, is of the greatest importance on account of its influence on the tone quality and on the production of the higher harmonics. It is recognized that the shallower and smaller the cup the more easily are the higher harmonics produced; the sharper the angle at the bottom of the cup the more brilliant and incisive is the timbre, given, of course, the correct style of blowing. The diameter of the cup varies according to the pitch and to the lip power of the player who chooses a cup to suit him.

There are three principal kinds of trumpets: (1) the natural trumpet. mainly used in cavalry regiments, in which the length of the tube and pitch are varied by means of crooks; (2) the slide and double-slide trumpets. in which a chromatic compass is obtained, as in the trombone, by double tubes sliding upon one another without loss of air; (3) the valve trumpet. similar in its working to all other valve instruments. The first and second of these alone give the true trumpet timbre. The tone of the valve trumpet approximates that of the cornet; nevertheless, it is now almost universally used.

In the trumpet the notes of the harmonic series from the 3rd to the 10th or 16th upper partials are produced by the varied tension of the lips and pressure of breath called overblowing. The fundamental is not often used but the second harmonic is the regular pitch note of the modern trumpet; the next octave from the fourth to the eighth harmonics contains only the third, fifth and minor seventh, and is therefore mainly suitable for fanfare figures based on the common chord. The diatonic octave is the highest and its upper notes are only reached by very good players on trumpets of medium pitch.

The lituus or cavalry trumpet of the Romans seems to have vanished with the fall of the Roman empire. Its successor, the cavalry trumpet of the 15th and succeeding centuries. was evolved from the straight busine, an instrument traced, by means of its name no less than by the delicate proportions of its tube and the shape of the bell, to the Roman buccina (*q.v.*). The bending of the tube of the trumpet in three parallel branches, thus creating its modern form, has usually been claimed for a Frenchman named Maurin (1498–1515). But the transformation was really made much earlier, probably in the Low Countries or north Italy; in any case it had already been accomplished in the bas-reliefs of Luca della Robbia intended to ornament the organ chamber of the cathedral of Florence where a trumpet having the tube bent back as just described is very distinctly figured. And this shape the instrument retained for more than 300 years. Later crooks and slides were introduced, then keys, and finally in 1815 Heinrich Stölzel made the first completely satisfactory chromatic trumpet by the invention of the ventil or piston. (See Wind Instruments.)

TRUMPET CREEPER, common name for *Campsis*, a genus of ornamental deciduous perennial vines. One species, *Campsis vudicans*, also called trumpet vine and cow itch, occurs naturally in the United States from Pennsylvania and Illinois to Florida and Texas. Although often an aggressive weed in parts of the south, it is frequently grown as a climbing ornamental and as a cover for banks. It clings firmly to its support by the aerial rootlets developed at the nodes. Numerous handsome, tubular orange and scarlet flowers are borne in terminal racemes. The Chinese trumpet creeper. C. *grandiflora* (*C. chinensis*). produces few to no aerial rootlets and thus is not a good climber, but produces larger and more brilliant flowers. It is not hardy in the U.S. as far north as the native species. A hybrid between the two species, sometimes referred to as *C. tagliabuana* or *C. kybrida*, is rather intermediate but tends to be more bushy. It blooms while quite small and is suited for pot growing. Trumpet creepers are propagated by seeds. by cuttings of both green and mature wood, by root cuttings and by layering. (J. M. Bl.)



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TRUMPET CREEPER (CAMPSIS RADICANS) FLOWERS

TRUMPETER or Trumpet Bird, a South American bird of the Psophiidae family, so called from the sound it utters. The family contains the single genus *Psophia* with half a dozen species, differing in little but colour and size. The range of several species seems to be separated by rivers (Wallace, *Geogr. Distr. Animals*) and in this connection it may be observed that the birds seldom fly, though they run very fast. The best-known species, *P. crepitans*, inhabits Guiana and is about the size of a large barn-door fowl, but with longer legs and neck. The plumage is black with green and violet reflections on the tips of the neck feathers and a brown and gray patch on the back. The legs are bright green and the hird lays white eggs, about the size of a bantam's egg.

Although the trumpeters must undoubtedly be accorded the rank of a distinct family, Psophiidae, like so many other South American birds they seem to be the less specialized descendants of an ancient generalized group — perhaps the common ancestors of the Rallidae and Gruidae. The structure of the trachea, though different from that described in any crane (*q.v.*), suggests an early form of the structure which in some of the Gruidae is so marvellously developed, for in *Psophia* the windpipe runs down the breast and belly immediately under the skin to within about an inch of the anus, whence it returns in a similar way to the front of the sternum, and then enters the thorax. Analogous instances of this formation occur in several other groups of birds not at all allied to the Psophiidae.

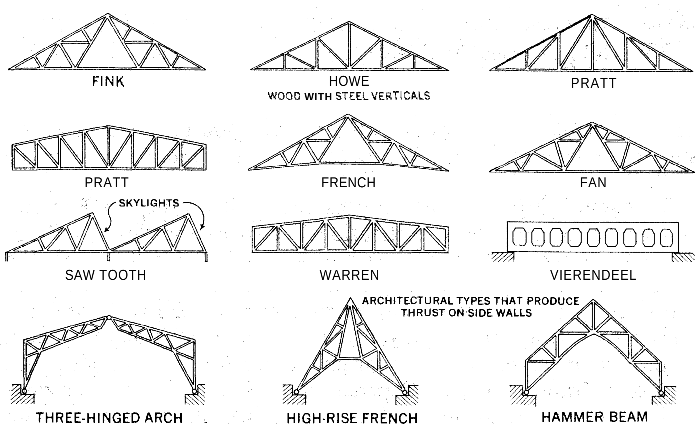
TRUMPLER, ROBERT JULIUS (1886–1956), Swiss-U.S. astronomer known for his extensive studies of galactic star clusters. for observational tests of relativity theory and for his study of Mars Born at Zurich. Switz., on Oct. 2, 1886. he was educated there and in Germany After a postdoctoral year at Gottingen (1911) and a period with the Swiss geodetic survey, Trumpler became a staff member of the Allegheny observatory, Pittsburgh, Pa., in 1915. He joined the staff of the University of California's Lick observatory in 1919 and transferred to the Berkeley campus in 1938. He retired, as professor emeritus, in 1951.

Trumpler who was a skilled observer, discovered the differences in galactic clusters used to determine their ages and proved that there exists in the Milky Way a tenuous interstellar haze that dims the light of stars seen through it. Recognition of the existence of interstellar material and its effects brought about a profound change in modern understanding of the character and extent of the stellar system in which the sun and planets are located He was elected to the National Academy of Sciences in 1932. Among his publications are: *Observations of the Deflection of Light Passing Through the Sun's Gravitational Fzeld,* with W. Campbell (1923); *Spectral Types in Open Clusters* (1925); *Observations of Mars at the Opposition of 1924* (1927); *Preliminary Results on the Distances, Dimensions, and Space Distribution of Open Star Clusters* (1930); *Observational Evidence* of *a Relativity Red Shift in Class O Stars* (1935). (H. F. Wr.)

TRURO, a cathedral city and municipal borough in the Truro parliamentary division of Cornwall, Eng., 25 mi. S.W. of Bodmin. Pop. (1951) 12,860; area 4.1 sq.mi. It lies in a shallow valley at the confluence of the Kenwyn and Allen, uhich together form the Truro, and its rise was greatly due to this position at the head of a tidal estuary. It is the administrative and ecclesiastical centre of Cornnall. The cathedral church of St. Mary, begun in 1880 by J. L Pearson, is in Early English style with Normandy Gothic spires. The episcopal see covers the whole of Cornwall, the Scilly Isles and three parishes in Devon. In the town are technical and art schools. a library and a museum. Truro's municipal charter dates from between 1130–40; a new charter was given in 1589; in 1877 the borough became a city. From 1295 to 1885 Truro returned two members to parliament. Industries include a pottery. sawmills, a biscuit factory and knitting mills. Small vessels can lie at the quays, though the harbour is dry at low water. China clay is the chief export

TRUSCOTT, LUCIAN KING (1895–), U.S. army officer, was born at Chatfield. Tex., Jan. 9, 1895. Commissioned as a 2nd lieutenant of cavalry in 1917, he had an uneventful career in World War I followed by long training as a student and instructor in army schools during the 1920s and 1930s and two tours as commander of a troop. During World War II. after unique and valuable experience in the Dieppe raid (Aug 1942), Truscott, as a major general. successively commanded a brigade-size task force in the north African invasion. (Nov. 1942), served as the "eyes and ears" of Gen. Dnight D. Eisenhower during the reverses in southern Tunisia and trained and led the U.S. 3rd infantry division in the Mediterranean through the operation in Sicily and the early phases of the Italian campaign As deputy commander of the 6th corps in Italy, he took energetic measures to strengthen its defense and frustrated the Germans' strongest efforts to eliminate the beachhead at Anzio Taking command of the 6th corps in March 1944. he planned and directed the breakout of the beachhead, and later led the amphibious assault on southern France and the drive up the Rhône valley. Returning to Italy in Dec. 1944, he led the 5th army in its final victorious drive to the Alps. Truscott's *Command Missions* (1954) stands out as an honest and knowledgeable contribution to the study of war.

TRUSS, as used in engineering and architecture, is a structural member usually fabricated from straight pieces of metal or timber to form a series of triangles lying in a single plane. This member gives a stable form capable of supporting considerable external load over a large span with the component parts stressed



FROM LINTON E. GRINTER'S "THEORY OF MODERN STEEL STRUCTURES'; REPRODUCED BY PERMISSION OF THE MACMILLAN CO., 1949

ROOF TRUSSES

primarily in axial tension or compression. The individual pieces intersect at truss joints, usually called panel points, where they may be connected by bolts, rivets or welds. The connected pieces forming the top and bottom of the truss are referred to respectively as the top and bottom chords. The sloping and vertical pieces connecting the chords are collectively referred to as the web of the truss. Trusses are formed in many shapes, varying from circular to those in which the top and bottom chords are horizontal. the latter being called parallel chord trusses. The two most commonly used methods of web configuration are the Pratt and the Warren systems. In the Pratt truss the sloping web members are parallel to each other on either side of the centre of the truss. In the Warren truss the sloping web members alternate in direction of slope along the length of the truss.

Trusses are used in buildings to support roof and floor loads, and in pairs to form bridges to carry various types of loads. The trusses are usually connected by a floor system that supports the external load. Other bracing is generally used between the trusses to give lateral stability and to carry horizontal forces such as wind. Sizable trusses are found in many large office and industrial buildings. Trusses are used for industrial purposes, as in the construction of cranes. Truss principles are incorporated into the design of airplane and automobile frames. The world's longest truss span, 1,800 ft.. is in the cantilever bridge across the St. Lawrence river at Quebec, Can.

Trusses were probably first used by primitive man in lake dwellings during the early Bronze Age, about 2500 B.C. The first trusses were built of timber. Cast iron was first used in the 18th century, wrought iron during the first part of the 19th century and steel later in the 19th century. Aluminum alloys are used for trusses in airplane wings and fuselages. The early trusses were proportioned by art and intuition. Andrea Palladio, a famous Roman architect, published a four-volume work *A Treatise* on *Architecture* in the 16th century; it contained his plans for wooden trusses and had great influence on the development of trusses. The later growth of railways gave impetus to the further improvement of truss design and construction. Squire Whipple, a U.S. engineer, published the first scientific and rational analysis of trusses in 1847. Herman Haupt. another U.S. engineer, published his *General Theory of Bridge Construction* in 1851; this contained much material on the design and construction of trusses. August Ritter, a German engineer, published a complete and general method for the analysis of simple trusses in 1863. James Clerk Maxwell (*q.v.*), English physicist, and Otto Mohr, a German engineer, simultaneously developed and published procedures for analyzing highly indeterminate trusses in the late 19th century. Karl Culmann (*q.v.*), another German engineer. developed graphical procedures for truss analysis during the same period.

In the early part of the 20th century the Vierendeel truss was invented. a type of truss composed of individual pieces formed into rectangles but without sloping web pieces. Such a truss is highly indeterminate, and the individual pieces are stressed directly in bending as well as axially. *See* Architecture: *Tech-*

niques; BRIDGES; ROOF: *Forms* of Roofs. (J. M. H.)

TRUST, as used in this article, means the legal relationship in which one person has title to property, subject to a duty as fiduciary to apply the property to the benefit of another. Business monopolies, sometimes called trusts, have no relation to the subject here treated (see MONOPOLY). For corporations engaged in the business of executing trusts, see TRUST COMPANY.

History.—Origins.—As early as the 11th century in England lawyers invented a legal institution known as the "use." Property was conveyed to a grantee "to the use" of another, with the purpose of making it the duty of the transferee to give that other the benefits of the property or permit him to take such benefits. This transaction was employed not only as a legitimate method of providing for property management and for conveyancing, but also to defraud creditors, deprive feudal landlords of their dues and permit religious institutions to derive the benefit of land they could not own directly. The use was framed on the model of the German Treuhand and not the Roman *fidei-commissum.* In this latter relationship, one who received property on the death of its owner was requested to hold it for the benefit of another and was under a duty to do so, For about 300 years the carrying out of the use depended on the conscience of the transferee to uses, since the common-law courts did not enforce it for lack of a writ to fit the case. But early in the 15th century the chancellor who administered equity began to issue decrees for its enforcement, and so the use changed from a merely honorary to an enforceable obligation.

Development of the *Use Into* the *Trust.*—By 1535 the use had become so objectionable because of its frequent employment for improper and illegal objects that parliament enacted the Statute of Cses (27 Henry VIII, ch. 10), which was intended to abolish the use. However, the courts construed the statute as destroying only uses of real property where there were no positive duties on the part of the grantee, as not abolishing uses where the donee to uses had active duties, and as not affecting uses of personal property. The uses that thus survived the Statute of Uses were called trusts, and they constitute the foundation on which the modern law of trusts exists. The trust is peculiar to the English system of law, in force in Great Britain and in the commonwealth and the United States. There was no trust in the Roman law, and there is none in countries whose jurisprudence is founded on that law, except to a limited extent as a result of recent statutes (*e.g.,* Louisiana, Puerto Rico, Mexico and Cuba).

Development of Trusts After the *Statute* of Uses.—For about 300 years following the enactment of the Statute of Uses the rules of trust law were developed by decisions of the courts of equity, with little influence from statute law. In the 19th and 20th centuries, however, there was a strong tendency to codify that law in statutory form. as shown in England and the commonwealth by the Charitable Trusts act of 1853, the Trustee act of 1925 and statutes regarding judicial and the public trustees; and in the United States by many statutes covering part of the topic, including the Uniform Fiduciaries, Principal and Income, Trusts, Common Trust Fund and Trustees' Accounting acts, drafted by the Commission on Uniform State Laws under the auspices of the American Bar association. Furthermore the American Law institute published a complete statement of trust law, with comments and illustrations, in a document called Restatement of Trusts (1935; 2nd ed., 1957), which is not a statute and has no binding effect on the courts but is highly influential.

Classification of Trusts.—With respect to their method of creation trusts are classified as (1) express, arising because of clearly stated intent that they shall exist; (2) resulting, coming into being because of an inferred or implied intent; and (3) constructive. created by the courts to remedy a wrong. From the point of view of their purposes trusts are classified as (1) private, for the financial benefit of described persons; or (2) charitable, for the welfare of society.

Elements Involved in a Trust.—Certain features are always found in a trust.

Settlor.—The settlor is so called because early trusts in England were created in marriage and other settlements. He is the person who owns property and goes through the acts necessary to create a trust of it. With negligible exceptions, any person who owns or has a power over property may create a trust of it.

Trust Property.—There can be no trust without identified property to which the trust is to attach, which is called the trust property or subject matter. It may consist, for example, of stocks, bonds, mortgages, insurance policies or a bank account. Certain other legal relationships do not impose obligations with regard to any particular property, but merely personally. This is true with regard to contract or debt.

Trustee.—Although a trustee is not necessary in order that a trust be created (since the court will supply one if none is named by the settlor), the trust cannot be carried out without some person in whom title to the trust property can be vested and who can perform the acts of trust administration. There may be two or more trustees. They are usually persons in whom the settlor has confidence (relatives, friends or business associates) or corporations to whom the power to carry out trusts has been given by statute (banks and trust companies [*q.v.*]). Because of the great difficulties of modern trust administration, a very large percentage of trusts is handled by corporate trustees. A person who is named as trustee may decline or accept, as he chooses. After acceptance he may resign (usually by court permission); he may be removed by the court if he has committed serious breaches of trust or if his continuance greatly endangers the welfare of the beneficiaries. In most cases before a trustee can act he must go through certain formalities called qualifications; *e.g.,* filing a surety bond for the faithful performance of his duties. Corporate trustees are generally excused by statute from giving a bond but are required to deposit a security fund with a public official to guarantee their responsibility.

Beneficiary.—No private trust can exist without beneficiaries who are identifiable legal entities (natural persons or corporations) or a class of persons (*e.g.,* children of the settlor). While the beneficiaries must be described with certainty at the beginning of the trust, provision may be made for the addition of new beneficiaries as persons are born and other events happen, and so the group may shift in membership from time to time, as long as all are clearly identifiable at any particular time.

In the United States the interest of the beneficiary may be made nontransferrable and not subject to the claims of creditors by the insertion of a clause in the trust instrument to that effect, the phrase "spendthrift trust" or "spendthrift clause" being used to describe the result. Where this is done, the beneficiary is unable to sell or give away his right to future payments from the trustee, and his creditors cannot take for the collection of their claims this right to payments later to be made; but after trust income or capital has been turned over by the trustee to the beneficiary, such payments may be freely spent by the beneficiary or taken to satisfy his creditors. In England spendthrift trusts are not allowed, but another trust (the protective trust), having somewhat similar effects, is sanctioned. In the protective trust the beneficiary's interest ends when he attempts to transfer it or when his creditors attempt to take it, and immediately a new trust begins for the benefit of the family of the original beneficiary, so that the transferees and creditors of the original beneficiary will have no rights, and yet the benefits of the new trust will in all probability come to the original beneficiary in part through the medium of his family.

In the case of charitable trusts the beneficiaries are not identifiable persons, since society is the beneficiary of such a trust, and any human beings who are involved are merely conduits through whom the advantages flow to the state. Thus, in the case of a trust to aid the poor, the individuals chosen yearly by the trustees to receive trust income are not the beneficiaries: rather society, which is benefited by the relief of poverty, is the beneficiary. Since charitable trusts are allowed to continue indefinitely and are granted many other privileges (*e.g.,* freedom from taxation), it often becomes important to decide whether a trust purpose involves substantial social advantages and is therefore technically charitable or is a private trust. Certain purposes are admittedly charitable, as, for example, the advancement of education and scientific research, the prevention or cure of disease, the relief of poverty and the support of religion. According to Lord Macnaughten (1891 A.C. 531) there is another class of charitable gifts, that is, those "for other purposes beneficial to the community." In this class may be cited gifts to furnish governmental services and to beautify towns and cities. Among borderline cases may be placed gifts for cemeteries and monuments, generally not charitable at common law but made so by many statutes: the furnishing of recreation and amusement, not charitable in England until very recently but approved in the United States; and the protection and care of animals, charitable if for domestic animals in general but not if for particular animals or for wild animals that are hostile to man. Trusts to care for poor relatives of the settlor or to aid a political party are not charitable.

The social benefit involved in a charity must be substantial. Hence the aid of a business enterprise that has small incidental public advantages is not charitable. The views of the courts as to what is charity are controlling and not the opinion of the settlor. At one time in England religious trusts were not charitable unless for the benefit of the established church, but toleration acts have changed the law. In the United States the support of any religion would probably be sustained as charitable; trusts for masses are now regarded as valid religious charitable trusts. In England and in a minority of U.S. states donors of property to trustees for charity have been restricted by the so-called mortmain acts, which either require such a gift to be made a considerable period before the death of the donor (*e.g.,* one year), or limit the proportion of the estate that can be given to charity if the donor left certain described close relatives.

Private trusts may be created to accomplish any legal purpose. They are used to achieve a variety of objects. If the end sought is illegal, *e.g.,* to defraud creditors, they are not enforced.

Trust Instrument.—The trust instrument is the document in which the settlor expresses his intent to have a trust and describes its provisions. It usually consists of a deed or a will.

Methods of Trust Creation.—There are several ways in which a trust may be created.

A property owner may declare himself trustee of that property; he may convey it during his life to another to hold in trust; or he may give it by will to a trustee who is to take the property at the death of the maker of the will. The trusts created by the first and second of these methods are called living trusts; those created by will are called testamentary trusts.

Trusts also may be created by decree of a court. Resulting trusts arise because the court finds that a property owner intended to have a trust, although he did not expressly say so, as where one pays for land and has the deed made out to another without any agreement as to the intended effect (so-called purchase-money resulting trust), and where the courts find that the payer of the price did not intend to give away his money but rather expected the grantee to hold the land for him. Constructive trusts are created by court decree, where the court finds a person holding property which in all fairness should belong to another, and the court adjudges the titleholder to be a constructive trustee for the wronged person, with a duty to convey to him (*e.g.,* where a son who is the sole heir of his father murders the father in order to inherit the father's property, and a trust is constructed for those who would have been the father's heirs if the son had predeceased the father).

No consideration is necessary to the creation of a trust. It is not necessary that the settlor be given anything of value in return for the act of trust creation. Herein lies a great difference between trust creation and the formation of a contract. Most trusts are by way of gift and yet are just as enforceable as if the settlor had been paid for their creation. In England from 1676 until the 20th century a trust of real estate created during the life of the settlor was unenforceable against the objection of the trustee unless it was proved by a signed writing, but this did not apply to resulting or constructive trusts; and in most states of the U.S., a writing is required for express trusts of land. If an attempt is made to create a trust to begin at the death of the settlor, he must make a will which complies with the statutes as to the execution of wills, which usually require a signed writing with witnesses.

Duties of the Trustee.—Some of the more important duties of the trustee are the following: (1) To use the care and skill a reasonably prudent and capable man would employ in managing property for objectives like those of the trust, and if he has or professes to have, greater abilities, to use them in his trust work. (2) To be loyal to the beneficiaries in all trust administration and thus to exclude consideration of his own selfish interest or the welfare of third persons; the courts set aside at the option of the beneficiary all disloyal transactions and take from the trustee the fruits thereof. (3) To display the utmost fairness in any direct business dealing with the beneficiaries, as, for example, the purchase of the beneficiary's interest under the trust. (4) To take possession of the trust property by procuring it from the settlor or his executor or a predecessor trustee. (5) To defend the trust against attack and not to attack it himself. (6) In the case of cotrustees, to be active and not to leave to fellow trustees the entire control of the trust. (7) To protect the trust property in whatever way is reasonable, as, for example, to place trust securities in a safety deposit box, deposit cash in a bank, repair buildings and take out insurance where prudent business practice would require it. (8) To make an inventory of the trust assets, keep adequate records of all transactions and obtain vouchers for payments made. (9) To keep, sell or buy trust investments as required by the terms of the trust or by the investment laws of the jurisdiction. (10) To pay the expenses of operating the trust and the carrying charges on trust property; *e.g.,* taxes, mortgage interest and principal. (11) To pay out trust income and capital to the beneficiaries as directed by the trust instrument or by statute. (12) To make a report or accounting to the beneficiaries in court when required to do so by the terms of the trust or by statute or court decree. (13) To familiarize himself with the terms of the trust and the law of trusts, in order that he may perform the duties laid upon him.

Powers of a Trustee.—A trustee has such powers as are expressly granted to him by the trust instrument or are implied because their use is necessary or highly convenient to the accomplishment of the settlor's purposes. Some of the commoner powers are to sell, make investments, collect and distribute income, make leases, carry on the business of the settlor or do any other act of trust administration that it is his duty to do. The powers of cotrustees of private trusts are jointly held, unless otherwise prescribed in the instrument, hence all must unite in performing the important acts of trust administration; a majority, however, may act in the case of a charitable trust. A trustee cannot lawfully delegate to a cotrustee or an employee the power to perform discretionary acts (*e.g.,* fixing the price of property to be sold), but he may leave to another work that a prudent businessman would delegate to a subordinate (*e.g.,* advertising the property for sale). The trustee's powers may be mandatory, where the settlor has ordered the performance of an act, or discretionary, where the trustee has the option to use the power or not, provided he does not abuse his discretion in making a decision.

Liabilities of a Trustee.—If a trustee violates his trust (*e.g.,* by making an unlawful investment), the beneficiary may hold him liable for any loss caused thereby. If the breach of trust was the wrongful transfer of the trust property to a third person, the beneficiary may reclaim the property or its proceeds as long as he can identify them, unless they have come into the hands of a purchaser who did not have notice of the breach of trust. A trustee may also be personally liable to others than the beneficiaries, as where he makes a lawful contract in connection with the trust business (unless he expressly excludes such personal liability in the contract), or commits a tort (*e.g.,* negligence) in managing the trust property. But if the contract was properly made, or the tort involved no personal fault on the part of the trustee, the courts will direct the use of trust property to reimburse or indemnify the trustee with respect to liability. There is a strong modern tendency to permit a contract or tort creditor to collect directly out of trust property by an action against the trustee in his representative capacity, both in the case of private and charitable trusts.

Accounting by Trustees. — The beneficiary has the right to have the trustee present in court at reasonable intervals a written statement of receipts and expenditures, how the trust has been operated and what its present situation is. In some states, statutes require periodic court accountings, but in other jurisdictions there are no such statutes and court accountings occur only when a beneficiary brings a suit to require an account or when the trustee voluntarily presents one in court. Corporate trustees frequently voluntarily send reports to their beneficiaries or voluntarily file accounts in court in order that the court may pass upon the validity of the trustee's acts and may award him compensation for his work since the last accounting. The beneficiaries are entitled to notice of the filing of an account in court, and may object to any item in the account and have the court pass upon the objection.

Compensation of Trustees. — In England, trustees originally were not entitled to any compensation, and this continues to be the rule there except where the trust instrument provides for pay, or the trustee will not act without compensation and the court therefore allows it, or the court authorizes the compensation of a corporate trustee that it appoints. In the United States, trustees are universally allowed fees, as well as payment of their reasonably incurred expenses, the amount of the compensation being set by different standards in the various states. Sometimes a fixed percentage of the trust income is granted to the trustee, while in other states the amount is left to the discretion of the court. Some settlors prescribe the amount of commissions in the trust instrument. Corporate trustees often have fee schedules and insist on an agreement that they be paid accordingly. The court has power to deprive a trustee of his compensation or reduce it, where his administration has been markedly defective; and in rare cases the court may award extraordinary compensation, where unusual difficulties have been encountered by the trustee.

Trust Investments. — One of the most difficult duties of the trustee is to secure for his trust the maximum practicable safety and at the same time secure a steady flow of reasonable income. He should shun speculation and investments for the purpose solely of capital gains. He should consider the tax situations of his beneficiaries, the need for readily saleable investments, hedges against inflation and a reasonable degree of diversification.

The rules as to trust investments have passed through three stages: (1) the fixing by the courts of a very small number of permitted investments (government bonds and first mortgages on real estate); (2) the adoption by the legislatures of lists of classes of investments, but not particular investments, in which a trustee was permitted or required to invest; and (3) the establishment by the courts, or more frequently by statute, of the so-called "prudent man rule," under which a trustee is protected in holding, selling or buying investments if he uses the skill and care of a reasonably prudent man in managing investments for purposes similar to those of the trust in question. This latter rule has the virtue of great flexibility and of taking account of changes in investment practices. The second rule named above is applied in England; it once was followed in most American states and is still in force in a few, but a large majority of the states have shifted from the statutory lists to the prudent man rule. While corporate shares were rarely approved as trust investments under the older case and statutory law because of their supposedly speculative nature, the courts acting under the prudent man rule allow a reasonable proportion of common or preferred stocks on the basis of the satisfactory performance of stocks in recent years and the practice of prudent investors.

A trust investment device popular in the U.S. is the common trust fund, which consists of a group of investments purchased with funds of many trusts; each contributing trust has a share in the capital and income of the common trust fund corresponding to the amount of its participation. Such a fund provides diversification and permits ready investment of small balances. These funds are recognized by federal and state law for operation by corporate trustees, and their use is spreading.

Many modern trust instruments grant to the trustee discretion as to the making of investments, which is believed equivalent to making the trust governed by the prudent investor rule. If the instrument prescribes certain investments, the trustee will be protected in following these directions, if he used reasonable care in doing so.

Principal **and** Income Problems. — Since nearly all trustees act for income beneficiaries with temporary interests and also for remaindermen beneficiaries who are to take the capital of the trust at a future date, they have the problem of determining what receipts are to be applied to the income account and what to the capital fund, and also from which of these two sources expenditures shall be made. The court decisions and statutes attempt to give the income account that portion of the receipts which represents earnings or gains from the use of the trust property (*e.g.*, interest, rents, cash dividends) and to treat as trust capital the results of a mere change in the form of the trust property, as where land is sold and cash received in return. With respect to expenditures, the burden of merely maintaining and preserving the original trust property should be placed on the income account (*e.g.*, taxes, repairs and insurance), while the cost of adding to the value of the trust property should be taken from trust capital (*e.g.*, improving real property by constructing buildings). There are many complicated problems in this field that cannot be treated here. The modern tendency is to treat stock dividends as trust capital.

Enforcement of Charitable Trusts. — Enforcement is usually by the attorney general and not by persons who would obtain benefits from the charity, since the government on behalf of its subjects or citizens is the real beneficiary of a charitable trust and the attorney general is in charge of enforcing the government's rights; but private persons may begin proceedings in the name of the attorney general, if he refuses to act. It has been recognized that many charitable trusts are neglected and not enforced, due to lack of knowledge by the attorney general of their existence. This situation brought about legislation in England requiring registration of charitable trusts in a public office and regular reports as to their situations, and giving public authorities powers of investigation, the charities commissioners being employed for these purposes. Similar statutes applying to the attorney general have been adopted in several states of the C.S.

Revocation, Termination or Alteration of a Trust. — Unless a settlor reserved to himself, or granted to another, in the trust instrument a power to revoke the trust so as to procure a return of the property to the settlor, no such power will be recognized by the courts. There is no implied power to revoke, even though the creation of the trust was by way of gift and there has been a change in the circumstances of the parties. The same rule applies to the amendment or alteration of the trust. There is a small amount of statutory law in the United States permitting the settlor to revoke, either alone or in conjunction with the beneficiaries. The insertion of a power of revocation may cause the trust property to be regarded as property of the settlor for income and death tax purposes. Frequently the settlor alone, or the settlor and the beneficiaries or merely the beneficiaries, attempt to procure from a court a decree terminating the trust, and either the return of the property to the settlor or the distribution of it immediately to the beneficiaries. If the settlor is the sole beneficiary or if he secures the joinder of all the beneficiaries in his request for termination, the courts are inclined to grant the application, since a property owner should be allowed to enjoy his property as he likes, and the donees of a gift should be able to return it to the donor if they are competent and so desire. But if the settlor is not joined in his application for court termination by all the beneficiaries — either because some refuse or because there are possible contingent beneficiaries for whom no one can act or because certain of the beneficiaries are incompetent mentally or by reason of minority and the court does not permit a representative to act for them — then, if the trust purpose as expressed originally by the settlor has not yet been accomplished, the court will not decree a destruction of the trust A similar rule applies if the applicants are merely beneficiaries, the settlor having died or having refused to join in the application. If the trust purpose has been accomplished or has become impossible of accomplishment, the court mill end the trust. In some cases where there is bona fide litigation regarding the validity of the trust, the court will sanction a termination of the trust and a compromise distribution plan, where it believes that the interests of all parties would be foruarded thereby.

When a single provision in a trust instrument proves to be an obstacle in the way of carrying out the purposes of the settlor, the courts have power to direct the trustee to ignore the undesirable clause and to deviate from the methods of administration prescribed by the settlor. The machinery he devised for running the trust is of slight importance as compared with the benefits he wished his beneficiaries to obtain. For example, if the purpose of a trust is to furnish a comfortable living for the settlor's children, and he directs that the trust fund shall be invested in government bond: exclusively, and these bear interest at such a low rate that the beneficiaries are in want, the court might direct the trustee to ignore the settlor's investment clause and to invest in stocks and bonds that would bring in tnice as much income. This power may also be used to advance the date of payment of trust income or capital. It may not be used in the United States to vary the amounts of the gifts to the beneficiaries, but in Great Britain the power to vary the trust under the Trustee act includes this latter change

Cy Pres Power.—The courts of equity have the power to vary the administration of a charitable trust, when circumstances have changed since the creation of the charity so that it is now impossible or highly inexpedient to use the fund for the charity named by the settlor The court or in England the charity commissioners, may substitute another charitable purpose as nearly like the original as possible and direct the trustee to apply the fund for this substituted purpose. For example, if the original trust purpose was the prevention and cure of a named disease, and modern discoveries had so reduced the danger of contracting the disease and the cost of treatment of it that the sum given to the trust is greatly in excess of the amount that can reasonably be used for the original purpose, the court might "frame a scheme" for revised administration and apply part of the property to prevent and cure other diseases

In the early terminology of the English law this was called the *cy près* poner. a phrase abbreviated from the Norman French *cy pres comme possible,* meaning that the new plan was as nearly like the old as possible and that it carried out nhat the settlor would have nanted.

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TRUST, INVESTMENT: *see* INVESTMENTS: INDIVIDUAL.

TRUST COMPANY is a corporation engaged in ninding up estates. administering trusts and performing agencies for individuals, partnerships, corporations, associations and institutions both public and private, under authority of law. The trust company may be engaged exclusively in trust business or it may perform commercial banking functions as well as those of a savings bank.

In all of its purely trust functions, the trust company acts as a fiduciary for its customers in that it acts for the benefit of someone other than itself. It cannot delegate the performance of its duties.

In the United States, trust powers are granted to corporations by governmental authority; they are not implied rights. National banking Institutions receive their trust powers from the federal government. Other corporations receive their trust powers from state governments. Power to engage in trust business in one state does not carry with it power to engage in trust business in other states of the United States. Each corporation must meet the requirements of the governmental authority under which it wants to do business. Each state has the authority to determine the conditions under which a corporation may conduct a trust business within its borders.

In addition to its trust charter, each trust company must obtain a licence to operate. National banks receive their licences to operate from the board of governors of the federal reserve system. State banks apply to the state banking authority for their licences.

Other requirements are imposed on corporations before they can engage in trust business. The laws of the various states are not uniform. Some require a minimum capital and surplus which is fixed according to the population of the city in which the corporation is located, while others base the requirement on the volume of the trust business of the corporation. Some states further require that a deposit be made with the proper state authority to protect the trust property. In some states a deposit of securities of a fixed amount permits the handling of an unlimited volume of trust business.

The trust company renders three kinds of service for three distinct groups of persons. The three services are: distribution of property; administration of property; and custody and agency functions with respect to property. These three services may be rendered for individuals, for business firms, or for public institutions. For convenience, most trust companies classify their services as personal trusts and corporate trusts.

Personal Trusts.—The trust company serves individuals in many ways but its chief function is that of executor or administrator of estates. When a person dies, leaving property and a will that is admitted to probate, he often nominates a trust company to wind up his estate. The court of competent jurisdiction usually appoints the trust company so named and it is knonn as the executor of the estate If an executor is not named in the will, or if the person so named is not appointed by the court, the court appoints someone to act. Such a person is knoun as an *administrator with a will.* Should the person nho dies leaving property not make a valid will, the court appoints an *administrator.* The trust institution so appointed is known as the *administrator of the estate.*

The principal duties of the executor or administrator are to obtain *letters testamentary* or *letters of administration* from the court giving the trust company authority to settle the estate, assemble the assets of the estate, take such steps as are necessary to protect the assets, pay all just claims, and distribute the remainder to the heirs.

Personal Trusteeships.—The administration of personal trusteeships constitutes the second main function of personal trusts A trutt exists when one person has legal title to property and another person hai the beneficial ownership Personal trusts are of two hinds testamentary trusts and living trusts

A testamentary trust is created by a person who leave5 a will which transfers his title to property to one person to hold for the benefit of a third person or persons A living trust is created when a person during his lifetime conxeys title to property to another person to he held for the benefit of himself or a third person. I hese living trusts may be revocable or irrevocable The living trusts are of several kinds

Guardianships.—Under court appointment trust companies serve individuals as guardians ot property In some states a trust company may also act as guardian of a person Guardianships of property arise nhen the court appoints someone to manage the property tor an incompetent person Such appointee is known as a guardian trustee or conservator The incompetent person may be mentally incapable ot managing his own property or he may be a minor

A guardianship differs from a trusteeship in that under the former the title to the property remains in the minor or the incompetent whereas under the latter the title resides in the trustee The administrator of estates under guardianship is controlled by the statutes and court decisions of the state. Under trusteeships the trustee derives his powers and duties from the trust instrument creating the trust.

Agencies. — The third principal function performed by trust companies for individuals is that of agent. Agencies are created when one person authorizes another to act for him. The principal retains title to his property and may terminate the agency at any time. It is automatically terminated on the death of either the principal or the agent. Agencies are of many kinds but may be grouped under five headings: safekeeping, custodianships, management agencies, attorneyships-in-fact and escrow agencies.

Safekeeping is the simplest kind of agency and involves the receipt of property or claims to property, care in its protection and delivery upon order of the owner. No responsibility other than due care and diligence in the physical protection and delivery of the identical property is imposed.

Custodianships constitute the next step beyond safekeeping. The custodian, in addition to receiving, caring for and delivering property performs many other duties set forth in the agreement. The custodian is expected to relieve the principal of the details connected nith ownership.

Management agencies represent the third step in activity and responsibility under agencies in that the exercise of judgment is involved. In addition to the duties of safekeeping and custodianship, the management agent may be expected to render a multitude of services in which it must exercise the same kind of care and judgment that it would for property held in a trust account.

Attorneyshzps-in-fact arise from a written authorization by the principal conveying to the agent authority to perform certain acts. Attorneyships-in-fact accepted by trust institutions do not involve the practice of law.

These agencies may cover any business transaction which the principal has a legal right to perform.

Escrow agencies constitute the fifth agency function of trust companies. In performing this service the escrow agent acts as a stakeholder for two or more persons engaged in a business transaction. The agent exercises no discretion and assumes no responsibility other than following the instructions agreed upon.

Corporate Trusts. — Corporate trusteeships are one of the principal services rendered by trust companies. As corporate trustee, a trust company serves as trustee under bond issues. It takes title to property under deed of trust from corporations which wish to sell notes or bonds. The trustee holds title for the benefit of the noteholders or bondholders. The trustee certifies that each bond or note is one of a series issued under trust deed.

It protects against an overissue but does not guarantee the value of the security. As agent, the trust company acts as transfer agent or registrar. As transfer agent, it acts for corporation stock and registered bonds. It also acts as transfer agent for many forms of business paper such as warrants for stock rights, voting trust certificates and receivership certificates. As registrar, trust companies guard against an overissue by checking the certificates against the number of shares authorized. When certificates are issued the registrar checks the old and new certificates. Another function of the trust company is that of depositaryship. These services are governed by the depositary agreement. The trust company accepts the securities, accounts for their safety and delivers them on demand. Because of the vast detail involved in connection with the payment of dividends on stocks, interest on bonds and the payment of matured issues, corporations appoint trust companies as paying agents.

Trust companies also serve corporations as custodians, management agents, escrow agents and attorneys-in-fact.

In addition to their services for corporations and individuals, trust companies act as fiscal agents for governmental bodies and for social institutions such as clubs, schools, churches and fraternal institutions. (H. F. W.)

Historical Development. — The first trust companies in the United States were not chartered as trust companies originally but as insurance companies; trust activities remained secondary until, with the growth of wealth, the fiduciary services became of greatest importance. whereas insurance and annuity business was secondary. By 1822 several companies were placing chief emphasis upon the fiduciary business. Their development before the Civil War was slow, and by 1850 there were about 50 trust companies scattered throughout the commercial states.

Besides performing trust functions, some of these early trust companies operated as savings banks and provided safe deposit facilities. The charters of trust companies around the middle of the 19th century included these functions specifically.

With the development of a national banking system and a national currency after 1863, trust companies grew in importance and number and developed into powerful financial institutions. In the 25 years following the Civil War great changes took place in the activities of trust companies. Whereas state banks were decreased in number and in extent of their operations as a result of the National Banking act of 1863, trust companies began to grow in number and resources. The regulatory measures provided in their charters were regulatory in name only.

Deposit banking and discounting activities became the chief functions of trust companies. The old alliance with insurance and annuity business was completely dropped and fiduciary business began to occupy a rank of secondary importance.

After 1880, trust companies became commercial banks in reality even though not always in name. As a result of the growth of trust companies, banks complained that they were being discriminated against and clamoured for state supervision of trust companies. The three chief complaints of the banks were that trust companies were not subject to taxation as were banks; that trust companies kept no reserves, but depended on the banks for cash and clearing service; and that trust companies were not subject to state supervision and regulation in their operations, which constituted a danger to sound banking. After many heated controversies measures of relief were started. New Tork enacted a trust company reserve law in 1906, but the law was changed in 1908 and trust companies were brought under the same law as banks.

Other states followed suit. When the Federal Reserve act was passed in 1913 the same powers to act in a fiduciary capacity as were enjoyed by trust companies were extended to commercial banks. The act also provided that trust companies could become members of the reserve system.

After that time, trust companies became almost indistinguishable from commercial banks, though they generally place a heavier emphasis on fiduciary business than do most commercial banks. By 1939 about one-third of the country's banking resources were in the hands of trust companies. (B. F. H.)

TRUSTEESHIP SYSTEM, the method provided in art. 75 of the Gnited Nations charter for the administration and supervision of such nonself-governing territories as may be placed thereunder by individual agreements. The system superseded the mandate system which had similar functions under the covenant of the League of Nations *(see* MANDATE). As the trusteeship system was established following World War II, there were, however, certain distinct differences from the mandate system, both with respect to (1) the form of international supervision; and (2) the geographical scope to which this system may apply.

Concerning supervision, the United Nations charter provides for periodic UN visits of inspection to the various trust territories and it also provides that the UN general assembly or Trusteeship council may hear petitioners from such territories in person. Although these two provisions were not specifically excluded from the mandate system, they were not explicitly made a part of that system. Both practices are widely regarded as rendering United Nations supervision more effective and realistic.

The UN charter also provided that the system may apply to (1) the former mandated territories; (2) territories detached from enemy states as a result of World War II; and (3) other nonself-governing territories which might voluntarily be placed under the trusteeship system by the states responsible for their administration. In each case, however, it was provided that a subsequent agreement between the state administering the territory and the United Nations would be necessary to bring any such territory under the trusteeship system.

Except for one territory — Somalia, which was taken from Italy, following World War 11 — there was in fact no extension of the system beyond the former mandated territories. The territories under UN trusteeship in the late 1950s are shown in the table.

Trust territory	Population	Area (in sq.mi.)	Administering authority
Togoland (French)*	1,052,318†	22,008	France
Cameroons (British)	1,439,870‡	34,081	United Kingdom
Cameroun (French)	3,077,080§	166,795	France
Ruanda-Crundi	3,964,697‖	20,916	Belgium
Tanganyika	8,788,466¶	362,688	United Kingdom
Somalia	1,268,253♁	178,201	Italy††
Western Samoa	97,327♀	1,131	New Zealand
New Guinea Northeast New Guinea Bismarck archipelago Certain of Solomon Is. (Bougainville, etc.)	1,206,749**	93,000	Australia
Nauru	3,473**	8	Australia, New Zealand and United Kingdom
Pacific Islands Mariana or Ladrone Is. (except Guam) Caroline Islands with Yap Is. and Palau Is. Marshall Islands	54,843‖	687	United States
	20,953,076	879,515	

*République autoname du Togo, 1956. †1953 est. ‡1953 census. §1952 est. ‖1950 census. ¶1957 census. ♁1955 est. ♀1956 census. **1954 census.
††Placed under Italian trusteeship, 1950.
Note: Following World War II, the Union of South Africa refused to place South-West Africa (*q.v.*), a League-mandated area, under UN trusteeship.

In practice; the trusteeship system may be described as a system of national administration under international supervision. Although the United Nations is itself empowered (art. 81) to administer a territory, it has. in fact, not done so. The states which administer trust territories are referred to as "administering authorities." and the precise terms under which they administer the respective territories are indicated in detail in the separate trusteeship agreements made between them and the United Nations general assembly.

Objectives and Purposes.—The basic objectives of the trusteeship system are defined in the charter (art. 76) as "(a) to further international peace and security: (b) to promote the political. economic, social. and educational advancement of the inhabitants of the trust territories. and their progressive development towards self-government or independence as may be appropriate to the particular circumstances of each territory and its peoples and the freely expressed wishes of the peoples concerned . . . ; (c) to encourage respect for human rights and for fundamental freedoms for all without distinction as to race. sex. language, or religion, and to encourage recognition of the interdependence of the peoples of the world; and (d) to ensure equal treatment in social, economic and commercial matters for all Members of the United Nations and their nationals. and also equal treatment for the latter in the administration of justice, without prejudice to the attainment of the foregoing objectives. . . ."

Strategic Areas.—The UN charter provides (art. 82) that there may be designated in any trusteeship agreement a strategic area or areas which may include part or all of the territory to which the agreement applies. Under this provision, the United States agreed in 1947 to place the Trust Territory of the Pacific Islands (the Marshalls, Marianas and Carolines) within the trusteeship system under a strategic trusteeship agreement. Art. 13 of this agreement provided that while the territory might be broadly administered as an ordinary trusteeship with the relevant articles of the charter applying to it, the administering authority may determine the extent to which art. 87 and 88 of the charter may be applied to any areas in the territory "which may from time to time be specified by it as closed for security reasons." The charter provides (art. 83) that the functions of the United Nations relating to strategic areas shall be exercised by the Security council and that the annual reports on the territory shall be made to it, but the article also provides that the Security council shall avail itself of the assistance of the Trusteeship council in political. economic, social and educational matters. In practice, as regards the Trust Territory of the Pacific Islands, the Trusteeship council examined its annual reports in the same manner as the reports made on all the other trust territories. but its report was made directly to the Security council and was not discussed, as were the other reports, in the general assembly. (See also PACIFIC ISLANDS.)

The Trusteeship Council.—The United Nations Trusteeship council examines the annual reports of the various administering authorities, hears petitioners and sends visiting missions every three years to each of the territories. Under the charter (art. 86), the council was comprised of all the member states of the United Nations that administered trust territories, and an equal number of other members elected for three-year terms by the general assembly. The Soviet Union and China were, however, ex officio members by virtue of their permanent membership in the Security council. The president of the council was elected annually and in practice was chosen alternately from among the two classes of members.

The Trusteeship council roughly combined the functions of the former League of Nations permanent mandates commission, a technical body, and the former League council, a political body. to which the permanent mandates commission had reported. The Trusteeship council was composed (art. 86) of one "specially qualified" person appointed by each of the member states. Thus, it was intended that the council should, as one body, take into account both the technical and political aspects of the operation of the trusteeship system. How far this blending of competencies succeeded was disputed,

Origins of Trusteeship.—The concept of trusteeship, which has analogies to the relationship of the guardian to his ward. is traced by some authorities to Edmund Burke. who, in a speech on Fox's India bill in 1783 in the house of commons, said that "all political power which is set over men . . . ought to be some way or other exercised ultimately for their benefit"; and that "every species of political dominion and every description of commercial privilege . . . are' all in the strictest sense a trust; and it is of the essence of every trust to be rendered accountable." The term "trusteeship" was widely used during the 19th and 20th centuries, especially in England and the British colonies during the struggles for the abolition of the slave trade and slavery. When, therefore, a new expression was sought during and after World War II to replace the mandate system, it was quite readily agreed at the UN organizing conference in San Francisco in 1945 that the new system should be known as the "trusteeship system." The term "sacred trust" was used in the covenant of the League of Nations in connection with the mandate system and, in fact, the underlying concept of both systems was in essence the same. Both were based on the idea of some degree of collective responsibility among the family of nations for the welfare of still dependent peoples. and both systems assumed that the harsher forms of alien rule over such peoples should give may to collective action and responsibility under which the interests of the inhabitants were to be considered paramount. The basis of both the mandate and trusteeship systems derived from Pres. Woodrow Wilson's fourteen points (q v), in which he proposed (point 5):

> A tree, open-minded, and absolutely impartial adjustment of all colonial claims, based upon a strict observance of the principle that in determining all such questions of sovereignty the interests of the populations concerned must have equal weight with the equitable claims of the government whose title is to be determined

Visiting Missions.—The visiting mission feature of the trusteeship system was regarded as the most important added element in the supervisory function of the United Nations. As of the late 1950s the Trusteeship council organized a mission each year to spend six or eight weeks in eastern Africa. western Africa or the Pacific area, each area being visited every third year.

In order that the principle of balance uhich was basic in the Trusteeship council's composition might be maintained in its visiting missions, the council annually invited two administering members and two nonadministering members each to nominate an individual to participate in the visiting mission. The council, upon receiving the nominations, retained the right to approve or disapprove such nominations on the ground that the individual members of the visiting missions in a sense represented the entire council, were paid their expenses by the United Nations and reported directly to the United Nations. Participants did not go under instructions from their governments but acted in an individual and expert capacity. The council customarily elected the chairman of the mission. alternating each year between members from the administering and nonadministering groups. Five or six members of the trusteeship department of the UN secretariat customarily accompanied the mission and assisted it in drawing up its report.

When a visiting mission visited an area it reported separately upon each individual territory. Reports were submitted for comment to the administering authority concerned. The report of the visiting mission and the observations were laid before the Trusteeship council and with the annual report of the administering authority and written and oral petitions with respect to that territory, furnished the basis for the eventual evaluation made by the council in its annual report to the general assembly.

Targets and Final Goals. — The rate of progress made toward self-government or independence by UN trust territories aroused frequent comment by visiting missions. UN member states which were critical of the colonial relationship, even in its trusteeship form, tended to urge early independence, and in some cases recommended a fixed time limit for its attainment. Such a time limit, for instance, was fixed in the trusteeship for Somalia in the assembly's 1950 agreement with Italy, pursuant to the peace treaty with Italy. In every other instance, however, the administering authorities took the position that until a territory was clearly near its goal, such time limits were unrealistic and impracticable. The council did not adopt recommendations calling for such fixed time limits, but it did recommend that administering authorities consider specific intermediate plans for political, economic and social development involving targets of three or five years.

Administrative Unions. — Another subject of protracted consideration was the practice of governing a trust territory as an integral part of a neighbouring colony. Although the trusteeship agreements provided for governing certain trust territories under so-called "administrative unions," it was nevertheless required that the trust territory be maintained as a separate entity for the purpose of reporting statistical and other information. It was also considered necessary that the development of a trust territory toward independence should not be jeopardized, regardless of the political development of a neighbouring territory with which it might be administratively associated.

Administration But Not Sovereignty. — In each trusteeship agreement it was provided that the administering authority should have full powers of legislation, administration and jurisdiction in the territory, subject to other provisions of the agreement and of the UN charter. This enabled the administering authority to extend such of its legislation and administrative machinery to the trust territory as it might deem necessary. Nevertheless, it was clearly understood that such powers should in no sense be construed as meaning that the administering authority might annex the territory or that it had sovereignty over the territory. It might exercise many of the prerogatives of a sovereign, but it was recognized that a trust territory, unlike a colony, was not under the sovereignty of the country which governed it.

Termination of Trusteeship. — Since the objective of trusteeship was defined (art. 76) as self-government or independence, the attainment of either goal was regarded as a valid basis for termination. Thus, the trusteeship for British Togoland was terminated in 1957, after a UN-supervised plebiscite showed that a large majority of the population favoured union with Ghana. The 11th general assembly completed the formalities and hailed the successful outcome of the first territory to "graduate" from the system.

Three UN trust territories gained their independence during 1960: French Cameroun became a republic on Jan. 1, French Togoland became the Republic of Togo on April 27 and Somalia (formerly Italian Somaliland) became independent on July 1 and was united with former British Somaliland.

Conclusions.—Colonialism in all its manifestations had come in the second half of the 20th century to be looked upon as a temporary expedient which should give way as rapidly as feasible to self-government or independence. The colonial relationship, even in its trusteeship form. was widely regarded as objectionable, since no people desired to be governed by alien authorities.

Most of the states which emerged after World War II from colonialism, on the other hand, did so without going through the trusteeship phase, and it seemed unlikely that many of the colonial peoples would consider that trusteeship was an advantage to them in attaining self-government or independence.

It might be concluded, therefore, that since both colonies and trust territories were rapidly moving toward these goals, the trusteeship system, with all its possible benefits, had only a limited future. In the meantime, the eyes of the world closely scrutinized these territories, and high administrative standards would be necessary in order to satisfy the opinion of mankind.

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TRUSTS: see MONOPOLY.

TRUST TERRITORIES: see TRUSTEESHIP SYSTEM.

TRUTH. There has always been, since the first beginnings of philosophy, some topic of current philosophical discussion to which could be assigned the title "the problem of truth." It would be easily admitted, however, that it is not one single question which has been debated under this heading — indeed, that some of the questions so discussed have been only remotely connected with each other.

That all might be expressed in the formula "What is truth?" is a matter of superficial verbal resemblance. In the course of time, however, there has occurred some profitable narrowing of the points at issue, so that in examining here the most important group of modern theories on this subject, we have the advantage of being able to concentrate, not indeed on one single question, but at least on questions that are reasonably akin.

The Correspondence Theory. — The theory with which it is natural to begin, on the ground that it seems to accord most closely with common sense, is the so-called correspondence theory. This theory's pedigree is extensive and respectable: it could be traced back, through the medieval definition of truth as "*adaequatio intellectus* et *rei*," to Aristotle. But a conveniently precise and not overelaborate statement of it may be taken from G. E. Moore's *Some Main* Problems *of* Philosophy, lectures originally delivered in 1910–11 but not published until 1953.

Moore takes beliefs to be that to which the predicates "true" and "false" are applicable. He then proposes to show what the difference between true and false beliefs is, or what property there is uhich is common to all true beliefs but possessed by no false one. His argument proceeds as follows. Consider for example the (true) belief that Leeds is in Yorkshire. Now there is, Moore holds, between this belief and the fact that Leeds is in Yorkshire a certain relation, which that particular belief cannot be said to have to any other fact; there is, in general, such a relation between any true belief that p and the fact that p. Moore names this relation "correspondence" and proceeds at once to answer his questions. The difference between true and false beliefs is that every true belief, but no false belief, corresponds to a fact; the property common to all true beliefs is the property of corresponding to a fact, and no false belief possesses this property. Moore's conclusion is characteristically guarded. He does not insist that, when we say that a belief is true, we must mean that it has the property of corresponding to a fact. Nor does he deny that there may be other senses of the word "true" to which his observations would not apply. He definitely asserts only that very often, when we say truly that a belief is true, it in fact has the property of corresponding to a fact; though he is also inclined to believe that this is actually what is meant by saying that it is true.

One minor adjustment should be made to this account: there are objections to Moore's restriction of the discussion to beliefs. For, with this restriction, nothing could properly be said to be true or false unless someone believed it; whereas we may, for instance, quite properly ask whether it is true or false that fish can hear (presupposing that it is one or the other) without being obliged first to establish that anyone believes that fish can hear. This objection can be met (not without some harmless artificiality) by substituting "statement" for "belief." For though no doubt any statement is normally believed to be true at least by those who make it, it may be true even though no one believes that it is; nor perhaps is it excessively unnatural to say that there are true (and false) statements which no one has ever either made or believed. With this amendment. Moore's view may be briefly stated as follows: a statement is true if it corresponds to a fact and false if it does not correspond to a fact. This simple observation forms the foundation of any correspondence theory of truth.

The Coherence Theory. — This theory's traditional rival, the coherence theory, must next be briefly described, though. since there are at least two widely different versions of it and each raises very extensive problems, the description given here must be somewhat bald.

According to some idealist critics. of whom F. H. Bradley may be taken as representative. the correspondence theory errs fundamentally in taking any single statement whatever to be wholly true. To say that a statement is true if it corresponds to a fact is to assume. it was argued, that the statement. the fact and the relation between them can be properly assessed in absolute isolation; whereas in reality (or, in Reality) nothing whatever is thus separate from anything else. To suppose that there are facts each singly capable of being uniquely correlated with its own statement was held to be to impose upon reality a "mutilation"; indeed, according to Bradley, there are, strictly, no facts—if we try to find them, we get merely an "artificial extract," a "fragment" resulting from mutilation *(The Principles of Logic,* 2nd ed., p. 584, 1922).

There is thus, in reality, nothing for our ordinary statements, or "judgments," to correspond to. Though each purports to correspond to its distinct "fragment" of reality. reality in fact contains no fragments. Presumably there is. ideally, one exhaustive and all-embracing truth; but since no judgment that we can actually make can be thus exhaustive. our judgments may at best be partially true — fragments of an unattainable whole which alone would be adequate to reality. On this view. then, the correspondence theory is really a theorists' myth; its apparatus of distinct judgments and distinct facts is a tissue of "abstraction," a grave intellectualist misrepresentation of the actual character of reality.

A much later view, which has also been called a coherence theory, is that formulated by Rudolf Carnap in *The Logical Syntax of Language* (1937). But the motives underlying this theory differ from Bradley's. Two considerations can perhaps be picked out as its starting points. First, it was realized that there are occasions, particularly in scientific contexts, on which it is to some extent a matter of choice how observed phenomena are to be described, and the choice made is likely to be determined by the aim of maintaining the consistency, or "coherence," of some theory or symbolic system already adopted. Second, it mas felt (perhaps less explicitly) that, whereas the relations of sentences to each other seemed perfectly clear and intelligible, the relation between statements and facts alleged in the correspondence theory seemed only the more obscure and artificial the more closely one sought to examine it (this latter problem did not arise in Moore's treatment, since Moore made no attempt at all to analyze the relation which he called "correspondence"). It had been supposed that statements corresponded to facts in somewhat the same way as a picture corresponds to what it portrays, that facts and sentences had some identity of "elements" and of "structure"; but this view, taken seriously, was soon felt to be a hopeful myth rather than a statement of the actual case, nor was it thought that amendments of it offered much promise.

Accordingly, truth became identified with the consistency of propositions: a proposition is false if inconsistent with some chosen corpus of propositions, true if it can be consistently included in that corpus. Efforts were made, though they did not meet with much success, to explain how this corpus itself comes to be chosen.

Pragmatism. — Though regarded by idealists with scorn and detestation. pragmatism in fact displays, at least in its account of truth, important points of resemblance to Bradley's doctrine. For it expresses, as that doctrine did, dissatisfaction with the notions of "facts" and of "correspondence" to facts, as these notions were employed for instance by Moore.

William James in his *Pragmatism* (1907) did not deny that truth could be defined as correspondence to fact or to reality; but he regarded this as a mere item of lexicography, of no interest unless the further question were raised, in what correspondence to reality consists.

His own answer to this question is somewhat obscured by his preoccupation with colourful metaphor, but at least his general position is clear and indeed familiar: those beliefs are true which it is expedient for us to act upon and believe, and to say that they correspond to reality is only another way of saying the same thing. (*See* PRAGMATISM.)

Tarski's Semantic Conception. — This survey of theories of truth may be concluded with a brief account of A. Tarski's influential article "The Semantic Conception of Truth" *(Philosophy* and *Phenomenological Research,* vol. iv, 1944; also in *Readings in Philosophical Analysis,* edited by H. Feigl and W. S. Sellars, 1949). In the attempt, apparently, to avoid philosophical complications, Tarski construes the predicate "true" as being applicable to sentences; it forms part of a so-called "metalanguage" in which statements are made about the sentences of an "object-language."

Hence. he maintains, the notion of truth must always be related to a specified language, "for it is obvious that the same expression which is a true sentence in one language can be false or meaningless in another." He then introduces the technical notions of a "sentential function" and "satisfaction" of a sentential function by objects; defines a sentence as "a sentential function which contains no free variables"; and concludes that "a sentence is true if it is satisfied by all objects, and false otherwise." This definition he declares to be "formally correct" and "materially adequate"—the test of material adequacy being that it should imply all equivalences of the form "The sentence 'snow is white' is true if, and only if, snow is white."

It should be particularly observed that this definition of truth is offered as applying only to languages having a "specified structure." in the author's sense of that expression; and that "at the present time the only languages with a specified structure are the formalized languages of various systems of deductive logic." In spite of this evidently severe restriction. however. Tarski does "happen to believe that the semantic conception does conform to a very considerable extent with the common-sense usage," though he also considers this usage to be very gravely blurred by vagueness and possibly disrupted by ambiguity. He adds, moreover that. if the "philosophical problem of truth" is not to be formulated in some such question as he has undertaken to answer, nor solved by some such answer as he has supplied, then he does not know what this problem is — indeed he does not believe that there is such a problem.

He insists that all that his own definition requires is that. whenever for instance we assert or deny that snow is white. we must also be ready to assert or deny that the sentence "snow is white" is true. To this at least, he contends. there seems small possibility of objection.

General Considerations. — It is now possible to attempt some general assessment of the problem, in the light of the above-mentioned disparate and conflicting contributions to it. Let us first reconsider the question to what it is that we ordinarily apply the predicate "true."

Consideration of this question at once reveals the limited relevance of Tnrski's remarks. For it is clear that only in rare and peculiar cases can we say, as he would have us say, that a sentence is true (or false). For example, the words "The cat is on the mat" certainly constitute an English sentence; but clearly it is out of place to raise the question whether this sentence is true or false. For these words might be used on many occasions to say something true and on many other occasions to say something false; whether what is said is true or false will depend on the context (in a broad sense) in which the sentence is uttered, and unless some context is specified no question of truth or falsehood can arise. (This becomes obvious if one considers, for instance, the sentence "It rained yesterday.") There appear to be two cases in which we might say that a sentence is true or false: first. where a context of utterance is understood; and second, where the context of utterance does not matter. We might say. for example, "The very first sentence he uttered was untrue," where the sentence is understood to have been used on a particular occasion to make a particular assertion. An example of the second case might be, for instance, a sentence in a system of geometry, the truth of which is a matter solely of the rules of the system and not dependent on any other contextual factors. Here lve might well say that the sentence is "true in" that system, though of course it might not be true in another. It seems clear, partly from Tarski's observation that strictly we ought always to say "true in" a particular language and partly from his account of "formalized" languages of "specified structure." that his definition of truth was framed with an eye to cases of this latter kind; *i.e.*, cases where the context of utterance of a sentence may be neglected.

However. in ordinary spoken or written languages, cases of this kind are exceedingly rare and quite exceptional; nor, incidentally. is it in place to entertain the hope that a natural language. if suitably modified. might be somehow endowed with the necessary independence of context. It thus appears that Tarski's definition of truth is very far removed from "the common-sense usage." since the predicate "true" so defined could have hardly any (if any) application to languages ordinarily employed. It is not necessary to assert that there are no cases in which it is employed in the sense that Tarski defines. but at least it must be said that in enormously many familiar cases it cannot be supposed to be thus employed. An important indication of this is the fact that his expression "true in English" is not English.

Let us then return to Moore's observation that a belief or statement (not a sentence) is true if and only if it corresponds to a fact. What exactly, if any, are the proper objections to this? The idealist criticism has sometimes been said to rest on a simple confusion. on passing from the fact that no statement which we can make could he supposed to state the whole of the truth to the conclusion that no such statement can be wholly true. More fundamentally, however. it rests upon a metaphysical view of "reality" as an unanalyzable, indissoluble n-hole. which. however persuasively and powerfully presented, there is, we must state dogmatically, no need to share.

The later coherence theorists may be thought justified both in their contention that attempts to analyze the relation of "correspondence" were apt to prove unsatisfactory and also in their view that sometimes the aim of maintaining consistency with other propositions determines our choice of words to describe so-called facts: but they cannot but be thought mistaken in their evident implication that nonlinguistic phenomena can play no part at all in determining truth.

The pragmatist account in terms of the satisfaction of our interests could be held, it may be suggested. to explain our adoption of certain theories. or more generally our employment of certain conceptual systems, but it seems to he grossly out of place as an account of the truth of such simple, conceptually unperplexing statements as "The cat is on the mat."

However. it may well be felt that William James was justified in objecting to the correspondence theory as unilluminating, as hardly more than an item of lexicography. The crux of this objection would be that the notions of "truth" and of "fact" are not independent.

Facts cannot be conceived as nonlinguistic objects *about* which we make statements; on the contrary, they are *what* we may be said to state when we make true statements and may themselves be said to be *about* that of which we are speaking. If so, the project of defining truth in terms of facts, although it can hardly be mistaken. can make almost no progress; for the notion of "fact" already includes exactly those features of the notion of "truth" which require elucidation. What is presumably required is an account of the relations between the words which we use in making statements and the things (persons, events. etc.) *about* which we speak and *of* which what we say is true or false. But if we confine our attention to statements and iacts. these relations are not brought into view at all.

More importantly. it is misleading to suggest that when a true statement is made. there is between the words and the world just one relevant relation, called "correspondence." For: as J. L. Austin points out (in the Aristotelian society's *Supplementary Volume* xxiv. p. 116), it is important to distinguish. even in the simplest subject-predicate statement, at least two radically different types of correlation between words and world: (1) that of "demonstrative" conventions, which dztermine what our words are taken to be referring to; and (2) that of "descriptive" conventions, which determine what we are understood to be saying *about* that to which we refer. He further points out that the name "correspondence" is liable to suggest the relation which a portrait bears to,its subject, or a map to the ground. whereas both these relations are fundamentally unlike the conventional relations between things and words. It is not in virtue of any natural, pictorial. or structural similarity between words and things that words spoken or written may be "true of" things; that they may be so is a matter of the existence of rules or conventions for the employment of words. The philosopher's task is to elucidate the nature and working of these conventions. for instance by comparison and contrast with the conventions of map making or signaling, and with the use of other linguistic predicates such as "accurate," "vague" or "exaggerated." This P. F. Strawson (*Supplementary Volume* xxiv, p. 142) has called the problem of "elucidating the fact-stating type of discourse." It is to this problem that the traditional correspondence theory must be supposed to have made its misleading, indeed almost nugatory, contribution.

It is now, perhaps, natural to suppose that. if a satisfactory account were given of the ways in which the words of a true statement are related to that about which it is made, we could conclude that. in saying that the statement is true. one is asserting that those relations obtain; *i.e.*, to suppose, in other words. that an elucidation of the fact-stating type of discourse comes essentially to the same thing as a definition of the predicate "true." Strawson, however, argues forcibly that'this is not so. Although, he contends, the words used in making a true statement of course are related in diverse ways to that about which the statement is made, to say that the statement is true is not to state that they are so related; it is rather to agree with what the maker of the statement has said.

To say "That is true" is neither to make the same statement as that the making of which is the occasion for one's so saying; nor is it to make a different statement, namely about the relations between the words used and the world. It is rather to endorse (or confirm, or admit, or concede, according to context) what has been said. The words "That is true" might often be replaced satisfactorily by "Yes" or "I agree." The problem of elucidating the nature of the empirically informative type of communication must be distinguished, Strawson maintains, from that of determining the functioning of the word "true" within the framework of that type. On this view, the "problem of truth" as traditionally conceived should be further divided into at least two problems: first, that of examining "the fact-stating type of discourse"; and second, that of describing our actual employment of "true." *See* also Index references under "Truth" in vol. 24. (G. J. WK.)

TRUXTUN, THOMAS (1755–1822), U.S. naval officer, was born at Jamaica, Long Island, N.Y.. Feb. 17, 1755, and, at the age of 12 went to sea in the London trade. During the Falkland Island war scare (1770–71) he was impressed for a short space in the British navy. At the outbreak of the American Revolution he was engaged in importing powder, but turned early to privateering.

From 1777 to the close of the war, he commanded letters of marque bringing supplies from France and the West Indies. and won a number of hard-fought engagements with enemy vessels. He engaged in the China trade during the peace years, and was appointed a captain in the new U.S. navy by President Washington in 1794. He superintended the building of the frigate "Constellation" at Baltimore, and commanded her during most of the quasi-war with France.

Truxtun won naval renown on Feb. 19. 1799, when he took the French frigate "Insurgente" in a spectacular fight off Antigua, and added to his reputation a year later when he defeated the

French frigate "Vengeance," and drove her into Curacao. His resignation from the command of a fleet planned to combat the Barbary pirates in 1802 was interpreted by the secretary of the navy as a resignation from the navy itself. Highly incensed and cherishing the supposed slight, Truxtun refused overtures from the navy department during the War of 1812. He engaged successfully in Pennsylvania politics until his death in Philadelphia on May 5, 1822.

See *Quasi-War With France* and *Barbary Wars* (1935–1942); John Frost, *The Pictorial History of the American Navy* (1854).
(W. B. Ck.)

TRYON, DWIGHT WILLIAM (1849–1925), U.S. painter of delicate New England landscapes, was born at Hartford, Conn., Aug. 13, 1849. In 1876 he went to Paris for study; rejecting Impressionism, he chose for his principal teacher Jacquesson de la Chevreuse, the favourite disciple of J. A. D. Ingres. After his return to the United States (1881), he taught first in Hartford and from 1885 at Smith college, Northampton, Mass., where the art gallery bears his name. He became a member of the National Academy of Design in 1891. Extravagantly praised while alive, his work later seemed to appear unduly repetitious in colour and design. He died at South Dartmouth, Mass., 'July 1, 1925.
(Vl. B.; X.)

TRYPANOSOME, the common name for single-celled parasitic flagellated animals of the genus *Trypanosoma*. As adults they are mostly blood parasites of vertebrates, especially fish, birds and mammals. Most species require an intermediate host (often an insect or a leech) for completion of the life cycle. African sleeping sickness of man is due to *Trypanosoma gambiense* or *T. rhodesiense,* both transmitted by tsetse flies. In South and Central America *T. cruzi* (agent of Chagas' disease) and the innocuous *T. rangeli* are both transmitted by bloodsucking bugs. Other species induce economically important diseases of livestock: nagana, surra, mal de caderas and dourine. *See* also Parasitic Diseases; Protozoa; Sleeping Sickness; Trypanosomiasis. (T. C. v. B.)

TRYPANOSOMIASIS (American or Brazilian Trypanosomiasis, or Chagas' Disease) is a disease condition produced by a flagellate protozoan, *Trypanosoma* (or *Schizotrypanum) cruzi,* transmitted to man by a bloodsucking bug. The causative agent was discovered by Carlos Chagas in Brazil in 1909 in the intestine of the bug *Panstrongylus megistus*. Chagas named it in honour of Oswaldo Cruz, a prominent Brazilian microbiologist. Later he found the parasite in the blood of patients who were thought to be suffering from atypical forms of malaria and described the main clinical and pathological aspects of the disease.

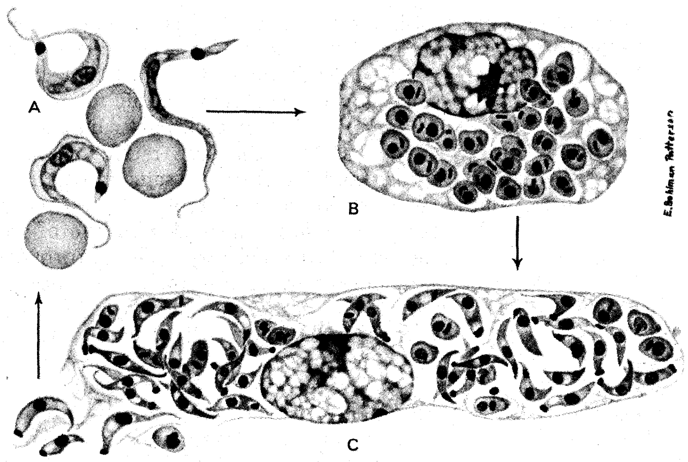
Natural **History.**—Trypanosomiasis is endemic in most rural areas of Central and South America, especially in Brazil, Argentina and Chile, where infection rates of over 10% are reported. Only sporadic cases have been reported from Mexico and one indigenous case from the United States. Many mammals, especially dogs, cats and rodents, may be infected and act as reservoirs of the infection.

The insect vector belongs to the Reduviidae, a family of the order Hemiptera, which includes the true bugs. The commonest species involved in the transmission of Chagas' disease are *Triatoma infestans, Panstrongylus megistus* and *Rhodnius prolixus*. The bugs infest huts and rural dwellings made of mud or adobe, hiding in cracks of the walls during the day and feeding nocturnally on sleeping persons by biting exposed areas of the skin, especially sites where the skin is thin. One of the preferred places is the eyelids. Such species as *Triatoma protracta*, which exist in the southwestern United States, particularly in Texas and California, seem to be less adapted to live in human houses, and this fact probably explains the low incidence of Chagzs' disease in North America.

The insect vector becomes infected by sucking the blood of an infected mammal. Trypanosomes, upon entering the bug's intestine with a blood meal, transform into developmental stages and reproduce intensively. Later, infective trypanosomes appear in the posterior gut of the insect and are eliminated with feces. As the insects regularly defecate while sucking blood, the wound made by the bite is easily contaminated. Also trypanosomes may penetrate undamaged mucous membranes.

The complicated life cycle of this trypanosome in the vertebrate host includes nonreproducing trypanosome stages that are found in the blood (*see* fig. [A]), and reproductive stages that are found in the cells of different tissues. The reproductive stages are small rounded bodies, without flagella (fig. [B]), resembling the protozoa of the genus *Leishmania,* which cause leishmaniasis. T. *cruzi* can infect any cell, but prefers connective-tissue cells and muscle fibres, especially those of the heart.

Disease in Man.—An incubation period of about one week follows the first inoculation of *T. cruzi,* after which local signs appear at the site. Frequently the disease begins with an edematous swelling of the eyelids on one side of the face, where the bug has contaminated the conjunctiva or the eyelids. The lymph nodes near the ear and in the neck and the tear gland are usually enlarged. The patient may have fever and prostration for several weeks. Children sometimes develop severe reactions with generalized edema. high fever and heart and nervous symptoms. Following



(B) AND (C) REDRAWN FROM W H TALIAFERRO AND T PIZZI, CONNECTIVE TISSUE REACTIONS IN NORMAL AND IMMUNIZED MICE TO A RETICULOTROPIC STRAIN OF TRYPANOSOMA CRUZI" IN 'JOURNAL OF INFECTIOUS DISEASES", BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

DIFFERENT STATES OF TRYPANOSOMA CRUZI IN THE MAMMALIAN HOST (MAGNIFIED 1,500 TIMES; SPECIMEN STAINED WITH HEMATOXYLIN-EOSIN-AZURE II)

(A) Nonreproducing trypanosome forms in the blood; (B) reproducing leishmanialike forms in a macrophage of the spleen; (C) transformation of leishmanialike forms into trypanosome forms In a fibroblast of the skin just before reentering the blood

this acute stage, the disease may enter a chronic stage, characterized chiefly by heart symptoms, mainly disturbances of the rhythm. Sometimes heart failure occurs due to the development of the parasite in the muscle fibres of the heart and to the accompanying inflammatory reaction. The infection may end in death, or the course of the disease may be mild with recovery. In Chile and other countries of the Pacific coast and in Central and North America. the disease is generally mild.

Diagnosis is usually made by finding the parasite in the blood, either directly in acute cases or indirectly by inoculating blood into animals. Uninfected reduviid bugs may be applied to the patient, and the insect feces may later be examined. Serological reactions. such as the precipitin test, are useful during the acute stage, and complement fixation is of value during the chronic stage.

No known drug will cure infections with T. *cruzi*. Some quinoline derivatives, mainly primaquine (*see* Malaria), have a transient suppressive action. Prevention and control are centred in providing "insectproof" houses and in eliminating the insect host by insecticides. *See* also Parasitic Diseases; Sleeping Sickness.

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(T. P. P.)

TSAIDAM (ZAIDAM), a mountain basin south of the Nan Shan in Tsinghai province, China, covering about 50,000 sq.mi., with its floor at an elevation of nearly 9,000 ft. It is covered with thinly grown marsh, brackish lakes and, in the east, some salt lakes.

In the east salt is produced by evaporation, and the upper slopes of the basin provide grazing for goats, sheep and horses. The basin is sparsely populated.

The Peking government built a new motor road east-west along the northern margin of the marshland and another north-south through the marsh. In the late 1950s successful exploratory drilling for petroleum was carried out along the northern marsh margins. (J. E. SR.)

TSANKOV, ALEKSANDR (1879–1959), Bulgarian statesman, was born in 1879 in the town of Oriakhovo and studied law at Sofia university, where he became professor of economics. In 1922 he became leader of a small group called the National Concord (Naroden Zgovor), drawn from the intelligentsia of the various political parties and the mass of former officers, which aimed at combining the dispersed national forces for a struggle against the semidictatorship of Aleksandr Stamboliski. To him fell the premiership of the coalition government, representing all the political parties except the Communists, that took power on June 9, 1923, after a military coup *d'état,* in the preparation of which Tsankov's National Concord had its share. Tsankov remained prime minister until 1926, when he was replaced by Andrei Liapchev (*q.v.*). His tenure of office coincided with one of the most tragic periods in modern Bulgaria's history. The disturbance that broke out after Stamboliski's overthrow took thousands of lives. On Sept. 9, 1944, after Soviet troops had occupied Bulgaria, Tsankov formed a National Bulgarian government in Austria under German auspices and tried to recruit a volunteer corps. The advance of the Russians put an end to these efforts; Tsankov surrendered to the U.S. forces and, for several months, was interned at Kitzbuhel in Austria. Later, he was released and emigrated to South America. From 1948 he lived in a suburb of Buenos Aires, Arg., where he died on July 17, 1959.

TSCHAIKOVSKY, PETR ILICH: see TCHAIKOVSKY, PETR ILICH.

TSCHUDI, GILES or AEGIDIUS (1505–1572), Swiss historian, a zealous Catholic, who became the chief magistrate or *landammann* of Glarus in 1558, and in 1559 was ennobled by the emperor Ferdinand, to whom he had been sent as ambassador. He is best known as the historian of the Swiss Confederation. His great work is the Chronicon *helveticum,* or Eidgenossche Kronik, dealing with the period from 1000 to 1470. In spite of its many inaccuracies, falsifications and acceptance of baseless legends (comp., *e.g.*, the article, TELL, WILLIAM) this work is one of great interest and merit, and was long considered the leading authority on its subject. It enshrines the text of many ancient documents that would otherwise have been lost.

Tschudi's chief works were not published until long after his death. The Beschreibung Galliae Comatae appeared under Gallati's editorship in 1758, and is mainly devoted to a topographical, historical and antiquarian description of ancient Helvetia and Rhaetia, the latter part being an early work on Rhaetia revised and greatly enlarged. This book was designed practically as an introduction to his magnum opus, the Chronicon helveticum above mentioned, which was published by J. R. Iselin in two stately folios (1734–1736).

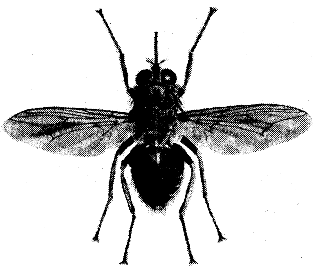
See Lives by I. Fuchs (1805) and C. Vogel (1856).

TSENG KUO-FAN (1811–1872), Chinese scholar, military leader and statesman, was born Nov. 26, 1811, at Hsiang-hsiang, Hunan province, of a peasant family. Tseng studied for the Imperial examinations and passed the first in 1833, one year after his father passed the same examination. In 1838 Tseng passed the highest examination at the capital and became a Han Lin academy member. After holding high office in several central government ministries he returned home in 1852 to observe mourning for his mother. During this period the T'ai P'ing rebellion (1851–64) had spread through central China and the rebels established tneir capital in Nanking in 1853. Since the corrupt imperial troops were too weak to resist the rebels, the government encouraged members of the scholar-gentry to organize local self-defense corps in their home areas. Tseng became the most outstanding of these new military leaders. He not only established a local corps but combined the units formed by several scholars in his home district into a regional army. This army, paid and equipped by voluntary contributions and local funds, was loyal to Tseng and his officers. Tseng's example was followed by other regional leaders such as Tso Tsung-t'ang and Li Hung-chang who first served on Tseng's staff and then organized their own regional armies under Tseng's general direction. Beginning in 1860, the imperial government found it necessary to appoint the new military men as governors general and governors of the provinces that their troops occupied. The armies of Tseng wrested from the rebels their supply areas along the upper Yangtze and finally besieged and captured their capital, Nanking, in 1864.

After the defeat of the T'ai P'ing, Tseng devised the strategy, carried out by Li Hung-chang, for defeating the Nien rebellion in northern China. Tseng and other regional leaders were loyal to the imperial government, but the autonomy of regional political and military organizations established by them remained after the rebellions were suppressed and led eventually to the downfall of the dynasty. Tseng died on March 12, 1872. Tseng was a voluminous writer and his collected works were edited and published after his death by Li Hung-chang. (F. H. MI.)

TSETSE FLY, any of 21 species of African bloodsucking flies of the genus *Glossina,* family Muscidae (see FLY), certain of which are of great medical and economic importance as carriers of human sleeping sickness and of a similar disease in domestic animals.

In Africa these insects are usually known simply as fly, or tsetse, a name from Bechuanaland, meaning a fly that destroys cattle. As the flies readily attack man, his herds and his beasts of burden, it seems probable that the relatively slow development of agriculture, communications and other practices of modern civilization in tropical Africa has been in large measure due to the widespread presence of the tsetse in that region.



BY PERMISSION OF THE BRITISH MUSEUM (NATURAL HISTORY)

TSETSE FLY (GLOSSINA PALPALIS), FOUND IN WEST AND CENTRAL AFRICA. ENLARGED ABOUT 2 TIMES

All species of tsetse are similar in appearance, being robust, sparsely bristly flies, usually somewhat larger than the related housefly, although ranging in length from 6 to 16 mm. Their colour varies from yellowish brown to dark brown; the thorax often is grayish above with darker markings, and the abdomen sometimes is banded. The stiff, piercing mouthparts, directed downward as the fly bites, are at other times held horizontally, ensheathed by the elongate maxillary palps and giving the appearance of an unusually conspicuous proboscis. In repose, the wings are held flat over the back. A bristlelike appendage (arista) on the antenna bears a single row of long, branched hairs. These characteristics apply equally to both sexes of Glossina and differentiate them from all other flies.

Tsetse flies ordinarily live one to three months, occasionally longer, the life span depending on many environmental factors. All species bear their young alive. A larva, hatched from an egg within the female fly, feeds on a nutrient fluid secreted by paired "milk glands" on the uterine wall. Embryonic development and three stages of larval growth require about nine days. Without a sufficient blood meal, the female fly will produce a small, underdeveloped and nonviable larva; when adequately fed, however, she will produce a fully matured larva about once every ten days throughout her life.

Larvae are usually deposited near food sources, as along shaded game trails or near resting places of reptiles or mammals. The larva takes no further food but burrows into the ground and pupates within an hour. Several weeks are required for the development of the adult within the pupal case.

Species of tsetse vary in their environmental requirements. In general they occur in woodlands, although they may fly out a short distance into open grasslands when attracted by the sight of a host animal.

The flies have a discontinuous distribution corresponding to the irregular occurrence, in areas known as fly belts, of characteristic associations of trees and shrubs comprising their particular appropriate environment. *Glossina palpalis,* a species of medical importance, occurs primarily in dense stream-side vegetation, while G. *morsitans,* in contrast, feeds in more open woodlands.

Both sexes suck blood, feeding almost daily, especially in the brightest, warmest part of the day. Although some tsetse bite at night, most of them cease activity soon after sunset, or at temperatures below 60° F. Of the flies attacking man usually 80% or more are males; the females seem more attracted to larger animals.

The genus *Glossina* occurs from Gambia eastward through Nigeria to western Abyssinia, southeastward through Kenya and Uganda to Mozambique, and southward through the Belgian Congo to northern Angola. One species has been found in the southwestern Arabian peninsula. Within this vast area the distribution of tsetse is largely governed by vegetation and climate. Although the genus is now virtually restricted to Africa, four fossil species in Miocene deposits (about 21,000,000 years oid) of North America indicate a once widespread distribution.

Only two species of tsetse commonly transmit the flagellate protozoan parasites (trypanosomes) causing human sleeping sickness (*q.v.*). Taken up in a blood meal by the fly, these microscopic blood parasites may be transferred unchanged from one host to another within a couple of hours, but otherwise they undergo a transformation within the fly's body, passing from the alimentary tract to the salivary glands. The fly once more becomes infective after 11 to 18 days. When the tsetse bites, it injects saliva into its host to prevent blood coagulation, and during this process trypanosomes are transferred. In this way, *Glossina palpalis* of western and central Africa infects man with *Trypanosoma gambiense,* one of the trypanosomes causing sleeping sickness.

When this disease was first introduced into eastern Africa, however, its virulence was much greater; between 1901 and 1906, there were in Uganda an estimated 200,000 deaths from sleeping sickness, a frightful toll representing probably two-thirds of the human population of the affected region. Sleeping sickness in east-central Africa is usually caused by *Trypanosoma rhodesiense,* carried by *Glossina morsitans*. Although relatively rare and of local occurrence, this form of sleeping sickness is more severe and is often fatal within a few weeks or months. *Trypanosoma brucei* and two other trypanosomes cause nagana, a wasting disease in cattle but usually fatal to horses. Certain wild game, particularly ungulates such as antelope, are regarded as the natural reservoirs of trypanosome infection, although they themselves seem unaffected by the parasites.

The most effective control of the flies has been environmental — destruction of wild game, clearing of woodlands, and periodic burning to prevent growth of brush. Fly trapping, control by natural parasites, and application of insecticides to livestock have not been successful. Aerial sprays of residual insecticides have given inconclusive results.

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TSIMSHIAN, an American Indian linguistic stock on Nass and Skeena rivers and Milbank sound, British Columbia. They are typical north Pacific coast tribes, forming, with the Tlingit, the Haida and certain Athabascans of the adjacent interior, a matrilineal sub-culture group.

The four Tsimshian phratries, Raven, Wolf, Eagle and Grizzly Bear, are distributed through the three tribes composing the stock, namely Tsimshian proper, Niska and Gitksan. Population, originally estimated, 7,000; 1906, 3,700.

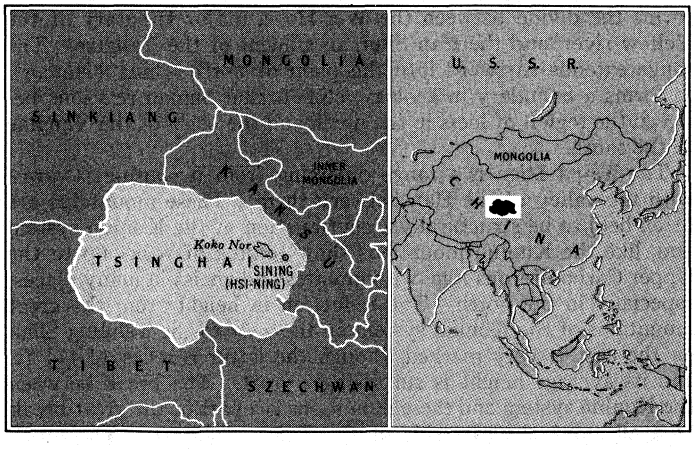
TSINAN (Chi-nan), the capital of Shantung province in north China. Pop. (1957 est.) 862,000. Tsinan is situated at the northwestern corner of the Shantung highlands (near T'ai Shan, China's most sacred mountain), at the edge of the hill country, along a line of springs which fostered very early settlement. Its history is bound up with that of the ancient states of Chi and Lu in the classical (Chou) period, and almost continuously it has been a regional centre and political capital of importance. With the creation of the modern Shantung province during the Ming dynasty (1368–1644) — closely corresponding to the territory of the two feudal states — Tsinan became the political capital. The return of the Hwang Ho (Yellow river) to a course north of Shantung in 1852 brought the river within five miles of the city and augmented its strategic location for modern affairs.

Tsinan was brought into contact with foreign trade through the building of the railway (1899–1904), by German interests, from Tsingtao to a point very close to the city. The city was voluntarily opened to foreign commerce in 1904, and a suburban settlement was created outside the old city. Though not a treaty port, the foreign population grew to sizable proportions, and the participation of foreign concerns in local trade helped to make Tsinan one of the most westernized of the large cities of China. With the completion of the Tientsin-Pukow (P'u-K'ou) railway in 1912 Tsinan became a rail junction, and the city became an important regional trading centre for one of the most productive portions of the north China plain. Though the Yellow river and other local waterways are not fully navigable, small-boat traffic has focused on Tsinan. Because there was ample coal not far away, silk and cotton textile manufacturing, flour milling, vegetable oil extraction and a variety of light manufacturing developed. A government arsenal set up near Tsinan caused the city to be the military objective of contending factions between 1915 and 1937, when it was occupied by Japanese forces and held until 1945; it was seized by the Chinese Communists in 1948. The Communists have not earmarked Tsinan for spectacular expansion. but iron and steel manufactures and heavy machinery and chemical (soda ash) industries have grown steadily. (J. E. Sr.)

TSINGHAI (Ch'ing-hai Sheng), province of northwestern China, in the Tibetan highlands. Area 278.378 sq.mi., pop. (1957) 2,050,000. About 90% of the territory consists of mountains and high plateaus, whose sparse grasslands are used for livestock raising. Animal products (sheeps' and yaks' wool and hides) make up a large part of the provincial economic production. The stock herders (about 440,000 in 1953, or 27% of the total population) are made up of non-Chinese minorities, Tibetans, Mongols and Kazakhs, who inhabit their own autonomous areas. Crop raising is largely limited to the northeastern corner east of Koko Nor (*q.v.*) and around Sining, where the province's Chinese population (approximately 1,000,000) is concentrated. Farming in this area is also the main occupation of some ethnic minority groups, Chinese Muslims, Tu and Salar, based within their own areas of national autonomy.

Food crops include spring wheat, millet and barley. Tsinghai

TSINGHAI PROVINCE. IN THE TIBETAN HIGHLANDS OF CHINA



is traversed from east to southwest by a truck highway linking Lanchow, in Kansu province, with Lhasa, in Tibet. Construction of a railroad from Lan-chou to Hsi-ning began in the late 1950s. Under the Communist regime, an intensive petroleum-exploration program was organized in the Tsaidam (*q.v.*) basin of northwestern Tsinghai. The Five-Year plan of 1958–62 called for a production of 3,000,000 tons of crude oil by 1962. Other mineral resources include coal, mined at Ta-t'ung north of Hsi-ning, borax and salt from the numerous salt lakes. Hsi-ning (1953 pop. 93,700), the provincial capital, was the only large city of the province. Tsinghai became a province in 1928 when the Hsi-ning area was detached from Kansu. (T. SD.)

TSINGTAO (CH'ING-TAO), city and port on the south coast of Shantung province, China, situated on Kiaochow bay (Chiaochou Wan), an iniet of the Yellow sea. It is connected by a railroad with Tsinan, an inland city, 190 mi. W.N.W. Kiaochow bay was occupied by Germany after the murder of two missionaries in Shantung in 1897, and negotiations followed, resulting in a lease of land to Germany for 99 years. The area leased was about 117 sq.mi. and all points within 32 mi. of any point on the bay were held not to be affected by Chinese ordinances without German consent.

A free port was created at Tsingtao in 1899, and a branch of the Imperial Maritime customs was established there for collection of duties on shipments to and from the interior. The German government built up the city of Tsingtao, and created educational and agricultural institutions in the leased territory. After Japan had declared war on Germany in World War I, the first Japanese objective was the reduction of Tsingtao, which served as an operational base for German sea marauders menacing Allied trade routes in eastern Asia. In August, 1914, the Japanese navy began a blockade of Tsingtao, and the following month, Japanese troops landed at Lung-k'ou (Lungkow), on the north coast of Shantung, and advanced on the German stronghold. The Japanese were fortified by a British force and on Nov. 7, 1914. Tsingtao capitulated after a week-long attack on its land positions and bombardment by the Japanese blockading fleet. Japan held Tsingtao until 1922, when the port was handed over to China under the Washington agreement.

During the Chinese-Japanese war, Japan again seized control of the port in 1938 and held it until 1945. During the Nationalist-Communist hostilities following World War II, Tsingtao was briefly headquarters of United States naval forces in the Pacific until the Communist conquest of the mainland.

Under the Communist regime, after 1949, Tsingtao's industries provided a major base for the industrial construction effort in the interior. The city has a large cotton-milling industry, paper mills, oilseed and flour mills, as well as locomotive and rolling stock shops, shipyards and a rubber tire factory. Many industrial plants are situated in the suburbs of Ssu-fang (Szefang) and Ts'ang-k'ou (Tsangkow), north of the city proper. Tsingtao is a major fishing port, with extensive saline deposits nearby. It is the seat of Shantung university, and has an Institute of Technology. Pop. (1953), 916,800; (1957 est.) 1,121,000. (T. SD.)

TSINLING SHAN (CH'IN LING), a range of mountains which forms the divide between the Wei Ho, a major tributary of the Yellow river, and the Han Shui, an affluent of the Yangtze. The range extends eastward into the plain of north China (Honan). It forms a boundary in geology, climate and human relations between the region of loess in the north and the basin of the Yangtze to the south.

The Ta-pa Shan is a range diverging from it south-eastwards, with the valley of the Han between them. These mountains are often held to be structurally a continuation of the Kunlun system and, like the Kunlun mountains show folding of rocks up to the Upper Carboniferous Age, with granites and gneiss in many places, especially in the north. The reduction in height from the great mountains of the Kunlun system on the west to the Tsinling Shan on the east is very marked, though the latter reaches 13,474 ft. and its average height is surprisingly great. The break between the Kunlun system and these mountains is a part of the great break seen all along the east side of the Tibetan plateau. The north face is very steep and loess reaches up to about 3,300 ft. above sea level at places along it. The top of the range is broad, with sharp heights. The south face has rounded heights and wild, deep-cut valleys.

Despite its size and height the range is essentially one mass, not a complex of chains such as found in the Alps. (T. SD.)

TSO TSUNG T'ANG, one of the high scholar-officials in China who made their careers as military leaders in the suppression of the great rebellions that threatened the imperial government during the second half of the 19th century. Born in Hunan province in 1812 of a scholarly family of moderate means, Tso passed, at an early age, the examination which admitted him to the privileged scholar-gentry group.

When the T'ai P'ing rebellion broke out in 1850 Tso helped organize local defense forces against this uprising. He joined the staff of Tseng Kuo-fan (*q.v.*), and as commander of a major branch of Tseng's Hunan army, drove out the Taiping rebels from Chekiang and Fukien and was appointed governor-general of the two provinces in 1863.

In 1866 he was sent to Shansi and Kansu as governor-general to fight the Moslem rebels there. After recovering the provinces by 1869 Tso argued in favour of the reconquest of Sinkiang from the rebel Yakub Beg since, without the control of the Sinkiang frontier passes, China's whole inner Asian position would collapse. In a brilliant campaign started in 1875 he succeeded not only in destroying Yakub Beg but in re-establishing Chinese power so convincingly that China regained, in the Treaty of St. Petersburg in 1881, the important border passes which Russia had occupied during the Moslem rebellion.

In 1882 Tso was appointed governor-general of Liang Kiang and in 1884 he was placed in charge of China's defense in the war with France. He died at Fuchow on Sept. 5, 1885. *See* also CHINA: *History: 19th Century and Revolution.* (F. H. Mr.)

TSU, industrial city and capital of Mie prefecture, Japan, originated in an ancient castle town on Ise bay. Between 1940 and 1960 its area expanded from 9 sq.mi. to 31 sq.mi. and the population from 68,600 to 110,900. Textiles woven frorn cotton and artificial fibres are the chief industrial products.

There are two large temples Kannonji and Shitennōji. The latter rebuilt in 1615, marks the site of one of the earliest Buddhist temples of Japan. (C. A. MR.)

TSUSHIMA, a group of five rocky islands in Nagasaki prefecture, Japan, located in the strait separating Japan and Korea. The islands divide the strait into the Eastern channel or Tsushima strait, 56 mi. wide, and the Western channel or Korean strait (formerly called the Chosen strait), 56 mi. wide. The warm Tsushima current, a branch of the Japan or Kuroshio current, flows through the straits into the Sea of Japan. The five islands, the largest of which are Kamiagata and Shimoagata, have a total land area of about 274 sq.mi. Between 1940 and 1960 the population increased from 56,600 to 69,556. The principal towns are Izuhara, the administrative centre, and Keichi. Most of the people are fishermen.

Japanese mythology credits the creator gods with producing Tsushima as one of the original islands of Japan. The islands played a critical part in history as a steppingstone between Korea and Japan. Archaeological evidence shows this was a route followed by ancient men in their migration to Japan. Throughout its early history Tsushima was raided by Korean and Japanese pirates. From the 12th century to the Restoration of 1868 the islands were the fief of the Sō family who were *daimyo* (feudal lords) and frequently acted for Japan in diplomatic relations with Korea. During the Mongol attempt to invade Japan in 1274 and 1281 the population was massacred. In 1861 Russia made an unsuccessful attempt to secure concessions. A Japanese fleet under Adm. Heihachiro Togo completely defeated a Russian fleet under Adm. Z. P. Rozhdestvenski in the battle of Tsushima (May 27–28, 1905), north of the islands. (C. A. MR.)

TSWANA, or BECHUANA, are the westerly division of the Sotho- (Bantu-) speaking people of South Africa. They are thought to have emigrated from northeastern Africa and to have arrived in the area of eastern Bechuanaland and southern Transvaal by A.D. 1600. A process of dispersal and fission was accelerated during the 19th century by a series of invasions by Sotho, Nguni and Europeans, as a result of which the various Tswana people lost much of their territory. In the second half of the 20th century they comprise several groupings, the most important of which are the Hurutshe, Kgatla, Kwena, Rolong, Tlhaping and Tlokwa.

Tswana are to be found in western and central Transvaal, British Bechuanaland and at Thaba Nchu, all within the Union of South Africa, and in the Bechuanaland Protectorate, especially its eastern and northern peripheries. Within this area, the Okovango depression is the home of the Tawana (Kwena) tribe; the Motloutse basin is occupied by the Ngwato (Kwena) with their alien dependents; the Limpopo-Molopo watershed and its eastward extension into the Crocodile river basin supports concentrations of Kgatla, Ngwaketse (Kwena), Tlokwa and Malete living on tribally owned land or on European farms: and the Kuruman-Molopo river area is occupied by Tlharo (Hurutshe), Rolong and Tlhaping. The Tswana number about 750.000, of whom 580.000 live in South Africa. Bechuanaland has about 167,000 Tswana, but it is usual to add about 100,000 who, though subject to Tswana tribes, are ethnically, culturally and linguistically heterogeneous.

Tswana live in a grassland environment in which they practise animal husbandry (their main interest) and a precarious subsistence agriculture. Livestock kept include sheep, horses, donkeys and cattle, the index of wealth and status. Basic crops are maize and sorghum. The plough is in general use and both men and women are employed in agriculture. Game is sufficiently plentiful in the Bechuanaland Protectorate to permit casual and professional hunting as a profitable supplementary activity. This simple peasant economy is complicated by the seasonal and periodical migration of large numbers of men to work at the mining and industrial centres of South Africa. All three aspects of modern Tswana economy disturb the routine of settled home life: herd boys are obliged to spend long periods at grazing camps distant from their homes; fields are usually far away from villages so that, during the cultivating season, family units live in temporary huts on their own arable land; and the demands of wage earning take the younger adult men out of the country for periods of nine months or more at a time.

Tswana material culture reflects the widespread intrusion of European goods and standards. House forms range from the traditional circular single-roomed dwelling with a conical thatched roof to the multi-roomed, rectangular house roofed with corrugated iron. Transport similarly varies from ox-drawn sledges to motor vehicles. European dress prevails generally.

The Tswana language is the common tongue, but many other African languages are in everyday use by the numerous alien communities. English and Afrikaans are in frequent use. Tswana literature, including regular newspapers, was becoming increasingly available in the second half of the 20th century to meet the needs of a growing literate population. Christianity is the official religion of most tribes and, of the traditional cults, ancestor veneration alone survives. Greater resistance to change is displayed by beliefs in traditional medicinal practices and the magic of hate and spitefulness: the curing of sickness, the protection of person and property and the safeguarding of crops and livestock all have their general practitioners, diagnosticians and specialists, who continue to play an important part in everyday life, but malevolent and deliberate use of harmful medicines is distinguished from a fictional belief in the activities of witches.

Historical and cultural differences within the whole Tswana population are expressed through a system of descent groups. Every Tswana is affiliated to the descent group of his father, each group being associated with a distinctive symbol which serves as a polite mode of address and sometimes as a surname. These groups, which are neither corporate nor localized, are not to be confused with marriage regulating groups. They are carriers of historical and cultural tradition, each being differentiable from others in terms of myths of origin, variations of ritual and customary practices and of slight dialectical differences.

Social Organization. — This varies with circumstances and the following details refer particularly to those Tswana living in self-administering political units, and especially in the Bechuanaland Protectorate. The essential social unit is the ward, a readily identifiable, self-contained, social and administrative entity, comprising a number of lineally related family groups together with their dependents and servants. Its leader is usually the head of the senior family. It is always territorially distinct, forming a residential group of the small village pattern when in a rural setting and of the precinct pattern within larger villages and tribal capitals. Within the ward, the smallest kinship group is that of the simple family; more important and more self-sufficient is a group consisting of a simple family together with a number of dependent close relatives and occupying a homestead enclosed within a single wall or fence. In the case of polygynous marriage, each wife usually has her own homestead. Several homesteads, the heads of which are lineally related, frequently congregate and form homestead clusters of varying size. Such groups of homesteads are usually laid out in a circular plan, enclosing an open space which serves as meeting place, court and administrative centre.

Kindred groupings, embracing all people who are related by ties of descent and marriage, are wider in territorial range and less concentrated than kin and residential groups. Their greater dispersal is partly a product of marriage rules and practices. Among the Tswana, there exists no formal objection to first-cousin marriage: marriage with cross cousins is more highly favoured than that with ortho-cousins and, among the latter, marriages with a mother's sister's daughter are rare. In practice, however, most people marry nonrelatives and so help to unite members of many different wards into loose, unformalized but practical associations. Age distinctions serve to build up associations cutting across ward loyalties. Adult status depends upon admittance to a formal age set or regiment, a parallel organization permitting the differentiation of males and females. New regiments are formed periodically on a tribal basis, each commanded by a member of the tribal chief's family, although traditional initiation ceremonies and training courses are being abandoned. Their continued importance lies in their function as organized labour units for public works and in the fact that, being self-administering, they provide an instrument of social control on a tribal-wide basis. But the most extensive and intensive form of inter-ward integration is that achieved by the political administrative system. The Tswana favour the clustering of many wards to form large villages within which each ward maintains its own clearly defined precinct. The isolated hamlets and small villages are usually the homes of alien adherents and dependent people. Most Tswana tribes have one large capital village or town (*e.g.,* Serowe) at which the majority of Tswana members reside. The entire Tlokwa tribes of Bechuanaland Protectorate, live in one large settlement. The government of these large settlements of the Tswana and the Tlokwa and of the surrounding arable land, grazing areas and hunting grounds is vested in a hereditary chieftainship; *e.g.,* Tswana tribe is a political association united by loyalty to a single political head, who is responsible for tribal government and administration, subject only to the overriding authority of a European government. Tribal membership is heterogeneous and Tswana members are often in the minority, so that a Tswana tribe accordingly lacks cultural and even linguistic uniformity. The chief rules with the assistance of advisers and officials, but at the same time all matters of public policy usually require the approval of a general council open to all adult male tribal members. Within this framework, local administration is vested in heads of lineally defined groups which form the structural core of the various settlement units. The emphasis placed upon the political mode of tribal aggregation and government serves to demarcate hereditary strata within Tswana society. The alien tribal members are clearly differentiated from those members of Tswana descent, who are in turn divided into "nobles" (*i.e.,* agnatic descendants of ruling lineages) and commoners; within these strata finer distinctions depend on family position and political role. Hereditary status is modifiable by the acquired status conferred by wealth, personal prowess, education and occupation. Aliens who are voluntary immigrants into Tswana society may become assimilated with the commoners, but the others, such as Bushman and Kgalagadi people, are relegated to a more or less permanent socially, though no longer legally, servile position. The essentials of Tswana social organization thus consist of the initial formation of small, localized, lineally integrated groups and their ultimate combination in terms of kindred ties, age organizations and a political system.

See J. T. Brawn, *Among the Bantu Nomads* (1926); I. Schapera, *Ethnic Composition of Tswana Tribes* (1952), *Tswana* (1953), *A Handbook of Tswana Law and Custom* (1955). (V. G. J. S.)

TUAM, the ecclesiastical capital of Connaught and the chief market town of the northern part of east Galway, Ire., lies 21 mi. N.E. of Galway and 120 mi. W.N.W. of Dublin by road. Pop. (1961) 3,500. Tuam is the seat of a Roman Catholic archbishop, the see having been founded by St. Jarlath (c. 550), and of a Protestant bishop. The Protestant cathedral was probably founded by Toirdelbhach Ua Conchubhair (Turlough O'Connor), king of Connaught, in *c.* 1130. The chancel, of red sandstone, is all that remains of the ancient structure, the rest having been rebuilt in its original style in the 19th century. The Catholic cathedral, in late Gothic style, is outside the town. In the market square stands the cross of Tuam which bears inscriptions in memory of Turlough O'Connor and Abbot O'Hoisin, archbishop in 1152.

TUAN CHI-JUI (1864–1936), Chinese politician, was born in Anhwei. He succeeded Yuan Shih-kai as viceroy of the Hukuang province, and was one of the signatories to the memorial of Jan. 1911, urging the emperor to abdicate. He was acting premier from May to July 1913, minister of war in 1914, and premier in April 1916. In Oct. 1918 Tuan Chi-Jui resigned, and, after an ill-advised coup on behalf of the Anfui club, played no great part in affairs till Nov. 24, 1924, when he succeeded Tsao Kun as president.

TUAPSE, a town on the Black sea in the Krasnodar *krai* of the Russian Soviet Federated Socialist Republic, U.S.S.R., in 44° 10' N., 38° 59' E., linked by a branch line with Armavir on the Rostov-Baku railway. It is the terminus of pipelines from the Grozny and Maikop oil fields and has refineries. Pop. (1956 est.) 34,100.

TUAREG, also TAWAREK (sing. *Tarqi)*, the name given by Arabs to the western and central Saharan Berber peoples in the desert from Tuat to Timbuktu and from Fezzan to Zinder, an area of about 1,500,000 sq.mi. The Tuareg resort to the centres from which the trade routes radiate, Timbuktu, Ghat, Ghadames, Murzuk and Tuat. Their general colour is reddish yellow. Their hair is long, black and silky, beards black and thin, eyes generally black; noses small, hands delicate, and bodies muscular. They are tall and graceful. The aristocratic section is called *Tmajagh;* Arabs call them *muleth themin* (veiled people). The men wear the veil day and night, the women never. The Tuareg, at any rate the noble class, are among the purest of the Berber stocks but have become largely Arabized. The script, known as T'ifinagh, consists of 40 to 50 symbols. They dress generally in a black tunic (some wear white), trousers of white cotton, and wear a cloth called *litham* or *tagilmus,* the end of which is drawn over the face, leaving visible only the eyes and the tip of the nose. These cloths are dark blue or white. To this difference of colour is due the terms "black" and "white" Tuaregs.

TUAREGS OF THE REPUBLIC OF NIGER

PAUL ALMASY

Socially the Tuareg are divided into six classes: *Imajeghan* or nobles; *Marabout* or priests; *Imghad* or serfs; *Irejanaten* or mixed people, issue of noble and Imghad; *Ikelan* negro slaves and *Buzu* outdoor slaves. The nobles are all pure blooded and provide the tribal chiefs. They do no manual work. Among the Imghad serfdom is hereditary, and they are bound collectively to a noble tribe or group of tribes.

See BERBER.

TUATARA (TUATERA), the last surviving species *(Sphenodon punctatus)* of the reptilian order Rhynchocephalia ("beak-heads"). This lizardlike reptile of New Zealand has two pairs of well-developed limbs, a strong tail and a scaly crest down the centre of its neck and back. The scales that cover the entire animal vary in size. Adults are between 24 and 30 in. long. The tuatara is easily distinguished from the lizards by the presence of a third eyelid, the nictitating membrane, which mcves horizontally across the eye. Also the tuatara has a bony arch low on the skull behind the eye, which is not found in lizards. It was the presence of this bone that first suggested that the tuatara was a survivor of the otherwise extinct order Rhynchocephalia and not a lizard. The pineal eye, a median uncovered spot on the head, is prominent in young tuataras for about six months after birth. It is not known what function this structure serves: there is no evidence that it acts as an endocrine gland, and experiments to test it as a light or heat receptor give inconclusive results.

JOHN MARKHAM

TUATARA (SPHENODON PUNCTATUS)

Originally living on the two main islands of New Zealand, the tuatara exists only on certain of the smaller islets, where it is protected from introduced, domesticated animals that probably exterminated it from the main islands. The tuatara burrows in the top soil and emerges to bask in the sun for short intervals during the day. It is active at night and feeds mostly on insects.

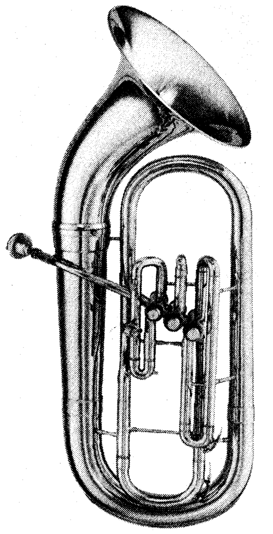
The eggs are laid in spring in shallow excavations, usually at some distance from the home burrow. Development of the embryo is slow, and hatching does not take place until the following spring. *See* REPTILES.

See also W. H. Dawbin, "The Tuatara in Its Natural Habitat," *Endeavour,* vol. xxi, no. 81, pp. 16–24 (Jan. 1962). (R. F. I.)

TUBA, in music, the tubas — bombardon, helicon, euphonium —are a family of valved instruments of powerful tone forming the tenor and bass of the brass wind. In the orchestra these instruments are called tubas; in military bands euphonium (tenor), bombardon and helicon (bass).

The modern tubas owe their existence to the invention of valves or pistons by two Prussians, Stolzel and Bliimel, in 1815. The tubas are often confounded with the baritone and bass of the saxhorns, being, as they are, the outcome of the application of valves to the bugle family. There is, however, a radical difference in construction between the two types. Given the same length of tubing, the fundamental octave of the tubas is an octave lower than that of the saxhorns, the quality of tone being immeasurably superior. This difference is due to the proportions of the truncated cone of the bore and of the column of air within. By increasing the calibre of the bore in proportion to the length of the tube it was found that the fundamental note of the harmonic series was obtained in a full rich quality, and by means of the valves, with this one note as a basis, a valuable pedal octave, absent in the saxhorns, is obtained.

The modern tuba finds its prototype in the Roman tuba. Comparedwith the other military service instruments of the Romans, the buccina and cornu, the tuba was straight and was used to sound the charge and retreat, and lead the soldiers in action.



BY COURTESY OF THE BUESCHER BAND INSTRUMENT COMPANY

EUPHONIUM. ONE OF THE TUBAS

TUBE, a term that has various meanings as applied to industry, electronics, transportation and medicine. *See* AQUEDUCT; BOILER; ELECTRON TUBE; GLASS; IRON AND STEEL; LIGHTING; PNEUMATIC CONVEYING; RADIOLOGY; STEAM; SUBWAY (UNDERGROUND RAILWAY).

TUBER, in botany, a short fleshy, usually underground stem bearing small scale leaves with buds or "eyes" in their axils, as the potato (*q.v.*). The name is also applied to a genus of fungi, in the Tuberaceae family of the Ascomycetes, characterized by subterranean tuberlike fruiting bodies, as the European truffle. *See* STEM; TRUFFLE. (J. M. BL.)

TUBE RAILWAY: see SUBWAY (UNDERGROUND RAILWAY).

TUBERCULIN. In 1890 Robert Koch found a specific substance produced in artificial culture media during the growth of tubercle bacilli (*Mycobacterium* tuberculosis) which caused an inflammatory reaction when injected into animals or human beings previously infected with the tubercle bacillus but not in uninfected persons. Koch called it old tuberculin (OT). It was made by sterilizing the culture, filtering off the bacilli and concentrating the whole germ-free culture liquid to one-tenth the original volume. This tuberculin and many succeeding modifications of it have Seen used for the diagnosis of tuberculosis.

One of the purest products isolated was the purified protein derivative (PPD), and this has been used extensively for the diagnosis of tuberculosis in all parts of the world since 1934. One large lot, prepared in 1940 and designated PPD-S, was adopted by the U.S. government and by the World Health organization as the standard for comparison of human-type tuberculins. All PPD preparations, in general, consist of tuberculoprotein, the specifically active fraction isolated by chemical means from germ-free filtrates of heated human tubercle bacillus cultures grown on synthetic nonprotein media. The protein fraction contains several proteins of the tubercle bacillus, and these proteins have been separated chemically. They differ in their relative skin-reacting power and are being compared for their specificity in detecting active disease.

Tuberculin Test. — The most quantitative method of administering tuberculin is known as the Mantoux test, after Charles Mantoux, who devised the method. A small amount of tuberculin (0.1 ml.) is injected intradermally, usually on the flexor surface of the arm. When the test is positive, a swelling, usually accompanied by redness, occurs within 48 hours at the site of injection. Other less accurate methods of testing are by scratch, patch, ophthalmic and subcutaneous techniques. PPD is so potent that only 0.00002 mg. is required to give a positive Mantoux skin reaction in 94% to 96% of all persons with active tuberculous infection. A dose of 0.0001 mg. will detect practically any case of clinically significant tuberculosis. A larger dose (0.005 mg.) is frequently given if the patient gives no reaction in 48 hours with either of the smaller doses, but the significance of positive reaction to this dose is still under investigation. Still larger doses are not used because there are indications that they give nonspecific reactions. A patient giving a negative reaction to the 0.005-mg. dose is considered to be uninfected. However, a rare person may fail to react in spite of known infection.

The specificity of the reaction is very great when used in the prescribed doses. Practically 100% of guinea pigs artificially infected with tubercle bacilli or persons vaccinated with attenuated tubercle bacilli (BCG) react to tuberculin after having been negative previously. Furthermore, in an isolated population in Dutch Guiana (Surinam), where there was no infection with tubercle bacilli, no reactions occurred even with the 0.005-mg. dose. However, in certain parts of the world, such as India and southeastern U.S., the correlation between the number of reactors to the 0.005-mg. dose and the extent of known tuberculous infection does not correspond with that found in other parts of the world. The explanation for this discrepancy is being sought.

The extent of tuberculous infection in any locality can be determined approximately by finding the percentage of reactors to low doses of tuberculin. These percentages correspond to the intensity of exposure, which usually reflects the prevailing economic and sanitary conditions. A positive reaction, however, merely indicates infection with the tubercle bacillus and not necessarily active disease. The test is a help to the physician in determining the source and time of an infection, and in distinguishing between tuberculosis and other pulmonary conditions, such as histoplasmosis and other fungus diseases, in which the pulmonary lesions resemble those of tuberculosis on X-rays.

Tuberculin Therapy. — Tuberculin was used therapeutically by Koch. It is seldom used today except in the treatment of tuberculosis of the eye and some other forms of nonpulmonary tuberculosis. Patients are desensitized by a series of injections of increasing dosage, beginning with a 1:100,000 dilution of old tuberculin.

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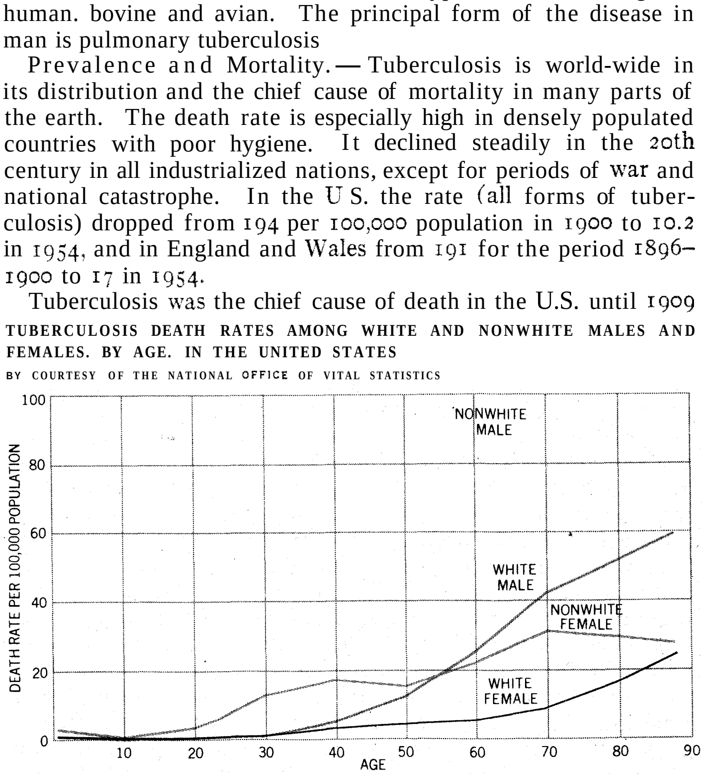
TUBERCULOSIS. Tuberculosis is an infectious disease of man and animals caused by the tubercle bacillus (*Mycobacterium tuberculosis*), which belongs to the acid-fast group of bacteria (*Mycobacteria*), and of which several types exist, including the human. bovine and avian. The principal form of the disease in man is pulmonary tuberculosis

Prevalence and Mortality. — Tuberculosis is world-wide in its distribution and the chief cause of mortality in many parts of the earth. The death rate is especially high in densely populated countries with poor hygiene. It declined steadily in the 20th century in all industrialized nations, except for periods of war and national catastrophe. In the U S. the rate (all forms of tuberculosis) dropped from 194 per 100,000 population in 1900 to 10.2 in 1954, and in England and Wales from 191 for the period 1896–1900 to 17 in 1954.

Tuberculosis was the chief cause of death in the U.S. until 1909

TUBERCULOSIS DEATH RATES AMONG WHITE AND NONWHITE MALES AND FEMALES. BY AGE. IN THE UNITED STATES

BY COURTESY OF THE NATIONAL OFFICE OF VITAL STATISTICS



and 11th in 1954, being exceeded by heart diseases. cancer, vascular lesions of the nervous system, accidents, certain diseases of infancy. pneumonia, arteriosclerosis, diabetes, congenital malformations and chronic nephritis.

In 1954 in the United States 16,000 deaths from tuberculosis were recorded.

It is calculated that in general the prevalence is approximately 20 times the mortality, but both prevalence and mortality vary considerably in different circumstances. Usually tuberculosis rates are higher in urban than in rural communities, because of crowding. greater opportunity for infection and the frequent hygienically less favourable position of large parts of some cities. However, with economic improvement, better sanitation, more widespread education and particularly with the establishment of public health practice, including specific measures for tuberculosis control, many cities have lower tuberculosis rates than adjacent rural areas. In the U.S. one of the chief factors influencing the mortality rate is the relative proportion of Negro inhabitants. The over-all mortality rate from tuberculosis is three times as high in nonwhites as in whites. In New York city, with an estimated population of 8,042,000, the tuberculosis mortality rate was 14 in 1955, but in central Harlem, with a predominantly Negro population, the rate was 53, while in adjoining Westchester county, a district with relatively few Negro inhabitants, the rate was only 6.

Economic conditions have a notable effect on the rate. The well-to-do and professional classes exhibit a low rate, while unskilled labourers have a high rate. A study by J. S. Whitney based on death rates in the U.S. in 1930 revealed a rate for unskilled labourers seven times as high as that among professional men. Sex and age are equally important.

Aetiology.—The view that tuberculosis might be a contagious disease is centuries old, but it was not until 1865, when Jean Antoine Villemin in Paris showed that it could be transmitted from tuberculous to healthy animals by inoculation, that it was proved to be due to an infecting agent. The actual cause, the tubercle bacillus, was discovered by Robert Koch in Germany in 1882.

The bacillus is the best-known member of the family of acid-fast bacteria, distinguished by their capacity to resist destaining by such reagents as acids, alkalies and alcohol when once stained with aniline dyes like fuchsin. As compared with other bacteria it grows slowly in artificial culture media. Once isolated it may be grown readily in large quantities on simple media of well-defined chemical structure. It is relatively resistant to the usual disinfecting agents, and withstands drying for long periods. It is killed quickly by sunlight and ultra-violet light from artificial sources.

The bacillus is a rod from one-half micron to four microns in length which reproduces apparently both by direct fission and by a complex division into minute particles from which new bacilli arise. Colony growth on solid culture mediums is of two types, "rough" and "smooth," which exhibit differences in virulence. Virulent bacilli tend to grow in serpentine cords, and can be distinguished from nonvirulent bacilli in some cases by a cytochemical reaction with neutral red and other dyes.

Advantage has been taken of its capacity to grow on media of known composition, to make exact studies of its chemical composition. In the bodies of bacilli grown on such media, lipides, carbohydrates and proteins occur in approximately equal proportion, The lipides of the bacillus were shown by R. J. Anderson, E. Lederer, J. Asselineau and others, to be distinctive for acid-fast bacteria, and one of them, a phosphatide containing a specific fatty acid, phthioic acid, was shown by Florence Sabin and followers to stimulate in animal tissue the histologic changes characteristic of tuberculosis. Certain waxy constituents of the bacillus were shown by Anderson and his co-workers to play a role in the phenomenon of acid-fastness. The proteins are extremely important, for they include the specific substance tuberculin, which is a valuable diagnostic agent and which is believed to be responsible for many of the toxic manifestations of tuberculosis in the body. The physicochemical studies of Florence Seibert showed that proteins of different tuberculin potency occur in the filtrate from cultures of tubercle bacilli, and that extremely minute amounts of certain of the proteins will elicit a tuberculin reaction. (See TUBERCULIN.) The carbohydrates are important in serological tests for the disease, including the haemagglutination reaction of G. Middlebrook and R. J. Dubos. They are closely linked to the lipides of the bacillus, and have a characteristic chemical composition, as shown by M. Heidelberger, M. Stacey and others.

Mode of Transmission. — Tuberculosis is transmitted to healthy bodies by way of the respiratory and alimentary tracts, and rarely by direct inoculation through the skin. Most tuberculosis is acquired by inhalation of bacilli from the sputum of persons with ulcerative pulmonary tuberculosis. Investigation has shown that the minute droplets may be discharged by cough or sneeze, and droplets of such size, sometimes containing hundreds of tubercle bacilli, may float in the air for hours.

The principal source of primary infection by way of the alimentary tract is contaminated milk. Secondary, endogenous infection of the alimentary tract, from swallowing sputum discharged from tuberculous ulcerations in the lungs or bronchi, is frequent in advanced pulmonary tuberculosis. In milk from cattle with infected udders, bacilli may be numerous, and the practice of pooling milk from several dairies may distribute tubercle bacilli widely in a city's milk supply if pasteurization is not practised. The bacillus concerned is the bovine type.

Pathology. — The anatomic unit of tuberculosis is a highly characteristic pathological formation known as the tubercle. When tubercle bacilli lodge in tissues the first reaction is an outpouring of polymorphonuclear leucocytes which surround and engulf the bacilli. This phase of reaction is over within a few hours, and is succeeded by a stage of infiltration of large mononuclear phagocytic cells which enlarge, with production of abundant cytoplasm, and engulf the polymorphonuclear leucocytes and their content of tubercle bacilli. The enlarged mononuclear cells, because of an early fancied resemblance to epithelial cells, have long been known as "epithelioid" cells. The latter tend to assume a radial arrangement around the site of infection, and among them appear large cells, designated by the name of an early describer as "Langhans' giant cells." These differ from the usual giant cells of foreign-body reaction in tissue in a distinctive arrangement of their nuclei. The giant cells arise from epithelioid cells as a result of fusion or incomplete division of the latter. In the normal course of development of the mass of epithelioid cells a specific type of necrosis of the central portion occurs, which is designated as "caseation" necrosis because of its cheese-like appearance when seen in large tuberculous masses. In time fibroblasts appear at the periphery of such an epithelioid mass. The complete structure, with a caseous centre, a zone of radially arranged epithelioid cells and a periphery of young mononuclear cells and fibroblasts, still microscopic in size, is known as an epithelioid tubercle. Most of the visible manifestations of tuberculosis, from barely visible nodules to large tuberculous masses, are fundamentally conglomerations of such tubercles, in which caseation necrosis progresses. Under certain circumstances large caseous masses tend to soften, and if such softened areas discharge their content into a segment of the bronchial tree, a cavity results. In typical pulmonary tuberculosis, varying in degree according to individual circumstances, exudation occurs into the pulmonary alveoli, and frequently into the pleural space.

In time reparative processes occur, with evolution of a chronic lesion characterized by localized destruction and scarring, with surrounding exudation.

The principal site of tuberculosis is the lung. Ordinarily pulmonary tuberculosis is a chronic disease, although many of the manifestations that enter into its complex character are acute. and rapidly progressive pneumonic forms, almost entirely exudative in character, occur. The typical lung of chronic advanced tuberculosis is characterized by cavity formation and scarring in the upper part, tuberculous consolidation with smaller cavities in the zone immediately below, and scattered shotlike tubercles in the lower regions. Ulceration, the result of the softening process described above, is the immediate cause of the chain of events leading to progressive tuberculosis. When this occurs, semiliquid material containing tubercle bacilli is poured into the bronchial tree and aspirated into adjacent bronchi, with the production of new tuberculosis, called "bronchogenic" from its mode of origin. As the disease progresses, new cavities develop and the process is repeated. At the same time reparative processes are under way, and scarring may be extensive.

Pulmonary Tuberculosis; Clinical Features. — Approximately 90% of all clinically recognized tuberculosis is pulmonary. The disease is insidious in onset and early course, and may reach a moderately advanced stage before identifying symptoms are manifest. The chances for cure are much better when the disease is discovered in an early rather than advanced stage.

Several classifications of pulmonary tuberculosis were in use in the mid-1950s. That recommended by the National Tuberculosis association in the U.S. is widely employed. It distinguishes primary and reinfection types of the disease, and minimal, moderately advanced and far advanced stages.

Primary tuberculosis (first infection) was formerly most frequent in children. In contrast to the reinfection type of tuberculosis in adults, first infection tuberculosis in children occurs in any part of the lung, and the draining lymph nodes soon become involved. The course in children is usually benign, and healing occurs in both the primary lung focus and regional lymph nodes, with scarring and calcification, leaving two or more nodules which are often readily visualized in chest X-ray films, and are easily found on post-mortem examination. Severe forms of primary tuberculosis sometimes occur in children, with rapid pneumonic progression, or with invasion of the blood stream and ensuant miliary tuberculosis or meningitis.

With improved measures for tuberculosis control primary infection is less frequent in children. First infection with tubercle bacilli often takes place in later life, when in its localization and character, it commonly resembles reinfection-type tuberculosis in adults more closely than it does primary tuberculosis in children.

Reinfection-type tuberculosis represents disease from repeated infection with tubercle bacilli. The bacilli concerned may come from fresh infection from a new source (exogenous infection) or from an already existing focus in the body (endogenous infection). Reinfection-type tuberculosis, in generally accepted classifications, is subdivided on the basis of its anatomical extent and the presence or absence of gross cavity formation, into minimal, moderately advanced and far advanced stages. Its onset is often difficult to detect. Fatigue, weight loss and cough are the usual symptoms. With advance of the disease these symptoms become more severe, and others may occur, the most striking of which is haemorrhage from the lungs (haemoptysis). Pleurisy with effusion of fluid into the pleural space is common.

Diagnosis is made by a combination of methods. Discovery of the tubercle bacillus in the sputum establishes it beyond question. In early stages this may not be possible, for tubercle bacilli do not appear in the sputum until ulceration of the lesion has occurred. Prior to the development of X-ray techniques chief reliance was placed on physical examination, with emphasis on differences in density of the lung, evident on percussion, and the detection of characteristic *râles* on auscultation with the stethoscope. X-ray evidence of infiltration of the lung is highly important in establishing the diagnosis. Early tuberculosis of minimal extent is usually found in the upper part of one lung, either above or below the clavicle.

Sputum is examined by a special staining technique used to detect acid-fast bacteria, either by direct smear of a selected portion of the expectorated material, or by concentration methods in which a large amount of sputum is reduced to a small volume by chemical treatment and centrifugalization. In cases where the presence of tubercle bacilli is suspected, but the amount of sputum is too small for examination, the contents of the stomach, containing small accumulations of swallowed sputum, may be aspirated and examined. When the number of bacilli is too small for detection by staining methods, they may be found by culture methods or inoculation of guinea pigs.

Treatment. — Tuberculosis is treated by rest, improved nutrition and hygiene, drugs and surgery. Until 1945 the chief treatment of the pulmonary disease was collapse therapy, in which an affected lung was collapsed and put at rest by artificial pneumothorax, effected by introducing air between the lung and chest wall, or thoracoplasty, in which a permanent collapse was induced by surgical removal of ribs. In 1943–44 S. A. Waksman and his associates discovered the potent antimicrobial agent streptomycin in the growth medium of the soil microorganism *Streptomyces griseus*, and in 1944–45 W. H. Feldman and H. C. Hinshaw demonstrated its specific effect in inhibiting tuberculosis. Wide clinical use promptly followed. Two defects were soon discovered, namely. some toxicity for the nervous system and a frequent development of tolerance to the drug by the offending bacillus. Lower dosage and combination with another drug, para-aminosalicylic acid (PAS), introduced in the treatment of tuberculosis by J. Lehmann of Sweden in 1946, largely obviated the difficulty. In 1952 a great advance was made with the introduction of another drug, isonicotinic acid hydrazide (isoniazid. INH), which came about with simultaneous discovery of its efficacy in the United States and Germany; a large number of investigators took part in demonstrating its therapeutic value, including W. McDermott, C. Muschenheim. E. H. Robitzek, I. J. Selikoff and G. Domagk. Isoniazid is usually administered with another drug, commonly PAS, to avoid development of isoniazid-resistant bacilli.

Trials in many countries rapidly proved the value of these drugs. Results rarely seen with the older methods of treatment became the rule. At the same time, and partly because of the protection afforded by the drugs, excisional surgery, with actual removal of affected parts of lungs, became a standard procedure, so that by the mid-1950s in medically progressive countries most known cases of active tuberculosis were under treatment by the drugs, excisional surgery or both. A significant part in the current great decrease in the mortality of tuberculosis was attributed to this therapy.

Nonpulmonary Tuberculosis. — Approximately one-tenth of clinically recognizable tuberculosis is nonpulmonary. The organs chiefly affected are the lymph nodes, bones and joints, serous surfaces, genital organs, kidneys, adrenal glands and skin. Lesions in these organs are usually caseous and there is a tendency for tuberculous abscesses and sinuses to develop. Tuberculosis of the intestines is common, but is usually a complication of pulmonary tuberculosis. Generalized tuberculosis of the lymph nodes (scrofula) was at one time one of the most frequent manifestations of tuberculosis, but with improved hygiene has become rare. Tuberculosis of the bones and joints is a grave disease requiring immobilization for arrest and usually leaving permanent damage to function when healing occurs. Tuberculosis may destroy the adrenal glands, in which case Addison's disease (*q.v.*) results. In countries where bovine tuberculosis is not well coiitrolled, nonpulmonary tuberculosis caused by infection with bovine-type tubercle bacilli is frequent. In the treatment of nonpulmonary tuberculosis, in addition to chemotherapy (*see* above), rest of the affected part is secured, in so far as possible. When practical, as in the case of tuberculosis of a single kidney, surgical measures are employed.

Generalization of tuberculous infection, with dissemination through the blood stream, is a not-rare complication of nonpulmonary tuberculosis. Miliary tuberculosis is a grave form, in which small nodules, likened by early investigators to millet seeds (and hence the term "miliary"), are scattered throughout the body. They represent individual implantations of tubercle bacilli discharged into the blood stream from a tuberculous focus which invades a vein wall, and are conspicuous in the lungs, in which they give rise to a characteristic X-ray picture. Tuberculous meningitis, the most severe of all forms of tuberculosis, is a frequent complication of miliary tuberculosis; at times it occurs without grossly evident miliary tuberculosis. Chemotherapy. especially with isoniazid, greatly improved prognosis in the severe forms of tuberculosis.

Resistance and Immunity. — Resistance and immunity in tuberculosis may be natural or acquired. Certain animals, like the monkey and guinea pig, are highly susceptible to the disease; others, like the cat, dog and horse, are relatively resistant. Some animals are susceptible to invasion by one type of tubercle bacillus and not by others. The rabbit succumbs to infection by bovine and avian strains of bacilli, but is resistant to the human type. Man is virtually immune to the avian type, but suffers from progressive disease caused by human- and bovine-type bacilli.

Heredity and constitution play an important part in determining the outcome of tuberculous infection. Before the discovery of the tubercle bacillus heredity was believed the chief determinant in man. That heredity is a vital factor in resistance has been proved experimentally by several investigators. In a long series of investigations from 1932 to 1956, M. B. Lurie showed that inbred strains of rabbits of different genetic constitution varied considerably in their resistance to tuberculosis and in the character assumed by the disease. Constitutional resistance is in part a function of the body's internal secretions. Cortisone depresses resistance and thyroid hormones appear to enhance it.

Racial variation in resistance to tuberculosis has also long been recognized. In 1908 S. Lyle Cummins called attention to the high rate of tuberculosis in Sudanese troops in Egypt; his subsequent studies indicated great susceptibility in "primitive" peoples in general. Negroes are more severely affected by the disease than whites, and different white stocks appear to vary in resistance. The significance of the higher death rate for Negroes in the U.S. is complicated by the generally unequal environmental conditions of the two races. Pathological studies disclose differences in the character of the disease in the two races, however; more extensive caseation necrosis and more frequent nonpulmonary tuberculosis are evident in the Negro.

Studies of populations in periods of deprivation show a correlation between nutritional deficiencies, particularly in proteins and vitamins, and increase in tuberculosis. Certain diseases, notably silicosis, depress resistance to tuberculosis.

Enhancement of resistance by infection itself is easily demonstrated experimentally. Animals inoculated with tubercle bacilli of low virulence reveal much greater resistance to subsequent infection with virulent tubercle bacilli than do normal animals. Advantage is taken of this fact in vaccination against tuberculosis. Animals, including man, when infected with tubercle bacilli, in addition to manifesting increased resistance to further infection from without, develop a remarkable hypersensitivity to a protein substance derived from tubercle bacilli (see TUBERCULIN). The virtually invariable development of hypersensitivity to tuberculin following infection of man and cattle with tubercle bacilli, regardless of the severity of infection, makes tuberculin valuable in detecting tuberculous infection and determining its prevalence in human groups and herds of cattle.

Prevention and Control. — Specific measures for the control of tuberculosis were inaugurated by Sir Robert W. Philip in Edinburgh, Scot., in 1887, by establishment of a tuberculosis dispensary in which patients convalescing from tuberculosis could be watched carefully and persons from households with a tuberculosis patient could be observed to detect evidence of developing disease. At the same time, through regular home visiting by dispensary personnel, efforts were made to improve the standard of living of the families under supervision, while the dispensary itself acted as a centre for the dissemination of knowledge concerning tuberculosis.

In 1889 in New York, H. M. Biggs, with his colleagues T. M. Prudden and H. P. Loomis, developed a similar plan based on the contagiousness of tuberculosis and need for protection of the public. Reporting of the disease to the department of health, was made compulsory by the New York city department of health, and public health measures for the prevention of tuberculosis became recognized as a governmental obligation. In the development of a sense of public responsibility in the control of tuberculosis, voluntary agencies played a great part. In the U.S. the National Tuberculosis association, founded in 1904, in Great Britain the National Association for the Prevention of Tuberculosis, in Canada the Canadian Tuberculosis association and similar associations in other countries, created a public understanding of tuberculosis that was reflected in steadily increasing official tuberculosis control. The National Tuberculosis association is financed by the sale of Christmas seals, a device originated in Denmark in 1904 by Einar Holbøll. By mid-20th century the association, made up of about 3,000 co-ordinated state, county and city units, was raising more than $25,000,000 annually by this means.

Local official tuberculosis control at the state level was practised in the U.S. long before a federal division for tuberculosis was organized. Many states developed strong programs with clinics, case-finding programs and state hospitals. In 1944 a tuberculosis control division was established in the bureau of state services of the U.S. public health service to aid state health departments in developing adequate programs, and to bring about other "measures for the prevention, treatment and control of tuberculosis." The direct operation of tuberculosis control programs remained a state, county and municipal responsibility.

In Great Britain the prevention and treatment of tuberculosis was a statutory responsibility of local government authorities until 1948. In that year new administrative machinery was set up under the National Health Service act of 1946 placing tuberculosis control in the hands of the minister of health, who was responsible only to parliament. Under the new plan all tuberculosis hospitals, sanatoriums and chest clinics, with few exceptions, were transferred to his jurisdiction. Regional hospital boards were set up with provision for specialist and consultant services in the treatment of chest diseases and for programs of case finding by mass X-ray surveys. Hospital accommodations were allocated by the regional boards and their specialist staffs. In 1954 about 30,000 beds were occupied by tuberculosis patients.

Financial help was given to patients on a standard scale by the ministry of national insurance supplemented in some cases by the National Assistance board.

Sanatoriums, in the notable decline of tuberculosis, played a highly effective role, not only in providing medical care, but in isolating tuberculous patients who would otherwise be sources of infection. In the early years of the 20th century most of the sanatoria in the U.S. were private; by mid-century the great majority of such institutions were under state, county or municipal control, and of hospital rather than sanatorium character. In 1900 there were only 4,500 beds for tuberculous patients in the U.S.; by 1956 there were approximately 100,000, exclusive of beds in mental and penal institutions.

With improved understanding of the means for combating tuberculosis, progressive health departments, ably assisted by voluntary agencies, incorporated extensive case-finding programs in their general procedure for tuberculosis control. Two methods came into use. In the older, an effort is made to ensure examination of all persons in the same household or in close association with a person known to have tuberculosis. This is based on the fact that tuberculosis is contagious, and the persons most likely to become tuberculous are those in intimate contact with the disease. In the later method large groups or whole communities are X-rayed by one of several inexpensive and rapid methods.

In World War II, mass X-ray examination was used to detect cases of tuberculosis in prospective recruits and draftees. After the war millions of examinations were made annually in co-operative enterprises by official and voluntary public health agencies.

In determining the prevalence of tuberculosis in a population, tuberculin is an important agent. A person infected with tuberculosis develops a specific inflammatory reaction when tuberculin is injected into the skin or placed in prolonged contact with the skin in an ointment. Only a fraction of those infected develop the disease, but possible future cases are thus recognized; when large groups are examined the results furnish a measure of the extent of infection in a community.

In guarding the health of previously uninfected persons exposed to the disease, such as members of the household of a tuberculous patient or nurses caring for patients, the tuberculin test furnishes the earliest evidence of infection.

An essential part of an adequate program of tuberculosis control is the prevention of human infection by bovine-type bacilli in milk. In countries with continuing measures for the eradication of tuberculosis in cattle and universal pasteurization of milk, human tuberculosis of bovine origin became rare, but in countries without such measures, bovine-type bacillus infection of children was still frequent.

Preventive inoculation against tuberculosis, in which live but attenuated tubercle bacilli are used as a vaccine. was introduced in France in 1921 by Albert Calmette and Camille Guerin. The strain designated BCG (Bacillus Calmette-Guérin) was one of bovine origin, which became attenuated while growing on culture media containing bile. After its introduction by Calmette, large numbers of children were vaccinated in France. elsewhere in Europe and South America; after 1930 the vaccine was used on an extensive scale.

The procedure met with little favour in the U.S. until after 1940, when studies by J. D. Aronson and S. R. Rosenthal were accepted as indicating definite value. A well controlled investigation by a tuberculosis vaccines clinical trials committee of the Medical Research Council in Great Britain, reported in 1956, also indicated substantial protective action against tuberculosis. The World Health organization (WHO) carried out an extensive program, emphasizing adequate organization, records and procedures for administration of the vaccine.

Rehabilitation of Tuberculous **Patients.**—When patients return to normal life after arrest of their disease. relapse may occur. A sheltered post-treatment environment. where work can be carried out under medical supervision and gradually increased until normal activity can be resumed safely. is important for many patients.

Likewise, for those who cannot arrest their disease and who may be a menace to society because of the persistence of tubercle bacilli in their sputum, but who retain the capacity for some degree of productive work. it is desirable to have an environment as nearly satisfactory as possible. with the medical supervision necessary to guard against undue strain and maintain proper facilities for medical treatment. The need in each respect was met by an increasing number of organizations for vocational training, part-time employment and custodial care with graded activity.

The Altro workshops in New York city, manufacturing washable garments, and the Associated Craftsmen in Bergen county, N.J., working on subcontracts from industry. became examples of sheltered workshops in which convalescing tuberculous patients could work within the limits of their strength and gradually increase their capacity for employment.

The Papworth Village settlement near Cambridge. Eng., achieved world-\vide fame for its provision of suitable living and working conditions for patients with chronic disease. The Disabled Persons Employment act (1944), the National Health act (1946) and coincident introduction of effective drugs for tuberculosis, enabled concentration on the return of patients to normal industry. through rehabilitation in former work or vocational training for more suitable occupation.

Tuberculosis in Animals and Birds.—Tuberculosis is occasionally encountered in wild animals and birds in their native state; it is much more frequent when they are in captivity. Presumably the greater exposure and opportunity for infection in captivity account for the difference. One form. the vole bacillus, affects certain rodents. Among domestic animals and birds, tuberculosis is an important disease in cattle, swine and fowl.

Cattle are infected by the bovine type of bacillus and relatively infrequently by the avian, swine frequently by both and occasionally by the human type, and domestic fowl only by avian bacilli.

In cattle the mesenteric and other lymph nodes and the liver, spleen, serous cavities and other organs are involved; tuberculosis of the udder is frequent and is serious because it leads to heavy contamination of milk with tubercle bacilli.

In the U.S. bovine tuberculosis by mid-20th century was a vanishing disease. Less than 0.5% of the nation's herds included reactors to tuberculin. The slaughter of infected cattle, detected by the tuberculin reaction, had become a universally accepted procedure. and the avoidance of tuberculous infection from dairy products was made doubly sure by the general pasteurization of milk. In much of the rest of the world, however. bovine tuberculosis was still a common disease responsible for widespread infection of children. Adequate programs of control, including slaughter of infected cattle and pasteurization of milk, were expensive and still to be developed, but the principle was recognized and progress was being made.

The control of tuberculosis in swine had not been so successfui as in cattle. Cattle infect each other, as do humans, and in both species removal of sources of infection halts the spread of disease. Swine, however, are susceptible to avian-type tubercle-bacillus infection, as well as bovine. It is difficult to keep swine and poultry entirely separate, and birds other than domestic poultry are likely to establish sources of infection.

Tuberculosis in domestic poultry is also difficult to control. Intestinal ulceration is the rule, and droppings may be heavily contaminated. The most practical procedure is to market birds at an early age and thereby limit opportunities for infection. Avian tuberculosis is a source of serious economic loss, but is not, like bovine tuberculosis, a significant source of human disease. (See also INFLAMMATION.)

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(E. R. LG.)

TUBEROSE. The cultivated tuberose (Polianfhes tuberosa) of the amaryllis family (Amaryllidaceae; *q.v.*) is a plant distantly allied to the American agaves. but has not been found wild. The tuberose rootstock sends up a stem three feet in height, with numerous lanceolate leaves and terminal racemes of waxy white, funnel-shaped, very fragrant flowers. Each flower is about 1½ in. long. with a long tube and a six-parted limb.

The ovary is three-celled, and the ovoid fruit is crowned by the persistent flower. The plant is largely grown in the United States and at the Cape of Good Hope for export to England, as it is found that imported tubers succeed better than those grown in the United Kingdom. The double-flowered form is that principally grown.

TUBEUF, KARL (FREIHERR) VON (1862–1941), German plant pathologist, was born at Amorbach on Jan. 20, 1862. and was educated at the University of Munich, from which he obtained the degree of Ph.D. in 1886. He became *privatdozent* of botany at the University of Munich in 1888. and professor of plant anatomy, physiology and pathology in 1892, holding that position until his retirement in 1933.

Tubeuf was appointed a member of the Imperial board of health in 1898, becoming director of its biological section in 1901. He was also coeditor (1916–21) and editor (1925–36) of the *Zeitschrift für Pflanzenkrankheiten.*

Tubeuf was an outstanding plant pathologist, contributing many important works on the subject, as well as many on dendrology, forestry and mycology. His monograph on mistletoe, *Monographie* der *Mistel* (1923), ranks as one of the best works in the long list of literature on that parasitic plant.

He died on Feb. 8, 1941. (V. C. As.)

TÜBINGEN, a town of Germany, the capital of Baden-Württemberg, on the banks of the Neckar, at its junction with the Xmmer and Steinlach. 22 mi. S. of Stuttgart by road. Pop. (1950) 37,506. Tübingen is mentioned as a strong fortress in 1078, and was ruled from 1148 by counts palatine. In 1342 it was purchased by the count of Württemberg, whose descendants afterward acquired the title of duke.

The town was captured by the Swabian league in 1519, by Turenne in 1647, and again in 1688 by the French, who destroyed the walls.

The most conspicuous building is the old ducal castle of Hohentiibingen, built in 1507–35 on a hill overlooking the town, and now containing the university library and the observatory. The quaint old *Stiftskirche* (1469–83) is a Gothic building containing the tombs of the rulers of Wurttemberg; the town-hall dates from 1435 and was restored in 1872. Tubingen's chief claim to attention lies in its famous university, founded in 1477 by Duke Eberhard of Wurttemberg. Melanchthon was a lecturer here (1512–18). The university adopted the reformed faith in 1534, but in 1817 a Roman Catholic theological faculty was added to the other faculties. The leading faculty was long that of theology.

The university was attended in 1937 by about 1,500 students and had a teaching staff of 200. In the neighbourhood is the former Cistercian monastery of Bebenhausen, which was founded in 1183'.

TUBULIDENTATA, an order of placental mammals, including only the African aardvark or African ant bear. *Orycteropus,* representing the family Orycteropodidae. The aardvark was formerly associated with the true anteaters, sloths and armadillos (order Edentata) because, feeding on termites, it has a longish snout, a long, extensile tongue, a small gape, no teeth in the fore part of the jaws and cheek teeth defective in enamel and of persistent growth. In no other respects does it resemble the edentates; and although it is like the scaly anteaters or pangolins (order Pholidota) in certain internal anatomical features, these are characters common to many orders of mammals. *See* also EDENTATA; PHOLIDOTA.

The aardvark is a burrowing, heavily built animal, about six feet long (including body and tail), scantily covered with hair. with a long narrow head carrying huge rabbitlike ears and ending in a swollen mobile snout with terminal valvular nostrils closed with long hair. The tongue, although long, is not wormlike as in edentates and pangolins. The feet are powerful and very much alike except that the forefoot has no first toe; the toes are long, armed with huge flattened claws, and the second and third, which are the longest, are united by a deep and wide web. The tail is about two feet long, stout and tapering; and the external genital organs are situated on a preanal eminence containing a pair of scent glands opening in the male at the sides of the short penis and in the female at the sides of the vulva, which is provided with a cordate flaplike clitoris.

The teeth of the permanent set are unlike those of other mammals in being traversed by many tubules radiating from a central pulp cavity. They represent molars and premolars, the latter having milk predecessors; but in the newly born young traces of incisors and canines that never cut the gum have been discovered.

Aardvarks are found in Africa south of the Sahara both in deep forest and in the open. It is doubtful if more than one species is still in existence. Conservative estimates trace the tubulidentate line back to about 60,000,000 years. A species, O. *gaudryi*, nearly allied to the living forms, occurs in Lower Pliocene deposits of Bessarabia and the Greek island of Samos; and a distinct genus. *Palaeorycteropus,* has been recorded from the Upper Eocene deposits of southern France. The relationships of the Tubulidenta to other orders is still undetermined.

See AARDVARK.

TUCKER, ABRAHAM (1705–1774), English philosopher whose utilitarian theory of ethics anticipated William Paley's, was born in London on Sept. 2, 1705, the son of a wealthy city merchant. He was educated at Merton college, Oxford, and after traveling in England, Scotland, France and Flanders, he settled in 1727 on his estate at Betchworth castle, near Dorking, where he died, Nov. 20, 1774.

Tucker's chief work was a long series of disquisitions on metaphysics. psychology and ethics, *The Light of Nature Pursued,* of which the first four volumes were published in 1765 under the pseudonym Edward Search and three more posthumously (complete edition by Sir H. P. St. John Mildmay, 7 vol., 1805).

Simplicity and frankness characterize Tucker's manner of exposition, and he readily allows himself to digress from his main themes and to engage in some rather naive speculation. The general style of the work led to his being called "the Montaigne of metaphysics."

Tucker's contention that "every man's own satisfaction" is the ultimate end of action and that it is connected, through the will of God, with the "general good, the root where out all our rules of conduct and sentiments of honour are to branch," was later adopted by William Paley (*q.v.*) and presented systematically by him in his classic statement of the "theological" form of utilitarianism.

TUCSON, a city of southeastern Arizona, U.S., 125 mi. S.E. of Phoenix; the seat of Pima county. The city lies at an elevation of 2.400 ft., in a broad valley rimmed by mountains. The population in 1960 was 212,892, an increase of 368.4% since 1950 (part of which is accounted for by the annexation of suburbs); that of the standard metropolitan statistical area (Pima county) was 265,660, an increase of 88.1%. The metropolitan area includes several small settlements and one town, Ajo, built around a large open pit copper mine. (For comparative population figures *see* table in ARIZONA: *Population.*)

History. — Known as the Old Pueblo because of its interesting history, the story of Tucson goes back to Spanish colonists and missionaries. Padre Eusebio Kino, the great Jesuit, founded the mission San Xavier del Bac, 15 mi. from the modern city, in 1700. Later the Franciscan order built the beautiful church there which is a historic treasure of the southwest.

In 1776 the Spanish created a walled presidio of the adobe village Tucson (the Indian place name). When Spanish rule was superseded by that of Mexico, the walled town continued to be military headquarters of the province. Four flags have flown over the Old Pueblo: those of Spain, Mexico, the Confederate States of America and the United States.

Tucson was the territorial capital of Arizona from 1867 to 1877. The Southern Pacific railway reached Tucson from the west in 1880, and in 1910 it made connections with the Southern Pacific of Mexico, which gave direct service to Guadalajara and Mexico City. In 1900 Tucson became the see of a Roman Catholic bishop and the diocese maintains a cathedral; the Sisters of St. Joseph maintain St. Joseph's academy and the Franciscan fathers maintain San Xavier mission for Indians.

American pioneers changed the Spanish character of town life, although the majority of the inhabitants were Mexicans. Always a bilingual community with a large Spanish-speaking population, Tucson people have retained some customs and festivals from the Spanish past. Close relations are maintained with the Mexican state of Sonora, only 65 mi. S. Pioneers came from many states, as do modern inhabitants. Tucson mas chartered as a city in 1883 and has a council-manager form of government, in effect since 1930.

The Economy. — Climate was an asset in the development of Tucson. Its very dry air and bright sunshine attracted health seekers and visitors and tourism soon became important in the economy.' Recreation areas of unique desert vegetation, picnic grounds in the canyons and a ski run on Mt. Lemmon made Tucson a popular winter resort. The Arizona-Sonora Desert museum in the foothills of the Tucson mountains is a living museum of wildlife and vegetation in the Sonoran desert.

Good flying weather has made Tucson a natural focus for aircraft activities, and transcontinental and regional airlines serve the city. The U.S. air force maintains Davis-Monthan base on the outskirts of the city for jet fighters and bombers. International service with Aeronaves de Mexico began in the fall of 1960. The largest industry and largest employer is a company concerned with missile design and manufacture and with electronics. Several additional firms are engaged in electronic research and manufacture and some others in aircraft modification. The Southern Pacific has its division headquarters and repair shops in the city. Tucson is also the centre of one of the oldest agricultural districts of the state and there are many irrigated farms in its area.

Education and Cultural Activities. — The University of Arizona, situated in the city, serves the state and city in many fields (see also ARIZONA: *Education).* Tucson has an excellent public school system and several private ranch schools, and the U.S.

bureau of mines maintains a field office and experiment station in the city.

Artists, writers and other professional people have made their homes in or near the city. Art exhibitions, musical events and little-theatre programs provide varied cultural entertainment.

(A. M PE)

TUCUMÁN, a northern province of Argentina, surrounded north by the province of Salta, east by Santiago del Estero and south and west by Catamarca. Pop. (1960) 780,348. Area 8,697 sq.mi. The provincial capital is Tucumán (*q.v.*). The high Sierra de Aconquija occupies the western fringe of the province, but in the east the country is flat. alluvial and fertile. Tucumán owes its prosperity to the Aconquija range, nhich catches the warm moist winds from the east, with the result that there is abundant rain (about 37 in. yearly) and a number of permanent streams descend from the sierra to join the Rio Sali, a tributary of the Rio Dulce. Thus irrigation can be effected easily, and in some districts in normal years it is not even necessary. Moreover, because of the clouds in the proximity of the mountains, the province is free of frost. These favourable conditions have made possible the planting of sugar cane, the main source of wealth from the end of the 19th century. The second chief crop is maize and alcohol is manufactured. There are local railway lines to bring the cane to the sugar mills and national railways connect the province with other parts of the republic. (GE. P.)

TUCUMÁN (SAN MIGUEL DE TUCUMÁN), a city of Argentina, capital of the province of Tucumán (*q.v.*), located on the Sali river at the foot of the Sierra de Aconquija, approximately 700 mi. N.W. of Buenos Aires. Pop. (1960) 287,004. Although Tucumin is in a mountainous region, the climate is subtropical with moderate rainfall and infrequent winter frosts. The area is ideally suited to the major crop of sugar cane. for which the city is a processing and shipping centre. Tucumán was founded in 1565, moving to its present site after several inundations. It prospered due to its key position on the route from Córdoba to the Spanish mines in Bolivia. In 1776, with the creation of the viceroyalty of La Plata, control of the city passed from Peru to Buenos Aires. On July 9, 1816, a convention of delegates from the provinces of La Plata meeting in Tucumán signed the declaration of independence from Spain. The National University of Tucumán (1914) is a 20th-century addition to a rich colonial heritage. Construction of railroads in the 1880s further linked Tucumán to the coast and increased the importance of sugar production in the province.

(JS R. S.)

TUDOR. The house of Tudor, which gave five sovereigns to England, is derived by all the Welsh genealogists from Ednyfed Vychan of Tregarnedd in Anglesey, who is named in 1232 as steward of Llywelyn, prince of North Wales, and, seven years later, as an arbitrstor in a convention to which Davydd, the son of Llywelyn, was a party.

His descendant Tudor Vychan ap Gronw of Trecastell had four sons, of whom the eldest, Gronw Vychan, was in favour with the Black Prince and with Richard II. He was forester of Snowdon and steward of the bishop of Bangor's lordship in Anglesey. He died in 1382. an infant son being heir to his lands in Penmynydd, whose sister carried them to her husband Gmylym ap Gmffydd of Penrhyn.

Gronw's brothers Gwylym and Rhys served Richard II as captains of archers. Their youngest brother, Meredydd ap Tudor, escheator of Anglesey in 1392 and, like Gronw, an officer of the household of the bishop of Bangor, is said to have slain a man and fled to the wild country about Snowdon. He was the father of the handsome Owen ap Meredydd, commonly called Owen Tudor. a squire who appeared at the court of the infant king Henry VI and attracted the admiration of the queen mother. About 1428 or 1429. it must have been common knowledge that Owen Tudor and Queen Catherine were living as man and wife. There is no direct evidence for their marriage. Richard III denounced his rival Richmond as the son of a bastard, but it must be remembered that Richard was ready to foul the memory of his own mother in order to say the same of the young Edward V.

Five children were born to them, the sons being Edmund and Jasper and another son who became a monk. In 1436, a date which suggests that Bedford had been Owen's protector, the influence of Gloucester was uppermost. In that year the queen dowager was received within Bermondsey abbey, where she died in the following January. Her children were taken from her, and Owen Tudor was ordered to come into the king's presence. He had already seen the inside of Newgate gaol, and he would not obey without a safe conduct. When he had the safe conduct sent him he came up from Daventry and went at once to sanctuary at Westminster. Allowed to go back to Wales, he was retaken and lodged again in Newgate. He broke prison again and returned to his native Wales. When Henry VI came of full age he made some provision for his stepfather, who fought on the Lancastrian side. At Mortimer's Cross (Feb. 4, 1461) Owen fell into the hands of the Yorkists, who beheaded him in Hereford market place.

His eldest son, Edmund of Hadham (b. *c.* 1430), was knighted in 1449, and in 1453 he was summoned as earl of Richmond. He was declared of legitimate birth, and in 1455 he married Lady Margaret, daughter of John Beaufort, duke of Somerset. His only child, afterwards Henry VII, was born three months after his death.

Edmund's younger brother, Jasper Tudor, survived him many years. Jasper was knighted in 1449 and, about the date of Edmund's patent, was created earl of Pembroke. He bore the royal arms of France and England, differenced with a blue border charged with the royal martlets of the Confessor's fabulous shield, and the same was formerly to be seen upon his Garter stall plate of 1459. He fought at St. Albans in 1455 for the king who had advanced him, and two years later we find him strengthening the defences of Tenby. In 1460 he seized Denbigh, where the queen joined him after Northampton. He shared the defeat at Mortimer's Cross and left the country in 1462. In 1465 he made a last descent upon Wales, to be driven off by William Herbert, who was rewarded with his earldom of Pembroke, already forfeited by attainder. He came back again with Warwick in 1470 and was hurrying to join the queen when Tewkesbury was fought and lost. After many adventures he carried off his young nephew Richmond to Brittany. The two came back together in 1485. After Bosworth, Jasper was created duke of Bedford and restored to his earldom, the earl-marshalship being given him in 1492. He lived to fight at Stoke in 1487 against Lincoln and Simnel his puppet and to be one of the leaders of the host that landed in France in 1492.

He died in 1495 leaving no issue by his wife Catherine, the widow of the second duke of Buckingham and a daughter of Richard Widvile, Earl Rivers. But his bastard daughter Ellen is said to have been mother of Stephen Gardiner, bishop of Winchester.

TUDOR, ANTONY (1909–), English choreographer who worked extensively in the United States. In his dramatic ballets, *Lilac Garden*, *Pillar of Fire*, *Undertow* and *Romeo and Juliet*, he extended the range of classic ballet as an instrument of human expression.

Born in London on April 4, 1909, Tudor studied with Marie Rambert and for her company created his first ballet, *Cross-Gartered*, in 1931. When the American Ballet Theatre was founded in 1939 he joined it as dancer and choreographer. He was choreographer of the Royal Swedish Opera. 1949–50, and the Metropolitan Opera, New York city, 1950–51. After 1950 he directed the Metropolitan Opera Ballet school. (LN. ME.)

TUDOR PERIOD, in English architecture and the decorative arts, a loose term covering the final phase of the Perpendicular period (*q.v.*) and the earlier phases of the Elizabethan style (*q.v.*) or even the Jacobean style (*q.v.*), from which it is usually differentiated by the fact that those examples in which the Gothic influence predominates are termed Tudor, while those in which classic influence is more noticeable are known as Elizabethan or Jacobean. Since the Gothic tradition persisted in various parts of England and especially in Oxford and Cambridge until late in the 17th century, it is difficult to assign date limits to the Tudor style. In ecclesiastical architecture the Tudor period saw the climax of Perpendicular development. The characteristics in exterior secular work are: large groups of rectangular windows; rich oriel or bay windows; interesting and sometimes fantastic chimney treatments; complex roofs with many gables; much brickwork, frequently in patterns and lavish half-timber work (*q.v.*). In interior secular work this period saw an extraordinary development of wood paneling which was frequently used to cover all four sides of a room, and often enriched with linen fold decoration and occasional naïve travesties of classic forms and the lavish use of molded plasterwork for ceilings, cornices and walls.

Examples of the style are: the older portions of Hampton Court palace (1515–25); Layer Marney (1522–25); Moreton Old Hall, Cheshire (1550); Compton Winyates (c. 1520); Burton Agnes (1602–10); Ford's hospital, Coventry (begun 1529); at Oxford, Corpus Christi college (1516), the Founder's tower (1492–1505) and the hall (1541) at Magdalen. the tower of the old examination schools (c. 1620) and the chapel of Oriel (1637); at Cambridge, Queens' college (*c.* 1450), the two earliest courts of St. John's (between 1511 and 1600), and the King's gateway and Great Court at Trinity (built between 1518 and 1605). See GOTHIC ARCHITECTURE. (T. F. H.)

TUFF, a rock formed by induration of volcanic ash or dust. The loose fragmental ejecta of volcanoes are classified by size into (1) volcanic dust, less than 0.5 mm.; (2) ash, from 0.5 mm. to 4 mm.; (3) lapilli, from 4 mm. to 32 mm.; (4) bombs and blocks, larger than 32 mm. Bombs are plastic while blocks are solid when erupted. By compaction and cementation, volcanic dust yields dust tuff and ash yields tuff. If lapilli predominate over the finer constituents, a lapilli tuff results. Rocks composed chiefly of bombs are termed agglomerate (*q.v.*) and those consisting mainly of angular blocks are classed as volcanic breccia (*q.v.*).

Among the products of explosive eruptions, some form by expulsion of liquid magma as clots and spray. These are referred to as essential or juvenile ejecta. Other fragments are discharged in a solid state, being torn from the crater walls, from the tops of cones or the roofs of the underlying reservoirs. These are termed accessory ejecta. Still other ejecta are described as accidental, since they include pieces of any kind of rock torn from the subvolcanic basement. Many of these are intensely baked or wholly recrystallized, such as the limestone blocks periodically blown out by Vesuvius. The pipes of many extinct volcanoes are almost completely filled with accidental debris made up of pulverized sandstone and shale, as in the Navajo region of New Mexico. It is the violent expansion of uater vapour released from deep-seated bodies of magma that blasts these pipes through the overlying formations.

Tuffs may be grouped as vitric, crystal or lithic, according as they are composed principally of glass, crystal chips or the debris of pre-existing rocks. During some explosions, like that of Krakatoa in 1883, the ejecta consist mainly of pumice (*q.v.*), that is, of extremely porous, glassy fragments light enough to float on water, and of finely divided glass dust or pumicite, which, like pumice, has found use as a lightweight aggregate in the construction industry. Volcanoes fed by siliceous magma, such as rhyolite, dacite and trachyte (*qq.v.*), tend to produce the most voluminous and extensive deposits of this kind. However, some of the world's largest deposits of vitric tuff are produced by eruptions through a large number of narrow fissures rather than from volcanic cones. Foaming magma wells to the surface as an emulsion of hot gases and incandescent particles, and the material spreads swiftly even over gentle gradients as glowing avalanches. Such eruptions occurred in 1912 in the Valley of Ten Thousand Smokes (*q.v.*), Alaska. After coming to rest, the ejecta may be firmly compacted by adhesion of the hot glass fragments, and so form streaky, welded tuffs like those covering vast areas in New Zealand, Guatemala, Peru and Yellowstone National park, U.S.

Even fluid basaltic magma, such as that of Kilauea and Mauna Loa in Hawaii, may be inflated by expanding gas and tossed out as delicate glass threads and blebs, known respectively as Pele's hair and Pele's tears. But the chief fragmental products of basaltic volcanoes are the dark, porous, glassy lapilli and bombs which, from their superficial resemblance to the residues of burning coal, are spoken of as cinders. If the lapilli and bombs are sufficiently plastic when discharged, they assume rounded and ropy forms, partly in response to rotation during flight. More viscous clots fall to earth as subangular lumps with cracked, glassy skins that resemble bread crusts.

During other eruptions, the volume of ejected crystals exceeds that of glassy material, as at La Soufrière, West Indies, in 1902. Light crystals of leucite may accumulate by flotation close to the top of the conduit of Vesuvius during intervals of quiet, to be hurled out when activity revives; or clusters of heavy olivine and augite crystals may be expelled from lower levels. If the temperature of eruption is low, the explosions simulate steam blasts and none but angular, lithic fragments of old rock are expelled, as at Bandai-san, Japan, in 1888.

Fine ash and dust may aggregate into pellets or mud balls by falling through an eruption-cloud in which water vapour is condensing. Somewhat similar accretionary lapilli develop by the action of rain and wind on newly fallen ash.

In response to the dictates of gravity, the coarser and heavier volcanic ejecta tend to fall close to the source, while the finer and lighter particles are carried afar. Hence, in extensive deposits, tuff may vary greatly not only in texture but also in chemical and mineralogical composition.

Some ejecta fall directly into lakes or into the sea; others, having been deposited on land, are later washed into bodies of water and are there mixed with normal sediment. The ashy clays and sands thus produced may subsequently be converted to tuffaceous shales and sandstones.

When explosions take place underground the fragmental material may be forced violently into the surrounding rocks, forming intrusive tuffs or peperites.

There has probably been no geological period entirely free from volcanic eruptions. Tuffs therefore range in age from Pre-Cambrian to Recent. Usually, the older ones have lost all original textures and are thoroughly recrystallized. Many old basaltic tuffs are now represented by green chlorite and hornblende schists, and many rhyolitic tuffs by sericite schists.

From A.D. 1500, the world's volcanoes have discharged about 80 cu.mi. of fragmental ejecta, as against 16 cu.mi. of lava. The most voluminous explosions are generally associated with gas-rich magmas of volcanoes in mountain belts on the continents and adjacent islands, and follow long periods of quiescence. Among the most violent explosions of recent times are those of Tamboro, East Indies, in 1815; Coseguina, Nicaragua, in 1835; Krakatoa, Netherlands Indies, in 1883; and Katmai, Alaska. in 1912. Respectively, these volcanoes erupted approximately 8, 12, 5 and 6 cu.mi. of fragmental material. See also VOLCANISM; VOLCANO.

(H. Ws.)

TU FU (712–770), Chinese poet, whom most critics take to be China's greatest, was born in 712. His grandfather was an official and poet, his father attained medium rank in his official career, and through his mother he was remotely related to the imperial house. Tu Fu started his life in close accordance with the pattern of every educated Chinese but failed in the imperial examinations of 736. Much of his youth he spent traveling, and on his travels and during his sojourns at the capital he soon won renown as a poet and consorted with the other poets of the period, above all with Li Po.

During the 740s Tu Fu was also a highly regarded member of a group of high officials, even though he was without official position himself and failed a second time in an imperial examination. Between 751 and 755 he attempted to attract imperial attention by submitting a succession of literary products in which political advice was offered couched in a language of ornamental flattery, and this eventually resulted in a nominal position at court. Probably in 752, Tu Fu married and acquired some farmland, but already at that time he showed signs of a lung affliction. In 755 he was caught in the rebellion of An Lu-shan and experienced extreme personal hardships. He succeeded in escaping, however, and in 757 joined the exiled court, being given the position of Reminder. His memorials to the emperor, however, do not appear to have been particularly welcome. He again went through a period of poverty and hunger, wandered around and arrived late in 759 at Chengtu, where, with the help of friends, he was able to build himself a thatched hut and to experience a modicum of happiness.

For a time Tu Fu served a local war lord as military adviser. Then he started drifting again and in the mid-760s found himself at K'uei-chou in the service of another local war lord which enabled him to acquire some landed property and to become a gentleman-farmer. By that time he must have been sick; he even gave up drinking for a period because of his health. In 768 he again started traveling aimlessly toward the south, and he died late in 770, probably at T'an-chou.

Throughout his life the trenchancy of Tu Fu's political ambitions contrasted sharply with his lack of political acumen. His official biography calls his political comments "high-sounding rather than practical."

Tu Fu's varied but undistinguished life is matched by the broad but undistinguished range of his attitudes and passions. which are almost exclusively dictated by the tenets of a somewhat commonplace Confucianism. There is no reason to doubt the sincerity of his patriotism or of his affection toward his family and friends. Also, the depth of his compassion for human suffering is always genuine.

His poetic expression, however, is confined almost entirely to the dramatic, the general and the typical. and rarely ventures into the field of real lyricism. With all his ambitions and his self-pity, he is humane rather than personal. The poems written between 755 and 759, the period of extreme personal and national turmoil. are thus without doubt his most impressive.

Tu Fu's paramount position in the history of Chinese literature rests on his superb classicism. By his time, the development of poetic form had reached the acme of perfection. Tu Fu was a very erudite man. His intimate acquaintance with the literary tradition of the past was equaled only by his complete ease in handling the rules of prosody.

The wealth of his language makes use of all the connotative overtones of a phrase and of all the intonational potentials of the individual word. qualities that no translation ever will reveal. He was an expert in all poetic genres current in his day: but his mastery is at its height in the so-called regulated poem. particularly the seven-word regulated poem, the extreme formal restraint of which calls for the gift of a Tu Fu for being refined to the point of glowing intensity.

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TUGELA, the largest river in Natal. South Africa. its basin being about 11,500 sq.mi. in extent. It rises on Mont aux Sources, in the Drakensberg, at over 10.000 ft. above sea level. After a mile or two it plunges over the great escarpment forming the most rugged and picturesque scenery. and then flows as a dignified stream in a broad, open valley to a point a few miles below Colenso, about 60 mi. eastward from the source. Here the valley becomes steeper and narrower, owing to rejuvenation. This character persists until within a few miles of its mouth, the river being sometimes 2,000 ft. below the neighbouring plateau. The Tugela is quite unnavigable. Its volume has great seasonal fluctuations. being easily fordable in many places in winter, and often quite impassable during summer rains. The Tugela receives as tributaries on its right bank the Little Tugela, rising near Cathkin Peak, and the Bushman and Mooi rivers, which both originate near Giant's castle.

On its left bank it receives the Klip river, which flows past Ladysmith, the Sunday's river from the Biggarsberg, and the Buffalo river. which rises near Majuba and flows not far from Isandhlwana, at which place, and also at Rorke's Drift, on the Buffalo. memorable actions were fought in the Zulu War. The boundary between Natal proper and Zululand follows the Tugela from its mouth to the confluence with the Buffalo river, and then runs up the latter to its junction with the Blood river, so called on account of the defeat of Dingaan's impi by the Boers in 1838.

TUGGURT (TOUGGOURT), town in Oasis *département,* Algeria, 127 mi. S. of Biskra. with which it is connected by a railway. Pop. (1961) 26.117. Just within the northern of two gates is the market place and the chief mosque. The surrounding oasis contains about 200,000 date palms. Temacine, with a holy lake, seat of a branch house of the extensive Moslem religious brotherhood of the Tijani, is nearby.

From the city a road 75 mi. long leads across the desert northeast to El Wad.

TUGUEGARAO, a municipality and capital of the province of Cagayan. Luzon. Philippines, on the Cagayan river, about 60 mi. from its mouth, and near the southern boundary of the province. Pop. (1960) 43,044. The river is navigable to Tuguegarao for vessels of light draught. The surrounding region is the most productive of tobacco in the archipelago. Ibanag is the principal vernacular. (C. S. L.)

TUKE, the name of an English family, several generations of which were celebrated for their philanthropic efforts.

WILLIAM TUKE (1732–1822) was born at York on March 24, 1732. His name is connected with the humane treatment of the insane, for whose care he projected in 1792 the Retreat at York, under the management of the Society of Friends, which became famous as an institution in which a bold attempt was made to manage the inmates without the excessive restraints then regarded as essential. His son HENRY TUKE (1755–1814) co-operated with his father in his reforms.

Henry's son SAMUEL TUKE (1784–1857) continued the work begun by his grandfather. and published a *Description of the Retreat near York,* etc. (York. 1813). He also published *Practical Hints on the Construction and Economy of Pauper Lunatic Asylums* (181j). He died at Tork on Oct. 14, 1857.

Samuel's son JAMES HACK TUKE (1819–1896) is chiefly remembered for his philanthropic work in Ireland, which resulted from a visit to Connaught in 1847, where he witnessed much distress. Letters descriptive of the state of things he saw when he was distributing relief in 1880. were published in the *Times,* and in his pamphlet. *Irish Distress and its Remedies* (1880), he pointed out that Irish distress was due to economic rather than political difficulties, and advocated state-aided land purchase, peasant proprietorship. light railways. government help for the fishing and local industries, and family emigration for the poorest peasants. From 1882 to 1884 he superintended the emigration of poor families to the United States and the colonies. To his reports on the distribution of seed potatoes in 1885, and his letters to the *Times,* which were reprinted under the title *The Condition of Donegal* (1889), were due in a great measure the bill passed for the construction of light railways in 1889 and the Irish Land act which established the Congested Districts board in 1891. He died on Jan. 13, 1896.

DANIEL HACK TUKE (1827–189j), younger brother of James Hack Tuke, abandoned a solicitor's career to undertake work at the York retreat. After studying medicine in London, he graduated M.D. at Heidelberg in 1853. In 1858, in collaboration with J. C. Bucknill. he published a *Manual of Psychological Medicine,* which was for many years regarded as a standard work on lunacy. In 1853 he visited a number of foreign asylums, and later returning to York he became visiting physician to the York' retreat and the York dispensary. In 1859 he retired, but he resumed practice in London in 1875 as a specialist in mental diseases. In 1880 he became joint editor of the *Journal* of *Mental Science.* He died on Xfarch j. 189j.

Among his works were *Illustrations of the Influence of the Mind on the Body* (1872); *Insanity in Ancient and Modern Life* (1878); *History of the Insane in the British Isles* (1882); *Sleepwalking and Hypnotism* (1884); *Past and Present Provision for the Insane Poor in Yorkshire* (1889); *Dictionary of Psychological Medicine* (1892).

TUKHACHEVSKY, MIKHAIL NICOLAEVICH (1893–1937), Russian soldier. was born in the region of Smolensk. He was educated in the corps of cadets and at the Aleksandrovsky military school, graduating in July 1914. In Feb. 191; he was taken prisoner by the Germans. but escaped to Russia in 1917, and in June 1918 received the command of an army. He commanded successively the I. VIII and V armies and then the Caucasian front. After the successful conclusion of operations against Denikin, Tukhachevsky was given the command of the western front. After the Civil War he became chief of the military academy, and in April 1924 was appointed assistant chief of staff. On June 11, 1937, after a secret trial for espionage and high treason, he. together with seven other generals, was shot.

TUKULOR, a tall, long-headed, well-proportioned and muscular people with long faces, incorporating Serer: Wolof, Mandinga, Soninke and Fulani elements in Senegal and the French Sudan. They call themselves *Futankobe* or *Futanke;* the Wolofs call them *Tokoror* or dwellers in the Tekrur or Senegalese Futa, or Tukolor, the name adopted for them by the French. Their language resembles Fulani and is related to Wolof and Serer. The Tukulor organized a theocratic elective monarchy, with a religious chief *(Almamy),* a functionary whose office was abolished in 1881. Their modern organization is by territorial groups. The Tukulor are Moslems. They are skilled cultivators and cattle raisers.

TULA, an *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., surrounded by those of Smolensk, Moscow, Ryazan and Orel, and not coinciding with the pre-1917 province of the same name. Area 9,305 sq.mi. Pop. (1956 est.) 1,498,000 (urban 746,000; rural 752,000), mainly Great Russians. It consists of plateau land (950 to 1,020 ft.), deeply entrenched by the Don and its tributaries, the Cpa and Sosna. About 9% is forested, the northern region having coniferous trees, and the south small and scattered patches of birch, ash and oak. The south is in the steppe black earth region, but the north is poorer gray forest soil. The climate is extreme, with five months' winter frost, an average July temperature of 66° F. and 16–18 in. of rain per annum.

The chief crops include rye and oats. Buckwheat, potatoes, wheat, millet, grass, hemp and sugar beet are grown, while along the Oka in the northwest of the region, apples, cucumbers. cabbages and onions are cultivated. Coal is mined along the railway extending eastward from Aleksin on the Oka through Tula to the region of Ryazan.

TULA is also the name of the chief town of the above region, in the broad but low, marshy valley of the Upa, in 54° 12' N. 37° 37' E. Pop. (1956 est.) 320,000. Tsar Boris Godunov founded the first Russian gun factory there in 1595, and in 1632 a Dutchman, Winius, established an iron factory. The factories were rebuilt on a larger scale in 1705 and 1714 and toward the end of the 18th century a marked expansion of the industry took place. Industries developed there include the manufacture of samovars (tea urns), sugar refining, smelting, the making of cutlery, leather and sewn goods and flour milling. The town is first mentioned in 1147, but its former site seems to have been higher up the Tulitsa, an affluent of the Upa. Its wooden fort was replaced in 1514–21 by a stone *kreml* (old kremlin) or citadel, which was restored after World War II.

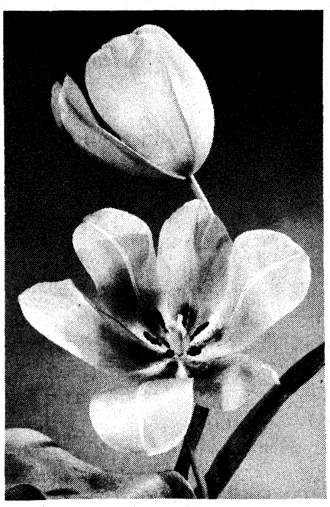
TULAREMIA is an acute infectious disease that resembles plague (*q.v.*) but is much less severe. It was described in 1912 in Tulare county, Calif., from which the name is derived. The causative agent is the bacterium *Pasteurella tularensis* (classified by some as *Brucella tularensis),* a minute microorganism cultivable only with difficulty. The disease is primarily one of wild animals, and human infections are only incidental to its life history. It occurs naturally in 48 species of vertebrates, of which the rabbit, especially the cottontail: *Sylvilagus,* is the most important source of human infection. Water-borne epidemics of the disease in man have occurred in the U.S.S.R. and Turkey; and naturally occurring infections in beavers and muskrats in the northwestern United States are well known. The disease is acquired by man from the animal reservoir of infection, in 90% of cases from the rabbit, either directly by handling the carcasses of infected rabbits, or indirectly through an insect vector. The most common vector transmitting the disease to man is the deer fly, *Chrysops discalis;* the human disease is also known as deer fly fever. Various ticks of the genera *Dermacentor*, *Haemaphysalis* and *Ixodes* may be largely responsible for maintenance of the animal infection. In addition, the infection is transmitted from the adult tick to the egg, and both larvae and nymphs are infectious and form an insect reservoir of infection.

The disease in man occurs in two forms, the more common glandular or ulceroglandular form, and the less common typhoidal type. Local lesions occur in the first, usually beginning with a papule at the site of initial infection, commonly a finger, that breaks down to form an ulcer. The infection then spreads to the lymph glands in the arms and armpits which become painful and swollen so that the glands may also break down with the discharge of purulent material. The general symptoms common to both forms of the disease are headache, bodily aches and fever. The disease persists for two to four weeks, and the case fatality is low, usually less than 5%. About 2,000 cases are reported each year in the United States; cases have been found in all the states and in the District of Columbia. Prophylactic immunization is relatively ineffective. The sulfonamides have little or no chemotherapeutic activity, chloramphenicol has slight activity, but the tetracyclines are reasonably effective. Streptomycin is the most effective chemotherapeutic agent, but the microorganism rapidly becomes resistant to it, often within the first two or three days of therapy. (W. Bu.)

TULCEA, a town of Rumania, in the region of Constanta, picturesquely situated on the right bank of the Danube, 42 mi. from its mouth at Sulina. Pop. (1956) 24,639. There is a large water-borne trade in cereals.

TULIP, a genus (*Tulipa*) of bulbous herbs belonging to the lily family (Liliaceae). The species are found wild along the northern shores of the Mediterranean, in the Levant, Armenia, Caucasus, northern Africa, Iran, and sporadically across north and central Asia to Japan. The cup-shaped flowers have six regular segments in two rows, as many free stamens, and a three-celled ovary with a sessile stigma, which ripens into a leathery many-seeded capsule. The species are numerous, and are distinguished one from another by the scales of the bulb being woolly or smooth on the inner surface, by the character of the flower stalks, by the filaments being hairy or otherwise, and by other characters. Owing to the great beauty of the flowers they have long been favourites in European and American gardens, and have been crossed and recrossed till it has become almost impossible to refer the plants to their original types.

The early flowering "Van Thol" tulips, the segments of which are mostly scarlet with yellow edges, are probably derived from T. *suaveolens,* a native of the Caspian region. T. *gesneriana,* a native of Armenia and central Russia, is the origin of most of the later flowering varieties. *T. oculussolis* and *T. clusiana* are lovely species, natives of southern Europe and *T. sylvestris,* with elegant yellow flowers, is a doubtful native of England. Owing to the exertions of Russian naturalists, a large number of new species were discovered in Turkistan and introduced into Europe. Some of these are very beautiful, and render it probable that by intercrossing with the older species still further difficulties will be presented in the way of identification. These difficulties are further enhanced by the fact that, quite apart from any crossbreeding, the plants, when subjected to cultivation, vary so greatly in the course of two or three years from the original species from which they are directly descended that their parentage is scarcely recognizable. This innate power of variation has enabled the florist to obtain, and ultimately to fix, many remarkable varieties. Millions of bulbs are cultivated in Holland for export every year; many are also grown in the Channel Islands, especially Guernsey, in the fen district of England, around Belfast, Ireland, and in the United States. Tulips were



ROCHE

COTTAGE TULIP (TULIPA), A LATE SINGLE FLOWERING KIND OF THE GEISHA VARIETY introduced into the Low Countries from Constantinople and the Levant in the 16th century; about 1637 they became the subject of an extraordinary speculation known as tulipomania in which prices for single roots rose to as much as 2,600 guilders. Thousands became bankrupt when the bubble burst.

Tulips, which have sprung from *Tulipa* gesneriana, are arranged in separate classes. Of these the most important are early, breeder, cottage and Darwin tulips. There are, in addition, various secondary groups, named bizarres, bybloemens, parrots, Rembrandts and striped tulips, according to their colour and marking. Tulips are readily raised from seeds, and the seedlings when they first flower (after about seven years' cultivation) are of one colour — that is, they are self-coloured. Judged by the florists' rules, they are either good or bad in form, and pure or stained (white or yellow) at the base; the badly formed and stained flowers are thrown away, while the good and pure are grown on, these being known as breeder tulips.

The breeder bulbs and their offsets may grow on for years producing only self-coloured flowers, but after a time, which is varied and indefinite, some of the progeny break, that is, produce flowers with the variegation which is so much prized. The flower is then said to be rectified; it is a bizarre when it has a yellow ground marked with purple or red, a bybloemen when it has a white ground marked with violet or purple, or a rose when it has a white ground marked with rose colour.

Tulips flourish in any good garden soil that has been deeply dug or trenched and manured the previous season. To secure perfect drainage and greater warmth a fair quantity of sand or grit should be present. Fresh manure should be avoided, but the remains from an old hotbed or mushroom bed may be incorporated. The best time to plant is in October and Sovember, the bulbs being buried about four to five inches deep and somewhat farther apart. The best effects are produced in formal beds by planting the same variety in each, to insure the plants being of the same height and in flower simultaneously.

Propagation. — Tulips are usually increased by offsets, which most varieties produce in fairly large numbers. These are taken off and sown in drills, like seed. They are usually strong enough to flower the third year from this sowing. Some varieties produce offsets sparingly and must be increased by seed—a slow and uncertain method. New varieties are raised from seed. (The colour variation in the flowers of seedlings is discussed above.) Seeds are sown in boxes or cold frames, in light sandy soil, and the young plants are allowed to remain undisturbed until the second year. They are then lifted and treated like offsets, being sown thinly in beds out of doors. They usually flower in about the seventh year. The soil in which tulips are propagated should be sandy, free working and thoroughly drained. A warm sheltered position is a necessity.

Forcing. — The early flowering varieties should be potted as early in September as practicable, later batches for succession being potted during October. Pots five and six inches in diameter are the most convenient for the early-flowering kinds, but seven-inch pots give the better results for the Darwin section of the May-flowering kinds which are now used for gentle forcing. Five or six bulbs are put in each pot and the tops should be covered with half an inch of soil and half an inch left for water. The soil should be a light and fairly rich compost, comprising about two parts loam, one part decayed manure or horse droppings that have been thoroughly sweetened, one part leaf mold and half a part of sand. Pot firmly: and plunge the pots in several inches of ashes out of doors, to protect the bulbs from frost! but it must be remembered that all garden tulips require a thorough winter chilling to bloom the next spring. As soon as growth commences at the top and a fair amount of roots are formed they may be introduced into the cool greenhouse, in batches according to the need and amount of stock available.

For market a slightly different method is adopted. The bulbs are placed in long shallow boxes, plunged in soil or ashes in semidarkness, and are afterwards transferred to benches in the forcing houses where they flower. Bulbs which have been forced are of no further value for that particular purpose. If planted in borders and shrubberies, however, they will continue to bear fairly good blossoms in the open air for several seasons.

Varieties.— —Many thousands of varieties are offered by dealers. The most generally useful fall into the following groups:

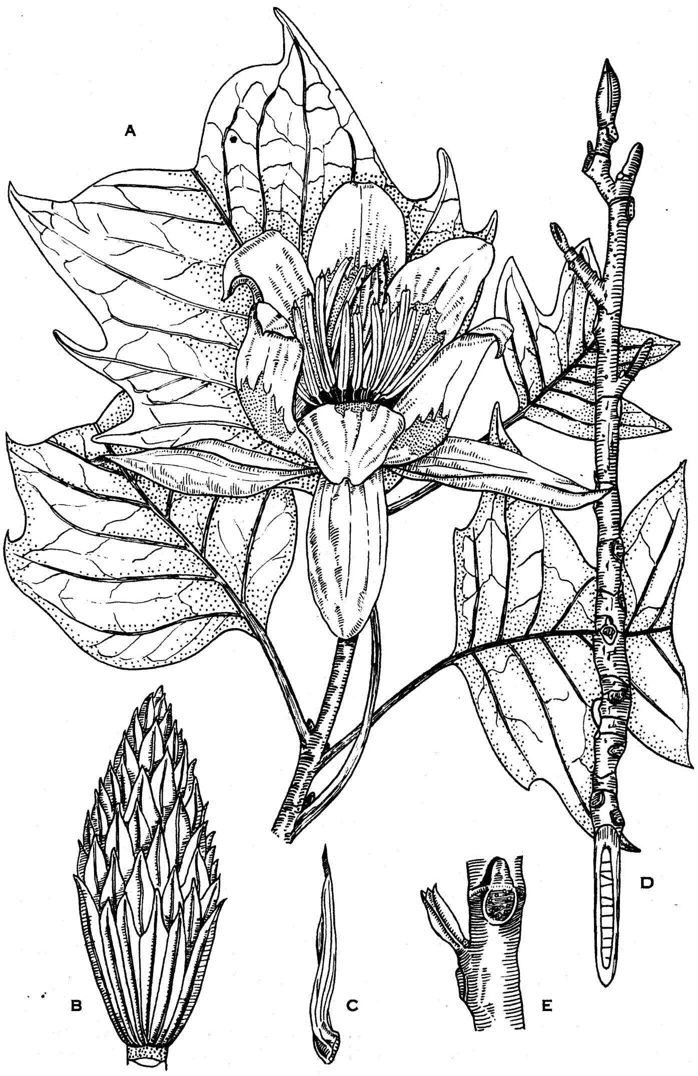
Early Single (or Double) *Flowering* Kinds are the most useful for bedding and pot culture.

Late Single Flowering Kinds. — These are all tall-growing hardy kinds suitable for growing in herbaceous borders where they can be left undisturbed; or for producing massed colour effects in flower beds. They include (a) Cottage or May-flowering tulips, so named because they were discovered in the gardens of old cottages, mansions, abbeys and monasteries throughout England, Scotland. Ireland, Belgium and France; (b) Darwin tulips which are a distinct race: having a wide range of large self-coloured flowers, but no yellows. The so-called black tulip belongs here.

Parrot Tulips. — This late flowering group is supposed to be derived from the curious green and yellow striped T. *viridiflora*. The flowers are mostly heavy and drooping, petals brightly coloured, the edges being curiously notched and wavy.

TULIP TREE (YELLOW POPLAR; Liriodendron tulipifera), an important timber tree of eastern North America, is one of two surviving species belonging to the genus Liriodendron, which! prior to the Glacial epoch, embraced at least 16 species..

Ranging from southern New England to Michigan and southward to Florida and Louisiana, the tulip tree or yellow poplar is



FROM HARRAR AND HARRAR, "GUIDE TO SOUTHERN TREES": REPRODUCED BY PERMISSION OF MCGRAW-HILL BOOK COMPANY, INC. DRAWN BY HELENE S. MILLAR

DENDROLOGICAL FEATURES OF THE TULIP TREE OR YELLOW POPLAR (LIRIODENDRON TULIPIFERA): (A) FOLIAGE AND FLOWER: (B) AGGREGATE OF SAMARAS; (C) SINGLE SAMARA: (D) TWIG; (E) LEAF SCAR most frequently encountered in mixed hardwood forest stands. Best development is attained on deep, rich, moist but well-drained soils of light texture. Second in girth only to the sycamore, and taller than all other American broad-leaved trees, it not infrequently surpasses a diameter of 6 ft. and a height of 190 ft. Its leaves, which bear no resemblance to those of other deciduous trees, are bilaterally two- to four-lobed with truncate or broadly notched apices; yellowish-green tuliplike blossoms, conelike clusters of terminally winged fruits and aromatic, purplish-brown twigs with winter buds resembling a duck's bill are also diagnostic.

Among the hardwoods, the annual harvest of tulip-tree timber is exceeded only by the oaks and the sweetgum. The light yellow to greenish-yellow wood is readily machined and utilized in prodigious quantities in the manufacture of furniture parts and plywood panels. It is also used in the production of paper, millwork, cooperage, boxes ,and crates.

Open-grown trees develop a crown of pleasing symmetry, but commonly begin to shed their leaves in early August, and the use of the tulip tree for a street or lawn tree is not recommended.

See also Forests and Forestry. (E. S. Hr.)

TULL, JETHRO (1674–1741), one of the greatest improvers of British agriculture, was born at Basildon, Berkshire, in 1674. He entered St. John's college, Oxford, in 1691, then Grays Inn, made the grand tour and was called to the bar in 1699. Necessity, however, compelled him to farm. For ten years he occupied Howberry farm, Cronmarsh near Wallingford, Oxfordshire, where he invented his seed drill which sowed the seeds in rows, thus allowing of cultivation in between. This treatment reduced the need for fallowing and incidentally for farmyard manure. In 1709 he moved to Mount Prosperous, in Shalbourne, Wiltshire. Two years later ill-health compelled him to travel in France and Italy. He was greatly struck by the remarkable effects of cultivation in the vineyards and on returning home in 1714 he developed some ingenious theories of plant nutrition and made a horse hoe to put them into practice. He was so successful that in 1731 he published *The New Horse Houghing Husbandry: or, an Essay on the Principles of Tillage and Vegetation,* expanding it greatly in 1733. Because of their novelty, his methods and ideas were violently attacked, and this, with ill-health and domestic worries, made his life unhappy. His many mechanical inventions were less important than his ideas on how cultivation should be done and what results it could achieve. His methods saved seed and kept down weeds; they were eventually taken up by the large landowners and formed the basis of modern systems of British agriculture.

Tull died Feb. 21, 1741. (E. J. R.)

TULLAMORE, a market town and the county town of County Offaly, Ire., on the Grand canal 60 mi. W. of Dublin by road. Pop. (1956) 6,147. A farm produce trade from a wide area is augmented by malting, distilling, bacon-curing and woolen industries.

The neighbourhood contains many Bronze Age and early Christian monuments. The adjacent ruined Sraith Ui Chatharnaigh castle dates from 1588; the modern hospital from 1942. (S. O. M.)

TULLE, a town of central France, capital of the *département* of Corrèze, 58 mi. S.S.E. of Limoges by rail. Pop. (1954) 15,813. Tulle (Tutela) owed its importance in the middle ages to the abbey of St. Martin, founded in the 7th or 8th century. The abbacy was raised to the rank of bishopric in 1317. The town was taken by the English in 1346. It was again conquered by the English in 1369; but, when the inhabitants succeeded in freeing themselves, they were exempted from all imposts by Charles V. The Protestants seized Tulle in 1585. The town extends along the narrow valley of the Corrèze, its streets here and there ascending the hill-slopes on either side by means of stairways. Of its 12th century cathedral, once attached to an abbey, only the porch, nave and a tower of the 13th century, with a fine stone steeple of the 14th century, remain. The neighbouring cloister (12th and 13th centuries) has been restored. The abbot's house (15th century) has a carved doorway and well-preserved windows. Tulle is the seat of a bishop, of a prefect, of tribunals of first instance and of a chamber of commerce and a board of trade-arbitrators. Its principal industry is the manufacture of small arms, established in 1690, and now carried on by the state. There are other minor industries. The well-known cascades of Gimel formed by the Montane are near Tulle.

TULLOCH, JOHN (1823–1886), Scottish theologian, notable for his efforts to arouse a spirit of liberal orthodoxy in the Church of Scotland, was born at Bridge of Earn, Perthshire, in 1823, and received his university education at St. Andrews and Edinburgh. In 1845 he becameminister of St. Paul's, Dundee, and in 1849 of Kettins, in Strathmore, where he remained for six years. In 1854 he was appointed principal of St. Mary's college, St. Andrews. At St. Andrews, where he held also the post of professor of systematic theology and apologetics, he lectured on comparative religion and treated doctrine historically, as being not a fixed product but a growth. In 1862 he was appointed one of the clerks of the general assembly, and from that time forward he took a leading part in the councils of the Church of Scotland. In 1878 he was chosen moderator of the assembly. Tulloch did much to widen the national Church of Scotland. He was deeply interested in the reorganization of education in both school and university, and acted as one of the temporary board that settled the primary school system under the Education act of 1872. He died at Torquay on Feb. 13, 1886.

Tulloch's most important works include *Rational Theology and Christian Philosophy in England in the Seventeenth Century,* 2 vol. (1872); *Modern Theories in Philosophy and Religion* (1884); *Movements of Religious Thought in Britain During the Nineteenth Century* (1885).

See Oliphant, M. O. W., *Memoir* (1888).

TULLUS HOSTILIUS, third legendary king of Rome (672–640 B.C.). His successful wars with Alba, Fidenae and Veii shadow forth the earlier conquests of Latian territory and the first extension of the Roman domain beyond the walls of Rome. It was during his reign that the combat between the Horatii and Curiatii, the representatives of Rome and Alba, took place. He is said to have been struck dead by lightning as the punishment of his pride. Tullus Hostilius is simply the duplicate of Romulus. Both are brought up among shepherds, carry on war against Fidenae and Veii, double the number of citizens, organize the army, and disappear from earth in a storm. As Romulus and Numa represent the Ramnes and Tities, so, in order to complete the list of the four traditional elements of the nation, Tullus was made the representative of the Luceres, and Ancus the founder of the Plebs. The distinctive event of this reign is the destruction of Alba, which may be regarded as a historical fact. But when and by whom it was destroyed is uncertain—probably by the Latins.

See Livy i, 22–31; Dion. Halic. iii, 1–35; Cicero, *De Republica,* ii, 17; and Rome: *Ancient History.*

TULSA, a city of northeast Oklahoma, U.S., on the Arkansas river about 200 mi. S.W. of Kansas City; the seat of Tulsa county. Tulsa calls itself the oil capital of the world. Nearly 800 oil companies of all types with investments throughout the world have offices there, and much of the city's economic activity is concerned with exploration, drilling, production, refining, transportation, marketing, financing, supply and research for the petroleum industry. The aviation industry is next in importance, and in addition there are approximately 700 firms in the Tulsa area manufacturing a wide variety of products. The city is also the commercial and financial centre of a rich agricultural area.

Tulsa began in the 1830s as a village of Creek Indian refugees, including many of mixed blood, from Alabama; the name of a Creek community in their former home was given to the new settlement. After the St. Louis-San Francisco railway reached the Creek Nation in 1882 a white community developed. It was incorporated in 1898. The population was only 1,390 in 1900, but with the discovery of oil at nearby Red Fork in 1901 and Glenn Pool in 1905, and the subsequent development of the mid-continent oil and gas region, Tulsa's growth was phenomenal. In 1960 the population of the city was 261,685, an increase of 43.2% in the decade; that of the standard metropolitan statistical area (Creek, Osage and Tulsa counties) was 418,974, an increase of

27.8%. (For comparative population figures for the city see table in OKLAHOMA: *Population.)*

The national headquarters of United States Junior Chamber of Commerce are in Tulsa and the International Petroleum exposition is held there. Educational facilities include the University of Tulsa, a Presbyterian institution founded at Muskogee as Henry Kendall college in 1894 and moved to Tulsa in 1907. The Tulsa Philharmonic orchestra; the Tulsa Opera, Inc.; the Philbrook Art centre; and the Thomas Gilcrease Institute of American History and Art are other significant cultural institutions.

The water system, which brings water by gravity flow from two lakes on Spavinaw creek, more than 50 mi. away. is one of Tulsa's greatest assets. The city has over 3,000 ac. in parks, the largest of which has golf courses, a zoo, picnic and recreation areas and a lake. Residents also have easy access to the numerous lakes of eastern Oklahoma. (W. A. SE.)

TULSI DAS (1532–1623), the greatest and most famous of Hindi poets, was a Sarwariya Brahman, born, according to tradition, in 1532, during the reign of Humayun, most probably at Rajapur in the Banda district south of the Jumna. His father's name was Atma Ram Sukal Dube; that of his mother is said to have been Hulasi. A legend relates that, having been born under an unlucky conjunction of the stars, he was abandoned in infancy by his parents and was adopted by a wandering *sadhu* or ascetic. with whom he visited many holy places in the length and breadth of India; and the story is in part supported by passages in his poems. He studied, apparently after having rejoined his family. at Sukarkhet, a place generally identified with Soron in the Etah district of the United Provinces, but more probably the same as Varahakshetra on the Gogra river, 30 mi. W. of Ajodhya (Ayodhya). He married in his father's lifetime, and begot a son. His wife's name was Ratnawali, daughter of Dinabandhu Pathak, and his son's Tarak. The latter died at an early age, and Tulsi's wife, who was devoted to the worship of Rama, left her husband and returned to her father's house to occupy herself with religion. Tulsi Das followed her, and endeavoured to induce her to return to him, but in vain; she reproached him (in verses which have been preserved) with want of faith in Rama, and so moved him that he renounced the world, and entered upon an ascetic life, much of which was spent in wandering as a preacher of the necessity of a loving faith in Rama. He first made Ajodhya (the capital of Rama and near the modern Fyzabad) his headquarters, frequently visiting distant places of pilgrimage in different parts of India.

During his residence at Ajodhya the Lord Rama is said to have appeared to him in a dream, and to have commanded him to write a *Ramayana* in the language used by the common people. He began this work in 1574, and had finished the third book (*Aranya-kand*) when differences with the Vairagi Vaishnavas at Ajodhya. to whom he had attached himself. led him to migrate to Benares, where he settled at Asi-ghat. There he died in 1623, during the reign of the emperor Jahangir, at the great age of 91.

The period of his greatest activity as an author synchronized with the latter half of the reign of Akbar (1556–1605) and the first portion of that of Jahangir, his dated works being as follows: commencement of'the *Ramayan,* 1574; *Ram-satsai,* 1584; *Parbati-mangal,* 1586; *Ramagya,* 1598; *Kabitta Ramayan,* between 1612 and 1614. A deed of arbitration in his hand, dated 1612, relating to the settlement of a dispute between the sons of a landowner named Todar, who possessed some villages adjacent to Benares, has been preserved, and is reproduced in facsimile in G. A. Grierson's *Modern Vernacular Literature of Hindustan,* p. 51. Todar (who was not, as formerly supposed, Akbar's finance minister, the celebrated Raja Todar Mall) was his attached friend. and a beautiful and pathetic poem by Tulsi on his death is extant. He is said to have been resorted to. as a venerated teacher, by Maharaja Man Singh of Jaipur (d. 1618). his brother Jagat Singh, and other powerful princes; and it appears to be certain that his great fame and influence as a religious leader, which remain pre-eminent to this day, were fully established during his lifetime.

Tulsi's great poem, popularly called *Tulsi-krit Ramayan* but named by its author *Ram-charit-+%pas,*"The Lake of Rama's Deeds," is perhaps better known among Hindus in upper India than the Bible among the rustic population in England. Its verses are everywhere, in this region, popular proverbs.

The poem is a rehandling of the great theme of Valmiki. but is in no sense a translation of the Sanskrit epic. Besides the *Lake of Rama's Deeds,* Tulsi Das was the author of five longer and six shorter works, most of them dealing with the theme of Rama, his doings, and devotion to him. The former are (1) the *Dohabali,* consisting of 573 miscellaneous *doha* and *soratha* verses —of this there is a duplicate in the *Ram-satsai,* an arrangement of seven centuries of verses, the great majority of which occur also in the *Dohabali* and in other works of Tulsi; (2) the *Kabitta Ramayan* or *Kabittabali,* which is a history of Rama in the *kabitta, ghanakshari chhappai* and *sawaiya* metres—like the *Ram-charit-manas,* it is divided into seven *kands* or cantos and is devoted to setting forth the majestic side of Rama's character; (3) the *Git-Ramayan,* or *Gitabali,* also in seven kands, aiming at the illustration of the tender aspect of the Lord's life—the metres are adapted for singing; (4) the *Krishnawali* or *Krishna gitabali,* a collection of 61 songs in honour of Krishna, in the Kanauji dialect —the authenticity of this is doubtful; and (5) the *Binay Pattrika,* or "Book of Petitions," a series of hymns and prayers of which the first 43 are addressed to the lower gods, forming Rama's court and attendants, and the remainder, no. 44 to 279, to Rama himself.

Of the smaller compositions the most interesting is the Vairagya Sandipani, or "Kindling of Continence," a poem describing the nature and greatness of a holy man, and the true peace to which he attains. This work has been translated by Grierson in the *Indian Antiquary,* xxii, pp. 198–201.

A manuscript of the *Ayodhya-kand,* said to be in the poet's own hand, exists at Rajapur in Banda, his reputed birthplace. One of the *Bal-kand,* dated Sambat 1661 (A.D. 1604), 19 years before the poet's death, and carefully corrected, it is said, by Tulsi Das himself, is at Xjodhya. Another autograph is reported to be preserved at Malihabad in the Lucknow district, but has not, so far as known, been seen by a European. Other ancient manuscripts are to be found at Benares, and the materials for a correct text of the *Ramayan* are thus available. Good editions have been published by the *Khadga Bilas* press at Bankipur (with a valuable life of the poet by Baijnath Das), and by the *Nagari Pracharini Sabha* at Allahabad (1903). The ordinary bazar copies of the poem, repeatedly reproduced by lithography, teem with interpolations and variations from the poet's language. An excellent translation of the whole into English was made by the late F. S. Growse, of the Indian civil service (5th edition, Cawnpore, 1891).

The best account of Tulsi Das and his works is contained in the papers contributed by Grierson to vol. xxii of the *Indian Antiquary* (1893). In Growse's translation of the *Raw-charit-Manas* will be found the text and translation of the passages in the *Bhaktamala* of Nabhaji and its commentary, which are the main original authority for the traditions relating to the poet. In the introduction to the edition of the *Ramayan* by the *Nagari Pracharini Sabha* all the known facts of Tulsi's life are brought together and critically discussed. For an exposition of his religious position, and his place in the popular religion of northern India, *see* Grierson's paper in the *Journal of the Royal Asiatic Society,* July 1903, pp. 447–466. (C. J. L.; X.)

See Sir G. A. Grierson, *Notes on Tulsi Das* (1921).

TULU LANGUAGE, also known as TULUVA. a language of the Dravidian family. spoken on the west coast of India in the South Kanara district of the state of Mysore. At mid-20th century there were estimated to be about 800.000 speakers. It has no literature. It is an independent language of the family and close affiliation with any one of the other languages is not yet clear. It has borrowed many words from Kanarese (*q.v.*) because of close political associations with this language. *See* also DRAVIDIAN LANGUAGES.

See *Linguistic Survey of India,* vol. iv (1906); Bishop R. Caldwell, *Comparative Grammar of the Dravidian Languages* (1913).

(M. B. E.)

TUMACO, a seaport city of southwestern Colombia in the department of Nariño. the southernmost of Colombia's port cities and, next to Buenaventura, the most important Colombian port on the Pacific side. Tumaco is located on an island on the south side of the bay of Tumaco. It is served by a short railroad line which goes only as far as Diviso, by the Barranquilla-Guayaquil air line and by a road which joins the Simón Bolivar highway between Pasto and Ipiales. Pop. (1951) 12,692. Tumaco and the region around it were visited by Francisco Pizarro, and the city later gained some importance because of its port facilities during the period when Colombia was attempting to win its freedom from Spain.

Tumaco is a shipping centre for goods sent down the Rio Patía, which drains into the bay of Tumaco.

TUMBES, a department of Peru, is situated on the' Pacific coast in the extreme northwest between Ecuador on the east and the department of Piura on the south. Formerly a littoral province, it was given departmental status in 1942. It is the country's smallest department, with an area of 1,827 sq.mi. Pop. (1954 est.) 33,700. Its capital is the city of Tumbes (pop. 8,602), on the Tumbes river 7 mi. from its port of Puerto Pizarro, with which it is linked by rail. The district was an ancient Inca stronghold, and Tumbes was a prosperous city when Francisco Pizarro made his initial landing nearby (1527) and used it as his base for the conquest of the Inca empire. The region's ready accessibility brought modern development early. In 1863 an oil well was sunk near Zorritos, marking the beginning of the important oil industry. The Zorritos-Chira oil fields (partly in Tumbes and partly in Piura) account for most of Peru's oil production and have reserves estimated at more than 5,000,000,000 bbl. Fishing, especially for lobster, is important. Other products include sugar, tobacco, coffee and cacao, along with salt and some gold. (L. W. Be.)

TUMBLEWEED, in the U.S. a common term for a plant which breaks loose at the ground line when dry, and is rolled about by the wind, scattering its seeds along the way. Tumbleweeds are most abundant and often noxious in semiarid regions. Examples are: tumbling pigweed (Amaranthus *graecizans*), Russian thistle (*Salsola kali*), winged pigweed (Cycloloma *atriplicifolium*), bugseed (*Corispermum hyssopifolium*), tumbling mustard (*Sisymbrium altissimum*) and witch grass (*Panicum* capillare).

TUMBLING MUSTARD (Sisymbrium *altissimum*), an annual tumbleweed of the mustard family (Cruciferae. *q.v.*), native to Europe and extensively naturalized in North America, especially in the northern states and adjacent Canada. It is tall, freely branching and has deeply cut leaves. The small pale-yellow flowers produce long, narrow, spreading seed pods. One plant may ripen more than 500,000 seeds.

TUMKUR, a town and district of southern India, in the west of Mysore state. The town (pop., 1951, 35,999), which is a health resort on the Devarayadurga hills, has a station on the Madras and Southern Mahratta railway, 43 mi. N.W. from Bangalore. The area of the district is 4,093 sq.mi.

It consists chiefly of elevated land intersected by river valleys. A range of hills rising to nearly 4,000 feet crosses it from north to south, forming the water parting between the systems of the Krishna and the Cauvery. The principal streams are the Jayamangala and the Shimsha. The population in 1951 was 1,151,362. The cultivated products consist chiefly of millets, rice, pulses and oilseeds.

TUMMEL, a river of Perthshire, Scot. It flows eastward from Rannoch moor to its junction with the Garry and then southeast to fall into the Tay near Logierait, a course of 58 mi. It drains a succession of basins in which the streams expand into lakes (Lochs Ericht, Rannoch and Tummel). The descent from each basin to the next is abrupt and marked by rapids or falls in the river. The falls of Tummel are much visited by tourists. Hydroelectric power stations have been constructed at several of these points where the river course is interrupted, *e.g.*, at Tummel bridge (1933) and at Pitlochry. (T. Her.)

TUMOUR. In its broad sense the word "tumour" may be applied to any localized swelling irrespective of origin, location or composition. In its restricted sense, however, it denotes an abnormal growth of new tissue, arising by unknown cause from preexisting body cells, having no purposeful function and being characterized by a tendency to autonomous and unrestrained growth. Thus we may recognize two main groups of swellings: false tumours or nonneoplastic swellings, and true tumours or neoplasms, conforming to the restricted definition just mentioned.

The essential basis for this distinction lies in the cellular composition of all living tissues, normal and abnormal. Only by a recognition of the distinctive appearance and characters of the individual cells forming a tissue or swelling can we attempt to define accurately the nature, origin and entity of a tissue mass. Swellings may be composed of (1) normal body cells, (2) abnormal body cells, or (3) foreign cells, introduced from without the body. Cells of the second variety differ from the first in having undergone alterations in appearance, character or arrangement as follows.

Hypertrophy denotes an increase in the size of individual cells. This feature is occasionally encountered in true tumours but occurs commonly in other conditions.

Hyperplasia denotes an increase in the number of cells within a given zone. In some instances it may constitute the only criterion of tumour formation.

Anaplasia denotes a regression of the physical characteristics of a cell toward a more primitive type. This is an almost constant feature of malignant tumours, though it occurs in other instances both in health and in disease.

True tumours in general are characterized by a growth of cells exhibiting one or more of these three variations from normalcy.

FALSE TUMOURS

These form a heterogeneous group. In most instances the cause and origin of the swelling is known and well understood.

Inflammatory Swellings. — These are formed in the normal course of the reaction of the body to irritants. The mass of the swelling is composed mainly of cells of normal body type which, in response to a noxious stimulus, are incited to multiply and concentrate in the zone that is the seat of the attack. The two common causes of inflammation are trauma and bacterial infection. Traumatic swellings of an acute nature include such conditions as a bruise, a haematoma (viz., a black eye), or a sprain. Examples of chronic traumatic swellings are calluses, bursitis (viz., housemaid's knee), or an overgrowth of bone after an inaccurately healed fracture. Infectious swellings of an acute nature include boils, abscesses, felons, and inflamed lymphatic glands. Those of chronic type result from tuberculosis, syphilis, actinomycosis, leprosy, etc.

Hypertrophic Swellings. — The essential feature of these is an increase in the size (hypertrophy) and number (hyperplasia) of the cells constituting the organ or part concerned. The excessive muscular development of the calves of the legs of some ballet dancers is an example, likewise the enlargement of the breasts and uterus in pregnancy. All such swellings result from normal physiological processes and as such do not constitute true disease.

Parasitic Swellings. — These result from the multiplication within the body of living cells introduced from without. The only common example is hydatid disease which gives rise to the formation of cysts in the internal organs. Both the wall and the contained fluid are derived from the foreign cells. They evoke a variable amount of inflammatory response on the part of the adjacent body cells.

Cysts. — These constitute a heterogeneous group since some cysts are true tumours, which happen to develop in spherical form with a central space occupied by degenerative fluid products of their own cells. Other cysts result from cystic degenerative changes occurring within the solid substance of true tumours. Many, however, are not related to tumours at all, the following being specific examples: retention cysts, dilated glands whose effluent ducts are blocked, *e.g.*, sebaceous cysts (wens); distention cysts, formed by the dilatation of closed sacs which normally contain but little fluid, *e.g.*, hydrocele; congenital cysts, which do not necessarily appear at birth but are all derived from embryological structures which have persisted fortuitously, *e.g.*, thyroglossal, branchial cysts; parasitic cysts (described above); degenerative cysts, *e.g.*, a ganglion of the wrist, blood cysts.

All cysts contain fluid free within a closed cavity. The nature of the fluid may be bloody, mucoid, milky, etc. Clear fluids such as lymph, in cysts near the surface of the body, will transmit light and hence are translucent. Aspiration of the contents is frequently practised as a means of diagnosis. Treatment consists in surgical removal where and when indicated.

Degenerative Swellings. — These result from distention of hollow organs or tissues following an abnormal weakness of their walls or their investing membranes. Examples include aneurysms, varicose veins, hernias, diverticula.

False Swellings. — Deeply seated organs or structures may become abnormally prominent because of the wasting of their superimposed coverings. A false impression of enlargement may therefore appear.

Swellings of Unknown Origin. — This group embraces a few swellings whose nature and origin is the subject of doubt and debate. They may or may not be true tumours, inflammations or degenerations. The outstanding example is Hodgkin's disease of the lymphatic glands.

Phantom Tumour is a term applied to the apparent enlargement of the lower abdomen that occurs in women who suffer from an hysterical conviction that they are pregnant. It is not infrequently accompanied by alleged concomitant accessory signs of pregnancy.

The "tumour" promptly disappears under the influence of hypnosis or anaesthesia.

TRUE TUMOURS

These are composed of masses of tissue cells developed from pre-existing body cells. In some instances the tumour cells are normal in appearance, faithful reproductions of their parent types; such tumours are generally benign. Other tumours are composed of cells slightly different from normal adult types, different in appearance, size, shape and structure; these tumours are usually malignant, and the specific changes in cell type are those of anaplasia.

Cause. — We have seen that the false tumours are initiated by a definite and in many instances a specific cause, but in the case of true tumours, the cause is unknown. The method by which a tumour grows; *i.e.,* the proliferation of body cells, is a process that normally occurs in health. Body cells, like men, have their allotted span of life, varying from a period of days to years, whereupon they are replaced. New cells do not arise *de* novo but by fission, one (mother) cell dividing into two (daughter) cells; the daughters (twins) are identical with each other and with their late mother. When tissue is lost, as by a burn of the skin, the defect is reconstituted by the multiplication of adjacent body cells. This process proceeds until the defect is properly repaired, and then it ceases. We can see the necessity and logic for the initiation of such a process but we can only marvel at the mechanism which finally throttles the cellular proliferation at the exact moment of normalcy. It is presumed that the reparative process of cell proliferation is initiated by a normal stimulus and is stopped by a similarly normal stimulus.

Tumours arise by a proliferation of body cells in the absence of a normal stimulus, or, alternatively, in the presence of an abnormal stimulus; the precise nature of both processes still defied elucidation at mid-20th century. Without any discernible cause, the cells of a tissue start to multiply as though to fill a defect that does not exist. One important difference from the normal reparative process is a tendency for the daughter cells to assume characters of a nature more primitive than that of their predecessors, hence becoming anaplastic.

Certain factors are generally believed to favour the initiation of tumour formation in isolated instances, and outstanding among these is chronic irritation. Employment in certain trades and occupations predisposes to the development of certain tumours; these occupations are associated with long continued exposure to mild irritation of various parts of the body. Experimental production of tumours by irritational methods has been accomplished in animals, but it is unlikely that these methods are identical with those that cause the spontaneous origin of tumours in otherwise normal human beings.

Among other factors is heredity. There is some evidence that inherited characteristics may predispose the development of tumours, particularly of the malignant type. Many experimental studies with mice demonstrate the possibility of breeding, by planned selection, a strain of animals that will show almost 100% cancer production. The extremely high incidence of human cancer in certain family groups is well known, but appears to constitute only a minor subfactor in the propagation of the disease.

Infection by micro-organisms has not been proved as a cause. Certain experimental tumours of fowl have been shown to be transmitted by a filterable virus. The only possible instance of this mode of tumour formation in man would appear to be the "crops" of "soft" warts commonly occurring in childhood, but there is some doubt that these warts are true tumours.

Trauma is a factor occasionally imputed, notably in instances coming to the attention of workmen's compensation boards. It would seem that in some instances certain tumours, usually of a sarcomatous nature, may be causally related to trauma, but definite proof was far from established at mid-century, since the experimental production of a tumour in this manner had yet to be demonstrated conclusively.

The Vicious Autonomy of Turnours. — Natural inflammatory swellings are primarily beneficial to the body since they constitute one phase of the protective response of the body to noxious stimulus. True tumours, on the other hand, serve no such useful function. In many instances their only role is to kill the patient. They grow for their own sakes alone, and at the expense of the body economy.

The capacity of inflammatory tumours to form and function depends upon the general healthiness of the body. In people who are poorly nourished or ill, the inflammatory response may be poor or absent. True tumours on the other hand observe no such compliance with the general body resources. Even though a person be so physically exhausted that a recently sustained wound may fail to show any attempt at healing, a true tumour currently present will continue to grow by cell proliferation, ignoring the ebbing vitality of the patient. In this respect tumours behave as parasites.

Whenever normal cellular proliferation is required to carry out body repairs, the multiplying cells tend to reconstruct as faithfully as possible the normal architecture of the part lost or destroyed. Proliferating tumour cells on the other hand follow no plan or deviate grossly from the original tissue pattern. This of course is at least consistent with their utter lack of function since no structural specification is therefore required. Indeed their perversity is sometimes manifested by the development of abnormal symptoms through their overproduction of malicious ferments, as in certain tumours of the thyroid gland and pancreas.

Clinical Manifestations. — The mass of newly formed tumour cells usually constitutes a definite localized swelling. Should such a mass occur on or near the surface of the body, it can be felt or seen as a lump. But since tumours may develop in any organ or tissue, however deeply placed, the swelling may not always be palpable.

Some tumours, notably those of the malignant variety, may assume physical characteristics other than that of lumps. Thus they may appear as ulcers, indurated cracks or fissures, wartlike projections, or as a diffuse ill-defined infiltration of what appears to be an otherwise normal organ or tissue. The tumour cells may replace completely the normal cells of the part and should the processes of proliferation of new cells and the destruction of normal cells both proceed at the same pace, there may be only little gross change in the size of the part, though there will usually be an alteration in the consistency of the tissues. In other cases the normal cells may disappear more quickly than the tumour cells appear, so that the affected part may actually shrink in size. This is seen in certain cancers of the breast and in the annular type of cancer of the bowel.

Tumours which arise in the tubular structures of the body; *e.g.,* the intestinal, biliary or urinary tracts, are prone to cause obstruction since the normal contents of these tubes are no longer free to pass along their lumina. Thus intestinal, biliary, etc., obstruction may be produced. Furthermore, such tumours, being located in the walls of these various tubes, actually may bleed into the tract concerned, and the blood subsequently appears at the natural body orifices; viz., the vomiting of blood resulting from cancer of the stomach, or the passage of bloody urine in cases of tumours of the kidney or bladder. Again, the tumour by virtue of its mass as a foreign body may initiate the production of pus or mucus and these substances likewise are passed to the surface of the body.

Tumours arising within the bony cages of the body; *e.g.*, chest, skull and spinal column, may cause symptoms by exerting direct pressure on adjacent vital structures such as the heart, brain and spinal cord. Those developing within the interior of a bone may so weaken the bone as to cause a collapse, bending or actual fracture. The destruction of specific tissue in which the tumour develops may so interfere with local function as to cause specific symptoms; *e.g.*, loss of vision in the case of an intraocular tumour.

Pain is a variable symptom. It may result from direct pressure on, or irritation of, adjacent nerve tracts. *e.g.*, the spinal cord, or by producing increases of pressure within a rigid cavity, *e.g.*, headache in the case of brain tumour; or by producing obstruction of a muscular tube with concomitant colic, *e.g.*, tumours of the intestine. Thus, in their early stages all tumours tend to be painless, and even though they grow to a large size, should there be no interference with local function, they may remain painless. Later, however, the malignant variety commonly causes pain by the direct invasion of nerve trunks or by destruction of bone. Tumours themselves are largely devoid of nerve fibres, excepting, of course, those that are composed of nervous tissue.

Classification of **Tumours.**—When we recall that tumours may arise in any part of the body and from every type of cell and tissue in the body, that they may possess the phenomenon of malignancy in any degree, we must realize that an accurate, all-embracing classification has yet to be achieved.

The fact that we are still uncertain of the identification of some of the precursor cells from which tumours arise serves only to augment the difficulty.

Since all tumours are composed of cells, we try to classify them according to the specific type of cell predominating in any particular instance. This constitutes the histologic basis of classification, the microscopic study of cellular structure. In general two main types of body tissue are recognized: (1) epithelial tissue, which forms the surfaces of the body and its tubular cavities and glands and (2) connective tissue, whose function is essentially supportive. It is therefore possible for tumours to be composed of three types of tissue, namely, epithelial tissue, connective tissue and tissues of mixed or uncertain type. The introduction of the last group adds a note of variability characteristic of all biologic processes.

Classification of Tumours

Classification according to behaviour	Classification according to tissue of origin		
	Connective tissue	Epithelial tissue	Tissue mixed or indefinite
Benign	lipoma fibroma angioma chondroma osteoma myxoma neuroma myoma fibromyoma osteochondroma glomus tumour	papilloma adenoma implantation dermoid	odontoma fibroadenoma adenomyoma fibropapilloma
Malignant	sarcoma	carcinoma	specific adrenal tumours
Variable malignancy or locally malignant	giant cell glioma endothelioma chordoma	rodent ulcer	melanoma mixed salivary tumour carcinoid tumour embryological tumours

Long before the advent of the microscope as an aid to histologic study, medical men classified tumours on the basis of their ultimate effect on the patient; *i.e.*, the clinical classification. While the histologic picture of a tumour is of interest to the pathologist, the effect of the tumour on the life and happiness of the patient is of far more importance to the patient himself. Hence the ancient clinical classification of tumours into the benign and the malignant types. The malignant tumours are those that, in general, always kill the patient eventually if left untreated or if not drastically eradicated at an early stage of development. This distinction of the clinical behaviour of tumours holds good only up to a point, for it is known that some benign tumours; *e.g.*, a lipoma, may readily cause death purely by virtue of location by exerting pressure on the spinal cord. Other tumours appear to fall between the two main clinical divisions in that they may be only locally malignant, destroying all normal tissue in their vicinity, but not spreading widely from their point of origin. Thus we may classify tumours on a clinical basis as benign, malignant, or of local or variable malignancy. Again the acknowledgment of a third group, while typifying the vagaries of biologic processes, serves also to enhance the difficulties in formulating a satisfactory classification of tumours.

Malignancy of Turnours.—Malignancy refers to the tendency of a tumour to produce death. But we have seen that any tumour, of any type, may produce death by local effects if appropriately situated.

Thus the specific definition of malignancy implies an inherent tendency, on the part of the cells composing it, to invade the body widely and relentlessly, to become disseminated by subtle means, and eventually to kill the patient unless all the malignant cells can be drastically and completely eradicated.

The outstanding gross characteristic of malignancy is the property of tumour cells to wander from their site of origin. Though the tumour may arise from one site in one tissue or organ, it may eventually establish metastases in almost every tissue and organ of the body.

In contrast, the cells of a benign tumour invariably remain in contact with each other in one solid mass centring at the site of origin. This gross physical continuity of the benign tumour cells enables them to be removed completely by surgical means, providing the location is suitable. But the dissemination of malignant cells, each one individually possessing the facilities and tendency to give rise to new masses in new and distant sites, precludes complete eradication by a single manoeuvre in all but the earliest period of growth.

The question frequently arises, does a benign tumour ever become malignant? In other words, is malignancy a property that may be acquired by benign tumour cells? We know that normal body cells, if subjected to the appropriate (and unknown) stimulus, may form tumours and these tumours may be either benign or malignant ab *initio*. Both types of tumour rarely are found in the same individual at the same time. Still more rarely does a primarily benign tumour appear to become transformed into a malignant one. It is not easy to be certain concerning the acquisition of malignant transformation; it is possible for a primarily malignant tumour to remain quiescent, mimicking a benign one clinically, for a long time.

Of the group of tumours in which malignancy is variable, some are benign from the start and remain so; others are apparently malignant from their moment of origin; and finally, a few appear to change from innocent to malignant type. In the latter case the histologic picture of the tumour before and after malignant transformation may show no differences. Thus, acquired malignancy is not necessarily dependent upon discernible changes in the appearance of the tumour cells.

To sum up, a benign tumour may undergo malignant transformation but the cause of such change is unknown. The regression of a malignant tumour to benign type is, lamentably, unknown.

For a discussion of malignant tumours *see* under CANCER; CANCER RESEARCH.

BENIGN TUMOURS

Characteristics.—Benign tumours tend to occur in younger people, most of them appearing before the age of 40. Histologically their cells show no great variation in detail from those of normal tissue, in contrast to the appearance of cancer cells. The arrangement of the new cells may suggest an abortive attempt to reproduce the normal structure of the part but this effort is usually crude and ineffectual. All tend to remain localized at the site of origin.

They enlarge by accretion, pushing aside the adjacent tissues without involving them intimately. Malignant tumours, on the other hand, invade the surrounding structures, thereby becoming fixed to them.

Many benign tumours are encapsulated. The capsule consists of a connective tissue derived from the structures immediately surrounding the tumour. While it serves to demarcate the tumour it does not act as a limiting membrane. Malignant tumours, as a rule, do not possess a capsule though some of the sarcomas arising from soft tissues may have a pseudocapsule in their early stages. The chief effect of the capsule is to lend the physical property of mobility to the tumour mass. Well-encapsulated tumours are not anchored to their surrounding tissues. It may be possible to bounce the tumour about in the part; *e.g.*, a fibroadenoma of the breast or, should the tumour arise from a bone (an osteoma), the enveloping muscles and tendons will move freely over and around the mass.

Benign tumours of any one type are frequently multiple, several arising in different parts of the body either simultaneously or in succession. In such'cases all the tumours are identical. It is most unusual for more than one malignant tumour to arise primarily, but, should this primary tumour give rise to metastases, these secondary masses tend to differ from the primary growth in their gross physical characteristics, though remaining identical histologically.

Benign **Tumours** Arising from Connective Tissue,

Lipoma.—This is the commonest of all neoplasms and consists of fat cells which are microscopically indistinguishable from normal fat cells. They are invariably ensheathed in a delicate transparent capsule which sends fine septa through the body of the tumour making it lobulated. Thus are explained the two outstanding characteristics of the tumour; namely, lobulation and a firm demarcated edge. Small lipomas tend to be plaque-shaped, larger ones hemispheroidal, while others may become pedunculated. Since normal fat is a soft structure, so too are most lipomas, though in their infancy they are frequently firm. Pain is a most unusual feature and suggests the rare complication of calcification. Since fat at body temperature is a clear fluid, prominent tumours near the surface of the body may be translucent in a strong beam of light.

They tend to occur in all situations where normal fat is found and thus may be classified according to site; namely, subcutaneous, subfascial, subserous, submucous, subsynovial, with rarer occurrence in the subperiosteal and subcapsular regions. By far the commonest site is the subcutaneous plane, immediately deep to the skin (see fig. 1). While commonly single, they may be present in scores. They vary from the size of a pea to that of a football and while they may arise at any age they are rare in the first decade of life. It is generally conceded that they are not subject to malignant change, those so-called malignant lipomas being liposarcomas from the start.

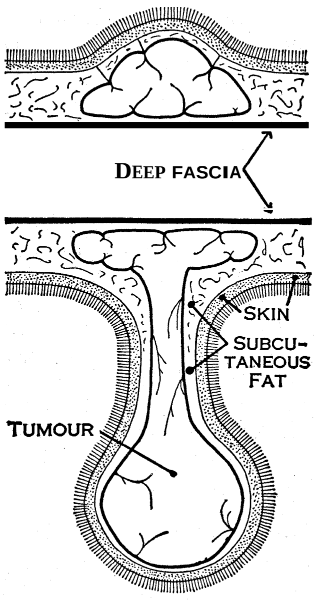


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FIG. 1.—SUBCUTANEOUS LIPOMAS

Treatment consists of removal of the tumour by surgical excision, the indications being cosmetic defect or interference with the function of local structures; *e.g.*, when the tumour is located within the bowel or is exerting pressure on the spinal cord. Complete removal is usually effected quite easily and is never followed by recurrence.

Diffuse lipomas are characterized by absence of a limiting capsule. They are probably not true neoplasms but rather result from disturbances of metabolism.

Fibroma.—This is a rare tumour composed of white fibrous tissue enclosed in a thick tough capsule. It is usually spherical in shape, hard, painless, freely movable and varied in size but it seldom exceeds the dimensions of an orange. A "soft" variety is described but is uncommon. They are found in the bones—chiefly about the gums of the jaws and the nasopharynx; in the tendon sheaths—chiefly on the back of the wrist; in certain glands of the body (breast, ovary, testicle); and in the nerves.

The latter site is the commonest. Here the tumours spring from the fibrous sheath of the nerve rather than from the conducting tissue—hence they contain no nerve elements. The eighth cranial nerve is especially prone to be affected, giving rise to the so-called acoustic neuroma.

Von Recklinghausen's disease consists of multiple small fibromas affecting the subcutaneous nerves of the body and is accompanied by a patchy discoloration of the skin. The condition tends to be inherited and of familial proportions. Molluscum fibrosum, plexiform neuroma and elephantiasis neuromatosa are other clinical manifestations of multiple fibromas. Two complications are observed, myxomatous degeneration and malignant transformation to sarcoma, the latter supervening particularly on the "soft" variety of fibroma.

Treatment consists of early excision of the single types. There is no uniformly satisfactory method of dealing with the disease in its multiple form.

Angioma.—This tumour is composed of vessels of which there are two types (1) haemangiomas, or tumours of blood vessels and (2) lymphangiomas, tumours of lymphatic vessels.

The haemangiomas are of three varieties, depending on the type of blood vessel forming the tumour.

The capillary haemangioma is the commonest form of birth mark. It consists of a mass of fine capillary vessels stuffed with circulating blood. It is seen most commonly in the skin but may affect deeper structures as well. In its typical form it consists of a reddish, roughened, raised patch, painless, often with an ill-defined border. The colour is due to the concentration of blood and frequently this can be expelled partially by pressure with a finger tip, causing the zone so pressed to blanch. It does not possess a capsule.

The tumours, either single or multiple, appear shortly after birth and tend to increase in size for a few months. Many of them disappear spontaneously.

The only serious complication is haemorrhage, which in some instances may be fatal. Treatment consists of excision if feasible, if not, in radiation by means of X-ray or radium. They do not tend to recur.

The cavernous haemangioma consists of a growth of blood vessels of the character of veins. Hence they appear, when near the surface, as soft, painless, bluish, wormy masses which can be emptied by compression and will refill by dependency. If located close to the trunk of the body, they may show an impulse on coughing. They occur in the subcutaneous plane, in the muscles, in the solid viscera and in the bones—one tumour only being the rule. In the bones they are prone to erode their parent site and cause collapse or fracture. Frequently they possess a partial capsule of thin connective tissue.

Treatment is best effected by excision if possible, otherwise as in vertebral sites—by radiation.

The plexiform haemangioma consists of a mass of large vessels of arterial type and calibre. Not infrequently large venous channels are present as well. The temporal region of the head is the only common site, where the swelling appears as a pulsating mass which may erode the skin and the underlying bone. Treatment consists of complete and careful excision,

The lymphangiomas are rare tumours and, like their haemal cousins, are of three types. Capillary lymphangiomas consist of tiny pearly vesicles the size of pinheads, affecting chiefly the lips and tongue. The cavernous type, also known as cystic hygroma, consists of large, thin-walled, translucent lymphatic cysts, usually found in the neck. The plexiform type consists of a wormy mass of grossly dilated lymphatic vessels and, like the capillary type with which they are frequently associated, they tend to affect the lips and the tongue. All lymphangiomas may be treated by excision or radiation. None possesses a well-defined capsule.

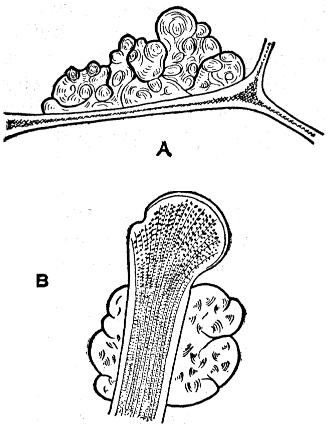

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FIG. 2.— (A) ECCONDROMA OF THE SCAPULA, (B) ECCONDROMA OF THE HUMERUS

Chondroma.—This is a tumour composed of hyaline cartilage which is the embryologic precursor of bone. While normally confined to bony sites, these tumours occasionally are encountered free in soft tissue sites. They form firm lobular masses enclosed in a thick capsule. Two types are described. The *ecchondromas* (fig. 2) grow outward from the surface of their parent bone—commonly the flat bones of the skeleton. They may attain the size of a coconut and they push aside the overlying structures. They are usually single. The *enchondromas* (fig. 3) develop within the interior of bones—usually the smaller long bones of the hands, feet and digits. They are commonly multiple and bilaterally placed. As they grow they expand and thin the cortex of their parent bone, producing considerable deformity. They may erupt through their bony covering and project outward into the surrounding soft tissues.

All chondromas tend to be painless, but are subject to myxomatous degeneration and sarcomatous change. All should be treated by complete surgical excision.

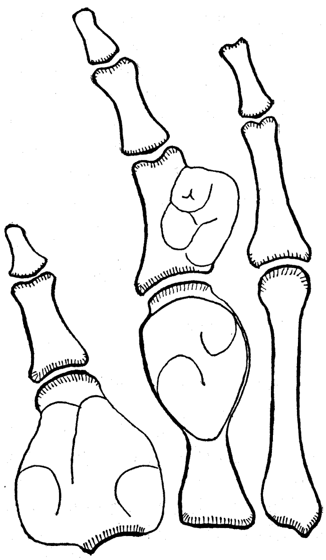

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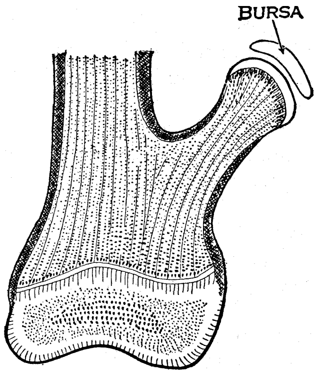
FIG. 3.—ENCHONDROMAS OF THE SMALL BONES OF THE HAND

Osteoma.—This is a tumour composed of bone. Two varieties are distinguished. The *cancellous* osteoma (fig. 4) is made up of all the elements of the shaft of a long bone, including both the spongy medulla and the firm compact cortex. Its gross appearance suggests a ballooning outward of a portion of the parent bone at one point. They form hard painless masses deeply attached to the skeleton; displacing the soft tissues about them. Not infrequently they are capped by a bursa which may be the seat of periodic inflammation, thus causing pain overlying the swelling. These tumours probably form as the result of an accidental deviation from the normal pattern of growth in a long bone, for they arise only during the period of bone growth—under the age of 2j, and they cease to enlarge when their parent bone reaches maturity. Both single and multiple varieties occur. Treatment is effected by surgical excision.

The *compact* osteoma (fig. 5) consists of a proliferation of the dense cortical layer only of a bone. They are usually single tumours and constitute the hardest substance the human body is capable of producing. They occur on the surface of the flat bones of the body. notably the vault of the skull and the lower jaw. In the case of the skull they may grow from either the external or internal surface, or both, thus occasionally projecting into the cranial cavity and exerting pressure on the brain. When growing externally they form a hard circumscribed boss over which the scalp rides freely. They occur at any age. Treatment consists of removal by sectioning the normal bone close to the periphery of the mass, since no instrument is sufficiently staunch to attack the tumour itself without fracturing the adjacent portion of the skull.



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4.—CANCELLOUS OSTEOMA OF THE LOWER END OF THE FEMUR

Myxoma is a rare tumour consisting of a mass of jellylike primitive connective tissue.

Neuroma is an equally rare tumour formed of nerve cells and fibres, usually derived from the autonomic nervous system.

Myoma, in pure form, is again a rare tumour consisting of muscle tissue only.

The *leiomyoma* is derived from smooth muscle fibres, the rhabdomyoma from striated muscle fibres.

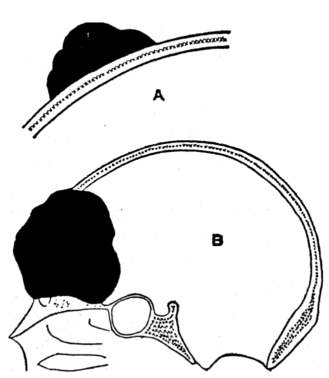

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FIG. 5.—COMPACT OSTEOMAS OF THE SKULL: (A) PROJECTING FROM THE EXTERIOR ONLY, (B) ENCROACHING ON THE CRANIAL CAVITY

Fibromyoma.—This is a tumour composed of two elements of connective tissue—fibrous tissue and smooth muscle tissue. It is a Common tumour, occurring much more frequently than either of its composites in pure form. Its site of election is the uterus, where it is colloquially termed a "fibroid." It is also the commonest of all tumours of the uterus and develops there in three situations—either projecting outward from the womb, enlarging the body of the womb, or projecting into the cavity of the womb in which case it is prone to bleed. These tumours may grow to a colossal size, are frequently multiple and are liable to undergo simple degenerations and malignant change. Treatment consists in surgical removal which, owing to their multiplicity and their deep-seated location, may demand the complete removal of the uterus.

Osteochondroma is the hybrid of the two "pure" tumours, osteoma and chondroma. They occur in sites common to the chondromas and clinically resemble the latter tumours closely. They should be treated by surgical removal.

Glomus Tumour.—This peculiar swelling consists of a mass of blood vessels, nerve cells and fibres and epithelioid cells. It occurs chiefly on the extremities; the hands, feet and digits are the common sites. It usually presents as a single, exquisitely tender, tiny reddish patch immediately deep to the skin or a finger nail. It is seldom as large as a grain of wheat when first discovered, the attention of the patient being focused by the inordinate pain which results from any manipulation of the part. It is believed to arise by proliferation of the local nervous mechanism of the lateral capillary "shunts." Treatment consists of surgical excision.

Benign Tumours Arising from Epithelial Tissue.—Pupil*loma* consists of a sprouting projecting mass of new tissue derived from a surface epithelium. Three histologic types are described, based on the type of epithelium composing the tumour. None are encapsulated.

Squamous papilloma arises from a stratified squamous epithelium. The skin is the commonest site; there the process results in a wart. These are frequently multiple and in some instances may not be neoplastic at all. Other sites include the tongue, mouth and vocal cords. All may be treated by surgical excision or radiation.

Transitional papillomas are confined to the urinary tract, the kidneys, ureters and bladder. They contain a rich arborization of blood vessels surrounded by a delicate layer of epithelium. Hence their usual complication is haemorrhage, which is manifest by the painless passage of blood in the urine. In addition they may give rise to urinary obstruction and infection. All transitional papillomas are prone to become malignant and should therefore be eradicated as soon as diagnosed. If they occur in the bladder they may be cauterized with an electric current.

Columnar cell papillomas spring from and project into the interior of the gastrointestinal tract, the larger ducts of the breast and the walls of certain cysts. They have a tendency to bleed easily, thereby producing bloody effluxes, and all are prone to undergo cancerous change. They should be removed surgically when diagnosed.

Adenoma in pure form is an uncommon tumour derived from the secreting cells and tubules of glands. They occur in the alimentary tract, mucous and cutaneous glands and in the glands of internal secretion. In the latter situation they have been known to elaborate an excess of secretion, thus producing symptoms of overactivity of their parent gland; namely, thyroid, pituitary, parathyroid or pancreas. Elsewhere they tend to bleed and in the intestine they may produce obstruction. They are usually small spherical painless masses surrounded by a definite capsule. Treatment consists in surgical removal.

Implantation dermoid (fig. 6) is a tumour which assumes the form of a cyst. The common sites are the palms of the hands and the fingers. The popular theory of origin implies the growth of a bit of skin transplanted to a depth in the subcutaneous tissues. The wall of the cyst is formed of stratified squamous epithelium and the contents consist of epithelial debris. They usually grow to the size of a pigeon's egg, are painless and frequently translucent. They are readily treated bv excision.

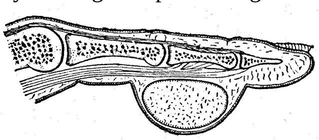

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FIG. 6.—IMPLANTATION DERMOID OF THE FINGER

Benign Tumours **of** Mixed Tissue **Origin.**—*Odontoma* (fig. 7) is a tumour derived from the elements of teeth and is therefore encountered only in the jaws. Since the teeth are derived from both epithelial and connective tissue elements, many varieties of odontoma may occur but man, in contrast to animals, is subject to few types but those of epithelial origin. As the process of tumour formation may afflict the teeth at any stage of their development three main types of epithelial odontoma are recognized; namely, fibrocystic disease of the jaw, dentigerous cyst and dental cyst. All these cause swelling of the jaw with considerable pain. All may be satisfactorily treated by excision.

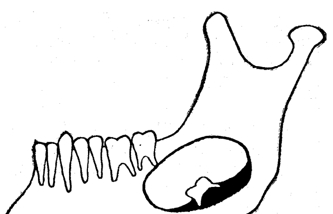

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FIG. 7 —A DENTIGEROUS CYST OF THE LOWER JAW

Fibroadenoma is a hybrid which, like fibromyoma, is of more common occurrence than each of its two "pure" composites. It consists of a mixture of white fibrous tissue and epithelial cells of a secreting gland. It is often multiple, usually painless, spherical in shape, firm in consistency and carries a thick capsule. Only two locations are commonly noted, the breast and the prostate gland.

It is the commonest tumour of the breast. where it must be differentiated from carcinoma—and vice versa. One or more tumours may be present in one or both breasts. It tends to develop before the age of 3j. An outstanding clinical feature is the great mobility of the tumour aithin the breast tissue. Three varieties are described, hard, soft and cystic. The latter two may reach the size of a football but the hard type seldom exceeds the size of an orange.

Fibroadenomas have a small but definite tendency to become malignant. They should always be removed surgically as soon as they are diagnosed.

Adenomyoma and *fibropapilloma* are examples of rare hybrids. They assume the clinical features of one or the other of their constituent tumour tissues.

Diagnosis of Turnours.—Two main methods are commonly employed.

The first and oldest is that of clinical examination, an appreciation of the physical characteristics of the swelling, the symptoms it initiates, its site, its mode of growth and spread if any, and its effect on local and adjacent structures and functions. The success of this method depends essentially on the experience, skill and judgment of the physician. It may frequently be supplemented by X-ray studies of the part, notably in the case of tumours of the bones. intestinal tract and the more deeply seated lesions that cannot be directly seen or palpated.

The second method employed is the more scientific and accurate means of biopsy. Since all tumours consist of a new growth of cells, the microscopic study of these cells will give a true picture of the nature of the tumour. A bit of tumour tissue is therefore removed from the patient and submitted to histologic examination. This manoeuvre is employed where the diagnosis is in doubt, where the necessity of an extensive operation is being debated or where the method of treatment is in doubt. Some subvarieties of any one specific tumour may best be treated by operation, others by radiation or by a combination of both methods. Biopsy will usually provide the answer. While it constitutes the mainstay of accurate diagnosis it must be admitted that in some instances, notably in the case of near-malignant tumours, it may fail to clarify the diagnosis.

Occasionally adjuvant methods of diagnosis are employed. While there is no constant biochemical criterion by which tumours can be diagnosed. some of them, particularly of the adenoma group, will at times produce substances that alter the chemical and physical processes of the body in such a manner that the presence of a tumour may be inferred indirectly. By the study of these secondary effects alone the diagnosis may be established with certainty and an operation initiated for the purpose of searching for and removing the offending tumour, for example, an adenoma of the pancreas or the parathyroid gland.

The early diagnosis of tumours depends primarily on the patient who harbours one. Once having cause to suspect an abnormality he should pursue the matter of investigation as soon as possible. As mentioned above, some normally benign tumours tend to become malignant but this feature obtains only in cases where the tumour has been present for a long time. It is therefore obvious that early diagnosis is an essential factor in successful treatment.

Tumour Research.—The appalling loss of life caused by malignant tumours alone spurred world-wide efforts to unravel the mysteries of tumours. All aspects of the problem received meticulous investigation. the causation of tumours, their method of spread, factors which influence their growth and methods designed to eradicate them. The various fields of research include histology, biochemistry, physical chemistry, tissue culture, bacteriology, radiology, animal experimentation, surgery, clinical research, vital statistics and public health surveys. While notable advances were being made by mid-20th century, a satisfactory understanding of the problem was still lacking. It was not clear as to where the answer might be. The discovery of the cause, *e.g.*, might not yield the answer to the treatment, and vice versa.

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TUMULUS, an artificial mound of earth or stone, usually conical in shape, erected either as a memorial, or over the grave of a royal personage, noble or hero, or the relic of a saint. Funerary tumuli are sometimes known as barrows (*q.v.*).

TUNA, any of several fishes of the mackerel family, belonging to the subfamily Thunninae. They are typically large fishes, of very robust body form, with a keel on each side of the caudal peduncle and with the pterotic bone excluded from the brain chamber by a deep pit or infolding behind the pro-otic bone. They are remarkable for maintaining their body temperature above that of the surrounding water and for having a peculiar vascular system, which is characterized by a large plexus along each side of the body. Most tunas inhabit warm seas and many of them are circumtropical. They are believed to migrate extensively. In the Atlantic ocean tunas spawn in the region of the Mediterranean.

They are among the most valuable food fishes in the world. The best-known types are bluefin, or tunny (Thunnus), the albacore (*Germo*), the yellowfin (Neothunnus) and the skipjack, or striped tuna (*Katsuwonus*). (See also TUNNY.) (L. A. WD.)

TUNBRPDGE WELLS (ROYAL), a municipal borough (1889) and inland watering place in the Tonbridge parliamentary division of Kent, Eng., 36 mi. S.E. of London by road. Pop. (1951) 38,400. Area 9.4 sq.mi. It owes its popularity to its chalybeate spring and its beautiful situation in a hilly wooded district. The wells are situated by the Parade (or Pantiles), a walk associated with fashion since the wells were discovered, and paved with pantiles in the reign of Queen Anne. A new assembly hall was opened in 1939. The town is built in a picturesquely irregular manner, and a large part of it consists of districts called parks occupied by villas and mansions. The medicinal springs were discovered by Dudley, Lord North, in 1606. After the Restoration it was visited by Charles II and Catherine of Braganza. It was a favourite residence of the princess Anne before her accession to the throne, and from that time became one of the chief resorts of London society. It reached its height in the second half of the 18th century, and is associated with Colley Cibber, Samuel Johnson, Richard Cumherland the dramatist, David Garrick, Samuel Richardson, Sir Joshua Reynolds, Beau Nash and Mrs. Thrale (Hester Piozzi). The Tunbridge Wells of that period is sketched in William Thackeray's Virginians. The industry known as Tunbridge Wells ware continued during 300 years, but the factory closed and the small existing supply comes from the spare time work of old hands. The mare includes tables, boxes, toys, etc., made of hard woods, such as beech, sycamore, holly and cherry, and inlaid with mosaic. Five miles southeast is Bayham abbey, founded in 1200, where ruins of a church, a gateway and dependent buildings adjoin the modern Tudor mansion. The vicinity of Tunbridge Wells is largely residential.

TUNDRA, the cold, desert, treeless plains which form the arctic lowlands of Europe and Asia. The name is also generally applied to a similar area in North America. The prevailing low temperatures are consequent on high latitude and proximity to the frozen northern ocean and result in very scanty vegetation.

TUNGABHADRA, a river of southern India, the chief tributary of the Kistna. It is formed by two streams, the Tunga and the Bhadra. which rise in Mysore in the Western Ghats.

T'UNG-CHOU (TUNGCHOW), a former town of Hopeh province. China. since 1958 included within the expanding city limits of Peking (*q.v.*). It is situated on the northernmost branch of the Grand canal, which there utilizes the channel of the Pai Ho. During the Mongol dynasty a canal was built connecting T'ung-chou with the national capital, enabling rice and other commodities to be shipped there from southern China. Later, when the canal fell into disuse, T'ung-chou was the river port of Peking. After the coming of railroad transportation to China, the importance of T'ung-chou declined. It was the headquarters of the Japanese puppet regime of East Hopeh set up in 1935, and the scene .of early fighting in the Chinese-Japanese war in 1937. T'ung-chou is connected with Peking's city centre by a light railway and by a suburban bus line. It was called T'ung Hsien from 1913 to 1954 when it reverted to its earlier name T'ung-chou. Pop. (1953) was more than 50,000. (T. SD.)

T'UNG-KUAN (TUNGKWAN), town in Shensi province, China, on the border of Honan province, 75 mi. E.N.E. of Sian. The town is situated at T'ung Kuan (T'ung pass), a historic gateway between the Yellow river and the Hua Shan, an eastern outlier of the Tsinling Shan. At T'ung-kuan, the Yellow river, flowing due south along the Shansi-Shensi border, receives the Wei Ho on the right, and makes a right-angled turn eastward through a valley hemmed in by great loess walls. The T'ung Kuan mas a strategic gateway throughout China's history, and a political division between the provinces of Shensi and Honan. The pass is used by the Lunghai railroad. China's main east-west trunk transportation line; and, in 1958, a bridge completed across the Yellow river established a link between the Lunghai line and the railroad station of Feng-ling-tu, the terminus of the railroad system of Shansi province. Completion of the bridge converted T'ung-kuan into one of China's leading railroad hubs. During the Chinese-Japanese War, T'ung-kuan was the westernmost point of the Japanese advance in central China. (T. SD.)

TUNG OIL has the valuable property of drying rapidly to a film that is hard, waterproof and highly resistant to acids and alkalies. Because of these characteristics the oil is used in the manufacture of high-grade protective coatings, such as paints and varnishes, for waterproofing and for many other industrial purposes. The Chinese first manufactured and used tung oil. In China it is expressed by primitive methods from the seeds of two native tree species, Aleurites fordii and A. montana. A. montana is tropical and grows only in areas that are practically frost-free. A. fordii is semitropical; it requires a long warm summer, but does not thrive without some cold weather in winter and when fully dormant can withstand a temperature of about 8" F. Each species is now grown in many areas of the world to which it is climatically suited. A. fordii was introduced into the United States in 1905. About 200,000 ac. of orchard in six southeastern states produce about 140.000 tons of whole fruit. From this crop, 15 to 20 modern mills process about 40,000,000 Ib. of oil, nearly enough for U.S. domestic requirements. (G. F. P.)

TUNGSTEN. The name tungsten (A. F. Cronstedt, 1755) means "heavy stone" (Sw. *tung*, "heavy"; *sten*, "stone".) and directs attention to the high specific gravity of the element and its ores (symbol W; atomic number 74; atomic weight 183.86). Up to the middle of the 18th century the mineral then known as tungsten, but now called scheelite, together with wolfram (or woliramite) were both considered minerals ,of tin. In 1781 K. W. Scheele showed that the mineral tungsten contained a peculiar acid which he named tungstic acid, combined with lime as a base. In the same year T. Bergman advanced the opinion that the new acid was a metallic calx or oxide. Two years later two students of Bergman, the Spanish brothers Juan José and Fausto d'Elhuyar, found the same tungstic acid in a black wolframite from the tin mines of Zinnwald. They heated this acid with carbon and isolated the metal tungsten.

Tungsten occurs in nature in the form of tungstates of iron, manganese and calcium, which may be divided according to their crystalline form into two groups. The iron and manganese tungstates, crystallizing in the monoclinic system, form the wolfram group, while calcium tungstate or scheelite belongs to the tetragonal system. Pure iron tungstate ($FeWO_4$) is known as ferberite and pure manganese tungstate ($MnWO_4$) as hubnerite. The mineral wolframite is normally a mixture of these two compounds in varying proportions. Waliramite generally occurs in columnar, bladelike or massive forms, though sometimes it is found in well-formed prismatic or tabular crystals. It breaks up readily into thin flakes and its specific gravity ranges from 7.0 to 7.5. The colour may vary from nearly black to a brownish tinge characteristic of specimens rich in manganese. Scheelite or calcium tungstate ($CaWO_4$) may occur in the form of well-developed crystals which are usually double tetragonal pyramids, but frequently it is found in a massive form with four good cleavages. The specific gravity is about 6.0 and the colour variable. It is generally gray, pale yellow or pale brown, rarely green or reddish, with a waxy lustre. The world's principal supplies of tungsten ores have come from China, Burma, Australia, Bolivia, Portugal, Korea and the United States.

In 1946 P. B. Nye and C. L. Knight reported on the deposit of scheelite at Grassy on King Island, Tasmania, one of the largest in the world, the reserves exceeding 2,000,000 tons at an average WO_3 content of 0.64%. It is a pyrometasomatic deposit formed by the replacement and alteration of beds of limestone interbedded with a series of hornfels. Within the mineralized zone the typical assemblage is garnet, diopside and epidote. Most of the scheelite occurs as grains less than 0.2 mm. in diameter. In the quartz veins the grains are relatively coarse.

Extraction and Manufacture.—The tungsten content of the ore mined is usually 0.5%-2.0%, so that a concentration process is necessary for extraction. The wolframite in the ore is associated with quartz and other gangue material, but it can be readily separated from these impurities because of its high density. To separate wolframite from cassiterite (SnO_2), which is present in a large proportion of the ores, magnetic methods are employed. Wolframite which contains iron is fairly magnetic, while cassiterite is not attracted even by powerful magnets. With the nonmagnetic scheelite, fortunately, the association of cassiterite is not common; otherwise, chemical processes would have to be employed to effect the separation.

Modern tungsten mills employ flotation as well as leaching methods to enhance the recoveries of tungsten from the ores. Tungsten concentrates throughout the British commonwealth are standardized at 65% WO_3 as against 60% WO_3 in the United States.

The tungsten industry employs two distinct methods of extracting the metal from these tungsten-ore concentrates. More than 80% of the tungsten produced in the world is used in special steels (see below and TUNGSTEN STEEL). The standard raw material for these steels is ferrotungsten with approximately 80% tungsten and very little carbon. This is exclusively made in the electric furnace. The fundamental reaction is:

$$FeWO_4 + 2FeSi = 2Fe + FeW + 2SiO_2$$

Since the melting point of 80% ferrotungsten is about 1,900° C. it is not poured from the furnace. Accordingly, upon completion of the reduction, the slag is tapped, the FeW alloy allowed to solidify in the furnace, the latter dismantled, the alloy cake removed and broken into small pieces suitable for tungsten-steel manufacture. The clcctric-power consumption ranges between 4,000 kw.hr. and 8,000 kw.hr. per ton of 80% FeW alloy.

For the production of tungsten metal to be used in tungsten lamps and vacuum tubes the wolframite concentrates are introduced into fused sodium carbonate (goo° C.–1,000° C.) in an oxidizing atmosphere. Sodium tungstate is thereby produced, and the iron and manganese present are converted to oxides:

$$4FeWO_4 + O_2 + 4Na_2CO_3 = 4Na_2WO_4 + 2Fe_2O_3 + 4CO_2,$$
$$6MnWO_4 + O_2 + 6Na_2CO_3 = 6Na_2WO_4 + 2Mn_3O_4 + 6CO_2$$

The soluble sodium tungstate is extracted with boiling water and on treatment with boiling hydrochloric acid an amorphous yellow precipitate of tungstic acid (H_2WO_4) is obtained which yields WO_3 on calcination In the preparation from scheelite the finely ground ore is decomposed with hydrochloric acid, whereby calcium chloride passes into solution, and tungstic acid. together with insoluble impurities like silica, remains as a sludge:

$$CaWO_4 + 2HCl = CaCl_2 + H_2WO_4$$

To purify the tungstic acid produced in these processes, it may be dissolved in ammonia and crystallized out as ammonium paratungstate, $5(NH_4)_2O$, $12WO_3xH_2O$. This is decomposed by hydrochloric acid to yield purified tungstic acid, or ignited in air to tungstic oxide (WO_3).

The above procedures may be repeated several times to attain a tungstic acid of the high specified purity from which the metal wire suitable for the lamp and vacuum-tube industry is obtained. The pure WO_3 thus produced is coarsened by heating at 1,350° C. for several hours. It is next reduced to metal (850° C.) by hydrogen: $WO_3 + 3H_2 = W + 3H_2O$. The metal powder obtained is converted into tungsten-metal bars by powder-metallurgy (*q.v.*) methods. It is not possible to melt tungsten in a crucible and cast it into rods simply because no crucible material melts at temperatures higher than tungsten (3,387' C.). Graphite heated to 3,387' C. disintegrates rapidly and/or forms carbides of tungsten.

Accordingly, the tungsten-metal powder is compressed into bars in a tungsten-steel mould at about one ton per square inch. The bars are then carefully removed and heated in a hydrogen atmosphere at about 1,300° C. Each sintered bar is then mounted in turn in a water-cooled metal bell jar filled with hydrogen. An electric current is passed through the bar until it almost melts. It is then allowed to cool in hydrogen and is now hot swaged (1,500° C.) and hot drawn (600° C.) down to the desired size. Short bearing dies are used in the swaging machine; tungsten-carbide and diamond dies are used in the hot drawing of the tungsten wire. The only serviceable lubricant for hot drawing is colloidal graphite (aquadag).

Physical and Chemical Properties.— Tungsten excels all other metals in having the highest melting point (3,387° C.—M. Pirani); the highest' tensile strength (600,000 lb. per square inch); the highest musical note; the lowest coefficient of expansion (4.4×10^{-6}); and the finest wire. There are five stable isotopes with mass numbers 180, 182, 183, 184 and 186. Nine radioactive isotopes, 176, 177, 178, 179, 181, 183, 185, 187 and 188, have been prepared. On the basis of the relative abundance of each stable isotope F. W. Aston calculated an atomic weight of 183.94 (Proc. Royal *Soc.*, A 132, p. 487 [1931]). Tungsten crystals are isometric and by X-ray analysis are fpund to be body-centred cubes with a lattice constant of 3.1592 A. The specific gravity of tungsten is about the same as that of gold. It is 19.3 in the annealed condition and as high as 21.4 in the wrought condition. The boiling point is 6,970° K. (6,700° C.).

Tungsten is paramagnetic. Magnet steels contain 4% tungsten but these permanent magnets have been largely superseded by the aluminum-nickel-cobalt-iron alloys.

Chemically, tungsten is a relatively inert metal. The distribution of electrons in the incomplete orbits (O and P) is: js^2, $5p^6$, $5d^4$, $6s^2$. Compounds have been prepared in which the element has positive oxidation numbers of 2, 3, 4, 5 and 6, the latter being of the greatest importance. Tungsten is not readily attacked by the common acids and alkalies nor by aqua regia. It reacts with a mixture of concentrated nitric and hydrofluoric acids. Very finely divided tungsten dissolves in hydrogen peroxide. The best solvent is fused potassium nitrite, the reaction being almost explosive. At incandescence tungsten reacts with all gases, including nitrogen, but excepting the noble gases helium, neon, argon, krypton and xenon. Tungsten alloys readily with the ferrous metals, with molybdenum, thorium, chromium, etc.

Applications.— The most important application of tungsten is in the production of tungsten steels and high-speed cutting tools. Tungsten steels are used for armament, for automobiles, for high-pressure equipment, etc. The Taylor high-speed steel contains approximately 18% tungsten, 5% chromium and 1% vanadium. The Stellite high-speed tools contain tungsten, chromium and cobalt. Aside from the use of tungsten metal in lamps and vacuum tubes it is used in electric contacts, X-ray tubes and fluorescent light tubes. The barium oxide-strontium oxide-coated tungsten cathode in these light tubes is one of the best electron emitters known. Scheelite is used as a phosphor in many of the fluorescent lamps. Tungsten carbide, WC, has replaced diamond in large drawing dies and rock drills; it is one of the best cutting tools, exceeded in hardness only by diamond and boron carbide (B_4C). An alloy of 90% tungsten, 4% copper and 6% nickel is used as protection in radium-beam therapy.

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TUNGSTEN STEEL. The earliest alloy of this type is Mushet steel. It contains from 5.5% to 9.0% of tungsten and also carries enough manganese to give it air-hardening properties and to class it as a quaternary alloy. This article considers principally commercial ternary alloys of tungsten. High carbon steels containing tungsten up to 6% are essentially water-hardening steels. *(See* IRON AND STEEL: *Metallography and Heat Treatment;* METALLOGRAPHY.) The atoms of tungsten, being so much larger and heavier than those of iron, diffuse comparatively slowly in solid metal, so that a high temperature is required for solution before the quench. Accumulation of carbide particles upon tempering is also slow, hence the ability of tungsten steels to hold their hardness at high temperatures. Tungsten carbide also has a very high intrinsic hardness, approaching that of the diamond. For keen-edged tools tungsten in the alloy seems to prevent small particles from being torn away during use, and thus retards dulling.

Steel containing 0.9% carbon or more together with 1% to 2% tungsten is used for hack saw blades and for reamers. broaches and other tools which must show a minimum change in dimension after heat treatment. Steels with 1% ccabon or more. and 3% to 7% tungsten, are much used for "fast-finishing" tools to cut hard metals or to make a fine smooth cut on softer tough metal. Dies for cold drawing wire and other shapes are made of higher carbon steels (2%) with tungsten ranging from 1% to 12%. Dies with the higher tungsten percentages are used for the harder metals or the finer wires. Chromium is often added to facilitate the diffusion of tungsten. When 0.5% or more is present the alloy may crack during water hardening. An oil quench, however, will harden it through to the centre. Chromium also causes the useful hardness to be retained at higher working temperatures. For working hot metal, tools mould be made of 0.3% carbon steel with 10% tungsten and $3\frac{1}{4}$% chromium (known as "semi-high-speed"). Permanent magnets for electric meters, magnetos, radio and telephone equipment absorb annually several thousand tons of steel containing 0.7% ccabon and 5% to 6% tungsten.

In tungsten-iron alloys, substantially free from carbon, tungsten has the property of lowering the temperature at which delta iron changes to gamma iron and also of raising the temperature at which gamma changes to alpha iron. Consequently, the American metallurgist W. P. Sykes was able to show that no gamma iron is formed in carbon-free alloys containing more than 7% tungsten. Such an alloy is permanently austenitic, and cannot be hardened or tempered by heat treatment. In the alloys containing more tungsten the compound Fe_3W_2 appears; its solubility decreases with the temperature, and it is precipitated throughout the metal at a slow rate. To harden such an alloy it is necessary to anneal or "age" it at a moderate temperature for several hours or days. Brinell hardness numbers indicate the extent of this action:

	Brinell
Carbon free iron	70
Carbon free solid solution alloy, 80% iron, 20% tungsten	160
Above after aging	330
Carbon free aged alloy, 78% iron, 22% molybdenum .	530

Such aged alloys of iron and tungsten and of iron and molybdenum (tungsten and molybdenum being very similar chemically) form excellent wire drawing dies, and have given 10 to 40 times the service that can be had from best high speed steel before the edge needs re-dressing. (See IRON AND STEEL; HIGH SPEED STEEL) (E. E T.)

TUNGUSES, a widespread north Asiatic people. They are the *Tung-hu* of the Chinese, probably a corrupt form of *tonki* or *donki,* that is, "men" or "people." The Russian form *Tungus,* wrongly supposed to mean "lake people," appears to occur first in the Dutch writer Massa (1612) ; but the race has been known to the Russians ever since they reached the Yenisei. The Tungus domain stretches from long. 60° E. to the Pacific ocean and from the Arctic to the Chinese frontier. The Tunguses are known to the Samoyedes by the name of *Aiya* or "younger brothers." The Oroches, Chapogir, Golds, Lamut, Manjour, Manegre and Oroke are partly in Manchuria and are Tungusic. The Tungus type is essentially Mongolic, with broad flat features, small nose, wide mouth, thin lips, small black and somewhat oblique eyes, black lank hair, dark olive or bronze complexion, low stature, averaging not more than 5 ft. 4 in. The square shape of the skull and the slim, miry, well-proportioned figure are features especially of the typical Tunguses. They are classed according to their various pursuits, as Reindeer, Horse, Dog, or Sedentary, Nomadic and Wandering Tunguses. A few have become settled agriculturists; but the great bulk of the race are still essentially forest hunters, using the reindeer both as mounts and as pack animals. Nearly all lead nomad lives in pursuit of fur-bearing animals, whose skins they barter in exchange for provisions, clothing and other necessaries of life. The national costume shows in its ornamentation and general style Japanese influence, due to intercourse at some period previous to the spread of the race to Siberia. Many of the Tungus tribes are reckoned as "Greek Christians"; but most of them are still Shamanists and nature worshippers, secretly keeping the teeth and claws of wild animals as idols or amulets, and observing Christian rites only under compulsion. Family and exogamic clan organization is relatively strong. Intercourse begins before marriage as soon as a portion of the bride price has been paid. Some practise polygamy. Exchange marriages occur. The levirate is common. A man may take his son's widow. Cousin marriage occurs and tree burial (*q.v*) is found among them.

See M. Czaplicka, *Aboriginal Siberia* (1914).

TUNICATA. Tunicates are exclusively marine animals, related to vertebrates and therefore sharing with man a common but primevally ancient lineage. They are common, cosmopolitan, frequently seen but rarely noticed since for the most part they are fixed growing organisms resembling more a potato than a fish. Yet, at some time in the career of each individual it is provided with the forerunner of a backbone, a uniquely dorsal tubular spinal cord found nowhere among invertebrate animals, and similarly distinctive gills. Of these features, equally typical of the early human embryo, only the last usually survives into the adult animal, and mature tunicate animals in general are permanently attached forms with no capacity for locomotion, using an enlarged and elaborate gill system as a means of filtering large volumes of sea water for the sake of its contained microscopic life. As the name implies, a tunic is secreted by the skin which not only helps to anchor the animal to some solid structure but gives rigidity to its outer form, and allows the delicate inner organism to suck in and filter sea water to its heart's content. Many tunicates are solitary individuals growing to the size of an orange, but like most kinds of animals that have given up freedom of movement for a sedentary life, many have become colonial forms in which the individual becomes subordinated to an organic community.

Tunicates virtually are universally distributed throughout the seas of the world, from the intertidal zones down to the deep abyss, and inasmuch as certain types have given up a fixed existence for a drifting. floating life, the vast expanses of the open ocean are also inhabited by these forms. The more primitive group. associated with the sea bottom, is known as the ascidians. or sea squirts, and may be found along or near the shore of all the seven seas, growing on seaweeds, on or under rocks, in submerged sand flats, on coral reefs. submarine cables, ship bottoms, wharfpiles, and even on the shells of elderly lobsters and sea snails. They abound from polar regions to the tropics. Some species are cosmopolitan, found from Spitsbergen to Cape Cod. Naples to Singapore, others so limited as to be known only from grottos on a Brittany beach, or the Kerguelen Islands of the southern Indian ocean.

The group has many peculiar and fascinating features. Alone among animals it secretes its coat of *tunicin,* a substance almost identical with the ever-present cellulose of the plant kingdom. It has a heart similar to that of a chick embryo a few days after the onset of incubation, but unlike the chick heart the tunicate's reverses the direction of its beat periodically. Its blood is unique. While the blood has no respiratory pigment and can carry no more oxygen than a similar amount of sea water, it is frequently rich in both sulphuric acid and the rare element *vanadium*, substances more associated with the production of steel than body fluids. Not only are individuals hermaphrodite, that is, possess both ovaries and testes, but in many cases the same final organism can be produced either by a fertilized egg or by the growth and reconstruction of a fragment of adult tissue. Lastly, as the name of one genus, *Pyrosoma* or firebody, implies, some are brightly luminous at night, *Pyrosoma* appearing as a glowing candle-shaped body drifting through the surface waters of warm oceans.

The great French anatomist, Georges Leopold Cuvier, at the beginning of the 19th century placed ascidians with his "headless molluscs" the bivalves, and the class was named and defined by the evolutionist Jean Baptiste Lamarck in 1816, although the chorddte nature and therefore the relationship with vertebrate animals was not recognized until many years later. Only after Charles Darwin's great theses on evolution had been published and become widely known, was it discovered that the sedentary sea squirts produced eggs that developed not directly into miniature sea squirts, but into tiny tadpoles of the same basic organization as the tadpole of the frog.

Life Cycle.—Ascidians are hermaphrodite animals, each individual producing both eggs and sperm, in many cases being able to fertilize their own eggs, in others unable to do so and cross-fertilization is obligatory. Most solitary ascidians produce small eggs in large numbers, each being surrounded by buoyant follicle cells which enable it to float away in the currents while development proceeds. The early developmental patterns, while on a small scale and also condensed in time, resemble closely those of primitive vertebrates and are unlike those of any invertebrate animals. This development leads directly to the formation of a minute swimming tadpole. In the case of these widely disseminated eggs the tadpoles are quickly formed—long before they are capable of feeding. They are equipped for swimming to the sea surface, at least for a few critical hours. Each possesses a tail for swimming consisting of a central supporting rod of cells, the notochord, which all vertebrates, including man, possess at some stage in their individual development as the immediate precursor of a vertebral column. In the case of ascidians, however, the development stops there. On either side of the notochord is a band of muscle fibres equivalent to the locomotory muscles of a fish, while a narrow tubular spinal cord overlies the notochord throughout its length. These features and their combined organization are distinctive of all vertebrate and chordate animals and definitely link ascidians and other tunicates with the main evolutionary line leading eventually to man himself, in spite of the obscure and bizarre appearance of the adult forms.

In the tadpole, the nerve tube expands in front as a small brain vesicle typically containing two sense organs. These enable the tadpole to orientate and swim towards the source of light, the sea surface, and away from the centre of gravity, away from the sea bottom. They represent an eye and an organ of balance in their simplest form.

The existence of such a tadpole ensures a wide dispersion of the species, compensating for the immobility of the adult. This purpose is served, however, after a few hours, and then degenera-

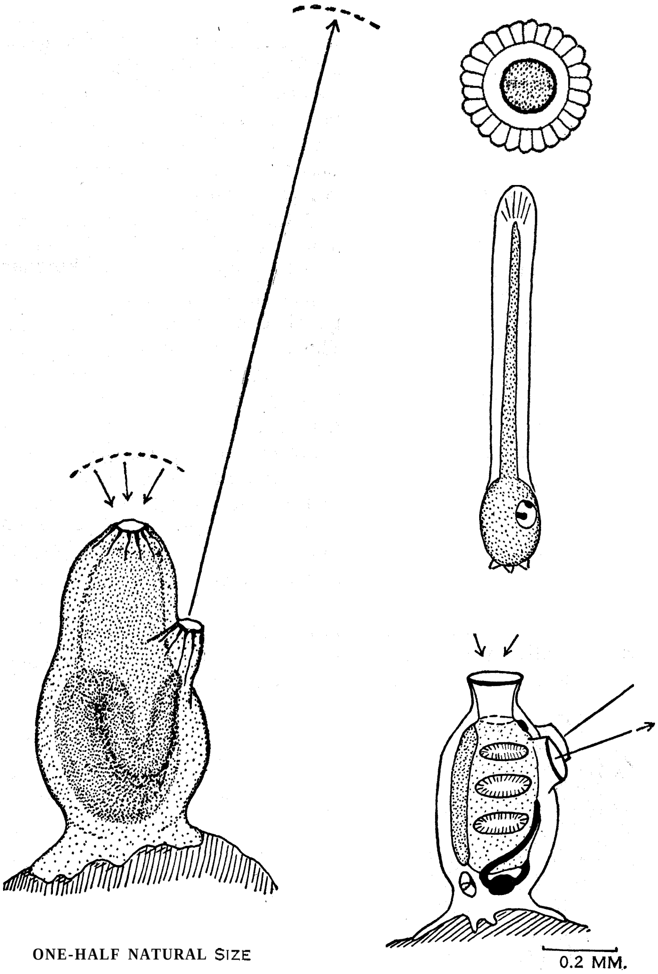

FIG. 1.—THE LIFE HISTORY OF AN ASCIDIAN

At the left an adult solitary ascidian of the genus Ascidia attached to a rock. The gill chamber and looped intestine show through the translucent protective tunic. The solid arrows indicate the direction and extent of the ingoing and outgoing water currents. At the right is the egg with its outer layer of buoyant flotation cells, the tadpole that develops from it with swimming tail, orienting sensory apparatus, and three adhesive papillae; and, beneath, the organism following the metamorphosis of the tadpole, namely, a young ascidian with three pairs of gill siits, intestinal loop and heart below, and brain lying between the siphons

tive changes commence in the tadpole organization. It sinks toward the sea bottom, the tail becomes immobile, and the tadpole becomes attached by three adhesive structures on its nose to any solid structure sufficiently clear of soft mud. With the tadpole anchored, the tail absorbing somewhat as in the case of the frog, development continues through this period of metamorphosis to form the first stage capable of feeding. This consists of a small barrel-shaped animal attached by what was originally its chin region, with a large funnel-like mouth facing upwards and allowing water to flow into a capacious pharynx or throat. This bears gill slits on each side through which the water passes into a surrounding chamber opening externally by another funnel. These funnels are called siphons, inhalent siphon and exhalent siphon respectively, and are characteristic of tunicates in general.

In essentials the adult ascidian differs from the newly attached feeding individual in little more than increased size and the acquisition of sex glands. The existence of tno such different types of organism as the ascidian tadpole and the ascidian adult has afforded the basis of much argument. Either the tadpole is a relic of a more aristocratic chordate ancestry and the adult represents a degenerate sacrifice of motility, or the attached adult is the more primitive type and the tadpole the newcomer. The first of these interpretations was the first to be adopted and is the orthodox view, the other is more recent and in many ways more plausible, but its implications concerning the origin of vertebrates are startling.

The typical ascidian is essentially a large sac corresponding to the throat region of a fish, into which leads the large inhalent siphon or mouth opening. The water taken in is strained through innumerable gill slits on each side of the sac, escaping into an external chamber leading to the exterior by way of the exhalent or atrial siphon. The remainder of the digestive canal is narrow and leads from the lower end of the gill chamber. It consists of an oesophagus, a simple stomach, and an intestine looped up to open close to the outlet of the exhalent siphon. In its loop the hermaphrodite sex gland is usually to be found. Close to the loop is a simple heart. A solid nerve mass, or "brain" lies between the two siphons, with nerves extending to each.

The reactions of the animal are practically limited to a swift closing of the siphons. At the base of the inhalent siphon a ring of tentacles prevents the passage of any particles too big to be managed, contact with the grid of tentacles producing the contraction reflex, and such a particle is rejected. Otherwise reactions are limited to mild responses to light stimulation.

Feeding Mechanism and Other Systems.—The mechanism for obtaining food is remarkable, both for its elaborate efficiency and for its ultimate evolutionary fate. The feeding mechanism consists essentially of two components, the production of mucus for the entanglement of food particles. and the production of a water current bringing in those particles. The water current streaming in through the inhalent siphon is produced by the outward-beating cilia (protoplasmic hairs) lining the numerous gill slits in the wall of the pharynx. On passing through these minute slits the water converges in the surrounding atrial cavity toward the exhalent siphon. It shoots out through this opening to a considerable distance, so that the water exhaled is not drawn in again

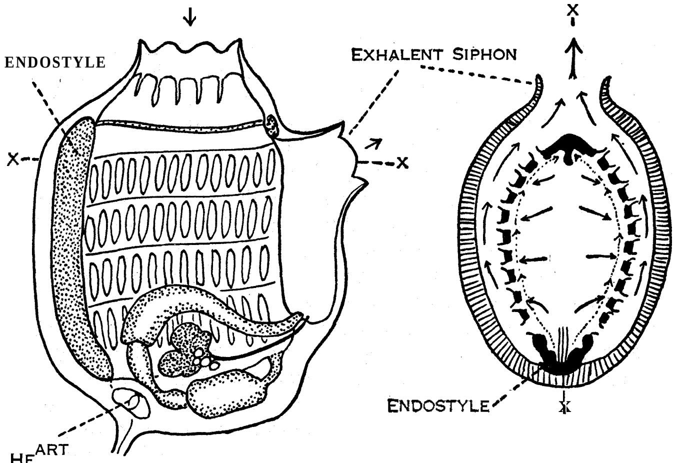

FIG. 2.—STRUCTURE AND FEEDING MECHANISM OF AN ASCIDIAN (GENUS PEROPHORA)

Solid arrows show direction of water currents, dotted arrows the direction of mucus transfer. Diagram at right represents a horizontal section at the level x —— x of the individual shown at the left. Water flows in through the mouth past tentacles into the gill chamber and flows out through four rows of gill slits in each wall into the surrounding protective outer chamber, finally to the exterior by the exhalent siphon. Food particles are trapped by mucus, secreted by a deeply-grooved band (the endostyle, the forerunner of the thyroid gland of man), which passes up the inner walls of the gill chamber. The particles are passed into and digested by the looped intestine lying at the base of the gill sac. The combined reproductive gland, ovary and testes, lies within the loop formed by the intestine

through the mouth. The water entering the gill chamber contains small living plant and animal organisms suitable for food. These are trapped by the endostylar mechanism. The mechanism consists of a mid-ventral groove, the endostyle, extending the whole length of the gill chamber, and a band of similar tissue extending around the anterior end immediately behind the anterior ring of tentacles. The groove and band consist of glandular tissue secreting mucus or slime in strands into the main cavity. Food particles encountering the strands are entangled and the cords of slime and organisms are wafted toward the upper side of the chamber. Along the mid-dorsal line the cords are rolled into a single cord with the aid of the dorsal membrane, and the cord passes back to the oesophagus. Passing through the oesophagus the cord reaches the stomach, is mixed with digestive enzymes and travels slowly through the looped intestine until the indigestible remnant emerges near the base of the exhalent siphon. Here the strong outgoing current carries away the faecal matter to a safe distance.

The food collecting apparatus as just described may become more elaborate in some, simplified in other forms of tunicates, but basically the system is the same in all. The same system is well developed in another chordate, *Amphioxus,* and even more significantly in the young of the lamprey, a true vertebrate. The adult lamprey, however, feeds in an entirely different manner and the greater part of the endostylar apparatus degenerates when the lamprey is about 6 in. long, except for the middle region of the endostylar groove itself, which emerges as the thyroid gland, the metabolic governor of all later vertebrates.

The blood and its circulation is of interest for several reasons. The pattern of blood vessels foreshadows that of the fishes. A large vessel passes from the heart forward beneath the endostyle, lateral vessels leave this and pass up the sides of the gill chamber to meet above in another longitudinal vessel. The heart itself is a tube folded lengthways within itself and has the unique property of periodically reversing the direction of its beat. After waves of contraction pass along it in one direction about 50 or 60 times, it slows to a stop and a new set of contractions begins, starting from the opposite end. The reversal is independent of any external nervous control. The blood is free to circulate in either direction owing to the absence of any valves limiting direction as they do in all vertebrates.

The blood itself is also peculiar. It transports no more oxygen than an equivalent amount of pure sea water and contains even less carbon dioxide. No respiratory pigment is present or necessary owing to the relatively enormous surfaces exposed to flowing water. At the same time pigmented cells are usually present in the circulating fluid and contain oxides of vanadium and free sulphuric acid. In certain solitary ascidians vanadium oxides may amount to as much as 15% dry weight of the blood, in spite of the fact that vanadium can barely be detected in sea water even by the most modern methods. How it is extracted by the animal and what part it plays in the activities of the organism are unknown. The sulphuric acid is also puzzling. Its presence is apparently associated—and probably its function as well—with that of vanadium. Apart from this it is difficult to understand how cells can tolerate within themselves a strong acid in a concentration sufficient to kill animal tissues in general.

Excretion of waste materials, especially the breakdown products of protoplasm itself, is managed in strange ways. Urates are deposited as solid concretions in sacs isolated within the body either single and large, or small and numerous, as permanent depositories. Other waste substances are eliminated at the external surface of the tunic. The tunic itself consists of tunicin, a substance closely allied with cellulose and secreted by cells characteristic of the middle body layer that have actually migrated through the outer skin to form a connective tissue in a most unusual place.

A tunicate could not be itself if it were not ambiguous. To complete the picture, there is a duct which passes from a glandular mass situated beneath the brain and opens by a ciliated funnel at the front and dorsal corner of the gill chamber. The structure of this apparatus and the nature of the cellular material passed down the duct to mix with the incoming water current indicate clearly that it is the homologue of the pituitary gland of vertebrates, the master gland of the body governing the endocrine glandular system as a whole. What the function is in the tunicates nobody knows.

Reproduction.—Tunicates have evolved in various directions not only as mature adult organisms but also in two other ways. The tadpole larvae vary remarkably in detail, while the faculty of reproducing nonsexually by the production of buds of various kinds has been evolved in some forms to a remarkable extent. The more elaborate types of tadpoles are relatively large with a relatively complex nervous system, beating heart and complex gill chamber almost ready for active life. In spite of such complexity, however, these tadooles may have a free-swimming life of oniy a few minutes, being designed primarily for the selection of limited and specialized habitats upon which to settle, in the immediate neighbourhood of their parents. They are also associated with viviparous forms, that is, the eggs are retained in the atrial chamber or in some special brood pouch and develop there safely at least until the tadpole stage is reached. Wide dispersion of the species by the usual means of oceanic currents is sacrificed to a maintenance of the population in local territory together with the selection of a specialized niche. The brevity of free-swimming existence not only limits the extent of distribution but greatly reduces the chances of any particular tadpole being eaten. In other words a relatively small number of large eggs are given a high degree of protection in several ways that ensure their survival to a comparatively advanced stage. This is in contrast to disseminating large numbers of small eggs to develop unprotected over a protracted period in the currents of the sea.

Viviparity, generally speaking, is usually associated with types able to reproduce also by budding. The plantlike method of reproduction, asexual reproduction or gemmation, is characteristic of many ascidians and has apparently arisen within the sea squirts on at least three separate occasions. It is a reproductive method very usual among nonmotile animals. If the tunicates as a whole are included, a fourth case of independently evolved budding should be added.

Budding is essentially a separating off, either physically or physiologically of a fragment of a mature or of a developing individual itself. The processes involved are essentially those in-

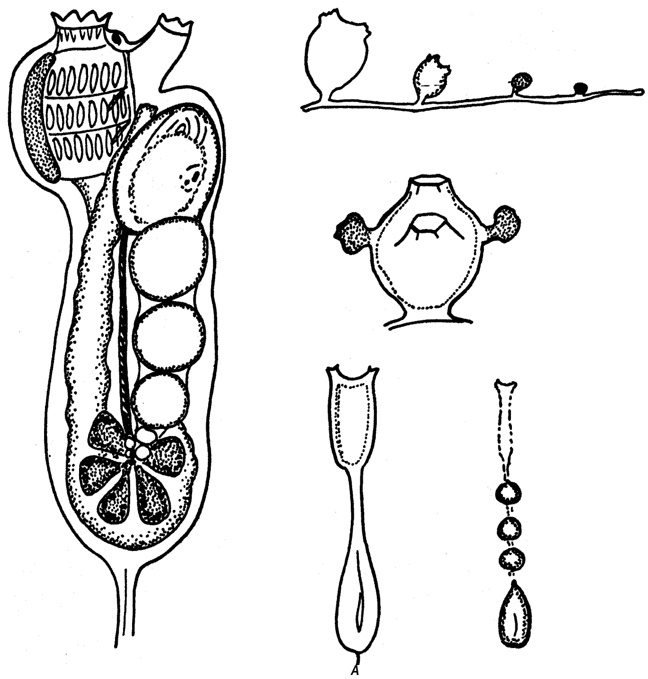

FIG. 3.—**VIVIPARITY** AND **BUD** FORMATION

Left: an individual (genus *Eudistoma*) with its intestinal loop extended posteriorly from the gill chamber shown with its ovary and testes still in the bend of the intestine, although the eggs are shown developing to the tadpole stage within the expanded oviduct. Upper right: buds are shown developing from a creeping stolon (Perophora), at the middle right buds develop from the lateral body wall of the parent (*Botryllus*), and at the lower right are two individuals (*Diazona*), one in functional form and one transformed into a string of living beads, each one of which is destined to form a new individual

volved in the regeneration of missing parts, a capacity tunicates have to a very marked degree. The nature of budding varies considerably among the different orders of tunicates, but in virtually every case it is due to some form of constriction by the epidermis which divides the contained tissues into separate masses, the nature of the whole isolated mass depending on the nature and part of the particular tunicate involved. The process is usually associated with the presence of reserve food storing cells known as trophocytes. These are produced in large numbers especially in those forms that undergo a winter regression. The main growing season naturally coincides with the spring and summer when the microscopic food organisms are abundant in the sea. In the early winter the food supply dwindles and many ascidians degenerate. In such as these the disintegrating tissues are absorbed by wandering reserve cells which subsequently migrate toward the base of the individual. There the epidermal constrictions divide the congested contained mass of reserve tissue into small masses or buds capable of surviving the winter and developing into new individuals in the spring. This type of budding leads to the formation of the group known rather loosely as the social ascidians, where many individuals of a common egg parentage are closely clustered together and may even become imbedded in the same glutinous external tunic. In others the buds may remain partly attached to the parent and either in connection with their parents or with other individuals of their own bud generation develop community systems of blood vessels and exhalent siphons. These are true animal colonies in which the individuals are actually subordinated to the activity of the whole.

Tunicates can be large and solitary, or small and aggregate or colonial; that is, growth can be expressed in either of these two ways but not both ways at the same time. It is the small individuals of the social and colonial forms that have departed from the production of large numbers of widely disseminated small eggs, and have evolved to a high degree the practice of viviparity or bearing their young alive.

Viviparity in ascidians is apparently easily attained and there is no doubt that among them it has been acquired independently on many occasions. All openings of the body proper, namely gill slits, anus, oviduct and sperm duct, open not directly to the exterior but into the atrial cavity, reaching the outside finally by way of the exhalent siphon. In egg-laying forms the reproductive ducts together with the intestine reach almost to the base of the exhalent siphon, and the outgoing stream of water carries all the products immediately away from the body. Accordingly all that is necessary for the retention of the eggs is a shortening of the oviduct so that they remain in the lower part of the atrial cavity, bathed by the water flowing through the gill slits. Increase in individual egg size ensures that under these circumstances the eggs will not be carried away by the water current, while the fact that the animals are hermaphrodite ensures fertilization and subsequent development of the retained eggs. When the tadpole stage is reached they swim away. This description applies to the majority of viviparous ascidians, but some are more specialized, such as *Distaplia,* and fertilized eggs are actually retained within the oviduct, which may bulge out from the side of the body as a distinct brood pouch. While in *Botrylloides* the egg is fertilized actually within the ovary, the tadpole escaping finally by bursting through the body wall.

While in many cases the presence of budding is little more than a process of reproduction, that is, increasing the number of individuals in a local population, in others there is a considerable degree of organic continuity and co-operation so that a superorganism is formed and the individuals are subordinated to it. The secretion of the external collagenous tunic plays an important part in this phenomena. The outer epidermis of different individuals remains distinct as in other forms of animal life, but the tunic secreted by adjacent individuals, if close enough together fuses into a compact whole. Budding therefore is always likely to result in numerous individuals becoming imbedded in a common mass of tunic material. This is the basis for a true colonial system. Individuals arrange themselves into systems or groups with, for example, all exhalent siphons converging toward a common centre to unite in forming a cloacal chamber and outlet. This condition frequently occurs. In a few types, as in *Botryllus* or *Symplegma,* buds remain in functional continuity with the circulatory system of the parents so that a colonial circulatory blood system is formed. Such a circulatory system within a mass of tunic survives though individuals associated with it may come and go as they each live through their individual cycles.

Selection of Habitat. — The form of solitary and colonial ascidians is closely adapted to the various types of possible habitats, or, to put it conversely the various special marine habitats are populated by ascidians that are able to survive in and exploit such niches.

Solitary ascidians are generally relatively large as individuals, with all three spatial dimensions well represented. They need plenty of room. They are to be found chiefly either attached to the surfaces of rocks, piles or ship bottoms, or imbedded in submerged sand or mud flats. Attachment is made by the grouing external coat of tunicin, aith its contained vascular processes. In quiet, more or less protected waters, such as harbours, estuaries, or relatively deep water, attachment is usually by the posterior end with the siphons reaching out into the water, as for example, *Ciona intestinalis,* the most cosmopolitan example of them all. Where there is considerable wave action, attachment is usually by the whole of one side. Some species are of but one habit or the other and are consequently limited in their range, while others, of which *Ciona* is as good an example as any, vary their attachment according to circumstances and occur in a diversity of habitats. In two families of ascidians, however, species have forsaken an attached abode for the sifting sand, mud, or shell gravel of the sea floor of the continental shelf. These are molgulids and polycarps, and in order to maintain their anchorage in such an unstable environment, they are large, more or less spherical, and have innumerable hairlike extensions of the tunic to which sand grains or shell particles adhere, the whole being submerged in the sand except for the emergent siphons. Sand or shell particles adhere also to the siphons and the animals are in consequence perfectly camouflaged. At certain depths of the continental shelf and coastal inlets extensive beds of mud, sand, or shell gravel of suitable consistency occur and these large and more or less globular species of the genera *Polycarpa* and *Molgula* are found in enormous numbers. The sea bottom habitat and its great extent has apparently made it less desirable to send tadpoles wriggling to the surface of the sea, and in these genera the tadpoles have independently allowed their eye to degenerate, being responsive only to the force of gravity, while in many species of sand-living molgulae, not only the eye of the tadpole, but its gravitational organ, the otolith, and the tail itself are lost. The effect is that large numbers of developing eggs are scattered over the sea floor nhere there is abundant room.

Budding or compound ascidians on the other hand are conspicuously unable to survive in such places, and for the most part are attached to relatively flat surfaces over which a good but not violent supply of clean water is assured.

Reproduction by budding, while leading to the formation of a colony unit rather than many separate individuals, has naturally an effect on the size of the individuals. An individual ascidian can either remain solitary and grow to a large size, or its growth is expressed in the formation of numerous individuals which repeat the budding process, thus increasing in number but hardly at all in individual size. If the process of budding is not too highly developed the individuals of a colony may be of a moderate size and number, and usually separate from though in contact with one another. These are often grouped together as the "social" ascidians to distinguish them from the "compound" forms that are more truly colonial. This grouping is not a natural one and brings together such distantly related types as *Clavelina* and *Stolonica,* genera which belong to different orders of ascidians. The individuals being, however, of fair size need a corresponding amount of space, and in general this group is found attached to protected submerged rock ledges, to the anchoring processes of large laminarian seaweeds, or to the surface of corals and sea fans.

Where budding is more active, the individual size is reduced and the numbers increased, tending to create a virtually two-dimensional colony. Colonies such as these are often large in area though of little thickness, with relatively minute constituent individuals. Together with bryozoans and certain sponges they tend to form an encrusting film over the underside of rocks, coral crevasses, stalks and fronds of seaweeds, and solitary ascidians, for the most part in the highly diversified environment of coastal waters, lagoons, mangrove swamps, rocky shores, estuaries and the intertidal zone itself. As long as the water flows freely bringing life-sustaining oxygen and microscopic food organisms this type of ascidian colony in general occupies a two-dimensional world of highly specialized niches. In relation to this and to the small size of the composing individuals, such organisms produce a comparatively elaborate form of tadpole larvae. The small hulk of a colony and particularly of an individual results in a correspondingly reduced capacity to produce eggs. When egg numbers are reduced below a critical value it becomes increasingly important to ensure the survival of an adequate number of those that can be produced. If large numbers cannot be produced it is better to produce a very few with a great chance of surviving to maturity than a moderate number with little chance. In any case the compound ascidians characteristically form a very small number of relatively large eggs that 'develop to the tadpole stage within the protection of the parental atrium or oviduct. Once liberated the best chances of the tadpoles of survival is attachment to surfaces similar to that of the parent and therefore in the near neighbourhood. Again in any case the tadpoles are not only good swimmers because of their relatively large size, but are also better equipped with sensory and hold-fast mechanisms so that some selection of a particular type of abode is possible; limiting their range to local territory, the length of the free-swimming period is reduced from the more primitive duration of one or several days to a mere few minutes. This form of adaptation has taken place in a number of unrelated families of ascidians independently, for example, *Botryllus, Perophora, Amaroucium, Clavelina* and *Didemnum.*

Colonial ascidians in particular are frequently brightly coloured with yellow, brown, red, green, and even blue pigments, while in some the constituent individuals become grouped in small star-shaped systems. *(Botryllus),* ladderlike rows *(Botrylloides)* or rosettes (*Polyclinum*).

CLASSIFICATION

The ascidians are but one of three orders of tunicates, the remaining two being oceanic orders.

Ascidians have been classified in various ways, but primarily with regard to the position and nature of the reproductive glands, and according to the nature of the branchial or gill structure. If the primitive type is considered to be relatively small with a moderately elaborate gill apparatus and an intestine looped beneath it and up one side toward the exhalent siphon, diversification within the order has been mainly in two directions. The intestinal loop may remain in this position while the branchial region is elaborated, or the branchial region may remain simple, but the intestinal loop together with the heart and reproductive glands descend down the attachment stalk.

Edmond Perrier divided the ascidians into Enterogona and Pleurogona, the Enterogona having the gonads or reproductive glands situated either within the intestinal loop or extending posteriorly from it, but in any case only a single unit of ovary and testis being present; the Pleurogona having gonads on each side of the body and extending into the outer wall of the atrial cavity. The division according to branchial structure was made by Fernando Lahille and later by Oswald Seeliger into three suborders, the Phlebobranchia with accessory longitudinal blood vessels internal to the branchial mall, the Haplobranchia without such vessels, the two suborders corresponding to the Enterogona; and the Stolidobranchia, corresponding to the Pleurogona, with internal longitudinai bars, in place of tubular vessels, the branchial wall usually being thrown into a series of folds.

The following is a synopsis of the group.

Class TUNICATA

Order I. ASCIDIACEA. Attached forms with dorsal exhalent siphon; branchial region (pharynx) with transverse rows of ciliated gill slits.

Section Enterogona. Gonads on one side only, either within loop of intestine or projecting beyond it posteriorly.

Suborder 1. PHLEBOBRANCHIA (DICTYOBRANCHIA). With internal longitudinal tubular vessels. Families: Cionidae, Perophoridae, Ascididae, Corellidae, Diazonidae.

Suborder 2. HAPLOBRANCHIA (KRIKOBRANCHIA). No internal longitudinal vessels or bars. Intestinal loop always extends posteriorly into stalk. Families: Clavelinidae, Polyclinidae, Didemnidae.

Section Pleurogona. Gonads usually paired, and in atrial wall.

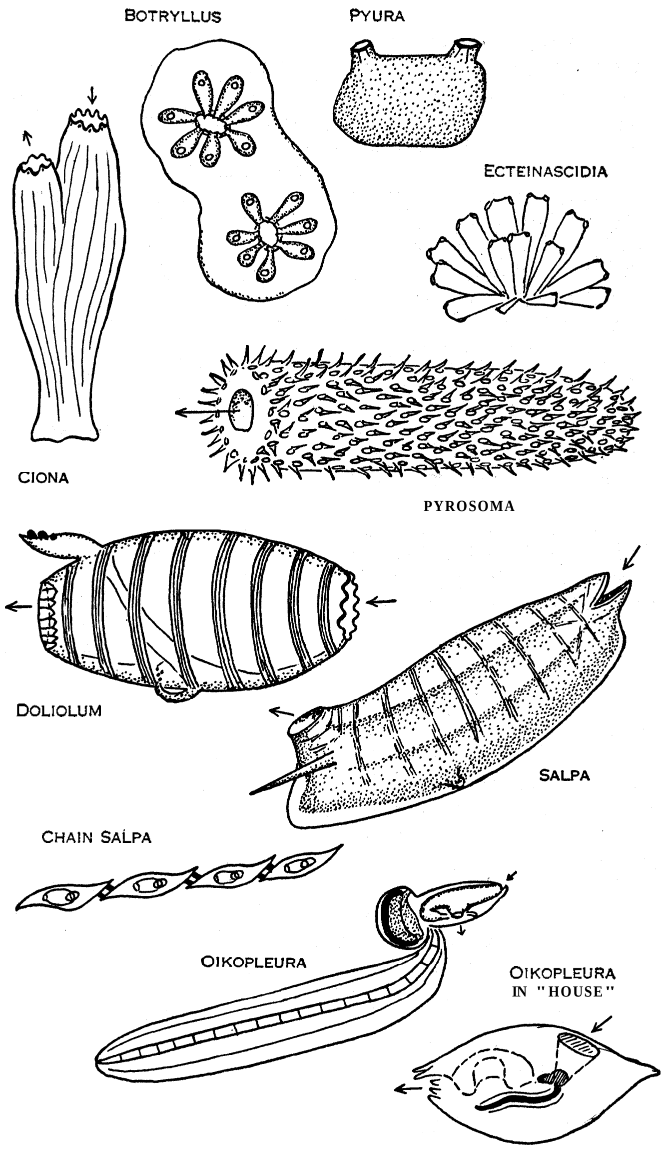

FIG. 4.— TUNICATES

Examples representing the classes Ascidiacea (all attached forms — the solitary Ciona and Pyura, and compound Botryllus and *Ecteinascidia),* Thaliacea (floating oceanic forms — the colonial Pyrosoma, both solitary and chain forms of Salpa, and *Doliolum* with buds forming on its dorsal spur), and Copelata (permanent tadpolelike forms — Oikopleura, with and without its temporary feeding "house"). Arrows show direction of ingoing and outgoing water currents

Suborder 3. STOLIDOBRANCHIA (PTYCHOBRANCHIA). With internal longitudinal bars and wall of pharynx folded longitudinally to create greater filtration surface. Families: Pyuridae, Molgulidae, Styelidae, Botryllidae.

In addition to the order Ascidiacea, the tunicates comprise two others, the order Thaliacea and the order Copelata. These are unattached forms inhabiting the oceanic currents, delicate transparent organisms not often seen but occurring in great numbers. The first of these is divided into three suborders, all members of which reproduce by budding to form colonies at some period of their life. The Copelata never bud and are permanently tadpole-like.

Order II. THALIACEA. Oceanic (pelagic), with inhalent and exhalent siphons at opposite ends of body; with long simple gill slits instead of rows of small gill slits.

Suborder 1. PYROSOMATA. Colonies form hollow floating tubes open at one end only, individuals being imbedded in the wall of the tube with their inhalent siphons extending from the outer surface and their exhalent siphons opening into the hollow interior of the colony. Eggs large, no tadpole larva being found. Family: Pyrosomatidae.

Suborder 2. DOLIOLIDA. Primary individual nonsexual, reproducing by budding. Budded individuals become sexually mature. Recognizable tadpole stage formed, but is temporary. Families: Doliolidae, Doliopsidae.

Suborder 3. SALPIDA. Primary individuals nonsexual, reproducing by budding. Buds form a long chain, sometimes in form of wheel, and function before being liberated. Eggs attached to parent and tadpole stage absent. Families: Salpidae, Cyclosalpidae.

Order III. COPELATA. Small oceanic forms with permanent tail; internal structures simplified; peculiar tunic house formed in relation to feeding mechanism. Families: Appendiculariclae, Fritillaridae, Kowalevskidae.

Both the Thaliacea and Copelata show adaptation to a pelagic existence in the upper layers of the ocean. *Pyrosoma* is the least modified and is essentially an unattached, floating colony, and is highly luminous. It glides slowly through the water by means of the water currents passed by each constituent individual into the hollow interior of the colony. The accumulating water escapes through the open end of the tube and the colony moves slowly in the opposite direction by a weak form of jet propulsion.

The Salps and Doliolids have given up producing water currents through their interior by means of ciliary activity and have substituted muscle contraction. Bands of muscle more or less encircle the body of an individual and their contractions force water through the barrel-shaped organism, thereby drawing the animal through the water.

The Copelata on the other hand retain the tadpole tail as the organ of locomotion. At times the action of the tail causes the animal to swim through the water, but most of the time there is present an external "house" of tunicin—secreted by the epidermis—which floats or drifts along, and the activity of the tail causes water to flow through it and from which microscopic food organisms can be filtered.

The relationship of the tunicates to chordate animals as a whole, and therefore to vertebrates and finally man, has been the subject of much speculation ever since the existence of a chordate tadpole mas first discovered. The first and Haeckelian interpretation was that the tadpole represented a relic of an ancient descent from an early vertebrate animal. the adult tunicate being in a sense highly degenerate, the tadpole being retained in the course of the development of the egg in conformation with the theory of recapitulation or biogenetic law. This view was universally held until the 1920s, and was relatively comfortable, for it accounted vaguely for the existence of the tunicates themselves as a byproduct and at the same time threw no slanderous aspersions on the origin of the chordate-vertebrate group of animals as forms which from the beginning swam in the light of the sun near the ocean surface, never descending for an apprenticeship on the plebian sea floor. Such a habit was supposed to account for the uniquely dorsal position of the nerve cord in vertebrates in contrast to the ventrally placed cord of belly-crawling invertebrates.

An alternative interpretation, however, appears to fit the facts better, a view first presented strongly and plausibly by Walter Garstang in 1928. This considers the attached ascidians to be of primitive habitat. Not present-day ascidians, but their ancestors of very ancient times, probably more than 1,000,000,000 years ago in the upper pre-Cambrian era, are thought to have been relatively small simple forms attached to the sea floor. There they evolved a dorsal nerve mass for controlling the siphons; gill slits evolved for the escape of the food-bearing current, and a ventral heart to pump the blood. Their eggs developed at first into simple larvae swimming by means of cilia like the larvae of most primitive marine groups. From this originally simple larva the ascidian tadpole gradually evolved.

No direct evidence can ever be obtained concerning the evolution of the tiny delicate organisms of pre-Cambrian times, but circumstantial evidence abounds and strongly supports this later theory concerning the origin of tunicates. If valid, then not only are the thaliacean tunicates colonial forms that have abandoned a sessile for a pelagic life, but the Copelata, which at one time were thought to be the most primitive of tunicates. are considered to be descendants of the Thaliacea and in no way primitive forms.

If the tunicates were merely an isolated group of animals with no self-important relatives, the more plausible of tno theories would be readily and more or less indifferently accepted. But somewhere near the level of tunicate organism are the remote beginnings of human evolution itself and the last theory directs the line of descent into and through the group instead of making a detour around into the great unknown. In effect, the great group of vertebrate animals would have their origin in the enterprising young of a group of tiny water filterers cemented posteriorly to the sea floor.

This is not implausible. Evolution does occur in relation to any stage in the life cycle of' an animal, and larval types are known to have become the sexually mature adults. Tadpole-like larvae could have evolved from simpler larvae within the tunicate group, and such larvae could have suppressed their metamorphosis into an old-fashioned tunicate, and continued to grow into a sexually mature swimming chordate organism from which the vertebrates eventually evolved.

It could have happened and such evidence as can be culled from living forms suggests that it did.

In other words, we can trace the dorsal position of our brain and spinal cord to the upward reaching siphons of a primitive attached tunicate, our heart and basic pattern of blood vessels to that of the same organism, our ear passage to a respiratory gill slit of an early shark and in turn to a water-escape passage of the sessile ascidian, our pituitary gland (the master gland of our endocrine system) to the subneural gland and hypophysial tube of the same form, while our tubular spinal cord and brain, our backbone and trunk muscles derive from the tail of the swimming larva the ascidian evolved and managed to make permanent.

Since the time primeval events such as these took place, the tunicates have had just as much time as all other surviving groups have had to become specialized in various ways, in their case to elaborate the gill-filtration system, budding and colony formation, etc., and there is no suggestion that in tunicates as they now exist we recognize our contemporary ancestors.

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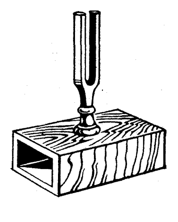
(N. J. B.)

TUNING FORK, a two-pronged instrument of high-grade steel, which by the vibration of its prongs gives out a single pure musical tone of constant pitch. The pitch depends upon the natural period of vibration of the prongs, that is, upon their length and thickness.



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THE TUNING FORK, INVENTED IN 1711

Tuning forks may be made for all musical pitches in the audible range, and the fork which gives the A above middle C is usually taken as the musical standard. For laboratory purposes the forks may be mounted upon hollow boxes to increase the volume of sound by resonance. They may be set in momentary vibration by a light blow, or kept in constant vibration by the action of an intermittently energized electromagnet upon one of their prongs. The tuning fork was invented by John Shore in 1711. (See PITCH, MUSICAL.)

TUNIS, capital of Tunisia, in lat. 36° 48' N. and long. 10° 12' E., is situated on an isthmus separating two salt lakes, the marshy Sebkha-el-Sejumi and the Bahira (Lake of Tunis), the west bank of which it occupies. Tunis stands, as Carthage did, on the threshold of the western bay of the Mediterranean, at the natural outlet of the western bay of the Tunisian Tell and in easy communication with the south. But its topographical situation differs profoundly from that of the ancient town. Built at the end of the shallow Bahira, it uses an intermediate town, Goletta (*q.v.*) or La Goulette, for a part of its sea trade. In 1893 a sea channel, 6 mi. long and 7.5 m. deep was cut through the Rahira to connect Goletta with the city of Tunis making the capital a seaport.

Tunis consists of two towns side by side. The old native town lies between the Bir Kassa and the Ras Tabia hills, on a slope down to the Bahira; the new town developed on the flat, low-lying ground between old Tunis and the lake. European Tunis is built on a regular, somewhat monotonous plan; the blocks of houses are bordered by rectilinear avenues, some of which are planted with trees. On one avenue, nearly a mile long, laid out from east to west, stand the ministries! surrounded by gardens, the cathedral, the casino-theatre, the banks and the principal hotels and cafés. It is the centre of the city's life.

The old town includes three distinct parts. The Medina, or central city, which represents the primitive settlement) several gates of which are still standing; the suburb of Bab-el-Suika on the north, where the Jews live; and that of Bab-el-Jezira on the south. The Jamaa-ez-Zituna, or mosque of the Olive Tree, is the seat of an important Moslem university, founded in 732 by the Omayyad governor Obeid-Allah and reconstructed by the Aghlabites (9th century); most of its buildings date from the 13th to the 1 jth centuries.

Behind the Zituna are the *suks,* which are the most interesting feature of the native town. They are composed of little shops opening on to narrow, tortuous streets, covered by arches or roofs of planks, where only foot passengers can go. Each kind of trade, each group of craftsmen, has its special quarter. Tunis possesses many mosques, notably those of the Kasba (13th century) and Sidi-Mahrez (17th century).

Tunis and Goletta together form the major port of Tunisia. Tunis is the centre of a rich farming region. Its industrial products include beer, soft drinks and syrups, chocolate, canned vegetables and fruits, tobacco, leather, textiles and chemicals; the manufacture of carpets is an old-established craft. The industrial suburbs lie to the southeast.

The population of Tunis and its suburbs, 410,000 (1956 census), included 119,500 Europeans and 32.000 Jews.

Southeast of the city, along the valley of the Melain, are magnificent remains of the Roman aqueduct from Jebel-ez-Zaghuan to Carthage. Carthage is on the coast to the north.

Tunis existed in the Carthaginian epoch, but its importance dates only from the Moslem conquest. It became the capital city toward the end of the 9th century, under the Aghlabites, and reached its greatest prosperity in the Hafsid period, when it is said to have surpassed Cairo. Charles V took possession of it in 153j; the Spaniards were driven out in 1569, retook it in 1573, but ceded it to the Turks in 1574. Thereafter the history of Tunis merged with that of Tunisia (*q.v.*).

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TUNISIA (Arabic AFRIKIYA), an independent republic (until July 1957 a beylicat, or kingdom) in north Africa bounded on the west by Algeria, on the north and east by the Mediterranean, on the southeast by Libya. The country, halfway between the Straits of Gibraltar and the Suez canal, forms, with Sicily, the barrier between the eastern and western Mediterranean. This situation and the possession of nearly 900 mi. of coast line gives economic and political importance to Tunisia.

PHYSICAL FEATURES

The mountains are formed of Secondary and early Tertiary rocks, while later Tertiary and Quaternary rocks cover the plains. The folds are Miocene in the main, as in the Atlas, but movement continued long after that period. There are numerous short discontinuous chains of varying orientation and a number of small circular or elliptical domes.

North of the concatenation of the Dorsal mountain ranges, which lies across the country from Tebessa to Ras Addar (Cap Bon), the chains of the Tell tend from southwest to northeast. Farther north rise the wooded sandstone mountains of the Khmir or Kroumirie (Fr. "Kroumir") country (3,000 ft.) and the Mogods, where the coast is hroken and wild. Next. standing round the alluvial plains of the middle and lower Mejerda (Medjerda) and of Bizerta and Tunis itself, there are mountains and hills of chalk and marl used for pasturage or cultivation. Relief is heightened in the High Tell, betneen Kef and Tebursuk (Titbomsouk), and in the Dorsal mountains (Chambi or Shambi, 5,065 ft.); but between the massifs there are wide depressions, varying in elevation from 1,300 to 2,600 ft., which are under crops.

South of the Dorsal, in the steppes, the barren mountain chains are not so high and tend southwest-northeast, west-east (Gafsa) and south-north; they are also further apart, with wide alfa-covered spaces between them. To the east the plains of the lower steppe. with Qairwan (Kairouan) and Sfax, are watered in the north by the aadis Marguellil and Zerud (Zeroud) but are characterized elsewhere by closed depressions nith sebkhas (salt lakes).

Finally, to the south of Gafsa, the Sahara begins with the clayey depression of the *shats* (Fr. "chotts") Gharsa, Jerid (Djerid) and Fejej (Fedjedj), the dunes of the eastern Erg and the plateau of the Matmata tribes and of the Dahar. The Dahar has on its eastern side the semiarid plain of the Jeffara (Djeffara), which borders the Gulf of Gabes. In the gulf itself are the islands of Jerba (Djerba) and Kerkena.

With a Mediterranean climate, Tunisia shows fewer contrasts in its different regions than do the Tell, the steppe and the Sahara in Algeria. The average January temperature at Tunis is 52.7° F.; the hottest month has an average of 79.2°.

The winds are chiefly northwest in winter and northeast in summer; the rainy season runs from October to May. Rain is heaviest in the winter. The distribution of rain is, however. highly irregular from region to region and from year to year; North Africa. in general, is in a zone of climatic discontinuity, and a small change of the winds may mean great changes in rainfall. One zone gets more than 24 in. of rain per year, and this includes the massifs of the Khmir country and the Mogods; the next zone, with 16–24 in. of rain, includes central Tunisia, the valley of the Mejerda, Cap Bon and the region of Tunis (Tunis 16 in., Tebursuk 20, Kef 19); a zone with 18–16 in. south of the Tunisian ridge includes the region of Qairwan and the Sahel (coast belt stretching from the Gulf of Hammamet to the south of Sfax); there is a zone with less than 8 in. in the south and extreme south (Gabes 4 in , Gafsa 6, Médenin 5). Despite the meagre precipitation there, the hills of the Sahel, the coastal plains of Sfax and even of the Jeffara and the islands of Kerkena and Jerba grow olives thanks to the humidity of the atmosphere, which condenses in the sandy soils.

The principal river is the Mejerda, rising in Algeria near Souk-Ahras and flowing into the Mediterranean near Porto Farina. It is 261 mi. long; its affluents are the wadis Melleg, Tessa and Siliana, which come down from the High Tell. In floodtime the volume of the Mejerda may be 35,315 cu.ft.; in drought it may go down to 35 cu.ft. This river has formed large alluvial plains, filling up the ancient Gulf of Utica and joining a series of shore islets. The rivers of the eastern slope (Zerud, Marguellil) dry up in basins of the lowland which communicate with the sea only when rains are exceptionally heavy.

The northern coast is much dissected. Standing out to sea is the island of La Galite; the Lake of Bizerta has kept its depth because the alluvium is deposited in another one above it.

Beyond the Cap Bon peninsula, the eastern limit of the Gulf of Tunis, the east coast is low and sandy, bordered by lagoons in several places and shelving slowly into shallow water around the Kerkena archipelago and Jerba Island.

Flora for the most part is Mediterranean; 1,350 out of 2,000 plant species occur also in Italy. Forest, scrub and steppe are the characteristic formations. The cork oak and the *zean* oak cover the Khmir country and the Mogods (400,000 ac.). The woods of the centre are less compact. The Aleppo pine (2,000,000 ac.) and the thuja are the chief forms. In the south one finds, chiefly, the juniper. with some Aleppo pines and pistachio nuts. Bled-Tala has a forest steppe with gum trees (Acacza tortila), the most northerly occurrence of a species found from Senegal to Arabia. The scrub is usually degraded forest, and its most characteristic tree is *Zizyphus* lotus, the spiny jujube tree. The steppe is covered by grasslike types such as the alfa or esparto grass and by species of Artemisia.

The fauna is much like that of Algeria, with European species. Mammalian fauna is mainly Eurasiatic, but among reptiles and fish some Africano-Brazilian forms persist. Stag (Cervus *elaphus barbus*) is found in Kroumirie and the sleeved mouflon in the mountains. (J.-J. Ds.)

HISTORY

The history of Tunisia begins with the establishment of the Phoenician colonies (see CARTHAGE; PHOENICIA). The Punic settlers Semitized the coast but left the interior almost untouched. Under the Romans, Punic speech and civilization gave way to Latin.

Rich in corn, herds and, in later times, oil, and possessing valuable fisheries, mines and quarries, the province of "Africa,': of which Tunisia was the most important part, attained under the empire a prosperity to which Roman remains in all parts of the country still bear witness. Carthage was the second city of the Latin part of the empire, "after Rome the busiest and perhaps the most corrupt city of the west, and the chief centre of Latin culture and letters." The emperor Septimius Severus and the philosopher Apuleius were Africans. Moreover, in the early history of Latin Christianity Africa holds a more important place than Italy; in Africa Christian Latin literature took its rise, and to this province belong the names of Tertullian and Cyprian, of Arnobius and Lactantius and, above all, of Augustine. Lost by Rome to the Vandals, who took Carthage in 439, the province was recovered by Belisarius (533–534) and remained Roman till the Arab invasions of 648–669. The conqueror, Okba ibn Nafi, founded the city of Qairwan (671), which was the residence of the governors of "Afrikiya" under the Omayyads and thereafter the capital of the Aghlabite princes, the conquerors of Sicily, who ruled in merely nominal dependence on the Abbasids.

Arab and Berber Dynasties. — The Latin element in Africa and the Christian faith almost disappeared in a single generation; the Berbers of the mountains, who had never been Latinized and never really Christianized, accepted Islam without difficulty, but showed their stubborn nationality not only in the character of their Mohammedanism — which has always been mixed with the worship of living as well as dead saints (marabuts) and other peculiarities — but also in political movements. The empire of the Fatimites (*q.v.*) rested on Berber support, and from that time until the advent of the Turks the dynasties of North Africa were really native, even when they claimed descent from some illustrious Arab stock. When the seat of the Fatimite empire was moved to Egypt (972), the Zeirids, a house of the Sanhaja Berbers, ruled as their lieutenants at Mahdia, and about 1050 Mu'izz the Zeirid, in connection with a religious movement against the Shi'ites, transferred his very nominal allegiance to the Abbasid caliphs. Sent in vengeance by the Fatimite caliph, a vast horde of Bedouins from Upper Egypt (Beni Hilal and Sulaim) ravaged all North Africa. Unable to found an empire or overthrow the settled government in the towns, the invaders made order and prosperity almost impossible in the open parts of the country until its effective occupation by the French. The Zeirid dynasty was finally extinguished by Roger II of Sicily, who took Mahdia in 1148 and established his authority over all the Tunisian coast. Even Moslem historians speak favourably of the Norman rule in Africa; but it was brought to an early end by the Almohade caliph of Morocco, Abd ul-Mumin, who took Mahdia in 1160.

The Almohade empire soon began to decay, and in 1336 Abu Zakariya, prince of Tunis, proclaimed himself independent and founded a dynasty which subsisted till the advent of the Turks. The Hafsids (so called from Abu Hafs, the ancestor of Abu Zakariya) assumed the title of "prince of the faithful," a dignity which was acknowledged even at Mecca when. in the days of Mustansir, the second Hafsid, the fall of Baghdad left Islam without a titular head. In their best days the Hafsids ruled from Tlemcen to Tripoli, and they received homage from the Merinids of Fez; they held their own against repeated Frankish invasions, of which the most notable were that which cost Louis IX of France his life (1270) and that which Louis II of Bourbon led (1390), when English troops took part in the unsuccessful siege of Mahdia. The Hafsids adorned Tunis with mosques, schools and other institutions, favoured letters and in general appear to have risen above the usual level of Moslem sovereigns. Their rule was troubled by continual wars and insurrections and later by family dissensions.

Turkish Rule. — The conquest of Algiers by the Turks gave a dangerous neighbour to Tunisia, and after the death of Mohammed the Hafsid in 1525 a disputed succession supplied Khair ed-Din Barbarossa with a pretext for occupying the city in the name of the sultan of Constantinople. Hasan, the son of Mohammed, sought help from the emperor and was restored in 1535 as a Spanish vassal, by a force which Charles V commanded in person, while Andrea Doria was admiral of the fleet. But the conquest was far from complete. The interior was a prey to anarchy and civil mar until, in 1570, Ali Pasha of Algiers utterly defeated Hamid, the son and successor of Hasan, and occupied Tunis. In 1573 the Turks again retreated on the approach of Don Juan, who had dreams of making himself king of Tunis; but in the next year Sultan Selim II sent a strong expedition which drove the Spaniards from Tunis and reduced the country to the status of a Turkish province. Nevertheless, the Spanish occupation left a deep impression on the coast of Tunis.

Within a few years after the Turkish conquest, a military revolution (1590) transferred the supreme power to a dey elected by the janissaries, who formed the army of occupation. The government of the deys lasted till 1705. The beys, whose proper function was control of the tribes and who from 1631 onward had overshadowed the deys, took full control when Hussein ben Ali was proclaimed sovereign by the troops under the title of "bey." Being a prince of energy and ability. he was able to establish the hereditary sovereignty which lasted without change of dynasty.

Under deys and beys alike Tunisia was essentially a pirate state. Occasional acts of chastisement (of which the bombardment of Porto Farina by Robert Blake in 1655 was the most notable) and repeated treaties, extorted by European powers. checked from time to time but did not eliminate the habitual piracies, on which indeed the public revenue of Tunis was mainly dependent. The powers were generally less concerned for the captives than for the acquisition of trading privileges, and the beys took advantage of the commercial rivalry of England and France to play them off one against the other. The definite abandonment of piracy may be dated from the presentation to the bey in 1819 of a collective note of the powers assembled at Aix-la-Chapelle. The government had not elasticity enough to adapt itself to so profound a change in its ancient traditions. No attempt was made to improve conditions in the country, except perhaps under Mohammed VI es-Sadik, who succeeded to the throne in 1859. In the third quarter of the 19th century not more than a tenth part of the fertile land was under cultivation. Taxation was ruinous, and borrowing in Paris increased the public debt enormously. The yearly charges on the debt exceeded the whole annual revenue. Discontent flamed into insurrection under attempted constitutional and military innovations, and the inevitable revolution was postponed only by the rivalry of the European powers and interests in the country. The French had come to regard Tunisia as the natural extension of Algeria, although after the Crimean War Turkish rights over Tunis were revived. After the Franco-German War, the bey turned toward Great Britain for advice, and a British protectorate was not an impossibility under the remarkable influence of Sir Richard Wood, British diplomatic agent at the court of Tunis from 1855 to 1879. The railways, lighthouses, gas and waterworks and other concessions and industries were placed in British hands. But in 1878, at the Congress of Berlin. Lord Salisbury agreed to allow France a "free hand" in Tunisia in return for French acquiescence in the British lease of Cyprus.

The French Protectorate. — After 1862, however, the kingdom of Italy began to take an interest in Tunisia. Italian residents outnumbered other European groups. Italians were the commercial and industrial leaders. In 1879. of the 683 vessels entering the port of Goletta, more than 500 mere Italian. When the country went bankrupt in 1869, a triple control mas established over Tunisian finances, with British, French and Italian "controllers." In 1880 the Italians bought the British railway from Tunis to Goletta. This and other actions excited the French to act on the understanding effected with the British at the Berlin congress. In 1881 a French force crossed the Algerian frontier and. advancing on the capital. compelled the bey to accept the French protectorate. The conquest of the country mas not effected without a serious struggle with the Tunisians. especially at Sfax; but all Tunisia was brought eventually under French control.

Mohammed VI signed the treaty acknowledging the protectorate at the Bardo palace on May 12. 1881. He died in Oct. 1882, and a new agreement, defining the protectorate, mas signed at La Lfarsa (June 8, 1883) by his brother and successor. hfohammed es-Sadik Ali IV. From 1884 onward the French, under a resident-general, carried out a thorough reform of the administration. Great Britain early recognized the protectorate, as did most of the other powers. Turkey did not, and though the boundary between Tunisia and Tripolitania was established by the treaty of May 19, 1910, between France and the Ottoman empire. it was not until the treaty of Lausanne (1923) that Turkish claims to the regency were finally renounced. Italy, however. was more deeply concerned by the establishment of the French protectorate, having looked forward to the acquisition of Tunis. The Italian government renounced its consular tribunals in Tunisia in 1884. as the other powers had done in 1883, but insisted on its other capitulatory rights (under a treaty of 1868) till 1896. By the terms of a convention then concluded the right of Italians in Tunisia to maintain their nationality was guaranteed. British subjects had the same right; this affected chiefly the Maltese settled in the country. The persistence shown by Italians and Maltese in maintaining their nationality, however, was a cause of annoyance and some practical inconvenience to the French. Decrees issued in 1921 declaring that British and Italian subjects, born of parents who were themselves born in Tunisia, would be deemed to be of French nationality provoked resentment: especially among the Italians. As to the British (*i.e.,* Maltese) an arrangement was reached in 1923 whereby the persons affected were entitled to decline French nationality. The Laval-Mussolini agreements of 1935, providing for the termination of Italy's special privileges, were never applied. They were to be denounced in 1938 by Mussolini, who made the acquisition of Tunisia one of the aims for which Italy declared war on France in 1940.

The nomad tribes in the south gave occasional trouble, but French rule was generally accepted. By the agreement of Sept. 12, 1919, the territory south of Tunisia forming salients between the oases of Ghadames and Ghat and between Ghat and Tummo was transferred to Libya.

Tunisian Nationalism. — Nationalism arose in Tunisia before World War I under the leadership of "Young Tunisians" influenced by European education and thought. The movement increased in importance under the stimulus of postwar movements in the middle east; in 1920 various groups united to form a Destour (Constitutional) party, whose program had the objective of securing democratic forms of government. In 1925 the French deported the leaders and broke up the movement.

The economic depression of the early 1930s and the appearance of younger leaders facilitated the revival of nationalism. These leaders, headed by Habib Bourguiba (*q.v.*), formed the Neo-Destour party with a program of vigorous action involving organization of the masses and the assistance of French leftist leaders and nationalists in Morocco and Algeria. The Neo-Destourians expected much from the French popular front government of 1936, which. however. added only minor reforms in 1937 to those granted in 1933 and 1935. After clashes with the police in April 1938, 200 nationalists were arrested and both the Destour and the Neo-Destour were dissolved. (P. W. I,; X.)

After the Franco-German armistice and Italy's entry into World War II (June 1940), Tunisia, like the rest of French North Xfrica, came under Vichy rule. Trade was paralyzed, and there was an acute shortage of imports, particularly of fuel and textiles. The day after the Allied landings in North Africa (*see* WORLD WAR II) the Germans, unopposed by the resident-general, Adm. J. P. Esteva, occupied the country (Nov. 1942). For six months Tunisia was a battleground; then in May 1943 the German and Italian armies collapsed. Esteva fled, and the bey, Mohammed el-Moncef, was deposed by the French and replaced by the heir apparent, Mohammed el-Xmin. Italian privileges were abolished by an ordinance of June 22. 1944. duly recognized by the Italian government.

Some political reforms were promised by the French but economic difficulties aggravated Moslem discontent, and nationalist agitation was resumed. A repressive policy was adopted, and in April 1945 Bourguiba, the leader of the Neo-Destour, fled to Cairo. In Aug. 1946 Salah ben Youssef, the secretary general of the Neo-Destour. summoned a meeting in Tunis of all the nationalist parties and groups, which unanimously passed a resolution condemning the protectorate and demanding complete independence. The principal nationalist leaders were then arrested, but were released a few weeks later.

In Feb. 1947, Jean Mons, the French resident-general, tried to form a nationalist ministry but failed because both the Destour and the Neo-Destour refused to accept either the continuance of the protectorate or the entry of Tunisia into the French union. In Aug. 1947 Mons therefore formed a Tunisian ministry composed of moderate elements with no definite party leanings. But whereas previously there had been only three Tunisian ministers, all departments of state being under French directors, all French directorships except those of education, finance and public works were now abolished and five more ministries given to Tunisians. These ministers were assisted by French councillors, whose agreement to ministerial propositions had to be obtained, differences between them being resolved by a "cabinet council" partly Tunisian and partly French. hlohammed Kaak, a lawyer, was prime minister and minister of justice.

In spite of great difficultiessome progress was made in education. But land-settlement plans came to nothing. health services lagged, and there was little diminution of the controlling power of the French in local as in central administration.

The nationalists were therefore very restive. Bourguiba (with official French sanction) returned to Tunisia in Sept. 1949 and for the next six months campaigned throughout the country for the abolition of the protectorate and for the grant of autonomy. In April 1950 he went to Paris and published a program in which, while renouncing the claim to complete independence and showing willingness to admit Frenchmen to elected Tunisian councils, he yet asked for a progressive transfer of sovereignty, for a new treaty and for internal autonomy.

In June 1950, Louis Périllier, the new French resident-general, admitted that substantial reforms were necessary and that direct administration should be ended within the framework of the treaties establishing the protectorate. In August a ministry was led by Mohammed Shenik in which the Tunisians participated in equal strength with the French and in which, for the first time, the Neo-Destour was represented by Salah ben Poussef. Because of pressure by the French settlers. no reform was achieved, but the Tunisian ministers' French advisers were removed. Another step toward internal autonomy, however, was taken in Feb. 1951, when it was decided that the council of ministers was henceforth to be under the chairmanship of the premier instead of that of the resident-general and that the certificate of the secretary-general of the residency was no longer required to validate ministerial decisions.

While French settlers made known their fear that Tunisian emancipation would end in the eviction of the French, Bourguiba tried to stir world opinion and sharply criticized the slowness of French policy. A nationalist agitation began in December and at the beginning of Jan. 1952 Jean de Hauteclocque succeeded Périllier as resident-general, The Shenik ministry made a complaint against France to the United Nations but this was ruled out of order by the Security council. Disorders increased after Bourguiba and 11 other Neo-Destour and Communist leaders had been arrested.

In March 1952 the French government proposed partial self-government for Tunisia but this proposal was criticized in the French national assembly as going too far and was rejected in August by the bey as insufficient. The situation deteriorated gravely as a result of the murder on the night of Dec. 4–5, 1952, of Ferhat Hashed, secretary general of the General Union of Tunisian Workers, a prominent supporter of Bourguiba. Terrorist activities of the *fellaghas* (rebels) spread throughout the country.

Independence. — Events took a dramatic turn when on July 31, 1954, Pierre Mendès-France, French premier, went to Tunis and told the bey that the French government was determined to give Tunisia internal autonomy, with an all-Tunisian government. Only foreign policy and defense were to remain under French control. The reciprocal obligations were to be decided by negotiation. On Aug. 7, Tahar ben Ammar, a Tunisian of moderate views, formed a ministry in which the Neo-Destour party was represented. At the beginning of December Gen. Pierre Georges Boyer de la Tour du Moulin, the French resident-general, agreed that a full amnesty should be given to all the *fellaghas* surrendering to the authorities and handing over their arms. By the end of 1954 almost all the rebels, about 2,500, had surrendered.

The Franco-Tunisian negotiations, initiated to implement the July promise of internal autonomy, ended on June 3, 1955, when a series of nine agreements was signed in Paris. Bourguiba, freed from internment, received an enthusiastic reception when he landed in Tunis on June 1. He told a crowd of 200,000 that "internal autonomy was only a step toward independence."

As a result of the French recognition of Morocco's independence (Nov. 6, 1955), the Tunisian government reopened the negotiations with France and on March 20, 1956, Tahar ben Ammar and Christian Pineau, the French foreign minister. signed a protocol abolishing not only the treaty of 1881, but the 1955 agreements as well. France recognized Tunisia's independence and its right to conduct its own foreign policy and to form its own army. Both countries recognized their "interdependence," which was, however, to be defined in further negotiations.

On March 25, the country's first general election resulted in complete victory for Bourguiba's National front, which won all the 98 seats of the constituent assembly. On April 25 Bourguiba formed a new government. Salah ben Youssef, however, opposed Bourguiba's policy, describing it as pro-French. He was to have been arrested in Jan. 1956 on a charge of treasonable conspiracy but succeeded in escaping to Libya and later moved to Cairo. There was a revival of *fellagha* activities which were carried out in co-operation with those of the Algerian insurgents.

A republic was proclaimed in July 1957, and the assembly elected Bourguiba as president.

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SOCIAL AND ECONOMIC CONDITIONS

Area and Population. — The republic covers-an area of 48,332 sq.mi.

The natives of Tunisia belong to two stocks, which may be roughly classified as the Berber and the Arab. about two-thirds being of Berber descent. Arabic is spoken everywhere and only about 1% speak Berber. The population is mainly Sunni Moslem but the inhabitants of the island of Jerba are mostly of the Ibadhite sect of Islam. The towns contain some primarily urban elements such as the Andalusian Moors and the Jews.

Among the Europeans Italians were in absolute majority in 1906; by 1955 that majority became decisively French not so much through immigration as through naturalization. (See Table I.) Of the European population, 85% live in the towns, 60% in Tunis alone. Europeans are predominantly Roman Catholics; there are, however, about 3.500 Protestants.

TABLE I.—Population of Tunisia

Nationalities	1906*	1921	1936	1956
Moslems				
Tunisian	1,750,000	1,826,545	2,265,750	3,383,213
Non-Tunisiant	40,000	62,843	69,873	86,149
Total Moslems	1,790,000	1,889,388	2,335,623	3,469,362
Jews	68,000	48,436	59,485	57,786
Europeans				
French	34,600	54,476	108,068	180,450
Italians	81,200	84,799	94,289	69,909
Maltese	10,300	13,520	7,279	7,973
Other.	2,800	3,320	3,569	
Total Europeans	128,900	156,115	213,205	255,332
Total	1,986,900	2,093,939	2,608,313	3,782,480

'Estimates. †Mainly Algerians and Libyans.

Tunis is the country's capital; between 1926 and 1956 its population rose from 185,996 to 410,000. Other important towns are (pop. 1926 census; 1956 census in parenthesis): Sfax 16,301 (65,63j); Sousse or Susa, 28.718 (48.172); Bizerta 19,529 (44,-681); Qairwan 32,299 (33,968); Gabès 22,512 (24,420). Other towns exist as ports, oases or agricultural centres.

Agriculture. — About 3,400,000 ha., out of a productive area estimated at 9,000,000 ha.. are held to be arable. The returns are generally poor. (See Table II.) Vineyards cover about 36,000 ha. (1954), mainly in the regions of Tunis and Grombalia. The average annual production in 1950–54 was 740,000 hl. The eastern part of Tunisia is particularly suited to olive growing. In 1954 there were 26,000,000 trees of which four-fifths were full-bearing. For livestock see Table III.

TABLE II.—*Agricultural Production*
(In thousands of metric tons)

	1934–38	1948–52	1953	1954
Wheat	385	452	580	624
Barley	167	218	180	170
Oats	21	15	12	6
Pulses*	27	42	40	48
Potatoes	15	19	14	20
Grapes (total)	222	105	96	149
Dates	22	35	28	39
Olive oil	45	53	92	60
Tobacco (tons)	600	1,003	2,107	1,270

*Broad beans, chick peas, dry peas and lentils.

TABLE 111.—Livestock
(In thousands of head)

Livestock	I	1947–51	1952	1953	1954	1955
Cattle	478	359	401	483	483	
Sheep	2,687	2,463	3,420	2,872	3,352	3,045
Goats	1,407	1,719	2,242	1,716	1,853	[illegible]
Camels	152	186	234	215	202	226
Horses	92	73	80	78	78	81
Mules	56	47	53	49	50	50
Asses	130	137	168	164	160	162

Forests (2,500,000 ac.) provide firewood and timber (railway sleepers, pit props and stakes for vineyards), as well as cork for export. Alfa (70,000 tons in 1954) is exported chiefly to England, for the manufacture of paper pulp. Sea fishing is carried on in Tunisia under more favourable conditions than in Algeria. The fish are also more varied in kind. There are 13,000 fishermen, of whom 12,000 are natives and 1,000 Italians. The catch consists mainly of tunny, sardines and sardinella. Sponge fishing is carried on along the whole of the east coast, from Monastir to the frontier of Tripoli, especially at Sfax and in the Kerkena Islands; production in 1954 was 180,100 tons.

Industry. — Tunisia possesses practically inexhaustible deposits of phosphates. The chief exploitation is carried on in the Gafsa region and exports go through Sfax. The phosphates of Kalaa-es-Senan and Kalaa-Jerda, found as a prolongation of those of Tebessa, are exported through Tunis. Iron ares, abundant and of good quality, are found, especially to the south of Kef and not far from the Algerian frontier, at Duaria. at Jerissa and at Nefzas in the Mogods. Lead and zinc came from the country round Béja and the High Tell. Other minerals are mercury, manganese, copper, iron pyrites and salt; petroleum has been sought at various places. (See Table IV.) From 1954 natural gas from Cap Bon was being used in Tunis. Between 1938 and 1954 production of

TABLE IV.—Mineral Production
(In thousands of metric tons)

Mineral	1950	1951	1952	1953	1954
Phosphate rock	1,525	1,679	2,265	1,719	1,823
Iron ore (55% Fe content)	758	923	977	1,057	950
Lead ore	30.7	3	36.5	37.9	41.6
Zinc ore	5.7	7.3	7.5	6.6	9.5

electricity rose from 66,965,000 kw.hr. to 203,475,000 kw.hr. Important industries include flour milling, oil refining, lead melting and distilling; after World War II, moreover, there was considerable industrial development. comprising preserved food, building materials and light engineering workshops.

Foreign Trade. — Tunisia is in customs union with France, but for wine an annual quota system was being applied; *i.e.*, only a certain quantity was allowed free into France. Of the imports 80% came in 1954 from the franc area, 3% from the sterling area and 4% from the dollar area; of the exports, 68%, 10% and 2% went to the same areas, respectively. Tunisia imports textiles and clothing (20% of the total value of imports); foodstuffs(18%; *e.g.* sugar, tea and dairy produce); raw materials and unfinished goods (21%); supplies for building and development (21%); and fuel. Principal exports are olive oil and minerals. (See Table V.)

TABLE V.—*Foreign Trade*
(In millions of francs)

Item	1951	1952	1953	1954	1955
Imports	63,819	64,879	60,121	59,268	63,199
Exports	37,536	40,060	38,840	44,214	36,984

Finance. — Tunisia is in monetary union with France and the Tunisian franc was at par with the metropolitan franc. The Banque d'Algérie acted as bank of issue for Tunisia. The note circulation between 1941 and 1954 rose from 1,635,000,000 fr. to 24,836,000,000 fr. For revenue and expenditure see Table VI.

TABLE VI.—*Budgets*
(In millions of francs)

Item	1951–52	1952–53	1953–54	1954–55	1955–56
Revenue	47,120	48,244	51,680	53,024	53,275
Expenditure	47,111	51,596	54,136	55,524	57,175

Transport and Communications. — In 1955 Tunisia had 14,714 km. of roads and tracks. including 7,210 km. motor roads. On Dec. 31, 1954, there were 52,275 registered motor vehicles, including 30.854 cars, 13,553 lorries, 696 buses and 7,172 motor cycles. State railways in 1954 amounted to 1.529 km.. including 483 km. of standard gauge (1.44 m.). The latter. in the north, are a section of the Algerian railways. In the centre and the south the lines have a gauge of 1 m. The privately owned Sfax-Gafsa system (455 km.) had the same narrow gauge.

The major ports are: Tunis (with Goletta as its foreport). Sfax, Susa and Bizerta (also an important naval base). In 1951–56 the annual average of goods unloaded in all ports amounted to 974,200 metric tons (incl. 722,000 tons in Tunis-Goletta) and of goods loaded to 3,585,000 tons (incl. 1,417,000 in Tunis-Goletta).

The Tunis airport is an important link between Europe, Africa and the east. In 1954 2,022 aircraft landed there (incl. 356 foreign) with 54,556 passengers, 875 tons of freight and 187.1 tons of mail.

By Dec. 31, 1954 there were 92,987 licensed wireless receiving sets.

BIBLIOGRAPHY.—Maps on the scales of 1:500,000, of 1:200,000, of 1:100,000 and of 1:50,000 are issued by the Institut géographique national (Paris); there are also geological maps on the same scales. *See* J. Despois, *L'Afrique du Nord* (Paris, 1949), with bibliography; the collection *Initiation à la Tunisie* (Paris, 1950), with bibliography; the volume *Tunisie* in the *Encyclopédie coloniale*, 2nd ed. (Paris, 1947); *Annuaire Statistique de la Tunisie*, annual (Tunis, 1946 *et seq.*).

(J.-J. Ds.; X.)

TUNNEL.

A tunnel is a subterranean passageway, horizontal or nearly horizontal in direction, excavated without removing the overlying rock and soil, and, as constructed by man, is of a symmetrical geometric form or roughly so. Tunnels are used for many purposes; in mining for removing of valuable mineral deposits; in transportation for the passage of canals, railroads, automobiles and all types of vehicles, as well as pedestrians; in urban development for sewers, water mains and various means of communication. Underground passageways formed by natural forces are very common and are frequently called tunnels if horizontal or nearly so, but may be more precisely termed caves. The process by which they are formed is called cavitation; the most common type is the removal of soluble minerals by water percolating through the underground or flowing in subsurface streams. In Asia Minor one of the rivers on the route of the Mersina railway extension passes through a hill by means of such a natural tunnel. The Mammoth cave of Kentucky, the caverns at Carlsbad, N.M., and the Peak caves of Derbyshire have been formed by such cavitation.

There are numerous terms closely associated with tunnels and sometimes used interchangeably. A partially completed tunnel is called a heading, and in mining operations small passageways are termed galleries, drifts or adits. If the passage leading underground is vertical, it is called a shaft; if inclined, it is called a slope or inclined shaft; if the shaft or slope is started at the surface, the operations are known as sinking; and if worked upward from a previously constructed heading or gallery, the opening is called a rising or stope. Fig. 1, an old engraving by Georg Agricola from mining operations early in the 17th century, illustrates several of these terms common in mining operations, and also indicates some of the hand methods by which early mining was done.

Tunnelling is the term used to designate the act or method of constructing a tunnel; it refers to the construction of such a subsurface passageway without the removal of the overlying cover of rock or earth. In the construction of modern subways and in many

FIG. 1.—EARLY MINING METHODS IN "DE RE METALLICA" (1566) BY GEORG AGRICOLA
A. Shaft. B, C, *D. Drifts. E. Tunnel. F. Tunnel mouth*

other types of subsurface utilities, it has become common practice to build the subsurface structures or tubes in an open cut and subsequently replace the excavated earth as backfill, re-establishing the original surface of the ground. When this "cut-and-cover" method of construction is used, it is subsequently difficult to differentiate clearly between the finished subsurface structures or passageways and a true tunnel. For the purpose of definition it may be desirable to refer to such construction as a subway, a conduit, aqueduct, water main or sewer, with particular reference to the purpose for which the particular subsurface structure is to be used.

HISTORICAL DEVELOPMENT

Prehistoric Tunnels. — Unquestionably the first tunnels built by man were during prehistoric times. It would be only natural that the earliest cave man must have at some time enlarged his abode or connected nearby caves by tunnels in the strictest sense of the word. How extensive such improvements for access, safety and convenience of the cave dwellers were is only a matter of speculation, but that such things were done is a logical certainty. Up to the era of recorded history there are also many examples of tunnelling for dwellings and tombs, water supply, drainage and other utilitarian objectives.

Ancient Tunnels. — One writer lists the earliest tunnel of recorded history as that built by a Babylonian king about 2180–60 B.C. This tunnel passed under the Euphrates river to provide a passage connecting the royal palace with the Temple of Jupiter on the opposite bank. Another very early tunnel was credited by legend to King Hezekiah of Judah and was constructed in the 8th century B.C. for the purpose of providing water to the city of Jerusalem during anticipated sieges. An early Greek tunnel was built on the Island of Samos in 687 B.C., also for the purpose of providing water supply. This tunnel was reopened in 1882 and found to be in a remarkable state of preservation.

The tomb of Mineptah, at Thebes, was driven at a slope for a distance of 350 ft. into the hill, when a shaft was sunk and the tunnel projected a farther length of about 300 ft., and enlarged into a chamber for the sarcophagus. Tunnelling on a large scale was also carried on at the rock temples of Nubia and of India and to some extent by the Aztecs in America.

Sir William Flinders Petrie traced the method of underground quarrying followed by the Egyptians opposite the pyramids. Parallel galleries about 20 ft. square were driven into the rock and cross galleries cut, so that a hall 300–400 ft. wide was formed. with a roof supported by rows of pillars 20 ft. apart. Blocks of stone mere removed by the workmen cutting grooves all round them, and. where the stone was not required for use, but merely had to be removed to form a gallery, the grooves were wide enough for a man to stand erect. Where granite, diorite and other hard stone had to be cut the work was done by tube drills and by saws supplied with corundum, or other hard gritty material. and water—the drills leaving a core of rock exactly like that of the modern diamond drill.

As instances of ancient tunnels through soft ground and requiring masonry arching, reference may be made to the vaulted drain under the southeast palace of Nimrod and to the brick arched tunnel 12 ft. high and 1j ft. wide, under the Euphrates, previously mentioned. In Algeria, Switzerland and wherever the Romans went, remains of tunnels for roads, drains and water supply are found. Pliny refers to the tunnel constructed for the drainage of Lake Fucino as the greatest public work of the time. It was then by far the longest tunnel in the world, being more than 3.j mi. long. It was driven under Monte Salviano, which necessitated shafts no less than 400 ft. in depth. Forty shafts and a number of cuniculi or inclined galleries were sunk and the excavated material was drawn up in copper pails of about 10 gal. capacity by windlasses. The tunnel was designed to be 10 ft. high by 6 ft. wide, but its actual cross section varied. It is stated that 30,000 labourers were occupied for 11 years in its construction. With modern appliances and a small percentage of men such a tunnel could be driven from the two ends without intermediate shafts in far less time.

Following the fall of the Roman empire and for about ten centuries thereafter there was a complete cessation of tunnel-building activities. Immediately following this period the first record of renewed activity in tunnel building includes the dungeons and passages which were unearthed in the subsequent construction of the Moscow subway and of which there was only legendary record. These tunnels are believed to have been built by Ivan "the Terrible" about 1565 and were found to constitute a fantastic underground city, which might be compared with the catacombs of Rome. Other tunnels of this period include the irrigation tunnels built by the Moors during their occupation of Spain. However, as a matter of well-documented record, the first substantial project of tunnelling after the middle ages was started in 1450 in the Maritime Alps to provide a road between Nice and Genoa. This attempt was abandoned for several centuries but was resumed in 1794 and carried on to a length of about 8,200 ft., when it was again abandoned and never completed. It was subsequently replaced by a surface highway built by Napoleon Bonaparte through the Col di Tende pass.

Up to this time more extensive tunnelling projects had been handicapped by the crude hand methods of excavation in rock and by the failure to develop adequate means of bracing and support in tunnels in earth. Further difficulties were encountered in ventilation of the tunnels and in the drainage of the large quantities of ground water frequently encountered. No practical advance was made in tunnelling methods of the Romans until gunpowder came into use. Old engravings of mining operations early in the 17th century show that excavation was still accomplished by pickaxes or hammer and chisel, and that wood fires were lighted at the ends of the headings to split and soften the rock in advance. (See fig. 1.) Crude methods of ventilation by shaking cloths in the headings and by placing inclined boards at the top of the shafts are also on record. Gunpowder was first used for subsurface excavation in connection with mining operations sometime about 1600, the exact date not being recorded. Explosives were first used in 1679 in the construction of the Languedoc canal in France. That canal was 510 ft. long, 22 ft. wide and 29 ft. high, and was driven through soft limestone.

TUNNELS FOR TRANSPORTATION

Canals. — Tunnels for the diversion of streams or canals are of early date. South of Seleucia, in Turkey in Asia, a river flows through a tunnel 20 ft. wide and 23 ft. high. excavated in the 4th century A.D., through rock so hard that the chisel marks are still discernible. In 1766 a tunnel 9 ft. wide, 12 ft. high and 1.63 mi. long was begun on the Grand Trunk canal, Eng., and completed 11 years later. This was followed by many others. The Languedoc canal ushered in an era of tunnelling in connection with canal building which continued until canals were gradually replaced by railroads, early in the 19th century. Inasmuch as canals require a level grade, tunnels became a contingent necessity wherever hills or mountains were encountered. Canal building in Europe centred in England and France and was carried to America where several early tunnels mere built in eastern Pennsylvania. The first tunnel of any kind built in the United States was a canal tunnel known as the Auburn tunnel in Schuylkill county, Pa. It was begun in 1818 and opened in 1821 and was 20 ft. high, 18 ft. wide and about 450 ft. long. It was subsequently converted into an open-cut waterway. Thereafter the oldest existing tunnel in the United States was to be found on the route of an old Pennsylvania canal near Lebanon, Pa. This tunnel mas completed in 1828.

Canal building was a rather temporary phase of transportation, as history goes, as it was barely under way in the early 19th century when railroads took the spotlight and soon replaced canals as a transportation facility. As a result, except for a few early tunnels of historic importance, there are few notable tunnels as a result of an obvious association with canal transportation. An exception to this statement was the tunnel built in connection with the Rove canal; the latter; largest of its kind. was completed in 1927, connecting the port of Marseilles. Fr.. by canal with the Rhône river. It is 72 ft. wide (width of water 60 ft.) and jo ft. high inside and 4.53 mi. long. The cross-sectional area is about six times that of the average double-track railway tunnel. Its construction occupied 1j years. and its cost was about 135,000,000 fr., paid by the French government, the chamber of commerce and the city of Marseilles. The entire cost was to be returned by tolls. The quantity of material excavated was greater than any other tunnel in Europe, about 2,250,000 cu.yd., or 25% more than the Simplon tunnel. It is lined with masonry, has a tow path 6 ft. wide on each side in the form of a series of small arches and has a large masonry portal at each end. This tunnel is 1.7 mi. longer than a similar canal tunnel between the Marne and the Rhine.

Railway Tunnels.––What is said to be the first railway tunnel in the world was started in 1826 near St. Étienne in France, known as the Terrenoire (Black Earth) tunnel. It was built on a horse railroad in operation prior to the advent of steam locomotives. Another very early railway tunnel was the Allegheny portage railroad tunnel in the U.S., built between 1831 and 1833. It was 20 ft. wide, 19 ft. high and 900 ft. long, and was built to serve as a portage through a spur of the Allegheny mountains about 4 mi. above Johnstown, Pa., on the Conemaugh river. Oddly enough, this first among American railway tunnels was later abandoned when railroads took over "through" transportation from the canal

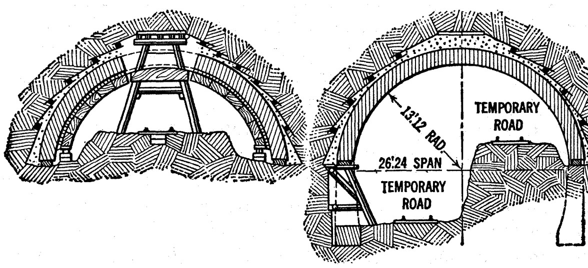


FIG. 2.—METHOD OF EXCAVATION OF ST. GOTTHARD TUNNEL

systems of that day and led to the abandonment of the Allegheny portage tunnel, which was nothing more than a link in one of the older routes of water-borne traffic.

Many of the most famous tunnels in the world were built in connection with the extension of railways of Europe through the Alps. In 1857 the first blast was fired in connection with the Mont Cenis work in the Alps; in 1861 machine drilling was introduced, and in 1871 the tunnel was opened for traffic. Located between Modane, Fr., and Bardonecchia, It., it is a single tunnel 7.98 mi. long, with a "horseshoe" section 26 ft. 3 in. by 24 ft. 7 in. The material penetrated was granitic and the average progress 7.7 linear feet per 24 hours. The approximate cost mas £7 j for each linear foot. With the exception of about goo linear feet the tunnel is lined throughout with brick or stone. During the first four years, by hand labour, the average progress was not more than 9 in. per day on each side of the Alps, but with compressed air drills progress at the end was five times greater.

In 1872 the St. Gotthard tunnel was begun, and in 1881 the first locomotive ran through it. Lying between Goschenen and Airolo, Switz., it is 9.3 mi. long and of the same dimensions as the Mont Cenis. The material also was granitic.

Mechanical drills were used from the beginning. Tunnelling was carried on by driving in advance a top heading about 8 ft. square, then enlarging this sideways and finally sinking the excavation to invert level. (See details in fig. 2.) Air for working the rock drills was compressed to seven atmospheres by water turbines of about 2,000 horsepower. The two inclines leading to the summit, which total about 36 mi., are 28% tunnel, which required seven spirals forming almost complete loops within the mountains in order to gain altitude and distance.

Driving of the Arlberg tunnel was begun in 1880, and the work was completed in little more than three years. It is a single tunnel. 25 ft. 3 in. wide and 6.36 mi. long. between Innsbruck and Bludenz, in the Tirol. The average progress in 24 hours mas 27.2 linear feet, and the approximate cost was F36 per linear foot. The main heading was driven along the bottom of the tunnel and shafts were opened to the upper heading 75 to 210 ft. apart, from which smaller headings were driven right and left. The tunnel was enlarged to its full section at different points simultaneously in lengths of 24 ft., the excavation of each occupying about 30 days and the masonry 14 days. Ferroux percussion air drills and Brandt rotary hydraulic drills were used, the performance of the latter being especially satisfactory. After each blast a fine spray of water was injected, which assisted the ventilation materially. In the St. Gotthard tunnel the discharge of the air drills was relied on for ventilation. In the Arlberg tunnel more than 8,000 cu.ft. of air per minute was thrown in by ventilators. To keep pace with the miners, 900 tons of excavated material had to be removed and 350 tons of masonry introduced daily at each end of the tunnel, which necessitated the transit of 450 wagons. The cost per linear foot varied according to the thickness of masonry lining and the distance from the mouth of the tunnel. For the first 3,000 ft. from the entrance the prices per linear foot were £3 16s. for the lower heading; £2 11s. for the upper one; £10 3s. for the unlined tunnel; £15 for the tunnel with a thin lining of masonry; and £41 8s. with a lining 3 ft. thick at the arch, 4 ft. at the sides and 2 ft. 8 in. at the invert.

The Simplon tunnel, begun in 1898 and completed in 1905, lies between Brigue, Switz., and Iselle, It.; it has a length of 12.3 mi. and is more than 30% longer than the St. Gotthard. The greatest depth below the surface is 7,005 ft. A novel method was introduced by driving two parallel headings. 56 it. apart, connected at intervals of 660 ft. by oblique galleries, which greatly facilitated ventilation and resulted in increased economy and rapidity of construction, while also ensuring the health of the men. One of the headings was enlarged at once to 16 ft. 5 in. wide by 19 ft. 6 in. high, for a single track railroad, but the second was left to be enlarged and similarly used at a later date. This was undertaken in 1918, during World War I, and completed a few years later. Had one wide tunnel been made instead of two narrow ones, it would have been difficult to maintain its integrity. Even with the narrow cross section employed, the floor was forced up at points in the solid rock from the great weight above, and had to be secured by building heavy inverts of masonry. About 2.5 mi. from the portal at Iselle, the "Great Spring" of cold water was struck. It yielded 10,564 gal. per minute at 600 lb. pressure per square inch, and reduced the temperature to 55.4° F., the lowest point recorded. A spring of hot water was met on the Italian side which discharged into the tunnel 1,600 gal. per minute with a temperature of 113° F. The maximum flow of cold water was 17,081 gal. per minute, and of hot water 4,330 gal. per minute. These springs often necessitated a temporary abandonment of the work. Water power from the Rhône at the Swiss and from the Diveria at the Italian end provided the power for operating all plants during construction of most of the work. The material penetrated was gneiss, mica schist, limestone, and disintegrated mica schist. The average progress per 24 hours was 35 linear feet and the approximate cost £49 7s. per linear foot. Among the able engineers connected with this work must be mentioned Alfred Brandt, who developed the drills which were used with much success.

A group of tunnels—the Tauern, Barengraben, Wocheiner and Bosruck—was undertaken by the Austrian government in connection with new Alpine railroads to increase the commercial territory tributary to the seaport of Trieste, which at one time was greater than Hamburg.

The Lotschberg tunnel, in the Alps of Switzerland, between Kandersteg and Goppenstein, is 9 04 mi. long and the maximum grade is 0.38%. It is a double-track railway tunnel, and its construction was begun in Oct. 1906 and completed in Sept. 1911. It was originally planned to be 8.5 mi. in length and straight. It passed beneath the ancient glacial gorge now filled with detritus and occupied by the Kander river, but at a great depth, and it was supposed it would be in solid granite. After driving the heading for nearly 2 mi., it broke through into the gorge, which was filled with sand, boulders and water under great pressure. In the space of a few moments about 8,000 cu.yd. of the material was carried into the heading. Twenty-five men, the drills and all equipment were lost. It was bulkheaded off. the line bent to throw it farther into the mountains and beneath the gorge, and it was then successfully completed, the length being increased one-half mile. The tunnel is operated electrically, using 15,000 v., single phase, alternating current of 16 cycles.

The Connaught tunnel at Rogers pass on the Canadian Pacific railuay pierces the Selkirk range of the Canadian Rockies. It is 5 mi. long and replaces a surface line 540 ft. higher up. Its construction saves 5 mi. of distance and replaces 5 mi. of snowsheds in a distance of 13 mi. It is a double-track tunnel, operated electrically, and has a maximum grade of 2.2%. It was built between 1913 and 1916 and was the first American tunnel in which a parallel pioneer tunnel was used. Progress on the pioneer heading reached as high as 817 ft. in 30 days

Much important tunnel construction has been done in Japan by the Japanese government railways. Probably the most notable is the Tanna tunnel between Atami and Mishima which was started in 1918 and not completed until 1934. Extraordinary difficulties were encountered, including great quantities of water under high pressure of 275 lb. per square inch, unstable soil and rock which collapsed, crushing heavy timbering, and, in fact, practically all of the difficulties that had been encountered on previous tunnels. Every method for combating these difficulties known to modern tunnel builders was employed, including cement grouting, compressed air, tunnel. shields, parallel drainage tunnels and the heaviest concrete lining ever employed, amounting to a maximum of $6\frac{1}{4}$ ft. in thickness at the top of the arch. The determination of the builders finally prevailed and the tunnel was completed after 16 years of unparalleled effort, but only after a cost of 70 lives and expenditures far in excess of anything anticipated.

The Moffat tunnel. on the Denver and Salt Lake railroad, replaced a surface line with 4% grades, crossing the continental divide about 50 mi. W. of Denver, Colo. At the time of construction it was the longest railroad tunnel in America. It lies at an elevation of 9,200 ft. above sea level, as compared with 11.660 ft. on the surface line at the summit of the divide. The work was begun in 1923, and the first train was run through in Feb. 1928. The work consists of two parallel tunnels, 75 ft. apart, one for a single-track railroad, 16 ft. by 24 ft., and one for a water tunnel, 8 ft. by 8 ft.. which may be used for the water supply of Denver. The work was done by the Moffat Tunnel commission, and paid for by a bond issue by a district of the state in the vicinity and Denver. The railroad tunnel is leased to the Denver and Salt Lake railroad. Its length is 6.1 mi., and the cost including the water tunnel was about $15,470,000. The grades of the railroad tunnel rise from the ends toward the centre, on rates of 0.3% from the east and 0.9% from the west. The construction of both tunnels at one time was taken advantage of to use the water tunnel as a pioneer heading with cross connections to the main railroad tunnel at intervals of about 1,500 ft., as was done in the Simplon tunnel and the Connaught tunnel. which offered advantages in speed and ventilation. Chloride of lime dumped in one of the lakes, 1,400 ft. above, was found in the tunnel water two hours later.

The Cascade tunnel of the Great Northern railway, between Berne and Scenic, in the state of Washington, is almost 8 mi. long (see fig. 3.) — fifth longest railway tunnel in the world and the longest railway tunnel in America in the 1950s. The alignment is straight and the grade 1.565% downward to the nest from Berne. Work mas started in Dec. 1925. The tunnel was driven from the two portals and a shaft, 622 ft. deep, 2.41 mi. from the east end, by the centre heading method, to allow radial drilling. A pioneer

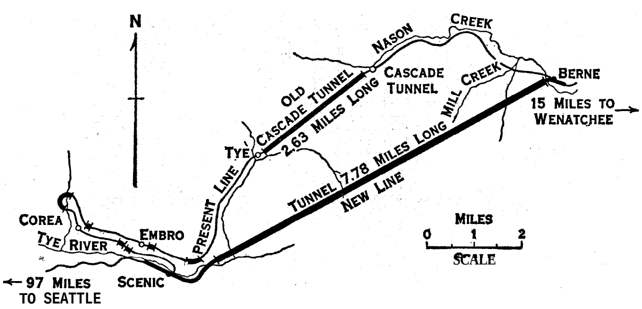


FIG. 3.— MAPSHOWING NEW AND OLD TUNNEL IN THE CASCADE MOUNTAINS, STATE OF WASHINGTON, U.S.

tunnel, 66 ft. to one side and parallel with the main tunnel, was also driven, from which cross drifts were driven at 1,500 ft. intervals. This provided a number of points of attack and ensured proper ventilation and drainage. The pioneer heading has a width and height of 10 ft. and was advanced 984 ft. in one month. The pioneer heading was holed through in May 1928 and the main tunnel was completed during the same year and put in operation Jan. 12. 1929. The power used in construction was 2,300 v., 60-cycle, 3-phase current. The total compressor capacity was 10,450 cu.ft. of free air per minute. Haulage in the headings was by 6-ton, 250-v. trolley locomotives, and for the full section 20-ton locomotives. The locomotives were equipped with gathering reels, which allowed their working 500 ft. beyond the suspended trolley. The line speed of the skip hoists at the shaft was 900 ft. per minute. A total force of about 1.800 men was employed, and because of the site's distance from any settlement, complete camps with cottages, schools, recreation halls, stores and shops were provided, equipped with water supply, electric lights, sewers and modern plumbing.

Notable English railway tunnels of early date include those under the Thames, the Severn and the hfersey rivers. In 1825 Marc I. Brunel began and in 1843 completed, after several suspensions of operations, the Thames tunnel between Rotherhithe and Wapping. It mas constructed for a highway. but was never used for that purpose. It was sold in 1866 to the East London railway, which operated its trains through it. This early tunnel, built of brick in the form of two arches with frequent openings between them, has a length of 1.200 ft. and required an excavation opening 27 ft. in width, which is still one of the widest ever built under such conditions. Brunel employed a peculiar form of shield, made of timber. in several independent sections. Part of the ground penetrated was almost liquid mud, and the cost of the tunnel was about £433 per linear foot.

The Severn tunnel. 4.33 mi. in length for a double line of railway, was begun in 1873 and finished in 1886. At the lowest part the depth of water was 59 ft. at low water and 104 ft. at high water, and the thickness of sandstone over the brickwork was 45 ft. Under a depression in the bed of the river on the English side there is a cover of only 30 ft. of marl. Much water was met throughout. In 1879 the works were flooded for months by a land spring on the Welsh side of the river and on another occasion from a hole in the river bed at the Salmon pool. This hole was filled with clay and the work completed beneath. The total amount of water raised at all the pumping stations was about 27,000,000 gal. in 24 hours.

The length of the railway tunnel under the Mersey between Liverpool and Birkenhead is 1 mi. between the pumping shafts on each side of the river. From each a drainage heading was driven through the sandstone with a rising gradient toward the centre of the river. This heading was partly bored out by a Beaumont machine to a diameter of 7 ft. 4 in. and at a rate attaining occasionally 195 ft. per week. All of the tunnel excavation, amounting to 320,000 cu.yd., was done by hand labour because heavy blasting would have shaken the rock. The minimum cover is 30 ft. betneen the top of the arch and the bed of the river. Pumping machinery is provided for 27,000,000 gal. per day, which is more than double the usual quantity of water. The firm of Brunlees and Fox was the engineers and the firm of Waddell the contractors. The work took six years and was completed in 1886.

The earliest of what was to become a maze of tunnels in and around New York city was built in 1837 as part of the New York and Harlem railroad. The actual tunnel was only about three blocks long at 91st street and can no longer be distinguished from New York's Park avenue tunnel, which was mostly open-cut but was later covered through the metropolitan area. Another historic American tunnel is the Hoosac tunnel, built in connection with the proposed construction of a canal from Boston to the Hudson river and later developed as a railroad. This tunnel, on the line of the Fitchburg railroad, was the first prominent tunnel in America and for many years the longest (4.73 mi.). It was begun in 1855 and finished in 1876 after many interruptions. It was memorable for the original use in America of compressed air drills and nitroglycerin, mechanical drilling being adopted in 1866.

Perhaps the most famous American railway tunnels of all are the Hudson river tunnels, the earliest of which uere constructed for'railways coming into New York city. The first of the Hudson river tunnels was started by D. C. Haskin and ran from Hoboken, N.J., to Morton St., New York city. This tunnel mas to be of two tubes, each 16 ft. wide by 18 ft. high. In June 1880 the northerly tube had reached 360 ft. from the Hoboken shaft. The compressed air blew a hole through the soft silt of the roof at this spot, and the water entered, drowning 20 men. With British capital and largely under the direction of British engineers, Sir Benjamin Baker and E. W. Moir, the northerly tunnel was extended 2,000 ft. to about three-fourths of the way across, but in 1891 the tunnel was allowed to fill with water and it so remained for ten years. Both tubes were completed in 1908, under the direction of Charles M. Jzcobs, engineer. In the meantime two others were started crossing under the Hudson from beneath the Pennsylvania railroad station in Jersey City to Cortlandt St., New York, and connecting tubes on the New Jersey side paralleling the Hudson river. These tunnels, forming parts of the Hudson and Manhattan railroad system, were put in operation in 1910 under electric traction by third rail. In addition to these Hudson river tunnels, a number of other tunnels of marked importance have been built under the East and Hudson rivers at New York. They are divided into two groups, those built as part of the Pennsylvania-Long Island railroad system, and those forming parts of the rapid transit system built by the city of New York.

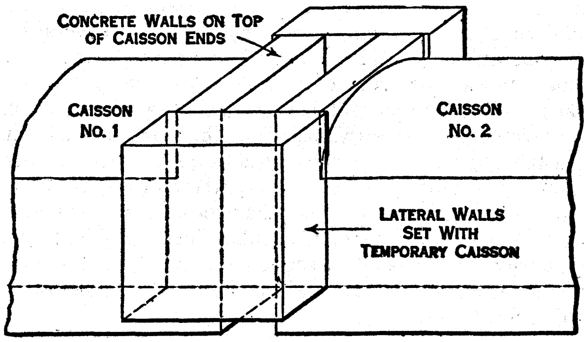


FIG. 4.— PERSPECTIVE SHOWING MANNER OF ENCLOSING SPACE BETWEEN TUNNEL CAISSONS FOR THE METROPOLITAIN UNDER THE SEINE AT PARIS

Railroads created the major demand for tunnels. It has been estimated that probably 4,000 or 5,000 railway tunnels had been built by mid-20th century, including some of the longest tunnels in the world, such as the Mont Cenis, St. Gotthard, Simplon and Lotschberg in the Alps, the Hoosac, Moffat and Cascade in the mountains of the United States. On mountain railways, tunnels often form a large percentage of the length; on one Mexican railway in a distance of 66 mi. there are 21 tunnels; on the Southern Pacific, 11 tunnels in 2j mi., including a spiral tunnel; and many other examples of this kind could be cited.

Subways and Rapid Transit. — With the growth of the modern city and the tremendous concentration of population, mass transportation became a great problem. While there are several forms of mass transportation, none has been more important in the large cities than the subways or rapid transit lines below the surface. This form of transportation is sometimes difficult to differentiate from railroad transportation, but the modern subway is so much a distinctive part of the modern city that it seems to deserve a special consideration. London was the first great city to recognize the advantages of subways, and its first underground line represented the beginning of the subway era. The first project of this nature for city traffic was authorized by parliament in 1856, and the first section of tunnel opened for traffic in Jan. 1863. It consisted of $3\frac{3}{4}$ mi. of 4-track railway in a tunnel of brick construction, 17 ft. high and $28\frac{1}{2}$ ft. wide. Many more such projects were to follow, and by 1939 the London underground network included about 96 mi. of tunnels for railways, mostly operated by electric traction. Most of those constructed after 1890, comprising about 50 mi. of double-tube railways, were tunnelled through clay by the use of cylindrical shields and have linings of cast-iron plates. The tubes are generally small, from 10 to 12 ft. in inner diameter, but shields about 23 ft. in diameter were used in constructing the stations on the Central London railway, and one 32 ft. 4 in. in diameter and only 9 ft. 3 in. long was used for a short distance on the Clapham extension of the City and South London railway. The first of the London tube railways to be built was 3.5 mi. of the City and South London, from the Bank under the Thames to Stockwell, built by J. H. Greathead and started in 1886. It was on this project that Greathead first combined the use of the shield and compressed air as a method of earth tunnelling, a combination almost universally used thereafter. When this first section went into operation in Dec. 1890, it added another first to its other distinctions, that of being the first electrically operated underground railway in the world.

The District subway of Glasgow, Scot., consists of a double-tube line in the form of a loop, connecting Partick and the northern districts with the centre of the city. It has a length of 6.5 mi. and consists in large part of circular tubes, 11 ft. internal diameter, built as tunnels, lined with cast iron and driven with a shield and compressed air. The line crosses twice beneath the Clyde. Work was begun in 1891 and the line opened to traffic in 1897.

Paris, Berlin and Moscow are other large European cities with extensive and well-known subway systems, many built as tunnels or subsurface cut-and-cover construction. Paris has an extensive system of underground railways, the Métropolitain, approximately 100 mi. in length in the 1950s, portions of which were built as tunnels and a considerable number of which were constructed under the engineering direction of F. Bienvenue. The first line was built in 1898, from Porte Maillot to Porte de Vincennes, and other lines followed at later dates. Instead of using completely cylindrical shields and cast-iron walls as in London, roof shields (*boucliers* de voute) were employed for the construction of the upper half of the tunnel and masonry walls were adopted throughout. In general, the upper half of the tunnel was executed first and the lower part completed by underpinning.

The tunnels of the Métropolitain of Paris under the two arms of the Seine, between Place du Chdtelet and Place St. Michel, tvere made by means of compressed-air caissons sunk beneath the river bed. They were built of plates of sheet steel and masonry, with temporary steel diaphragms in the ends, filled with concrete, making a cross wall with a level top about even with the outside top of the tunnel and about 2 ft. below the bottom of the Seine. The

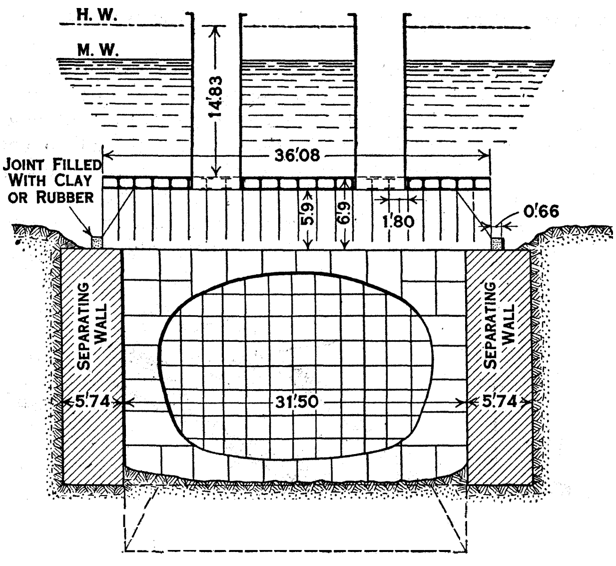


FIG. 5.— TRANSVERSE SECTION OF COFFERDAM SUPERIMPOSED OVER JOINTS BETWEEN CAISSONS IN TUNNELS FOR THE MÉTROPOLITAIN UNDER THE SEINE

caissons were sunk on the line of the tunnel so that adjacent ends and the walls just described were nearly 5 ft. apart (at that stage), with a core of earth between them. Side walls joining the end walls, and thus enclosing the earth core on four sides (fig. 4), were next made, by the aid of temporary small caissons sunk through about 26 ft. of earth under the river. The tops of the side walls were made even with the end walls. A steel rectangular cofferdam (figs. 5 and 6) was sunk to rest with rubber or clay joint on these surrounding walls. The cofferdam had shafts reaching above the surface of the water, so that the earth core was easily taken out in free air, after removing the water. The adjacent chambers under the caissons were then connected. Three caissons, of a total length of 396 ft., were used under the large arm and two, of an aggregate length of 132 ft., under the smaller arm of the Seine. Construction was started in 1905, and operation was begun in Jan. 1910.

New York, Boston, Philadelphia and Chicago are among large U.S. cities with subway systems. Boston was the first, starting in 1895 with the first section of its subway system, which consisted of 1½ mi. of mostly double-track and some four-track construction. Part of this was tunnel with roof shields, but large portions of it were cut-and-cover construction. It was opened to operation in 1898. New York is said to have the biggest subway network of any city in the world. The development of this great system began with an experiment, the old Beach tunnel of 1869 and 1870, although it was not until 1900 that the first contract was awarded for the construction of an actual underground line. There followed several decades in which New York city was the centre of the greatest tunnel building program that the world has ever seen. By 1937, there were 9 individual tunnels under the Hudson river and 1 under construction, 7 under the Harlem river, 26 under the East river and 2 under construction. These figures include not only rapid transit tunnels but also railroad, highway, large gas and water tunnels.

Next to New York, Philadelphia probably has the most extensive subway system in the United States. This was started with the Market street subway, a section of which began in 1903 and was completed in 1908. The Broad street subway followed, constructed over the period from 1915 to 1930. One of the unusual features of the Philadelphia subways is the extensive pedestrian passageways and concourses connecting the various subway stations and downtown office buildings, stores, hotels and banks, so that it is possible to traverse Philadelphia's underground city for six or seven blocks in any direction in the central business district.

Highways and Vehicular Tunnels. — The coming of the automobile brought on the most modern phase of land transportation and an unparalleled highway building program which in the latter 1950s was only mounting up to a peak. While highways do not have the limitations on grade which characterized canals and even railways, there have been many tunnels built in connection with road construction. However, it is one of the later phases of highway development, the superhighway, designed to handle large volumes of traffic at high speed. that again promised to make tunnel building a major consideration.

The earliest tunnel in recorded history, that built by a Babylonian king under the Euphrates river, would have to be classified as a highway tunnel, as it provided for the passage of chariots and pedestrians beneath the Euphrates river. Likewise, the first attempt at tunnelling the Alps was for a highway tunnel, a considerable length of which was built; and, even though it was never completed, it should also be considered in this classification. The earliest tunnel in London, started by M. I. Brunel in 1825, was intended for a highway, but was never used for such, being converted in 1866 to a railway tunnel.

In 1890–93 a shield-driven vehicular tunnel was constructed of sand and gravel across the Clyde in Glasgow, Scot. It consists of three parallel cast-iron tubes with an internal diameter of 16 ft., the centre one being a footway and the outer tubes for vehicles in each direction. The footway is reached by inclined ramps and stairs, but the vehicles are lowered and raised by elevators in shafts of 76 ft. inside and 80 ft. outside diameter. The distance between shafts is 700 ft. The cost was £287,000. The tunnel was not at first a financial success because of competition from a municipal ferry but its use, though interrupted, was later resumed.

The Blackwall tunnel, under the Thames about 6 mi. below London bridge, was built in 1892–97 through clay and 400 ft. of water-saturated gravel. The tunnel is about 3,116 ft. long, the external diameter 27 ft. and the internal diameter 24 ft. 3 in. The shield, 19 ft. 6 in. long, contained a bulkhead with movable shutters, as foreshadowed in Baker's proposed shield (fig. 8). There are a roadway 16 ft. wide for vehicles and two footwalks 3 ft. wide. The maximum grade is 2.78%.

The Rotherhithe tunnel, under the Thames about 2.25 mi. below London bridge, provides for a vehicular roadway 16 ft. wide and two footwalks 4 ft. 8 in. wide. It has a length of 4,863 ft. between portals, of which about 1,400 ft. are directly under the river. The exterior diameter of the tunnel is 30 ft. and the interior 27 ft. The maximum grade is 2.7%. It is constructed of cast-iron rings and concrete lining, and a shield and compressed air were used. It was begun in 1904 and finished in 1908. The top of the main

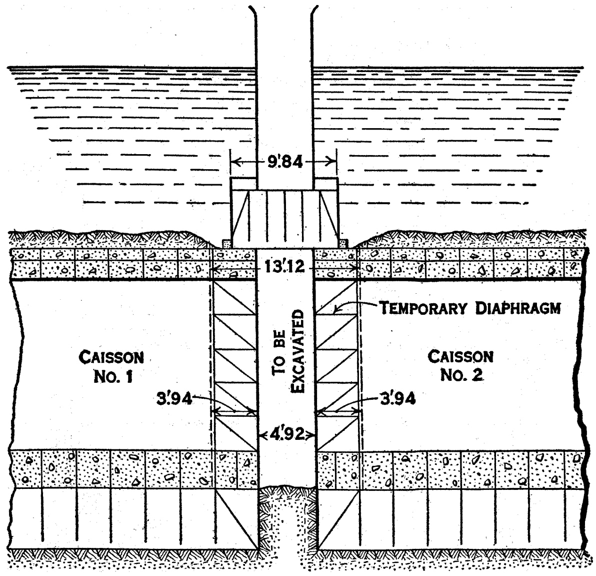


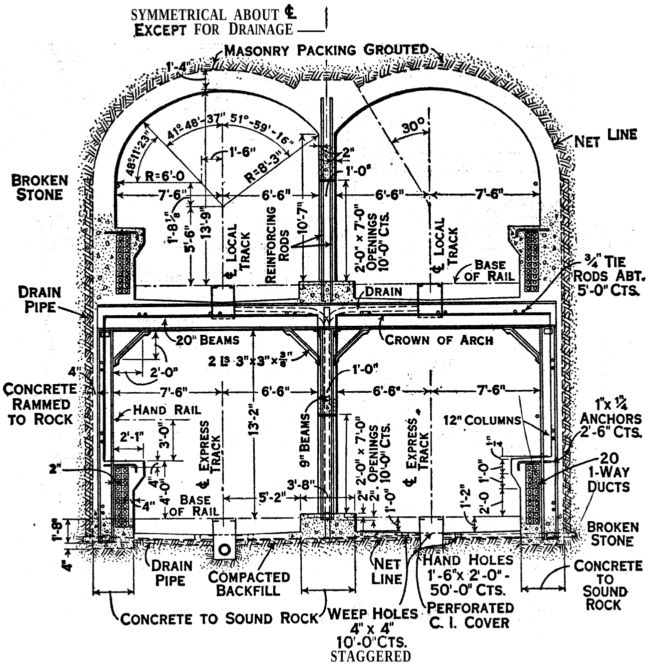
FIG. 6.—LONGITUDINAL SECTION OF COFFERDAM SHOWN IN FIG. 5

tunnel excavation in the middle of the river was only 7 ft. from the bed of the Thames, and a temporary blanket of filled earth, usual in similar cases, was prohibited because of the close proximity of the docks.

In 1914 a highway tunnel, started in 1907 and very similar to that at Glasgow, was completed in sand beneath the Elbe river at Hamburg, Ger. Access is here also obtained by elevators, in shafts 1,471 ft. between centres. The shafts are 72 ft. inside and 84 ft. outside diameter and each contains four elevators for vehicles and two for foot passengers. The lift is 78 ft. Each of the two tubes between shafts provides for a single roadway 6 ft. uide and two footwalks 4 ft. wide. The tubes are of cast iron, 19.7 ft. external diameter and the clear width inside is 14.8 ft. The lining is concrete faced with decorative tiles.

The notable Holland tunnels connect Canal street, New York city, with Twelfth street, Jersey City, passing beneath the Hudson river (see HOLLAND AND LINCOLN VEHICULAR TUNNELS). They comprise two tubes 1.61 mi. in length between the portals. Except for land approaches, they consist of circular cast-iron rings, 29 ft. in exterior diameter. They are solely for motor-propelled vehicular traffic, and each tube provides for two lines of traffic in one direction only, with a roadway width of 20 ft. The tubes beneath the river were driven with shields under compressed air. The maximum grade with traffic is 4%, and against traffic, 3.6%, both on the New York side of the river. The roadways are paved with granite blocks, and the clear headroom is 13 ft. 6 in. The interior walls are covered with glazed ceramic tile, and the tubes are brilliantly lighted by electricity. The entrance and exit portals are separated at each end by two city blocks, and large plazas are provided to prevent traffic congestion. Artificial ventilation is provided. The tunnels have fire fighting equipment, water lines, sand boxes, telephones, traffic signals, wrecking equipment, etc. A footwalk is provided for policing and inspection, but the tunnels are not open to pedestrians. Power for the equipment is obtained from two independent sources on each side of the river and three independent cables from each source of supply. Each cable has a capacity sufficient to carry the full load. It was estimated that the tunnels would have a traffic capacity of 1,900 vehicles per hour for each tube. About 52,000 vehicles have used the tunnels in a single day, without reaching their capacity. Construction began in 1920, and the tunnels were dedicated on Nov. 12, 1927. The cost of construction and real estate was about $48,000,000. Tolls are collected.

The Mersey river vehicular tunnel between Liverpool and Birkenhead, Eng., is the largest subaqueous tunnel in the world, having an outside diameter of 46 ft. 3 in. and inside diameter of 44 ft. The main roadway is formed at about the diameter line of the tunnel and provides for four lines of mechanically propelled traffic



BY COURTESY OF N.Y. CITY BOARD OF TRANSPORTATION

FIG. 7.— TYPICAL FOUR-TRACK TUNNEL IN ROCK

on a width of 36 ft. A narrow footwalk for patrol purposes is provided on each side. The whole of the upper part of the tunnel is exposed to view, there being no separate duct for the exhaust air, experiments having established this as unnecessary except near each exhaust shaft. Below the main roadway, in the portion of the tunnel under the river, there is space for a future roadway for two lines of traffic. The fresh air supply ducts are also located under the roadway. The bottom of the under-river tunnel at its deepest point is 170 ft. below high water. The distance between shafts on each side of the river is 1,735 yd., and the total length of main tunnel and branch tunnels is 2.62 mi. The branch tunnels have an inside diameter of 26 ft. 6 in., and only provide for two lines of traffic. They have a length of .6 mi. The gradient is 1 in 30. The capacity of the tunnel is 4,150 cars per hour, 100 ft. apart and moving at 20 m.p.h. At this speed the time required to pass through the tunnel is 6½ min. About 82,000 tons of cast iron were used in lining the tunnel, which was opened to traffic July 18, 1934. The total cost of construction, including land, but excluding interest charges during construction, was £6,919,000.

The vehicular tunnel beneath the Detroit river, from Detroit, Mich., to Windsor, Can., was started in 1928. It consists of one tube, 0.95 mi. long between portals, with an inside diameter of 28 ft. 4 in. The portion beneath the river, 2,500 ft. long, was built by the subaqueous trench method as in the case of the Michigan Central tunnel at Detroit and the second Harlem river tunnel at New York. The land portions, 1,000 ft. and 500 ft. in length, were shield-driven. The estimated cost was $10,000,000. Because of the international character of this tunnel, it was necessary not only to provide for collection of tolls but for customs and immigration inspection, which requires unusual plaza facilities at both ends of the tunnel.

The largest-diameter tunnel built by the subaqueous trench method is the Oakland-Alameda estuary tube, in California. It is a single tube, 0.67 mi. in length between portals, of which 2,436 ft. is made up of 12 sections of tubes, each 203 ft. long, sunk in a dredged trench, with a depth of water over the tubes of 42 ft. The tube sections present the novelty of being made of reinforced concrete, 37 ft. external diameter, with a shell thickness of 30 in., and they are enveloped with a membrane of three-ply waterproofing. They were cast in forms in a dry dock at San Francisco, then floated to position and sunk. The tunnel has a roadway for vehicles that is 23 ft. wide and also has footwalks that are protected by railings. The cost was estimated at $4,500,000 or about one-half the estimated cost if done by the shield method.

The Liberty, Pa., vehicular tunnels penetrate the south hills at Pittsburgh and, connect with the Liberty bridge over the Monongahela river. They consist of two parallel tunnels, 59 ft. between centres, each 26 ft. 7 in. wide, and 1.1 mi. long. Each tunnel provides a single line of street railway track not installed and two lines of vehicular traffic on a roadway 21 ft. wide. There is also a footwalk, 4 ft. wide, in each tunnel. The tunnels are lined with concrete 24 in. thick. The alignment is straight and the grade continuous at the rate of 0.392%. The work was begun in 1919 and completed about three years later. The total cost was about $6,000,000. For tunnels of their size, unusually rapid progress was made in excavating, largely because of a bonus system of paying the workmen. Eleven hours' pay was allowed for 9 ft. advance of excavation and 12 hours' for 10 ft., whether consumed or not. There was also sharp rivalry between the forces in the two tunnels, and the men completing their shift first were allowed to display an American flag at the entrance the following day, while their competitors were compelled to display a black flag. The average rate of advance per day in the tunnels was more than 10 ft. for a period of several months.

On superhighways, large volumes of high-speed traffic necessitate better alignment and flatter grade, approaching the requirements imposed by canals and railroads. The first section of the Pennsylvania turnpike made use of abandoned railroad tunnels through several ridges of the Allegheny mountains. The Goat Island tunnel linking the East bay and West bay crossing of the San Francisco bay bridge deserves special mention. This tunnel provides for a double-deck, two-lane highway and was 76 ft. high and 58 ft. wide in the rough, being 52 by 66 ft. inside its concrete lining. It has the largest cross section of any tunnel in the world, although its width is exceeded by the Rove canal tunnel. Another large highway tunnel of the western United States is the Waldo tunnel, 46½ ft. wide, 29 ft. high inside the concrete lining, and 4 mi. long, designed to provide for three northbound traffic lanes on route 101 in Marin county, Calif.

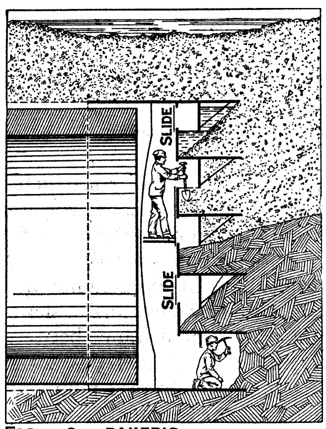
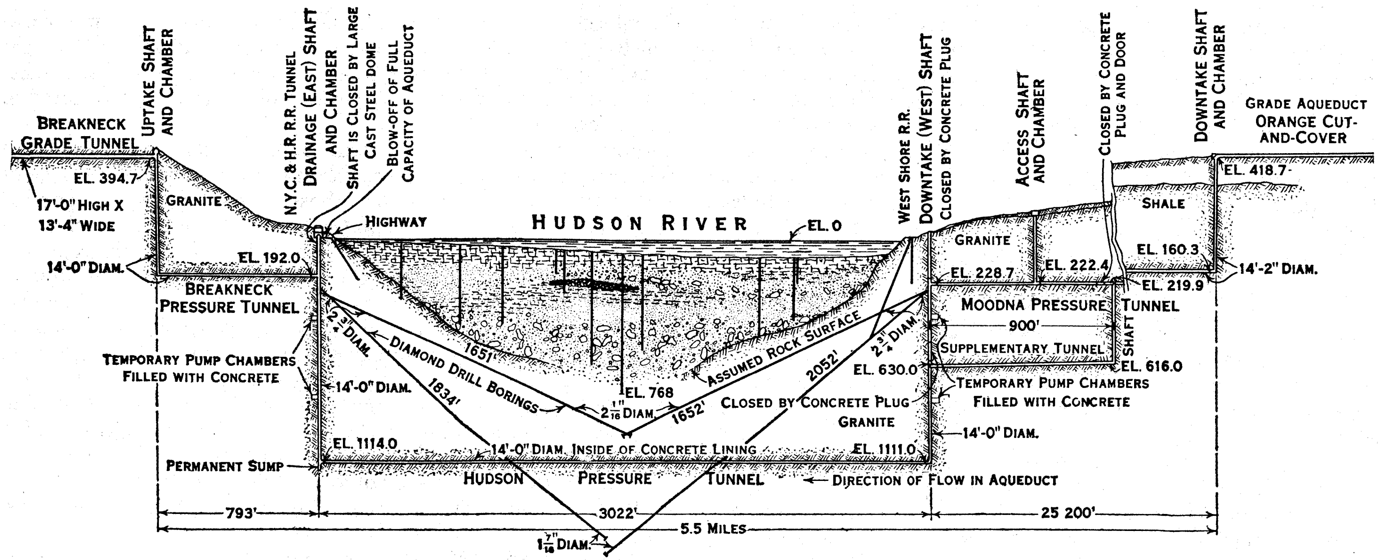


FIG. 8.—BAKER'S PNEUMATIC SHIELD

Aqueducts and Utilities.— Tunnels for conveying water are among the earliest tunnels of which there are any records. Reference has already been made to the tunnel built by King Hezekiah to supply water to the city of Jerusalem and to the water tunnel on the Island of Samos, both of which antedate the Christian era. Examples of the Roman aqueducts and drainage tunnels have also been previously noted; remains of Roman aqueducts are still scattered through Europe and Asia. In more modern times the use of tunnels for water supply and for disposal of municipal waste has become such an everyday occurrence that it is virtually impossible to compile anything like a complete record either as to the amount of tunnelling activity or the magnitude of the various projects. Many cities, both large and small, have become involved in such projects as a necessary part of supplying the public service required in any modern city. Many miles of tunnels have been built under the Great Lakes by Chicago, Detroit, Cleveland, Milwaukee and other cities. Gen-



BY COURTESY OF N Y CITY BOARD OF WATER SUPPLY

FIG. 9.— CROSSSECTION OF THE HUDSON RIVER CROSSING OF THE CATSKILL AQUEDUCT. LOOKING DOWNSTREAM. SHOWING THE LOCATION OF THE TUNNEL AND THE DIAMOND-DRILL BORINGS MADE TO EXPLORE THE ROCK TO DETERMINE ITS LOCATION

erally speaking, these tunnels are to serve as raw water conduits from intakes well out in the lake. or they serve as outfall sewers for disposing of municipal waste far enough from shore to eliminate nuisance and health hazards. Many of these tunnels, particularly those in plastic clay, were built by ordinary mining methods in the early days, nith or without the use of compressed air. Later, shield-driven tunnels became the more common, but they too may involve a combination of both shield and compressed air.

Both the largest and longest aqueduct tunnels are those supplying water to the city of New York. They also present the novelty of sinking to great depths below the hydraulic grade line and rising again to that line to pass beneath river gorges, which are crossed at many points, and also to pass beneath the entire length of Manhattan Island. This introduces an internal or bursting pressure in the tunnel, which is called "a pressure tunnel."

The Croton aqueduct, from the Croton dam to the gatehouse at 135th street, constructed 1885–90, forms a tunnel 31 mi. long and includes an inverted siphon or pressure tunnel, passing beneath the Harlem river. A number of short sections were built in open excavation and then covered over.

The Catskill water-supply system, extending from the Catskill mountains to New York city, a distance of about 160 mi., consists in large part of tunnels which at the time of their construction were both the largest tunnels for such purpose and the longest tunnels for any purpose in the world. All are concrete lined. There are 25 tunnels on the hydraulic grade with a total length of 32 mi., including the tunnel beneath the Shanddken mountains, 18.1 mi. long, about 40 mi. S.W. of Albany, N.Y., built by the city of New York (1917–24). It has a horseshoe section 11 ft. 6 in. high by 10 ft. 3 in. wide and was then the longest continuous tunnel in the world for any purpose. Seven shafts were used in constructing this tunnel. There are also seven pressure tunnels crossing beneath river valleys. including that beneath the Hudson river from Storm King to Breakneck mountain, at a depth of 1,114 ft. below sea level. It is 14 ft. internal diameter and 3,022 ft. between the shafts on either side of the river. (See fig. 9.) The total length of the Catskill aqueduct pressure tunnels exclusive of the city aqueduct tunnels is 17 mi., and they are from 14 ft. to 17 ft. 6 in. in diameter. The city aqueduct tunnel extends from Hillview reservoir, beneath the Harlem river and nearly the entire length of Manhattan Island and the East river, to shafts in Brooklyn. a distance of 18 mi. To provide resistance to the bursting pressure of the water and also watertightness, it was placed in the rock from 200 to 750 ft. below the surface of the streets beneath which it was built. It was driven from 25 shafts: averaging 4,000 ft. apart. The work of constructing the Catskill aqueduct system, including the reservoirs, the City tunnel and the Shandaken tunnel, occupied from 1905 to 1926.

In 1920, a tunnel 4.j mi. long, 9 ft. wide and 9.5 ft. high was begun in the Alps of Switzerland to convey water to a hydroelectric plant. The Nevada irrigation tunnel is 4.1 mi. long and has a cross section 9 by 9 ft. It was completed in May 1928 at a cost of $1,500,000.

One of the most unique tunnel systems in the world developed in connection with public utilities are the little-known freight subways under the city of Chicago. These tunnels were first undertaken for communication tunnels to carry telephone and telegraph lines beneath the surface, but being too expensive for this purpose, were later taken over by the Illinois Tunnel company and devoted to the transportation of freight between the large buildings in the business district. Ultimately, the system included 62 mi. of such tunnels with a rolling stock of about 3,300 small cars and 150 electric locomotives. It is a little railroad empire all its own, busily shuttling its freight and express back and forth under the city.

Tunnel activities of the western United States include such projects as the Gunnison irrigation canal: the Boulder (Hoover) dam diversion tunnels. and the power development tunnels of southern California and other Pacific coast aqueducts, including the famous Hetch Hetchy water supply project for the city of San Francisco. The Gunnison tunnel, built between 1905 and 1910, is about 6 mi. long and is 11 ft. wide and 10 ft. high inside the concrete lining, and somewhat larger in unlined rock portions of the tunnel. The Boulder diversion tunnels were really unusual in dimensions and the quantities of rock excavation and concrete involved in their construction. There were four such diversion tunnels, 56 ft. in diameter and approximately $\frac{3}{4}$ mi. long, which is a cross section exceeded only by the Rove canal tunnel and the Goat Island tunnel. The Boulder dam conversion tunnels were built in 1931 and 1932. Another noteworthy tunnel project was the Ward tunnel built by the Southern California Edison company in connection with a gigantic water power project. It included six large dams, eight tunnels and five power plants, including the $13\frac{1}{2}$ mi. Ward tunnel, which was 15 ft. in diameter, built between 1920 and 1925.

Of the Pacific coast aqueducts, those built in connection with the Hetch Hetchy water supply project for the city of San Francisco are the most impressive. This project, started in 1914 and completed in 1934, involved several series of tunnels through coastal mountain ranges. One division, known as the Mountain division. contained 19 mi. of tunnel: the Foothills division, $15\frac{3}{4}$ mi.; and, the Coast Range division. $28\frac{1}{2}$ mi. including a 25-mi. tunnel which, when built, was the longest continuous tunnel in the world. These tunnels mere mostly in rock, approximately $13\frac{1}{2}$ by 14 ft. unlined. Another large project of the Pacific coast is the Colorado river aqueduct built by the city of Los Angeles, which includes a total of 392 mi. of aqueduct, of which 108 mi. is tunnel, with an additional 55 mi. of cut-and-cover construction.

DESIGN AND CONSTRUCTION

Tunnel building as it has developed over the centuries since the first tunnels of recorded history may be regarded as an art rather than a science. representing. as it does, a gradual accumulation of experience gained in actual construction. The first tunnelling was in rock or other materials which were largely self-supporting and presented few problems other than the excavation to provide room for passage or other uses to which the tunnel was put. However, as tunnel projects became more and more ambitious, tunnel builders became aware of definite limitations imposed by the character of the material which was being excavated and other environmental conditions that were encountered.

Tunnels in Rock.—Early tunnels were in rock or earth masses of sufficient resistance to permit open mining, which for many years was carried on by crude and slow hand methods. Tunnelling through great mountains brought out a number of problems that the earlier tunnel builders had scarcely realized. Even in rock, temporary bracing and permanent linings were sometimes required to resist the great pressures, and tremendous quantities of ground water at high temperatures were encountered at great depths under the mountains. In the longer tunnels, ventilation became a serious problem. both during construction and the later operation of the tunnels. Gradually it was realized that even the most rigid materials would tend to flow like a plastic solid, provided the pressures exerted were sufficiently high. Even at mid-20th century there was much remaining to be done in the solution of the problem of stresses around such rock cavities, and the fundamental principles involved have not been well established.

There are two general approaches to the problems of the stresses around a tunnel, either in rock or in the less resistant earth masses. The first approach, which may be considered more highly theoretical, is based on the classical theory of elasticity and treats the earth or rock mass as an elastic medium in which it is assumed that the stresses are independent of the depth of overburden or weight above the tunnel. The second approach, which may be referred to as the rational method of design, considers that the weight of the overlying rock is a controlling consideration, and the equivalent vertical pressure acting on the horizontal projected area of the tunnel must be redistributed without exceeding the resistance of the mass surrounding the tunnel. Any pressure in excess of this limit must be carried by the lining. either temporary or permanent as the case may be. As in all problems of plastic flow, the rate of squeezing or displacement may be sufficiently slow as to permit a much lighter temporary lining than will be required to resist the pressure of the earth over much longer periods of time involved in the case of the permanent lining.

Tunnels in Earth.— The major difference which is immediately apparent in earth tunnelling is the relatively low resistance to the induced stresses and the almost universal necessity for continuous support placed concurrently aith the excavation operations. It is only in relatively shallow tunnels through the stiffest clays that unsupported tunnel openings may be made, even for short periods of time. The earliest methods of support included tunnel liner and bracing of timber. cast iron. steel or masonry, and permanent linings usually of brick, masonry or monolithic concrete. The introduction of shields and compressed air, used sometimes separately but usually in combination, made it possible for tunnelling to be successfully carried out even in the softest silts and clays. In cases of sand or gravel, or other permeable materials, ground water becomes a very serious problem, but here, too, shields and compressed air are effective means of protecting the tunnel excavation. In all tunnels, but particularly in earth tunnels, natural gases which may be encountered must be recognized as a contingent hazard. and there have been many examples of serious accidents from explosions or from lethal gases which may be encountered in the underground.

From the standpoint of design, earth tunnels present the same problems in principle, but the magnitude of the pressures dealt with may be much greater than those encountered in comparable rock tunnels. Both the theoretical and rational approaches referred to above are employed, and, while the modern science of soil mechanics has made considerable progress with these problems, much further development is needed. However, it should be emphasized that what is referred to by some writers on tunnels as "that most peculiar and dreaded phenomenon known to tunnel men as swelling ground" or squeezing rock, is not nearly as much of a mystery as may have been indicated in the past. This phenomenon is nothing more or less than the necessary result of a combination of pressures which are much too great to be redistributed by the materials involved. While the problems are difficult, they are not mysterious and uncontrollable as one might be led to believe.

Construction Methods.—In the history of tunnel-building (above) much has been said about construction methods. Some of the more important methods, with some examples not previously presented, are now summarized below.

Shields and Compressed Air.—In 1818 *M.* I. Brunel took out a patent for a tunnelling process which included a shield and mentioned cast iron as a surrounding wall. His shield foreshadowed the modern shield which is substituted for the ordinary timber work of the tunnel, holds up the surrounding earth during excavation, affords space within its shelter for building the permanent lining in telescope fashion, and is moved forward by pushing against the front ends. The advantages of cast-iron lining are that it has great strength in small space as soon as the segments are bolted together and its joints can be caulked watertight.

In 1830 Lord Cochrane, afterward the 10th earl of Dundonald, patented the use of compressed air for shaft sinking and tunnelling in water-bearing strata. Water under any pressure can be kept out of a subaqueous chamber or tunnel by introducing sufficient air of a greater pressure, and men can breathe and work therein—for a time—up to a pressure exceeding four atmospheres. To confine the compressed air, it is necessary to provide a substantial bulkhead across the workings. To pass men and materials through the bulkhead, there is a mechanical device (lock)—a large steel tube with doors at each end, both of which open inward toward the working chamber, and both of which can never be opened at one time because of the difference in air pressure between that in the working chamber and that back of the bulkhead. Valves are provided to admit compressed air to the lock from the working chamber, and also to exhaust it from the lock to back of the bulk. head, in order to manipulate the doors. Compressed air was first used in tunnel work by Hersent, at Antwerp, Belg., in 1879, in a small drift with cast-iron lining. In the same year compressed air was used for the first time in any important tunnel by D. C. Haskin in the famous first Hudson river tunnel from Hoboken, N.J., to Morton street, New York city.

The use of compressed air in the first Hudson tunnel and of annular shields and cast-iron lining in constructing the City and South London railway (1886–90) by Greathead became widely known and greatly influenced subaqueous and soft-ground tunnelling thereafter. The pair of tunnels for this 'railway from the Bank under the Thames to Stockwell, from 10 ft. 2 in. to 10 ft. 6 in. interior diameter, were constructed mostly in clay and without the use of compressed air, except for a comparatively short distance through water-bearing gravel. In this gravel a timber heading was made, through which the shield was pushed.

The St. Clair river tunnel from Sarnia, Ont., to Port Huron, Mich.. was built in 1889–90 through clay, and for a short distance through water-bearing gravel. It is 1.14 mi. in length and 21 ft. external diameter. This tunnel was the first one completed in America in which were used all the essential elements for successful subaqueous work; *i.e.,* a shield, compressed air and cast-iron rings.

In 1891 the tunnel of the Ravenswood Gas company in New Tork cıty was started beneath the East river and Blackwell's Island from betneen 70th and 71st streets in Manhattan to Ravenswood in Long Island City. It was expected to be a rock tunnel throughout, and the section was to be 8 ft. 6 in. high and 10 ft. 6 in. wide, to provide room for two gas mains, 3 ft. and 4 ft. respectively. Soft ground mas encountered, and great difficulty was found because of the depth and ·water pressure. Compressed air was adopted, the pressure at times reaching as high as 46 lb. per square inch. Eventually, it was necessary to line the soft ground sections with cast-iron rings of 10 ft. 2 in. internal diameter. The work was completed in 1894

The East Boston tunnel, built in 1901, was the first important example of a shield-built monolithic concrete arch; it extends from the Boston subway to East Boston. It is 1 4 mi. long, 3,400 ft. being under the harbor. One mile was excavated by tunnelling with roof shields about 29 ft. wide through clay containing pockets of sand and gravel. The shields reacted against iron bars set in the concrete and moved forward on the masonry side walls.

Subaqueous Trench *Tunnels*.—In the course of adjusting methods of tunnelling to meet the wide variety of conditions that have been encountered, there has arisen one type of construction which is not tunnelling in the strictest sense of the word, but the final result is so closely related to tunnelling that it seems desirable to include it in a general discussion of the subject. This may best be described as subdqueous trench tunnels.

In 1845, De la Haye, in England. doubtless having in mind the tedious and difficult work of the Thames tunnel, proposed to make tunnels under water by sinking large tubes on a previously prepared bed and connecting them together. Thereafter many inventors proposed similar schemes. In 1866 M. F. Belgrand sank twin-plate iron pipes. 3.28 ft. in diameter and 512 ft long, under the Seine at Paris for a sewer siphon. and there have since been numerous examples of sunk cast-iron subaqueous water pipes.

It is believed that the first tunnel of this class, large enough for men to move upright in. was by H A. Carson (in 1893–94), in the outer portion of Boston harbour. for the metropolitan sewer outlet. The tubes mere about 9 ft. exterior diameter, in sections each 52 ft. long and weighing about 210,000 lb., made of brick and concrete with a skin of wood and watertight bulkheads at each end. A trench was dredged in the harbour bed and saddles were accurately placed to support the tubes. The latter. made in cradles above the water alongside a wharf, were lowered and towed $\frac{1}{2}$ to $\frac{3}{4}$ mi. to their final positions. After sufficient water had been admitted. they were lowered to their saddles by travelling shears on temporary piles. The temporary joints betneen consecutive sections were made by rubber gaskets between flanges which were bolted together by divers. The later operations were backfilling the trench over the pipes and, in each section, pumping out the water. removing its bulkheads and making good the masonry between consecutive bulkheads, this masonry being inside the flanges. This work, about 1,500 ft. in length. was done without contractors. by labourers and foremen under the immediate control of the engineers, and was found perfectly sound.

The double-track railroad tunnel at Detroit, Mich.. made in 1906–09 for the Michigan Central railroad, is 1.5 mi. long, with a portion of 0.5 miles directly under the river. A trench was dredged nith a depth equal to the vertical dimension of the tunnel below the river bed and about 70 ft. below the river surface, and grillages were accurately placed in it to support the ends of thin steel tube forms, inside of which concrete was to be moulded and outside of which deposited. These tubes, each about 23 ft. in diameter and 262.5 ft. long, were in pairs (one tube for each track) and nere joined together at intervals of 12 ft. by thin steel diaphragms surrounding the tubes. The planking, to limit the concrete, nas secured to the outside edges of the diaphragms. The tubes were made tight, bulkheaded at their ends, floated into place, sunk by admitting water, set on the grillages, and the ends of successive pairs connected together by bolts through rubber gaskets and flanges.

The first subaqueous highway tunnel in the United States was that at Washington street, beneath the Chicago river in Chicago. It is not properly a tunnel, having been built in a cofferdam. It was constructed in 1866–69 with two roadways each 11 ft. wide and 13 ft. high, and a footway 10 ft. wide and 10 ft. high. It was twice rebuilt to provide a deeper waterway. the original depth being only 14 ft. After the great fire of 1871, it formed the only means of communication between the west side and the business district pending the reconstruction of the bridges. In 1869–71 a similar roadway tunnel was constructed at La Salle street and in 1889–94 one at Van Buren street, both beneath the Chicago river. These also required rebuilding at later dates to provide deeper waterways.

Tunnelling by *the* Freezing Method.—Tunnelling by freezing the water contained in the soil and then excavating through the frozen material in a manner similar to rock has often been proposed. The method has been used for sinking shafts with a fair degree of success in a number of cases. Siberian miners have for years taken advantage of low temperatures to penetrate saturated ground to reach mineral deposits. F. H. Poetsch applied the method in 1883 in sinking a shaft in Saxony for the Archibald mine.

While fairly successful as applied to shafts, the method has rarely been used for driving tunnels. and then not with entire success. In 1884–86 in Stockholm, Swed., a tunnel for pedestrians was driven in part by the freezing method. The length of the tunnel was 758 ft., and it passed beneath a ridge dividing two parts of the city. The cross section was 12 ft. 8 in. high and 13 ft. 2 in. wide, and the material was coarse gravel with large stones and some clay. It contained water and had very little cohesion. The material was frozen by using a dry air (Lightfoot) machine delivering 25,000 cu.ft. of air per hour. The temperature of the air at the machine was $-55°$ C.

VENTILATION OF TUNNELS

Ventilation of Steam Railway Tunnels.—The simplest method for ventilating a railway tunnel is to have numerous wide openings to daylight at frequent intervals. If these are the full width of the tunnel, at least 20 ft. in length, and not farther apart than about 500 ft., a tunnel can sometimes be naturally and adequately ventilated. Such arrangements are, however, seldom practicable, especially in long and deep tunnels, and then recourse must be had to mechanical means. Not only long tunnels, but often those relatively short, require artificial ventilation when on a steep gradient, as the smoke and gases have a tendency to travel up the grade with the locomotive, which is then working at full capacity. Natural ventilation depends for its action upon the difference of temperature within the tunnel or ventilation shaft, and the outer air. In winter the draught is upward and in summer often downward. In the spring and autumn there are often periods when there is little difference in temperature and, in consequence. little circulation of air. Most steam railway tunnels are poorly ventilated, except where the difference in elevation of the ends or the prevailing winds create a natural draught through them. The need for ventilation is far greater with steam locomotion than with electric motors.

The first application of mechanical or fan ventilation to railway tunnels was made in the Lime street tunnel at Liverpool, which has since been replaced by an open cutting. At a later date fans were applied to the Severn and Mersey railway tunnels.

Where possible, the principle ordinarily acted upon, where mechanical ventilation has been adopted, is to exhaust the vitiated air at a point midway between the portals of a tunnel, by means of a shaft with which is connected a ventilating fan of suitable power and dimensions. In the case of the tunnel under the Mersey river such kind of shaft could not be provided, because of the river's being overhead, but a ventilating heading was driven from the middle of the river (at ahich point entry into the tunnel was effected) to each shore. where a fan 40 ft. in diameter was placed. In this way the vitiated air is drawn from the lower point of the railway, while fresh air flows in at the stations on each side to replenish the partial vacuum.

The principle was that fresh air should enter at each station and "split" each way into the tunnel, and that thus the atmosphere on the platforms should be kept pure. In the Mersey tunnel there are five fans; two are 40 ft. in diameter by 12 ft. wide and two 30 ft. in diameter by 10 ft. wide, one of each size being erected at Liverpool and at Birkenhead respectively. In addition there is a high speed fan, 16 ft. in diameter, in Liverpool, which throws 300,000 cu.ft. per minute. The ventilation of this tunnel was satisfactory up to a train schedule of 300 trains per day, or one each way every five minutes. As the traffic increased the air

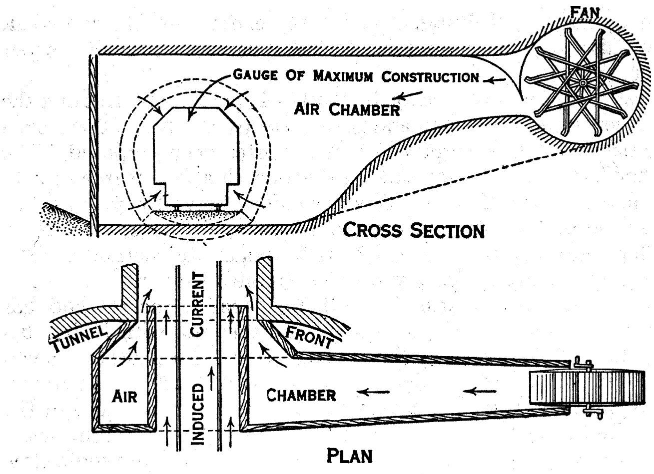


FIG. 10.— DIAGRAM ILLUSTRATING THE SACCARDO SYSTEM FOR VENTILATING TUNNELS

shaft became coated with soot several inches thick and arrangements were made to install electric power.

The central point of the Severn tunnel lies toward the Monmouthshire bank of the river and ventilation is effected from that point by means of one fan placed on the surface at Sudbrooke Monmouth, at the top of a shaft which is connected with a horizontal heading leading to the centre of the tunnel. This fan, which is 40 ft. in diameter by 12 ft. in width, removes from the tunnel some 400,000 cu.ft. per minute, and draws in an equivalent volume of fresh air from the two ends.

About 1896 an excellent system was introduced by Saccardo, an Italian engineer, which to a great extent minimized the difficulty of ventilating long tunnels under mountain ranges where shafts are not available. This system, which is not applicable to tunnels in which underground stations exist, is based upon the principie of the ejector, and is illustrated in fig. 10, which represents its application to the single-line tunnel through the Apennines at Pracchia. This tunnel is one of 52 single-line tunnels, with a gradient of 1 in 40, on the main line between Florence and Bologna. built by Thomas Brassey. There was a great deal of traffic which had to be worked by heavy locomotives. Before the installation of a ventilating system, under any condition of wind, the state of this tunnel, about 9,000 ft. in length, was bad; but when the wind was blowing in at the lower end at the same time that a heavy goods or passenger train was ascending the gradient the condition of affairs became very much worse. The engines, working with the regulators full open, often emitted large quantities of both smoke and steam, which travelled concurrently with the train. The goods trains had two engines, one in front and the other at the rear. and when, from the humidity in the tunnel due to the steam, the wheels slipped and possibly the train stopped, the state of the air was indescribable. A heavy train with two engines conveying a royal party and their suite, arrived on one occasion at the upper exit of the tunnel with both enginemen and both firemen insensible; when a heavy passenger train came to a stop in the tunnel, all the occupants were seriously affected.

In applying the Saccardo system, the tunnel was extended for 15 or 20 ft. by a structure either of timber or brickwork, the inside line of which represented the line of maximum obstruction of the tunnel, and this was allowed to project for about 3 ft. into the tunnel (fig. 10). The space between this line and the exterior constituted the chamber into which air was blown by means of a fan. Considering the length of tunnel, it might at first be thought there would be some tendency for the air to return through the open mouth, but nothing of the kind happened. The whole of the air blown by the fan, 164,000 cu.ft. per minute, was augmented by the induced current yielding 46,000 cu.ft. per minute, making a total of 210,000 cu.ft.; and this volume was blown down the gradient against the ascending train so as to free the driver and men in charge of the train from the products of combustion at the earliest possible moment. Prior to the installation of this system the drivers and firemen had to be clothed in thick woollen garments, pulled on over their ordinary clothes, and wrapped round and round the neck and over the head.

The Saccardo system was installed in 1899 at the St. Gotthard tunnel with most beneficial results. The ventilating plant is situated at Goschenen at the north end of the tunnel and consists of two large fans operated by water power. The quantity of air pressed into the narrow mouth of the tunnel is 413,000 cu.ft. per minute at a velocity of 686 ft., this velocity being much reduced as the full section of the tunnel is reached. After installation, a sample of the air taken from a carriage contained only 10.19 parts of carbonic acid gas per 10,000 volumes.

In the Simplon tunnel (12.3 mi. long), where electricity is the motive power, mechanical ventilation was installed at the time of construction at each end of the tunnel, both for construction purposes and to serve as permanent equipment. It is based on a different principle than the Saccardo system. A steel sliding door is arranged at each entrance to be raised and lowered by electric power. After the entrance of a train the door is lowered and fresh air forced into the tunnel from the same end at considerable pressure by fans. After completion of the second tunnel following World War I an additional ventilation plant was built at the north end of the tunnel.

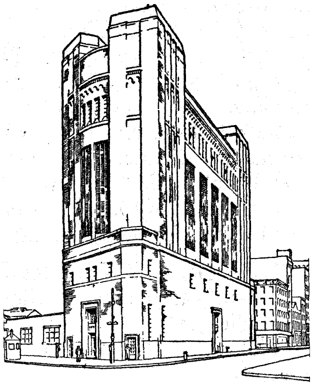
The Moffat tunnel in Colorado (6.1 mi. long) is ventilated by a mechanical plant based on the principle of forced or induced draught created at one end of the tunnel. A building was erected at the east portal which forms an extension of the tunnel and provides a fan chamber on each side. A vertical lift gate is provided to close the portal. Two fans are provided, which differ for experimental reasons. Each has a diameter of 9 ft. and a width of 6 ft. The motors are of 750 and 500 h.p. with capacities of 450,000 and 350,000 cu.ft. per minute, at velocities of 14 and 10 m.p.h., respectively. Only one fan is operated, the other held in reserve. The ventilation is by forced draught for eastbound trains and induced draught for westbound trains, which forces the smoke back along the train.

Other railway tunnels partially or completely ventilated by mechanical draft are the Giovi tunnel, in Italy; Hoosac tunnel, in Massachusetts; East Mahanoy tunnel, in Pennsylvania; Big Bend tunnel, in West Virginia; Elkhorn tunnel, in West Virginia; and the Gallitzen tunnel, in Pennsylvania.

Volume of Air Required for Ventilation of Steam Locomotive Tunnels.— The consumption of coal by a locomotive during the passage through a tunnel having been ascertained, and 29 cu.ft. of poisonous gas being allowed for each pound of coal consumed, the volume of fresh air required to maintain the atmosphere of the tunnel at a standard of purity of 20 parts of carbon dioxide in 10,000 parts of air is ascertained as follows: The number of pounds of fuel consumed per mile, multiplied by 29, multiplied by 500 and divided by the interval in minutes between the trains, will give the volume of air in cubic feet which must be introduced into the tunnel per minute.

Ventilation of Tunnels for Electric Traction.— The introduction of electric traction has simplified the problem of ventilating intra-urban railways laid in tunnels at a greater or less distance below the surface, since the absence of smoke and products of combustion from coal and coke renders necessary only such a quantity of fresh air as is required by the passengers and staff. For ventilation the shallow tunnels which form the underground portions of the Metropolitan and District railways in London, open staircases, blowholes and sections of uncovered track are relied on. When the lines were worked by steam locomotives they afforded notorious examples of bad ventilation, the proportion of carbonic acid gas amounting to from 15 or 20 to 60, 70 and even more parts in 10,000. Since the adoption of electricity as the motive power the atmosphere of the tunnels has very much improved. Samples taken from the cars in 1905 after the adoption of electricity gave as low as 11.27 parts in 10,000.

When deep level tube railways were first constructed in London, it was supposed that adequate ventilation would be obtained through the lift-shafts and staircases at the stations, with the aid of the piston action of the trains which: being of nearly the same cross section as the tunnel, would, it was supposed, drive the air in front of them out of the openings at the stations they were approaching, while drawing fresh air in behind them at the stations they had left. This expectation, however, was disappointed and it was found necessary to employ mechanical means. On the railway running from the Bank of England to Shepherd's Bush, a distance of 6 mi., the ventilating plant installed in 1902 consists of a 300 h.p. electrically driven fan, which is placed at Shepherd's Bush and draws in fresh air from the Bank end of the line and at other intermediate points. The fan is 5 ft. wide and 20 ft. in diameter, and makes 145 revolutions a minute, its capacity being 100,000 cu.ft. a minute. It is operated from 1 to 4 A.M. and, the openings at all the intermediate stations being closed, it draws fresh air in at the Bank station. The tunnel is thus cleared out each night, during the period when trains are not operated, and the air is left in the same condition as it is outside. The fan is also worked during the day from 11 A.M. to 5 P.M., the intermediate doors being open. In a number of the later tube railways in London—such as the Baker street and Waterloo, and the Charing Cross and Hampstead lines—electrically driven exhaust fans are provided at about half-mile intervals; these each extract 18,500 cu.ft. of air per minute from the tunnels and discharge it from the tops of the station roofs.



"COURTESY" N.Y. STATE BRIDGE AND TUNNEL COMMISSION

BUILDING FOR THE HOUSING OF THE MACHINERY BY WHICH FRESH AIR IS FORCED INTO THE HOLLAND TUNNEL AND USED AIR WITHDRAWN

The Boston system of electrically operated subways and tunnels is ventilated by electric fans capable of completely changing the air in each section about every 15 minutes. Air admitted at portals and stations is withdrawn midway between stations.

In the southerly 5 mi. of the first rapid transit subway at New York city, constructed between 1900 and 1904, which is a four-track structure of rectangular section, having the area of 650 sq.ft. and built as close as possible to the surface of the streets, ventilation by natural means through the open staircases at the stations was at first relied upon. The results were satisfactory as regards the proportions of carbonic acid gas found in the air, but when intensely hot weather prevailed the tunnel air was sometimes 5° hotter because of the conversion of electric energy into heat. Ventilation chambers were added on each side of the subway at points between stations, and the condition became much improved. These chambers are beneath the sidewalks and covered by gratings, and they have been incorporated in the construction of all subways built later. In addition. a partition wall separates trackways for trains running in opposite directions and the piston action of the trains induces a satisfactory circulation of the air.

Ventilation of Vehicular Tunnels.—The need of mechanical ventilation of vehicular tunnels is a development resulting from the advent of vehicles propelled by internal-combustion engines. The exhaust from such engines contains smoke and gases, which are irritating to the eyes and also contains a considerable percentage of carbon monoxide, a highly poisonous gas. The first studies of the need of ventilation for vehicular tunnels were undertaken in connection with the construction of the Holland tunnel, at New York, because of its length and the large volume of traffic which was expected to use it. At that time (1920) natural draught was relied upon for the ventilation of all such tunnels in operation, including the Blackwall and Rotherhithe tunnels in London. The traffic in them, however, was only about 100 motor vehicles per hour for each tunnel, compared with an estimated traffic of 1,900 motor vehicles per hour in each tube of the Holland tunnel. Research studies and exhaustive tests were made for this tunnel with the co-operation of the U.S. bureau of mines to determine first, the amount and composition of exhaust gases from motor vehicles; second, the physiological effects of these gases; and, third, the friction losses and power required to handle large quantities of air through concrete ducts.

In the Holland tunnel, the transverse system of ventilation was adopted. The fresh air is introduced continuously along each tube, from conduits provided for the purpose, and taken off at frequent intervals at opposite points. The air therefore travels a course transverse to that of the vehicles and there is a practically equal degree of purity at all points in the tubes. Because carbon monoxide is lighter than air and the exhaust motor gases are warmer than the fresh air introduced in the tunnel and therefore tend to rise, the fresh air ducts are placed beneath the roadways and the exhaust ducts above the roadway ceiling but all in the same tunnel tube. The fresh air is introduced in each roadway by continuous slots along each side above the floor, and the vitiated air is exhausted through louvers in the roof at 15 ft. intervals. The entire tunnel atmosphere is completely changed every $1\frac{1}{2}$ minutes or 40 times per hour, but so uniformly and gently that the current is hardly perceptible. This eliminates the fire hazard incident to a longitudinal circulation of draught. There are four ventilation shafts, one at each pierhead line and one about midway between the pierhead and portal on each side of the river. The fans are located in the shaft buildings and there are 84 in all, one-half blowers and one-half exhausters.

The Liberty tunnels were the first long vehicular tunnels in which artificial ventilation was used. The method adopted is the longitudinal draught system, based on Saccardo's, with modifications by C. S. Churchill. The flow of air in each tunnel is with the traffic. and is induced from a shaft near the centre of each tunnel. Each shaft is divided into two compartments, one of which is used to exhaust the air which enters at the portal from the first half of the tunnel, and the other to blow fresh air into the tunnel at the centre and force it forward to the exit portal. Suitably designed nozzles at the centre of the tunnels, at the shafts, prevent the mixing of the air being introduced and ejected. The flow of air is continuous in each tube in opposite directions and wind pipes are provided at the exit of each tube to prevent interference with the ventilation by adverse winds. The ventilating plant and fans are on the hilltop near the ceptre of the tunnels, at the shafts. The plant was designed to provide for a double line of motor cars in each tube, spaced 100 ft. apart, moving at 15 m.p.h. and a proportion of carbon monoxide at 6 parts in 10,000 at the point of exit, the average, therefore, being 3 parts in 10,000. This required the supplying of 280,000 cu.ft. of air per minute in each tube at a velocity of six miles per hour. (See also AQUEDUCTS; TRANSPORT; etc.)

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TUNNY or BLUEFIN TUNA (*Thunnus thynnus*), the largest of the tunas. It grows to a large size, in some parts of the world reaching a length of more than 10 ft. and a weight of 1,500 lb. It is robust in form, has a short pectoral fin. is bluish above, gray spotted with silver below. It is world-wide in distribution and generally is found in more temperate waters than are the other tunas.

It is excellent as food and the object of important fisheries in the Mediterranean, in California and in Japan. Anglers, ranking this fish among the greatest trophies obtainable, pursue it in many parts of the world with rod and reel. Large specimens are often called horse mackerel. (*See* also TUNA.)

TUNSTAL (or TONSTALL), **CUTHBERT** (1474–1559), English prelate, natural son of Thomas Tunstal of Thurland castle, Lancashire, studied at Oxford, at Cambridge and at Padua. Having held several livings in succession, he became chancellor to William Warham, archbishop of Canterbury, in 1508 or 1509. He was employed on diplomatic business by Henry VIII and by Cardinal Wolsey, being sent to Brussels in 1515 and to Cologne in 1519, while he was at Worms during the famous Diet of 1521. In 1516 he had been made master of the rolls; and he became dean of Salisbury in 1521, bishop of London in 1522 and keeper of the privy seal in 1523. He represented Henry in the negotiations with Charles V after his victory at Pavia in 1525 and he helped to arrange the peace of Cambrai in 1529. In 1530 he succeeded Wolsey as bishop of Durham. Tunstal adhered firmly to the traditional teaching of the Church, but after some hesitation he accepted the royal supremacy and publicly defended this position. In 1537 the bishop was appointed president of the new Council of the North, but although he was often engaged in treating with the Scots he took part in other public business and attended parliament, where in 1539 he participated in the discussion on the bill of Six Articles. Although he disliked the religious policy pursued by the advisers of Edward VI and voted against the first Act of Uniformity in 1549, he continued to discharge his public duties without molestation until after the fall of the protector Somerset; then in 1550 he was put under house arrest; and in Dec. 1551 he was committed to the Tower of London. A bill to deprive him of his see was introduced, but the house of commons refused to pass it; and the earl of Warwick obtained his deposition by a special commission in Oct. 1552. On the accession of Mary in 1553 he was released and the next year he was reinstated as bishop of Durham. He assisted at the trial and deposition of John Hooper and other Protestant bishops. When Elizabeth I came to the throne he refused to take the oath of supremacy, and he would not help to consecrate Matthew Parker as archbishop of Canterbury. He was placed under arrest at Lambeth, where he died on Nov. 18, 1559.

See C. Sturge, *Cuthbert Tunstal* (London, 1938).

TUPIAN (TUPÍ, TUPÍ-GUARANÍ), a linguistic stock of South American Indians of the Macro-Tupi-Guarani phylum. Aboriginally, they occupied the lower Amazon, Tapajoz, Xingu and Tocantíns rivers and the Brazilian coast south to Uruguay. Far-flung prehistoric and postnhite migrations carried them to eastern Paraguay (the Guarani), the Bolivian Andes (the Chiriguano) and the middle and upper Amazon. After white settlement, Tupi became the *lingua geral* of much of Brazil, especially on the Amazon.

The Tupians were tropical rain forest farmers, rivermen and coastal navigators. By slash-and-burn cultivation they grew manioc, sweet potatoes, maize, beans, peanuts, cotton and dyes. They took turtles and turtle eggs and from large dugout canoes caught fish and river mammals with arrows and harpoons. They also used vegetable drugs for fishing. Wild game was secondary.

Tupian society consisted of an extended, usually patrilineal family occupying a single large thatched house, but some Tupians had patrilineal clans. On the lower Amazon and the coast, palisaded, multihouse villages of several thousand persons occurred. These villages warred incessantly, capturing, torturing and eating their victims. Religion was largely shamanistic with little village ceremonialism.

See Alfred Métraux and others, "The Coastal and Amazonian Tupi" in *The Tropical Forest Tribes*, 3.57–191, *Handbook of South American Indians* (Julian H. Steward, ed.), Bur. Amer. Ethnol. Bul. 143 (1948).

(J. H. SD.)

TUPOLEV, ANDREI NIKOLAEVICH (1888–), Russian army officer and aircraft designer, was born on Nov. 10, 1888, in Pustomazovo, Russia, and educated at the Moscow Higher Technical school, graduating in 1918. In that year, together with N. Zhukovski, he organized the Central Aerohydrodynamic institute (TsAGI), of which he was assistant director from 1918 to 1935 and head of its design bureau from 1922. Under his direction, over 100 types of passenger aircraft and medium- and long-range bomber aircraft were designed and built. Some of the better known of these are the tno-engine TB-1, three-engine ANT-9, four-engine TB-3, and ANT-25, which flew in 1937 from Moscow across the north pole to San Jacinto, Calif. Other planes designed later by Tupolev were the twin-engine attack bomber TU-2, four-engine bomber TU-4 (a copy of the U.S. B-29). tactical twin-jet bomber TU-10 (1948), six-turbojet-engine TU-75 (1950), TU-104 (1955), TU-104.4 (1957) and TU-114 (1957). Of these, the TU-104 and 104A twin-jet airliners (transport versions of TU-10) were widely used on commercial air routes. In 1938 Tupolev was arrested as an "enemy of the people" but five years later was freed and restored to favour. He was made a lieutenant general during World War II, received several Stalin prizes and was elected to the Academy of Sciences of the U.S.S.R. in 1953. In 1957 Lieut. Gen. Tupolev was awarded a Lenin prize for designing the TU-104.

(D. CR.)

TUPPER, SIR CHARLES, BART. (1821–1915), Canadian statesman, was born at Amherst, Nova Scotia, on July 2, 1821, and studied medicine at Edinburgh university, where he received the diplomas of M.D. and licentiate of the Royal College of Surgeons.

In 1855 he was returned to the Nova Scotia assembly for Cumberland county. Tupper was a member of the executive council and provincial secretary of Nova Scotia from 1857 to 1860 and from 1863 to 1867. He became prime minister of Nova Scotia in 1864, and held that office until the Union act came into force on July 1. 1867. Tupper was leader of the delegation from Nova Scotia to the Union conference at Charlottetonn in 1864, and to that of Quebec during the same year; and to the final colonial conference in London, which assembled to complete the terms of union, in 1866–67. He was sworn a member of the privy council of Canada. June 1870, and was president of that body from that date until July 1, 1872, when he was appointed minister of inland revenue. This office he held until Feb. 1873. when he became minister of customs under Sir John Macdonald, resigning with the ministry at the close of 1873. On Sir John's return to power in 1878, Tupper became minister of public works, and in the following year minister of railways and canals. Tupper was the author of the Public Schools act of Nova Scotia. and had been largely instrumental in molding the Dominion Confederation bill and other important measures. Sir Charles represented the county of Cumberland until 1884, when he was appointed high commissioner for Canada in London.

Shortly before the Canadian federal elections of Feb. 1887, Tupper re-entered the Conservative cabinet as finance minister; he resigned in May 1888, when he was reappointed high commissioner for the Dominion of Canada in London.

Tupper was one of the British plenipotentiaries to the Fisheries convention at Washington in 1887. When the dominion cabinet, under Sir Mackenzie Bowell, was reconstituted in Jan. 1896 Tupper accepted office, and in the following April he succeeded Bowell in the premiership. At the general election in the ensuing June the Conservatives were severely defeated, and Tupper and his colleagues resigned, Sir Wilfrid Laurier becoming premier. At the next general election, in 1900, Tupper sustained in his own constituency of Cape Breton his first defeat in 40 years. He wrote *Recollections of Sixty Years* (1914).

See E. M. Saunders, *Life and Letters of Sir Charles Tupper*, 2 vol. (1916).

TUPPER, MARTIN FARQUHAR (1810–1889), English writer, the author of *Proverbial Philosophy*, was born in London on July 17, 1810, the son of a doctor of Huguenot descent. He was educated at Charterhouse and at Christ Church, Oxford. He was called to the bar at Lincoln's Inn, but never practised. He began a long career of authorship in 1832 with *Sacra Poesis* and in 1838 he published *Geraldine, and Other Poems*. For 50 years he was fertile in producing both verse and prose, but his name is indissolubly connected with his long series of didactic moralizing in blank verse, the *Proverbial Philosophy* (1838–67), which for about 25 years enjoyed an extraordinary popularity. The first part was, however, a comparative failure. and N. P. Willis, the American author, took it to be a forgotten work of the 17th century.

Tupper died at Albury, Surrey, on Nov. 29, 1889.

TURA, COSIMO (1430–1498), Italian painter, founder of the Ferrarese school, was born at Ferrara and spent most of his life there, being court painter to the dukes Bono and Ercole. Between 1465 and 1467 he decorated the library of the Pico della Mirandola uith allegorical figures, since destroyed. The decorations of Duke Borso's chapel at Belriguardo also have perished. The Kaiser Friedrich museum, Berlin, has one of the most important of Tura's works, "The Madonna and Child Enthroned With Saints." Another notable work is the "Madonna and Child Enthroned Surrounded by Six Angels Playing on Musical Instruments" (National gallery, London), the central panel of an altarpiece of which the lunette representing the "Pietà" is in the Louvre and one of the wings, representing "A Monk Kneeling and Two Saints," is in the Colonna collection. Rome. Other notable works are the "Madonna and Child in a Garden," in the National Gallery of Art, Washington, D.C.; the "Pietà," in the Civico Museo Correr, Venice; and a "Virgin and Child," in the Accademia Carrara, Bergamo.

TURBELLARIA, a class of flatworms or Platyhelminthes (*q.v.*) in which the body is unsegmented and covered with a ciliated epidermis, and an alimentary canal is generally present. Almost all the group are free-living.

General Morphology. — The body is either subcylindrical or flattened and leaflike or ribbonlike. In length the species range from a fraction of a millimetre to about 20 cm. (7.87 in.) In many forms there is a flat creeping (ventral) surface. At or near the anterior end there may be a pair or more of tentacles, and a

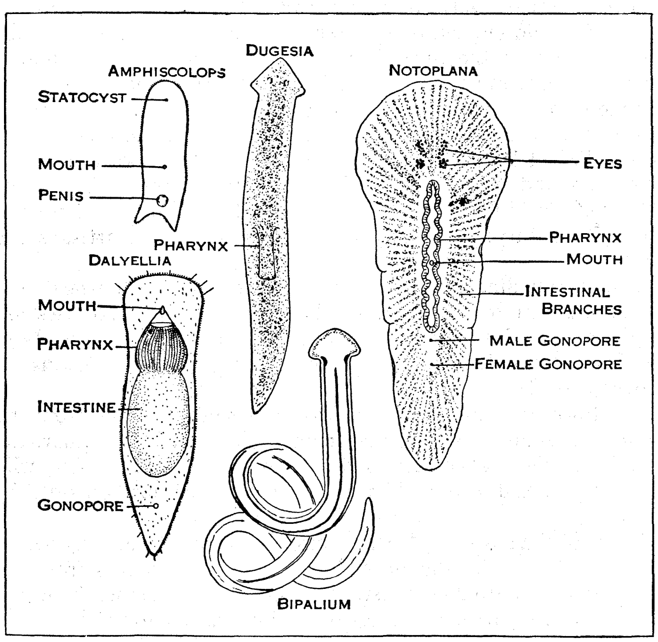
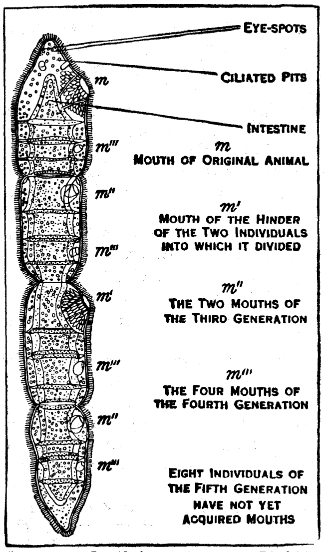


Fig. 1.—Some types of Turbellaria, not to scale. Upper left, *Amphiscolops*, example of the order Acoela; lower left, *Dalyellia*, example of the order Rhabdocoela, section Dalyellioida: upper centre, *Dugesia*, common fresh-water planarian, order Tricladida, suborder Paludicola; lower centre, *Bipalium* kewense, tropical land planarian often found in greenhouses, order Tricladida, suborder Terricola; right, Notoplana, common marine flatworm, order Polycladida, suborder Acotylea, family Leptoplanidae

pair of eyes, or numerous eye spots. The margins of the body, in some of the leaflike aquatic forms, are very mobile and can be thrown into undulations, enabling the animal to swim. The dorsal surface of the body is often pigmented, and the colours and markings, especially in terrestrial forms, may be very striking and brilliant. In certain aquatic species a green or brown colour is produced by the presence in the tissues of symbiotic green or brown algae.

The body is clothed in a cellular or syncytial epidermis, which mhy be completely ciliated but often lacks dorsal cilia. It gives off a mucoid slime that comes from gland cells sometimes situated in the epidermis but more often located in the parenchyme. The epidermis also contains elongated densely staining bodies, the rhabdites, believed to contribute to slime formation. Below the epidermis is a basement membrane, and below this various layers



FROM LANKESTER, 'TREATISE OH ZOOLOGY' (A. & C. BLACK LTD.)

FIG. 2.—RHABDOCOELAN TURBELLARIAN (MICROSTOMA LINEARE) THE PROCESS OF REPRODUCTION BY DIVISION

of muscle fibres (circular, longitudinal and usually also diagonal). As in the other classes of Platyhelminthes, the internal organs are embedded in parenchymatous tissue.

The mouth may be located anywhere along the midventral line but is usually more or less central. It leads, usually through a muscular pharynx, often more or less protrusible, into the intestine, except in the order Acoela, which primitively lack an intestine and in which food is taken into the interior parenchymatous mass. The intestine may be a simple sac or may be lobed or highly branched and as a rule, has no opening to the exterior except the mouth.

The nervous system consists of paired anterior ganglia lying ventrally to the gut, and giving off various lateral, dorsal and ventral fibres which are interconnected by other fibres. Tactile organs are generally distributed over the skin. and may take the form of special hairlike cilia. Other sensory organs also occur in the form of statocysts, ciliated cephalic pits or grooves, and eyes. The eyes are usually pigment cups containing the bulbous free ends of the retinal cells, notable for their rod border. An excretory system of the platyhelrninth type, with flame cells, is usually present. The external opening may be single or paired, ventral or terminal, or there may be multiple excretory pores on either surface. Almost all the Turbellaria are hermaphrodite, and the reproductive organs are usually complex. There may be separate male and female pores or a common gonopore, situated almost anywhere along the midventral line. Sometimes the sex ducts open by the mouth.

Classification. — The conservative classification here adopted follows Bresslau (Handbuch der *Zoologie,* vol. 2, 1928).

Order 1. **Acoela.**—Small marine flatworms with mouth and often simple pharynx but no digestive cavity. Usually with a statocyst and a frontal cluster of glands. Without excretory system. Gonads consist of strands of differentiating sex cells not delimited from the parenchyme. Oviducts absent but male ducts and simple penis present. The chief families are the Proporidae without, and the Convolutidae with, a seminal bursa, *i.e.,* a sac for receiving the partner's sperm.

Order 2. **Rhabdocoela.**—Small worms, marine, brackish or fresh-water with complete digestive tract; intestine a simple blind sac or tube. With excretory system and usually with oviducts. Seldom with a statocyst. Gonads few, mostly compact.

Suborder 1. CATENULIDA.—Fresh-water forms with simple pharynx, single median nephridium, no yolk glands. Asexual reproduction by fission. One family, Catenulidae, represented by the very common Stenostomum.

Suborder 2. MACROSTOMIDA.—Fresh-water or marine, with simple pharynx, paired nephridia, no yolk glands. Two families, Macrostomidae without, and Microstomidae with, asexual reproduction by fission (fig. 2).

Suborder 3. LECITHOPHORA.—Fresh-water, marine or terrestrial rhabdocoels with bulbous pharynx and yolk glands more or less distinctly separated from the ovaries. Reproduction exclusively sexual. Includes numerous families.

Section 1. *Dalyellioida.*—Rhabdocoels with a doliiform (cask-shaped) pharynx, oriented parallel to body surfaces. Chief family, Dalyelliidae, with complicated male apparatus.

Section 2. *Typhloplanoida.*—Rhabdocoels with a rosulate (spherical) pharynx oriented at right angles to body surfaces. Chief family, Typhloplanidae with genera Mesostoma, *Typhloplana,* Castrada, Phaenocora, etc.

Section 3 *Kalyptorhynchia.*—Mostly marine rhabdocoels with a protrusible food-catching proboscis at the anterior tip (in addition to the usual pharynx). Represented by *Gyratrix, Polycystis, Acrorhynchus,* etc.

Suborder 4. TEMNOCEPHALIDA.—Ectocommensal fresh-water rhabdocoels of dalyellioid affinities living on crayfish and other fresh-water animals. Found only in tropical and subtropical countries. The body has 2 to 12 fingerlike tentacles and one or more adhesive disks.

Order 3. **Alloeocoela.**—Slightly larger worms mostly of plump, cylindroid form, with simple or slightly lobulated intestine. Mostly with two ovaries and numerous testes. Chiefly marine, a few in fresh water. Represented by *Prorhynchus, Plagiostomum, Cylindrostomum, Monocelis, Bothrioplana,* etc.

Order 4. **Tricladida.**—Larger worms of flattened elongated form with plicate pharynx and three-branched intestine (fig. 3). With two ovaries, few to many testes, distinct yolk glands, copulatory sac for receiving sperm, and single gonopore behind the mouth.

Suborder 1. MARICOLA.—Marine planarians with copulatory sac behind the male apparatus. *Procerodes,* free-living, and *Bdelloura, Syncoelidium, Ectoplana* epizoic on the horseshoe crab, *Limulus.*

Suborder 2. PALUDICULA.—Fresh-water planarians with copulatory sac anterior to the penis. Familiar animals of ponds and streams; *Planaria, Phagocata, Dendrocoelum,* etc.

Suborder 3. TERRICOLA.—Terrestrial planarians of tropical and subtropical jungles, sometimes reaching great lengths, often with bright colour patterns. *Geoplana, Bipalium, Rhynchodemus,* etc.

Order 5. **Polycladida.**—Marine, often large, much flattened and leaflike flatworms with numerous eyes and much-branched intestine radiating from the pharynx to the periphery.

Suborder 1. ACOTYLEA.—Without a ventral sucker. Pharynx mostly ruffled, mouth not near anterior end. Tentacles when present borne near the brain. Stylochidae, Leptoplanidae, Planoceridae, etc.

Suborder 2. COTYLEA.—With a ventral sucker behind the genital pores. Pharynx ruffled or cylindrical, mouth anterior. Tentacles when present occur on the anterior margin. Pseudoceridae, Eurpleptidae, Prosthiostomidae, etc.

The classification proposed by Meixner (*Die Tierwelt der Nord-und Ostsee,* Teil iv b) differs in that the first three suborders of the Rhabdocoela are raised to the rank of orders and the Tricladida are made a suborder under Alloeocoela. While there are justifications for these changes, it seems best to adhere to the older classification.

Occurrence and **Habits.**—Most Turbellaria are aquatic. They are abundant on the seashore and in fresh water, where they lurk among weeds or under stones, and in the crannies of rock pools. They creep by a gliding movement caused in the smaller forms by ciliary action, in the larger ones by muscular waves; some are able to swim. Many species of triclads are terrestrial. These occur in damp localities and chiefly in tropical or subtropical countries, though a few are known in temperate latitudes. They are somewhat sluglike in form and habits. A few Turbellaria, mostly dalyellioid rhabdocoels, are parasitic. These are marine, and are found in such animals as sea-urchins, holothurians and molluscs. The free-living forms are almost all carnivorous, feeding either on microscopic organisms or on worms, molluscs and insects. The protrusible pharynx is used either to engulf the prey whole or to pierce it and suck up its juices after it has been enveloped in a coating of mucus.

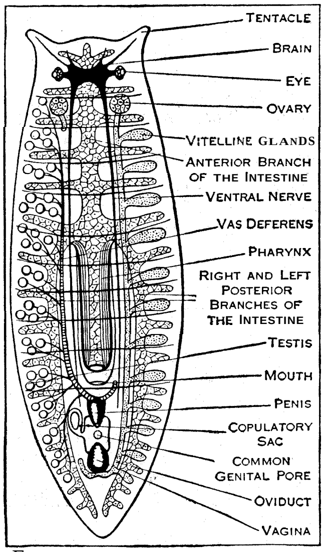


FIG. 3.—GENERAL STRUCTURE OF A TRICLADID TURBELLARIAN. THE THREE-BRANCHED INTESTINE IS CHARACTERISTIC OF THIS GROUP

Development and **Life** History.—The development of most of the Turbellaria is direct (*i.e.,* without metamorphosis). In certain polyclads, however, the embryo develops into a swimming larva ("Müller's larva") provided with eight ciliated lobes, and somewhat resembling the trochophore larvae of certain annelids. In the Rhabdocoela the eggs are generally enclosed in shells, each being provided with a number of separate yolk cells. In the Acoela and Polycladida the ova themselves may contain yolk granules, and the eggs are usually laid in clumps surrounded by a gelatinous envelope. The ova of triclads are laid, several together, surrounded by amoeboid yolk cells, in a cocoon.

A form of asexual multiplication occurs in certain rhabdocoels (Microstomidae) and triclads. In the former the body becomes constricted in the middle and forms two complete animals, each of which again subdivides, and so on, until a whole chain of individuals is formed, head to tail, eventually breaking up into separate organisms. In some of the triclads spontaneous fragmentation may occur, with regeneration of the parts to form complete animals. But even forms which at one season reproduce in this manner, do so at another by means of eggs. In certain rhabdocoels (e.g., *Mesostoma*) two distinct types of eggs are produced according to the season. During warm weather the eggs laid are thin-shelled "summer eggs" which develop rapidly, while thick-shelled "winter eggs," whose contents remain longer in a resting condition, are laid in cold weather. In other cases the eggs are apparently similar at all seasons, but develop more rapidly in warm water than in cold. Thus in shallow pools subject to sudden and frequent changes of temperature, the population increases rapidly during warm weather, while during cold spells the survival of the race is assured. (*See* PLATYHELMINTHES.) (H. A. B.; L. H. H.)

TURBERVILLE (or TURBERVILE), **GEORGE** (1540?–1610?), English poet, second son of Nicholas Turberville of Whitchurch, Dorset, belonged to an old Dorsetshire family, the D'Urbervilles of Thomas Hardy's novel, *Tess.* He became a scholar of Winchester college in 1554, and in 1561 was made a fellow of New college, Oxford. In 1562 he began to study law in London, and gained a reputation, according to Anthony a Wood, as a poet and man of affairs. He accompanied Thomas Randolph in a special mission to Moscow to the court of Ivan the Terrible in 1568. Of his *Poems describing the Places and Manners of the Country and People of Russia* (1568) mentioned by Wood, only three metrical letters describing his adventures survive, and these were reprinted in Hakluyt's *Voyages* (1589). His *Epitaphs, Epigrams, Songs and Sonets* appeared "newly corrected with additions" in 1567. In the same year he published translations of the *Heroycall Epistles* of Ovid, and of the *Eglogs* of Mantuan (Gianbattista Spagnuoli, called Mantuanus), and in 1568 *A Plaine Path to Perfect Vertue* from Dominicus Mancinus. The *Book of Falconry or Hawking* and the *Noble Art of Venerie* (printed together in 1575) may both be assigned to Turberville. He probably died before 1611.

TURBET I HAIDARI, a town in the province of Khurasan in Iran, situated at an elevation of 4,400 ft., about 76 mi. S. of Meshed, on the motor road to Zahidan (Duzdab), via Qain and Birjand.

The town is a centre of many roads. In the northeast are the ruins of an old citadel, or the Ark of Ishaq Khan; but the principal feature of the town is its bazaar formed of four dome-vaulted streets radiating from a larger central dame. Before the famine of 1871, Turbet i Haidari was populous, but the population was, it seems, reduced by 20,000. The town had recuperated before World War I owing to increased trade between Russian Turkistan and Afghanistan; the population (1956) is 19,807, chiefly of Turki Qarai stock. who were settled there by Timur in the 14th century; but many of the merchants and artisans are Yazdis.

The surrounding district is very fertile and much wheat and barley are sent to other parts. The chief trading activities are wool buying, silk production (now greatly declining), carpet buying from the Baluch nomads round about, and the making of copper utensils.

The town. formerly known as Zavah, derives its name from the *turbeh,* or tomb, of a holy man named Qutb ud Din Haidar, the founder of the ascetic sect of dervishes known as Haidaris, who died *c.* 1230 and is buried in a domed building just outside the town.

TURBINE: GAS. A gas turbine is a form of heat engine for producing work with the aid of heated gases. It differs from the conventional internal-combustion engine in the manner in which the heated gases are employed. In the internal-combustion engine. air and fuel are drawn into cylinders fitted with movable pistons connected to a crankshaft by means of connecting rods. By exploding the mixture of air and fuel in the cylinders, the pistons are forced to move back and forth, causing the crankshaft to turn. A flywheel is attached to the crankshaft to smooth out irregularities. The mechanism of internal-combustion engines is complicated and subject to inertia and vibrational forces that are difficult to eliminate.

The gas turbine is an attempt to achieve the advantages of internal-combustion engines without the complications associated with reciprocating motion. Its principle of operation is to direct a continuous stream of hot gases against the blading of a turbine rotor. In modern units. the air is first compressed in an axial-flow compressor before being directed into combustion chambers. In these. fuel is mixed with a portion of the air and burned. Some of the air is bypassed around the burner and subsequently mixed again with the products of combustion to prevent excessive temperature of the gases leaving the combustion chambers. The emerging gases are directed through nozzles and against the blading of the turbine rotor. furnishing sufficient power to drive the compressor with enough left over for useful purposes. The result is a smooth-running machine, incorporating the advantages of Internal combustion without the disadvantages of reciprocating pistons.

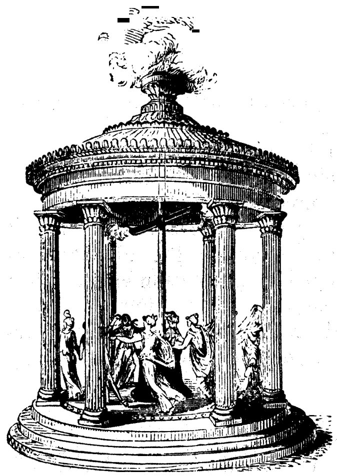


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FIG. I.— SKETCH OF HERON'S GAS TURBINE (ABOUT 130 B.C.)

HISTORY

Early. — The earliest known device which might be classified as a gas turbine is believed to be that suggested by Heron of Alexandria (*q.v.*) about 130 B.C. An early sketch of Heron's gas turbine is shown in fig. 1. It consisted of a circular rotating platform. not unlike that of a present-day merry-go-round, on which live persons could stand. Rotation of the platform was to be accomplished by means of air drawn through bent tubes, leading into a long central vertical tube culminating in the hearth of an altar fire located on the roof. The exact manner of operation was not clearly explained by Heron, but there is no doubt that the intention was to employ heated air as the motivating force.

Another early device called the smokejack is illustrated in fig. 2. It was designed to operate with the aid of hot combustion gases rising from a fireplace. The smokejack is believed to have first been sketched by Leonardo da Vinci. It was later more fully described in a book by John Wilkins, an English clergyman, later bishop of Chester, entitled ,*Mathematical Magick*, published in 1648. The device consists of a number of horizontal sails similar to those of a modern windmill, attached to a vertical shaft and placed in the chimney of a fireplace. The hot gases rising past the sails caused the device to rotate. With the aid of a simple gearing system it was possible to employ the smokejack for turning a spit, or to perform other simple tasks.

A somewhat similar device was later patented by John Dumbell of England. His device. shown in fig. 3, employed a large number of sails, one above the other, all attached to a hollow drum. In addition, he supplied his own furnace underneath, with means for supplying air and fuel and for keeping the component parts from melting. In his patent he stated that he "would apply whatever produces steam, smoke, rarefied air, or spirit. or which produces an inflammable vapour, either in combined or single state, or which may be drawn by distillation, or which possesses an explosive or combustible power effect." Some authors have interpreted the latter part of the sentence to mean that the device was a forerunner of the explosion-type gas turbine. In view of the patent drawings this view is difficult to substantiate since the drawings do not reveal anything like a constant-volume. explosion-type combustion chamber.

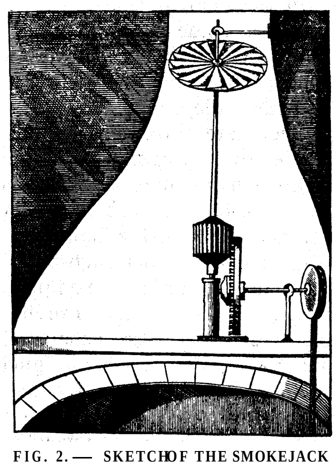

FIG. 2.— SKETCH OF THE SMOKEJACK TURBINE

The first patent for a gas turbine operating on a cycle resembling present-day units was issued to John Barber of England in 1791. A sketch of Barber's turbine. taken from the patent dranings, is shonn in fig. 4. The principle of operation was as follons: air and fuel from a gas producer, after being compressed in separate cylinders, were directed into a combustion chamber and burned. The products of combustion were released through a small nozzle onto a turbine wheel. The power thus produced was supposed to be sufficient to compress the air and fuel and to leave enough over for external work. From our modern knowledge of the cycle, and from the sketch supplied by Barber, it is known that his machine could not have operated successfully. It did, however, represent an ingenious invention and included most of the essential elements found in present-day gas turbines.

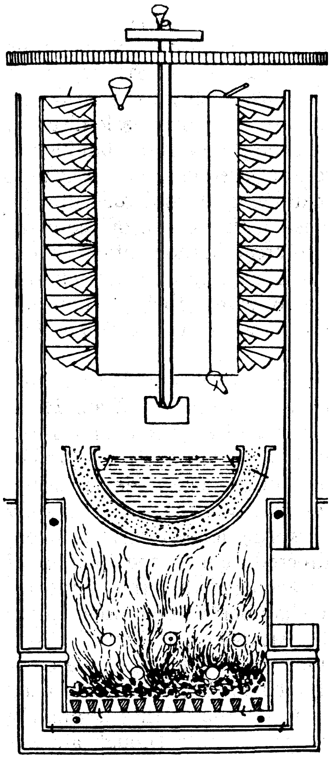

FIG. 3.— PATENT DRAWING OF JOHN DUMBELL'S TURBINE

Modern. — In the years following the issuance of John Barber's patent, many novel devices were proposed, but it was not until 1872 that a really significant advance in the art was made. This came with the granting of a patent to F. Stolze of Germany for his so-called fire turbine. Stolze's turbine consisted of a separately fired combustion chamber, a heat exchanger and a multistage axial-flow compressor directly coupled to a multistage reaction turbine. Operation was as follows: air, after being compressed, was directed into the heat exchanger where it was heated by means of combustion gases from a separately fired furnace. From the heat exchanger the compressed air passed into the turbine through which it was expanded back to the atmosphere. Even though Stolze's gas turbine embodied almost every feature of a modern, simple open-cycle gas turbine, it was unsuccessful. The reason was that the compressor and turbine lacked the necessary efficiency to sustain operation, using maximum turbine inlet temperatures permissible at that time.

The first successful gas turbine was built by R. Armengaud and C. Lemale for the Société des Turbomoteurs in Paris in 1903. This unit consisted of a three-cylinder multistage Rateau compressor followed by a combustion chamber in which liquid fuel was burned with air supplied from the compressor. The hot gases issuing from the combustion chamber, after being cooled to some extent by the injection of water, were expanded through a two-row impulse turbine wheel. The unit was capable of operating with an efficiency of about 3%. Although by later standards this was an unimpressive performance, it was nevertheless a significant achievement at the time. It is believed to be the first gas turbine capable of delivering work on a scale suitable for commercial purposes.

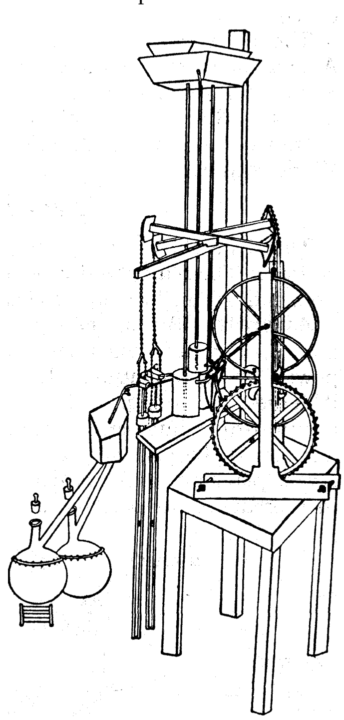

FIG. 4.— DRAWING OF JOHN BARBER,S TURBINE, PROBABLY THE FIRST TO USE A COMBUSTION CHAMBER

Two other contributions should also be mentioned. In these, a different principle of operation was employed, that of exploding a mixture of air and fuel in constant-volume combustion chambers and then allowing the products of combustion to flow through nozzles onto a turbine wheel.

The first of these was a two-horsepower, 10,000-r.p.m. unit built by M. Karavodine in Paris in 1908. It consisted of a simple De Laval impulse-type turbine wheel (see TURBINE: STEAM) about six inches in diameter with four explosion chambers arranged around the periphery of the wheel. each leading to a nozzle directed against the wheel. When in operation the products of combustion from the four explosion chambers were released in sequence against the wheel. An ingenious method of drawing air and fuel into the chambers was provided. After explosion, the inertia of the gases leaving the chambers was employed to create a momentary partial vacuum inside the chambers capable of sucking in a new charge. During tests the device was reported to have a fuel consumption of about 2.24 kg. of gasoline per horsepower-hour, corresponding to a thermal efficiency of about 2.5%.

The second and more important of the two contributions historically was the explosion-type turbine developed by Hans Holzwarth of Germany. who began a long series of experiments in 1905. His turbine consisted of a constant-volume combustion chamber into which a charge of fuel and air was introduced under pressure. Following ignition. the pressure was increased to approximately 49 times the original value, causing a spring-loaded valve to open, admitting the gases into nozzles directed against the blading of the turbine. The mechanism was so arranged that the valves remained open until the combustion chamber was emptied, after which a new charge was introduced. Although an air compressor was employed in the Holzwarth turbine, the efficiency of the compressor was not extremely important. This is because the air need be supplied at a pressure of only about one-fourth that ultimately achieved during explosion. and also because only enough air was required to furnish oxygen for combustion.

Over a period of about 30 years Holzwarth and various collaborators continued development of the turbine. Although now superseded by the constant-pressure combustion gas turbine, the Holzwarth explosion turbine represented a unique and important contribution.

The modern gas turbine is due to the work of many individuals. Among the most important was Sir Frank Whittle of England, who was among the first to recognize its application to jet propulsion aircraft. His efforts in this regard led to its development and use in military aircraft in America and the United Kingdom during World War II.

APPLICATIONS

The gas turbine is a versatile prime mover and has many applications. These may be divided into aircraft, electric power generation, industrial, locomotive, marine and automotive.

Aircraft.— By far the most important present-day application is in military aviation where the gas turbine provides the motive power for jet propulsion. In this application, illustrated in fig. j, it serves as a jet propulsion engine consisting of an axial-flow compressor. a number of combustion chambers arranged in parallel around the periphery of the engine, a turbine and a tailpipe. As the plane moves forward air is drawn into the compressor where its pressure is increased by several atmospheres. It then flows into

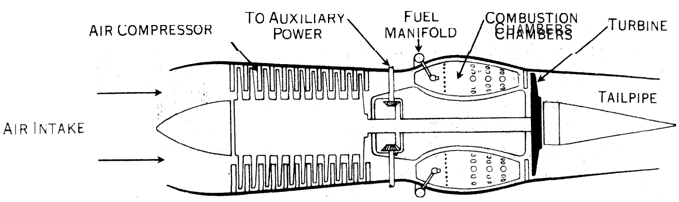

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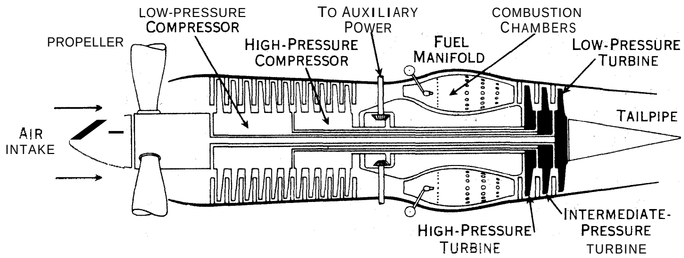
FIG. 5.— CUTAWAY DRAWING OF A JET PROPULSION ENGINE

the combustion chambers where a special grade of kerosene fuel is injected and burned, raising the temperature of the products of combustion to approximately 1,600° F. From the combustion chambers the hot products pass through the turbine, surrendering sufficient energy to drive the compressor. The gases then exhaust through the tailpipe at high velocity. The increase in velocity of the gases issuing from the tailpipe over that of the air entering the compressor provides the reactive force needed to drive the plane forward.

Modern military jet propulsion engines are capable of producing tremendous power. In emergencies this can be augmented still further with the aid of an afterburner, the purpose of which is to add heat to the gases just before exhausting from the tailpipe. This increases their velocity and adds to the forward thrust of the engine.

Another gas turbine application for aircraft is the turboprop, illustrated in fig. 6. In this application the gas turbine serves a dual purpose, that of driving a conventional propeller and that of producing additional thrust by means of the reactive force of the exhausting gases. This type of engine has the advantage of lower fuel consumption than a straight jet propulsion engine when operating at speeds and altitudes suitable for commercial flying. At the same time it offers some advantages over conventional reciprocating aircraft engines such as higher speed, smooth flight and less vibration.



BY COURTESY OF PRATT & WHITNEY AIRCRAFT

FIG. 6.— CUTAWAY DRAWING OF A TURBOPROP ENGINE

Electric Power Generation.— In the field of electric power generation the gas turbine must compete with the diesel engine and steam turbine. Gas turbines are limited in capacity by the fact that the pressure involved is low, making it necessary to employ large turbines and compressors in order to handle the huge volumes of air required. For this reason no serious attempt has been made to design a gas turbine power plant capable of competing with the modern central station steam power plant in which single units as large as 450,000 kw. have been built.

In the field of small power plants, a number of installations had been made in the United States and in Europe by the mid-1950s, but insufficient information was available to draw accurate conclusions as to just where the gas turbine would ultimately find its widest adoption.

There are three applications which deserve special mention. These are: (1) operation in combination with steam power plants as a means of increasing the over-all efficiency of the plant; (2) for stand-by and peak load service; and (3) for portable power plants. A promising combined steam turbine-gas turbine power plant is one in which high-temperature exhaust gases from a conventional gas turbine are employed to supply oxygen to the furnace of a steam boiler in lieu of preheated combustion air. This is feasible because the gases exhausted from a gas turbine still contain about 80% of the oxygen originally in the air supplied to the compressor inlet. Such an arrangement is capable of increasing the over-all efficiency of the plant by a substantial amount. It also offers savings in size and weight of the boilers required? less building volume: quicker starting of the boiler and elimination of the forced and induced draft fans normally required by the boiler.

Other ways in which the gas turbine can be employed to improve the efficiency of a steam power plant are to use the exhaust gases for feed-water heating or for the generation of steam in an exhaust heat boiler.

In the hydroelectric power field the gas turbine offers an attractive means of providing additional peak load and stand-by power. It can often be installed for this purpose at lower cost than additional steam or hydro capacity. Furthermore, it offers the advantages of virtually automatic operation, simplicity, small space requirements and minimum maintenance. Another similar application is for end-of-the-line voltage booster service on long-distance transmission lines. A third application is for portable power plants. Here the gas turbine can be mounted on railroad cars for emergency use by the military or other agencies.

Industrial Applications. — An early and still important application of the gas turbine in industry is in connection with the Houdry process of refining oil. In this application, air under pressure must periodically be passed over a catalyst for the purpose of burning off carbon accumulated during the refining process. The air employed thus becomes heated in the same manner as it would in a combustion chamber, and can therefore be passed through a turbine to perform useful work, including that of driving the compressor employed for supplying the air to the catalyst. The result is a gas turbine with the carbon burn-off operation substituted for a combustion chamber. A large number of these units had been manufactured in the Cnited States and were rendering satisfactory service by the mid-1950s.

Another industrial application is for natural gas pipeline compressor stations. For this purpose the gas turbine is ideally suited since natural gas is an excellent fuel and is available at low cost, making fuel economy of secondary importance. By using a regenerator, satisfactory efficiencies can easily be obtained and stations can be located anywhere along the line since no water supply need be available. Furthermore, fully automatic stations can be built which require practically no supervision and only a minimum of maintenance.

A third industrial application is in the steel industry. Here large volumes of air under pressure are required for reducing iron ore in blast furnaces. In present installations the hot blast-furnace gases leaving the furnaces are utilized as fuel for generating steam in a boiler. The steam so generated is used in steam turbines or large reciprocating engines which in turn drive large rotary blowers or compressors supplying air to the blast furnaces. This equipment occupies a great deal of space and is also quite expensive. In addition a large quantity of condensing water is required for the turbines or steam engines.

With the gas turbine it is possible to replace all this equipment with a single unit designed to operate with blast-furnace gas as fuel. In such an installation a portion of the air compressed is directed to the blast furnace while the remainder flows through the combustion chamber and turbine. The exhaust gases leaving the turbine can be passed through a regenerator to preheat the air flowing to the combustion chambers. thereby increasing the efficiency. The blast-furnace gas supplied to the combustion chamber as fuel can be compressed with the aid of a small compressor driven off the shaft of the turbine.

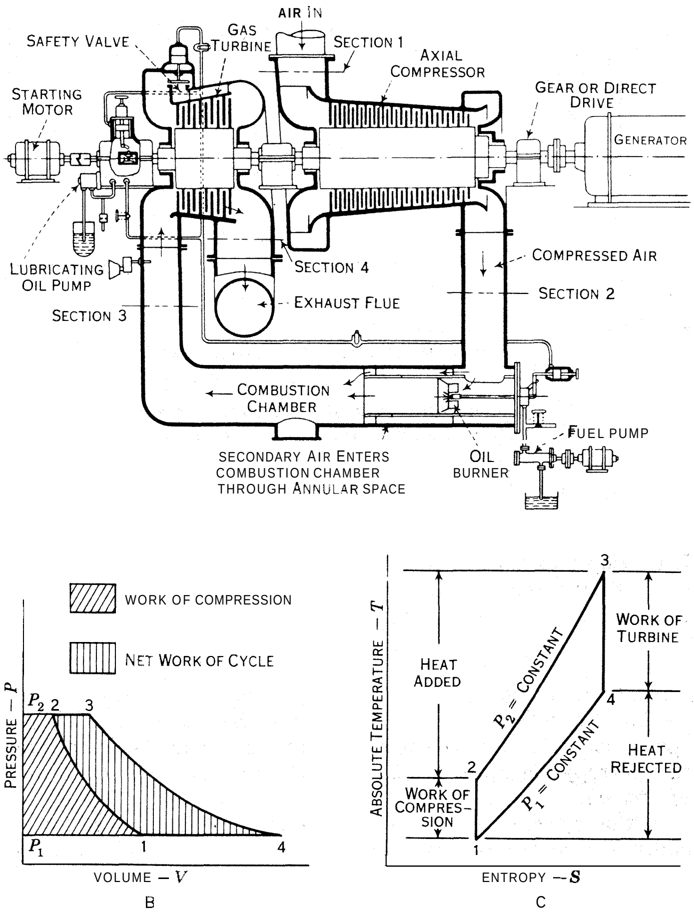
Locomotive. — A field of application receiving considerable attention in the 1950s was the railroad locomotive. Advantages of the gas turbine for this service are its smoothness of operation, simplicity and lack of need for water. 4 number of oil-burning gas turbine locomotives were built in the United States and Switzerland and were giving satisfactory service. Because of economic considerations, however, they were unable to replace the diesel locomotive. because they were less efficient thermally. Attempts were made to overcome this economic disadvantage by developing a coal-burning gas turbine locomotive, but the engineering difficulties are great, and much work remained to be accomplished before a successful unit could be built.

Marine. — In the field of small ship propulsion. the gas turbine offers advantages of lighter weight and less space requirement than a corresponding boiler and steam turbine plant. However, progress had been slow by the mid-1950s, and few units had been built. For marine service the advantage of intercooling can be utilized to obtain increased efficiency. (See *Theory* below.)

Automotive. — There is much speculation as to the future of the gas turbine for automotive applications. In the mid-1950s it appeared that the disadvantages outweighed the advantages, and that there was little likelihood of the gas turbine replacing the reciprocating engine in the near future. The principal advantages of the gas turbine over the conventional reciprocating automotive engine are its smooth vibrationless operation, flat torque versus speed characteristic, light weight, small space requirements, lack of need for a cooling system and the possibility of burning a cheaper fuel than gasoline. Its disadvantages are high cost of manufacture and materials. high fuel consumption, high speed and high noise level. Although no one could predict what will ultimately occur, it appeared that the gas turbine would eventually find important applications in the automotive field, even though it might never replace the reciprocating engine entirely.

Future of the Gas Turbine. — The many applications for which the gas turbine is especially well suited seem to assure an attractive future. In the fields of military and commercial aviation its status as the leading contender among all types of power plants is unchallenged. In the industrial field, there seem to be an increasing number of possible applications indicating continued growth in this area. The same growth can be confidently predicted for its use in all forms of transportation including marine, locomotive, truck and even automotive.

In the utility field it is unlikely that the gas turbine will supersede the large central station steam turbine. The reason for this is inherent in the gas turbine cycle, which requires that all air passing through the turbine must first be compressed. This means that a large portion of the work output of the turbine must be employed to drive the compressor, leaving only a fraction for driving the electric generator. Should the work of compression, for example, require half that of the turbine output, one would obtain only one-half unit of power for two units of rotating machinery. In the steam turbine, on the other hand, one would obtain essentially one unit of power for one unit of rotating machinery.



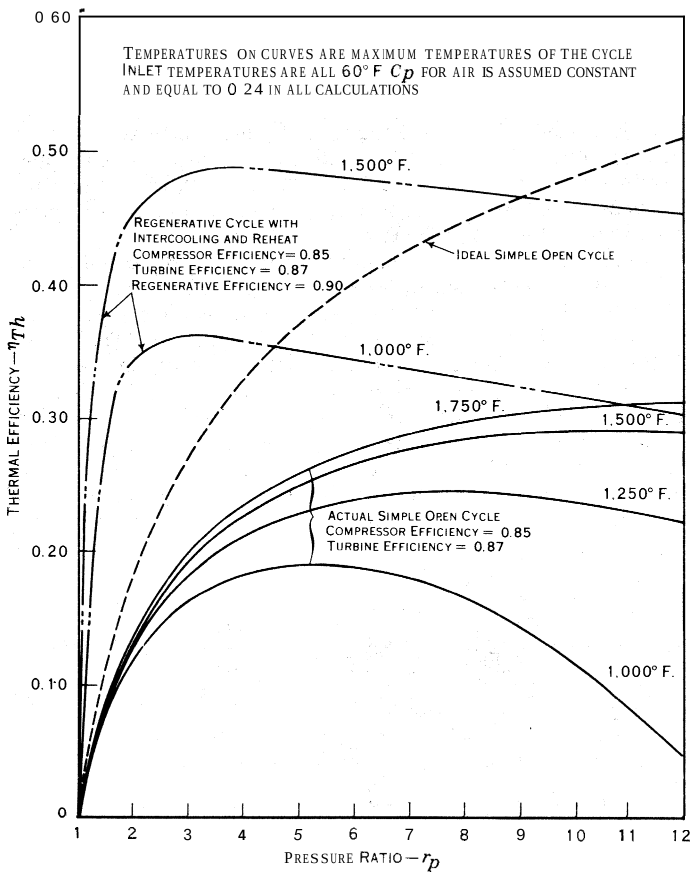
(A) ADAPTED FROM AN ORIGINAL DRAWING BY ALLIS-CHALMERS MANUFACTURING CO.; (B AND C) BY COURTESY OF R. A. BUDENHOLZER

FIG 7 — (A) IDEAL SIMPLE OPEN-CYCLE. CONSTANT-PRESSURE COMBUSTION GAS TURBINE: (B) PRESSURE-VOLUME AND (C) TEMPERATURE-ENTROPY RELATIONSHIPS FOR SUCH A TURBINE

This is because in the steam cycle, the only work of compression required is that of the boiler feed pumps, an almost insignificant portion of the turbine output.

Still another factor in favour of the steam turbine is its ability to expand steam through pressure ratios as high as 10,000 to 1 or more. This permits the use of very high initial pressures, resulting in relatively small turbine components. With the gas turbine, pressures are always low, making large components essential for high power output.

One method of partially overcoming this difficulty is to employ



BY COURTESY OF R A BUDENHOLZER

FIG. 8.— THERMAL EFFICIENCY OF VARIOUS CYCLES

a pressurized cycle in which the unit is first charged with air or other gases and then operated under a pressure level of several atmospheres. Although this has the advantage of reducing the size of the rotating machinery, it requires a cooling medium capable of lowering the turbine exhaust gases back to compressor inlet temperature before they can be reintroduced into the compressor. It is also necessary to add heat to the compressed gases in a separately fired furnace, or to continuously add sufficient new air and fuel to the cycle, under pressure, to maintain combustion.

THEORY

Nearly all modem gas turbines operate on the constant-pressure combustion cycle. In fig. 7 is shown a sketch of an idealized simple open-cycle unit with accompanying pressure-volume and temperature-entropy diagrams (see STEAM: *Steam* Engine and Properties of *Steam).*

In this cycle air enters the axial-flow compressor at section 1 under normal atmospheric pressure and temperature P_1 and T_1. It is then compressed adiabatically and reversibly (isentropically) to section 2 where the pressure and temperature are now P_2 and T,. From section 2 the air flows into the combustion chamber where fuel is iniected and burned at constant pressure, raising the temperature t o - . ~ ~From the combustion chamber the heated gases enter the turbine where expansion occurs to atmospheric pressure.

The amount of work obtainable from the unit is the difference between that required to compress the gas and that obtained from the turbine. 'This may be represented on the pressure-volume diagram by areas and on the temperature-entropy diagram by ordinates, as indicated in fig. 7(B) and 7(C).

The energy relations involved in each portion of the cycle can best be analyzed by using the steady-flow energy equation between any two sections a and b. (For a discussion of the theory concerning the equations, see THERMODYNAMICS: Thermodynamics and Heat Engines.) This equation is

$$\frac{Z_a}{J} + \frac{V_a^2}{2gJ} + h_a \pm {}_aQ_b \pm {}_aW_b = \frac{Z_b}{J} + \frac{V_b^2}{2gJ} + h_b \qquad (1)$$

where

$_a$ = subscript representing section a
$_b$ = subscript representing section b
$\frac{Z}{J}$ = energy possessed by the working fluid by virtue of its elevation above an arbitrary datum elevation, B.Th.U per pound
$\frac{V^2}{2gJ}$ = kinetic energy possessed by the working fluid by virtue of its velocity, B Th.U. per pound
h = enthalpy of the fluid, B.Th U. per pound
${}_aQ_b$ = heat added or abstracted from the fluid between sections a and b, B Th U. per pound
${}_aW_b$ = work done by or on the fluid between sections *a* and b, B.Th.U. per pound
$\pm$ = plus if heat or work is added; negative if taken away

If, in the ideal cycle, air is assumed to behave as a perfect gas one may replace h with C_pT, where C_p is the specific heat at constant pressure for air. Also, if it is assumed that changes in elevation are not great and that velocities entering and leaving various components of the unit are small, the terms $\frac{Z}{J}$ and $\frac{V^2}{2gJ}$ may be neglected. On this basis the equation becomes

$$C_pT_a \pm {}_aQ_b \pm {}_aW_b = C_pT_b. \qquad (2)$$

Applying equation (2) to the various components of the gas turbine gives:

Work of compression, in which ${}_1Q_2 = 0$ and ${}_1W_2$ is positive,

$$W_c = {}_1W_2 = C_p(T_2 - T_1). \qquad (3)$$

Heat added in the combustion chamber, in which ${}_2Q_3$ is positive and ${}_2W_3 = 0$,

$$Q_A = {}_2Q_3 = C_p(T_3 - T_2). \qquad (4)$$

Work done by the turbine, in which ${}_3Q_4$ is zero and ${}_3W_4$ is negative,

$$W_t = {}_3W_4 = C_p(T_3 - T_4). \qquad (5)$$

In the above equations W_c represents the work required to compress and deliver the air, Q_A the heat added to the air in the combustion chamber and W_t the work done by the turbine, all in B.Th.U. per pound of air.

Using the above equations, the net work of the cycle per pound of air passing through the turbine is,

$$W_{cycle} = W_t - W_c = C_p[(T_3 - T_4) - (T_2 - T_1)]. \qquad (6)$$

The heat added is $Q_A = C_p(T_3 - T_4)$ so that the thermal efficiency, representing the ratio of the work done to heat added, is

$$\eta_{Th} = \frac{W_{cycle}}{Q_A} = 1 - \left(\frac{T_4 - T_1}{T_3 - T_2}\right) = 1 - \frac{T_1\left(\frac{T_4}{T_1} - 1\right)}{T_2\left(\frac{T_3}{T_2} - 1\right)}. \qquad (7)$$

It is easy to show from the laws of thermodynamics that for a perfect gas undergoing the processes involved, $\frac{T_4}{T_1} = \frac{T_3}{T_2}$. The equation for the thermal efficiency of the ideal cycle therefore becomes

$$\eta_{Th} = 1 - \frac{T_1}{T_2}. \qquad (8)$$

It is also well known that when any two states of a perfect gas, 1 and 2, are joined by an isentropic process,

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = r_p^{\frac{k-1}{k}}. \qquad (9)$$

Where k is the isentropic exponent for the gas and r_p is the pressure ratio $\frac{P}{P_1}$ Substitution of this relationship into equation (8) gives the-thermal efficiency in terms of pressure ratio.

$$\eta_{Th} = 1 - \frac{1}{r_p^{\frac{k-1}{k}}}. \qquad (10)$$

A curve illustrating the variation of thermal efficiency with pressure ratio, derived in accordance with equation (10), is shown by the dotted curve in fig. 8. According to this curve, which represents only the ideal cycle, the efficiency increases with pressure ratio until a maximum value of unity is reached at infinite pressure ratio.

Actual Simple Open-Cycle Gas Turbine. — The principal difference between the ideal cycle described above and the actual cycle is that the compression and expansion processes cannot be carried out isentropically as assumed. Instead. the work of compression is increased and that obtained by expansion is decreased. The net result is a drastic reduction in thermal efficiency.

The reasons for this are illustrated in the temperature-entropy diagram of fig. 9. Here the actual processes are shown as solid lines and the ideal processes as dotted lines. As a result of inefficient comoression the actual amount of work reauired to compress the air becomes $W_c = \frac{C_p(T_2-T_1)}{\eta_c}$ where η_c is the efficiency of the compressor. Similarly, because of the inefficiency of the turbine, the work of expansion is reduced to $W_t=\eta_t C_p(T_3-T_4)$ where η_t is the efficiency of the turbine. The net work of the cycle therefore becomes

$$W_{\text{cycle}}=W_t-W_c=\eta_t C_p(T_3-T_4)-\frac{C_p(T_2-T_1)}{\eta_c} \tag{11}$$

The heat added in the actual cycle is that required to raise the temperature of the air leaving the compressor to T,; namely,

$$Q_A=C_p(T_3-T_2'). \tag{12}$$

By simple algebra and the thermodynamic relations for a perfect gas, it can be shown that the thermal efficiency becomes

$$\eta_{Th}=\frac{\eta_c\eta_t\left(\frac{T_3}{T_1}\right)-r_p^{\frac{k-1}{k}}}{1-\eta_c+\left(\frac{T_3}{T_1}\right)\eta_c-r_p^{\frac{k-1}{k}}}\left(1-\frac{1}{r_p^{\frac{k-1}{k}}}\right) \tag{13}$$

where the term in parentheses is equal to the thermal efficiency of the ideal cycle and the remaining portion represents a correction factor for inefficiency of the actual cycle. Curves showing the thermal efficiency of several typical actual cycles. similar to that depicted by the temperature-entropy diagram of fig. 8, are illustrated by the solid lines in fig. 7. In these. the efficiency of the compressor is taken as 85% and that of the turbine 87%. Maximum cycle temperatures. ranging from 1,000° F. to 1,750° F., about the maximum permissible with modern alloys, are employed.

The curves show that the thermal efficiency increases nith maximum temperature of the cycle T_3 and that there is an optimum value of pressure ratio r_p for each value of T_3. From these curves it is easy to verify that the maximum temperature must be high if a satisfactory efficiency is to be obtained. From the temperature-entropy diagram it is also evident that the lower the efficiencies of the compressor and turbine, the lower will be the net work output of the cycle. These facts explain the failure of Stolze's turbine and of all similar early models. They also explain the reason for Holznarth s efforts in attempting to perfect the explosion-type turbine. in which the efficiency of compression is less important.

Reheat, Intercooling and Regeneration. — There are three basic ways in which the efficiency of the simple gas turbine cycle can be increased. These are. (1) to increase the work output of the turbine; (2) to decrease work input to the compressor; (3) to decrease the amount of heat added by the fuel.

The first of the above objectives may be realized by dividing the expansion process into two or more steps. This is usually accomplished by employing a high-pressure and low-pressure turbine with a combustion chamber in betneen for reheating the air and combustion products. The effect is to increase the volume of the gas undergoing expansion, thus increasing the work of the turbine.

The second objective may be accomplished by compressing the air in a manner as near isothermal (constant temperature) as possible. The closest practical approach to this objective is to employ intercooling. This consists of compressing the air in tno or more steps with arrangements for cooling back to inlet temperature between steps. The purpose here is to maintain the volume of air as low as possible in order to reduce the power required for compression.

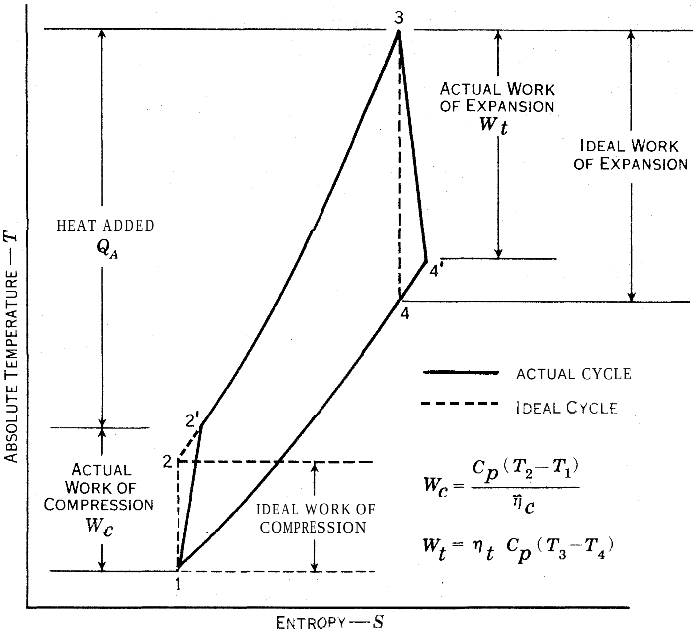


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FIG 9 — TEMPERATURE-ENTROPY DIAGRAM FOR ACTUAL SIMPLE OPEN-CYCLE GAS TURBINE

With respect to the third objective, examination of the temperature-entropy diagram in fig. g reveals that the hot gases leaving the compressor at temperature T_4' are higher than the temperature

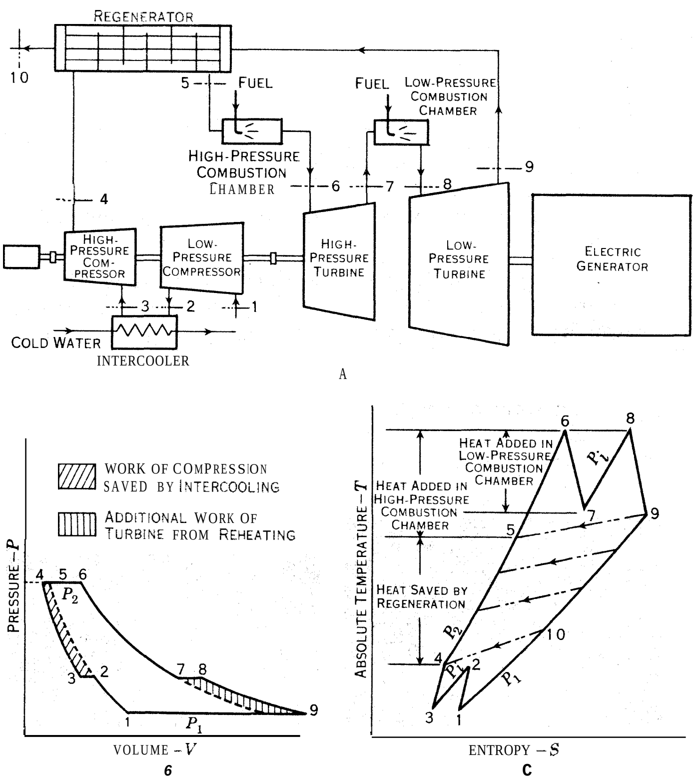

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FIG. 10.— (A) SCHEMATIC DIAGRAM OF ACTUAL CYCLE EMPLOYING INTERCOOLING, REGENERATION AND REHEAT; (B) PRESSURE-VOLUME AND (C) TEMPERATURE-ENTROPY RELATIONSHIPS OF SUCH A CYCLE

of the air leaving the compressor at T_2'. By employing a heat exchanger it should be possible to warm the air on its way to the combustion chamber, by transferring excess heat from the exhaust gases to the air. In practice this is accomplished by means of a regenerator in which the hot exhaust gases are passed counterflow to the air leaving the compressor in a manner such that the heat surrendered by the turbine exhaust gases is absorbed by the compressed air before entering the combustion chamber. This reduces the amount of heat added by the fuel.

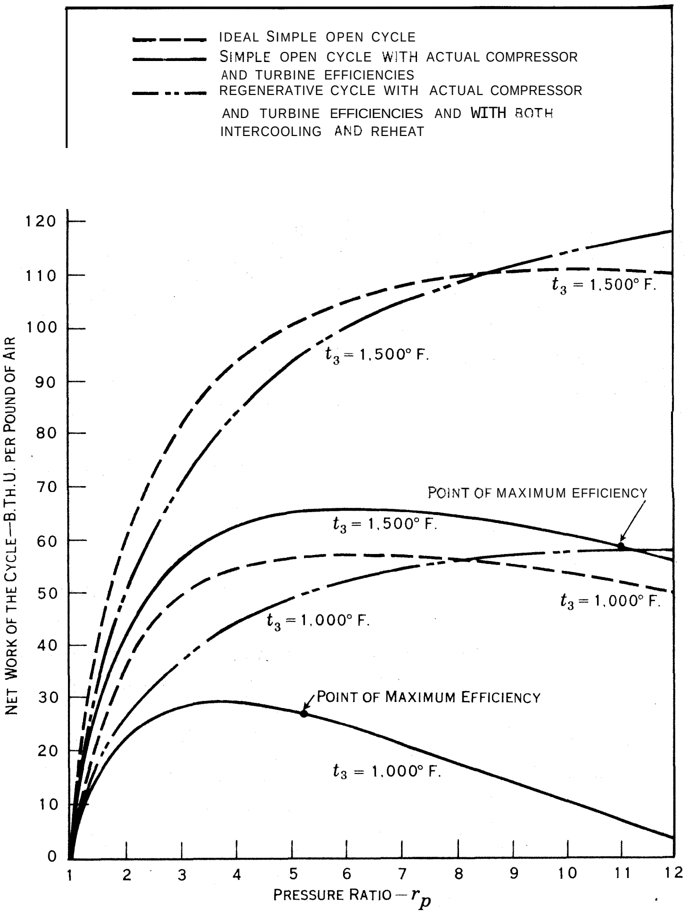

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FIG. 11.— CURVES OF WORK OUTPUT PER POUND OF AIR FOR CYCLES OF VARIOUS COMPLEXITY

Fig. 10 is a schematic diagram of a cycle incorporating all three of the features described above. Also shown in fig. 10 are the corresponding pressure-volume and temperature-entropy diagrams. With the aid of the pressure-volume diagram it is easy to represent, by crosshatching, the increased work of the turbine resulting from reheat and the decreased work of compression resulting from intercooling.

From the temperature-entropy diagram the transfer of heat from the hot exhaust gases to the cooler compressed air is illustrated together mith the consequent saving in heat added by the fuel. Although there is additional heat added in the reheat combustion chamber. the amount is not as great as the gain in work of the turbine. Therefore, reheating is an advantage from the standpoint of over-all thermal efficiency.

In fig. 8 are shown thermal efficiency curves for a regenerative cycle employing both reheat and intercooling, and having the same compressor and turbine efficiencies as before. For computing the efficiencies. frictional. pressure drop in the cycle was neglected and the regenerator was assumed to have an effectiveness of 90%. The advantage of the cycle is readily apparent insofar as thermal efficiency is concerned. However, the disadvantages of added complexity and first cost often outweigh the advantages.

Work Obtainable. — The work obtainable per pound of air passing through the cycle varies greatly with pressure ratio, maximum temperature and complexity of the cycle. In fig. 11 are presented curves showing the work obtainable, plotted opposite pressure ratio, for the various cycles discussed in the previous section. The point of maximum efficiency is marked on the curves representing the actual simple open cycle in order to indicate that the point of maximum work does not necessarily correspond to that of maximum efficiency. The curves are computed for a compressor efficiency of 85% and a turbine efficiency of 87%. When intercooling and reheat are employed each is assumed to occur at the optimum intermediate pressure for maximum efficiency, namely, $P_i = P_1\left(\frac{P_2}{P_1}\right)^{0.5}$. Pressure drop in the cycle is neglected and the specific heat of air is taken as constant and equal to 0.24 B.Th.U. per pound per degree Fahrenheit. Reheat and intercooling are assumed to restore the temperatures to their original values.

The curves clearly show the advantage of reheat, intercooling and regeneration on the work output of the cycle.

Design Features. — Although a detailed discussion of the many design features of gas turbines cannot be undertaken here, enough can be included to give the reader an idea of the arrangement of essential components. In fig. 12 is shown a cross section of an 8,750-r.p.m., 1,800-h.p. gas turbine. At the left is the axial-flow compressor where intake air is compressed to a pressure equal to about four or five atmospheres. In the centre are a ring of combustion chambers into which fuel is injected and burned, raising the temperature of the air and combustion products to a value of approximately 1,250° F. From the combustion chambers the hot gases are directed into the multistage reaction turbine which is directly connected through a central hollow shaft to the compressor. During expansion of the gases through the turbine, sufficient work is performed to drive the compressor and still leave a substantial amount for other purposes.

Fig. 13 is a view of the exposed compressor and turbine rotor. The blading is clearly visible on both compressor and turbine elements. (For a discussion of turbine blading see TURBINE: STEAM.)

In fig. 14 is shown a sectional scale model of a 5,000-h.p. gas turbine plant equipped with a regenerator. Air is first compressed

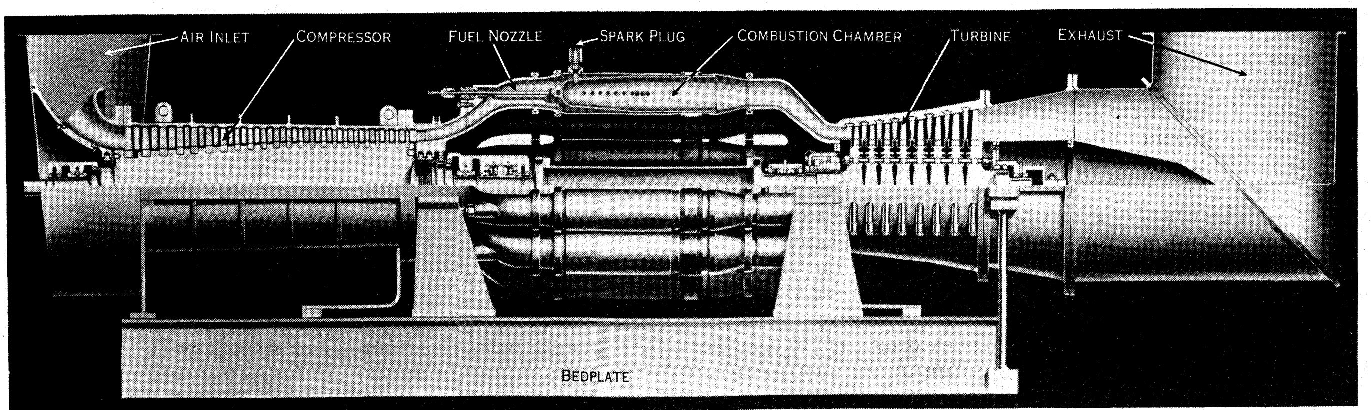

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FIG. 12.— CUTAWAY VIEW OF 1,800-H.P. SIMPLE OPEN-CYCLE GAS TURBINE

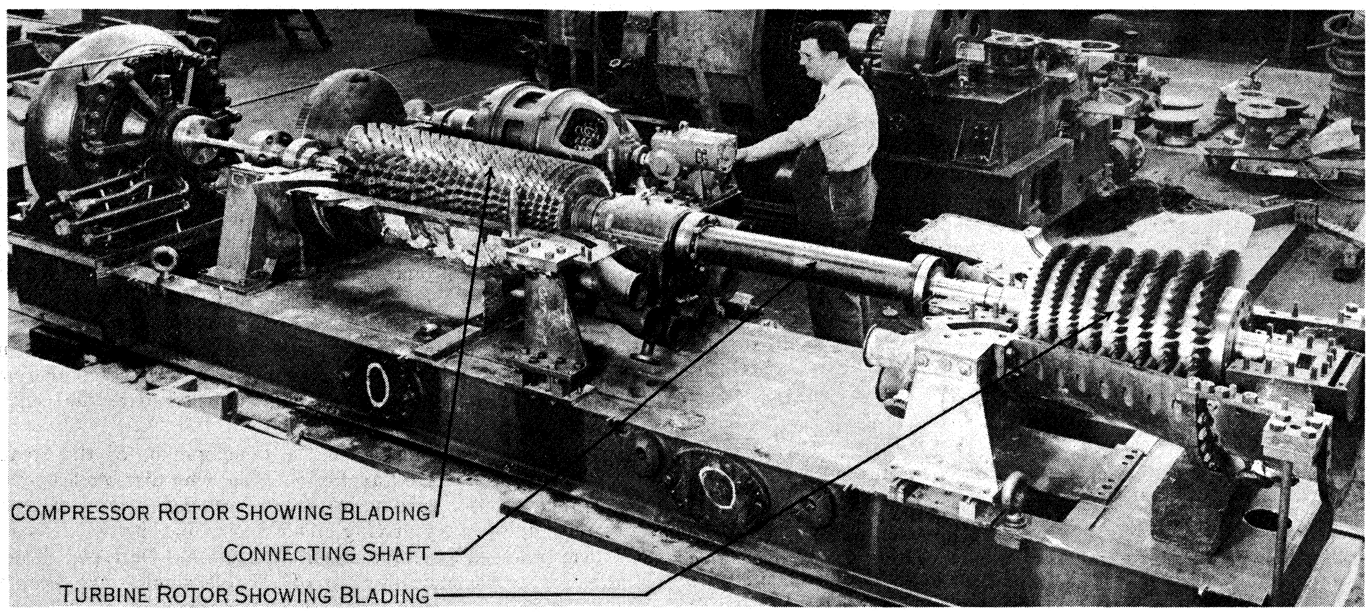

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FIG. 13.— EXPOSED VIEW OF 1.800-H.P. GAS TURBINE ROTOR

in the axial-flow compressor and then directed into the regenerator where it absorbs heat from the turbine exhaust gases. From the regenerator it returns to the combustion chambers to be heated further by the combustion of fuel before flowing into the high-pressure turbine. The latter is connected to the coniрressor by a hollow shaft and supplies the power required to drive it. From the high-pressure turbine the hot gases flow through the low-pressure turbine and out through the regenerator to the exhaust. The low-pressure turbine furnishes the power to drive an electric generator or other equipment. The arrangement of elements for a

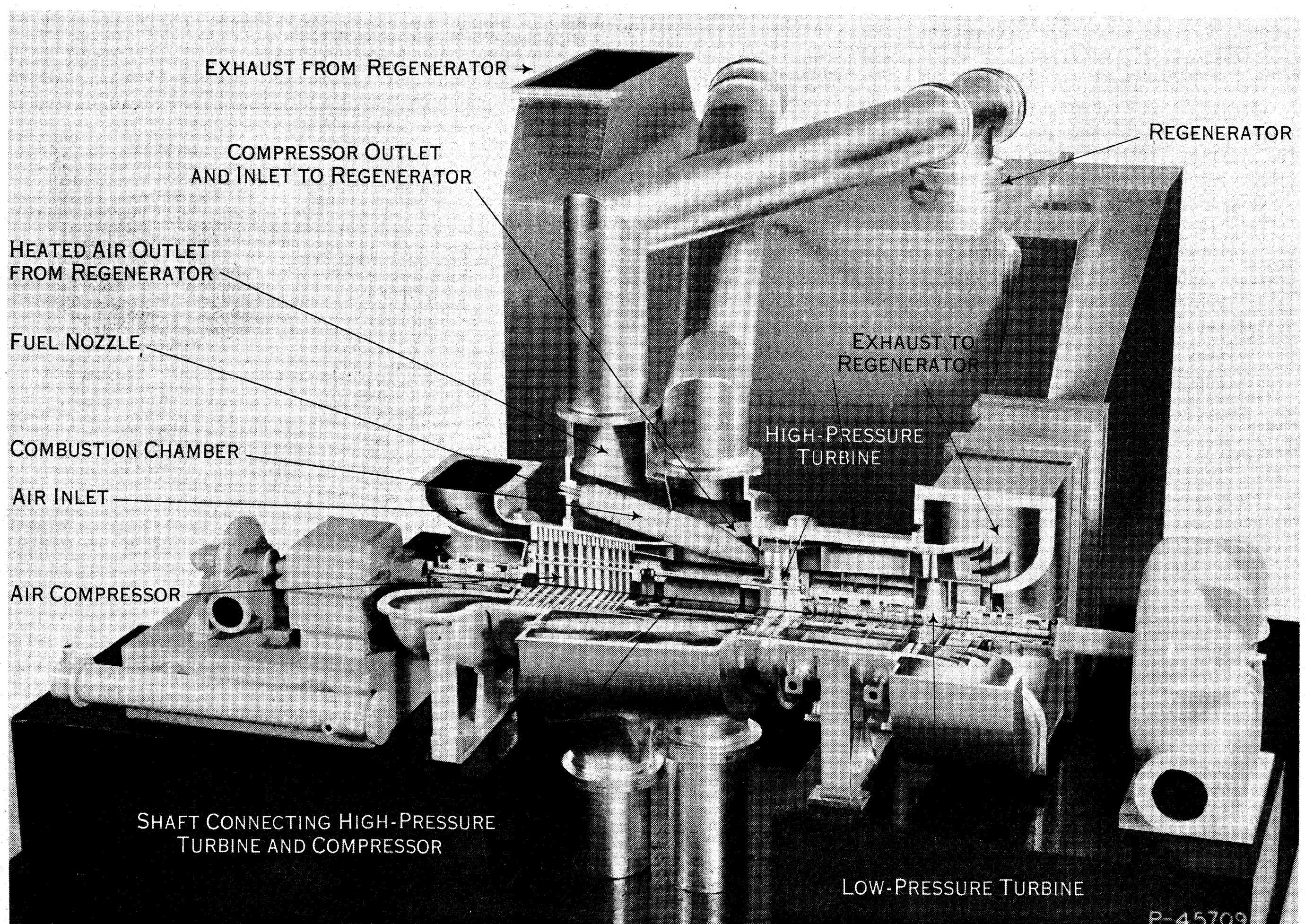

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FIG. 14.— CUTAWAYSCALE MODEL OF A REGENERATIVE-CYCLE GAS TURBINE POWER PLANT

jet propulsion engine is illustrated schematically in fig. 5. In the jet propulsion engine only a portion of the energy in the gases is employed by the turbine to drive the compressor. The remainder is reserved for building up velocity of the gases issuing from the tailpipe, thus providing the reactive force required for propulsion.

A turboprop engine with propeller, double-rotor compressor and triple-rotor turbine is illustrated schematically in fig. 6. In this unit the propeller is driven by the low-pressure turbine. The low-pressure section of the compressor is driven by the intermediate-pressure turbine. and the high-pressure section by the high-pressure turbine. Such an arrangement provides a wide degree of flexibility with respect to speed of both propeller and compressor elements.

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TURBINE: STEAM. A steam turbine is a machine for converting thermal energy stored in steam into work. It consists of a shaft or rotor resting in bearings and enclosed in a cylindrical casing. The rotor is made to turn smoothly by means of jets of steam issuing from nozzles located around the periphery of the turbine cylinder and impinging upon blades or buckets attached to the shaft. Thus, a steam turbine is a prime mover nhich generates motive power in the same manner as a windmill except on a vastly greater scale. Instead of a current of air being used to rotate the shaft. steam is employed as the working agent.

Because of its ability to develop tremendous power within a comparatively small space. the steam turbine has superseded all other prime movers except hydraulic turbines for the generation of large quantities of electrical energy (see TURBINE: WATER). The economic importance of the steam turbine has provided an incentive for continued development, resulting in units capable of generating over 250,000 kw. of power on a single shaft and over 450,000 kw. in other combinations.

History. — The earliest proposed steam turbines were of the reaction type in which rotation was achieved by steam issuing from curved tubes or nozzles, much as in the case of water issuing from a lawn sprinkler. The first such device is attributed to Heron of Alexandria about the year 130 B C. It consisted of a hollow sphere mounted betneen two hollow tubes through which steam was supplied. Attached to opposite sides of the sphere, in a plane perpendicular to the axis of the two tubes, were two curved nozzle outlets through uhich steam issued, imparting rotation in a manner similar to that of the familiar pinwheel employed for fireworks displays.

The first steam turbines having any commercial significance appear to be those built in the United States by William Avery in 1831. Their turbine consisted of two hollow arms about $2\frac{1}{2}$ ft. long, attached at right angles to a hollow shaft through which steam was supplied. The arms were of rectangular cross section about $\frac{1}{2}$ in. by 34 in. measured on the outside. At the extremity of each arm was a small opening about $\frac{1}{8}$ in. by $\frac{1}{4}$ in. in cross section through which the steam could issue. The openings were at the trailing edge of the arms so that rotation was achieved by the reactive-force of the steam. About 50 of these turbines were built for sawmills and wooduorking shops and at least one was tried on a locomotive. Although an efficiency approximately equal to that of contemporary steam engines was claimed. the turbines were abandoned because of their high noise level, difficult speed regulation and frequent need of repair.

It was not until the latter part of the 19th century that further significant contributions were made. Probably the most prominent among a number of early inventors in the steam turbine field was Sir Charles Parsons of England. He is recognized as the first to employ a large number of stages in series so that the energy release by the expanding steam could take place in small steps. It was this principle that opened the way for the development of the modern steam turbine. He also developed the reaction stage principle, in which pressure drop and energy release are equal through both the stationary and moving blades. Turbines- employing this principle are frequently called Parsons turbines in honour of the inventor.

Parsons' original ten-horsepower steam turbine was built in 1884 using a rotor and casing with attached multiple-stage blading, characteristic of modern turbines. Steam entered at the centre and flowed toward the ends.

Another prominent pioneer in the development of the steam turbine was Carl G. P. De Laval of Sweden. who first built a small 42,000-r.p.m. reaction turbine in 1883. Although several of these were later employed for driving cream separators. he did not consider them practical for commercial application. De Laval turned his attention to the development of reliable single-stage simple-impulse turbines similar to those with which his name is still associated. He is credited with being the first to employ a convergent-divergent type nozzle in a steam turbine in order to realize the full potential energy of the expanding steam in a single-stage machine.

During the period from 1889 to 1897 De Laval built a large number of turbines ranging in size from about 5 h.p. to several hundred. In 1892 he built a 15-h.p. turbine for marine applications uith two turbine wheels, one for forward motion and the other for astern operation. An early model similar to this was exhibited at the world's fair held in Chicago in 1893.

In addition to Parsons and De Laval two other pioneers in the field, C. E. A. Rateau of France and Charles G. Curtis of the United States, made important contributions. Rateau started his nork in 1894. He developed the multistage-impulse principle, now commonly known as pressure staging, in which pressure drop occurs only in the stationary nozzle elements and not in the moving blades. With this design, fewer stages are required than for a corresponding reaction-type turbine operating under the same steam conditions. Curtis began his work on steam turbines in 1897. He is responsible for the development of the velocity-compounded impulse stage in which two rows of moving blades are employed. In his design an intermediate row of stationary blading was inserted between the two moving rows in order properly to direct the steam from the first to the second moving row. He also developed the use of several velocity-compounded stages in series.

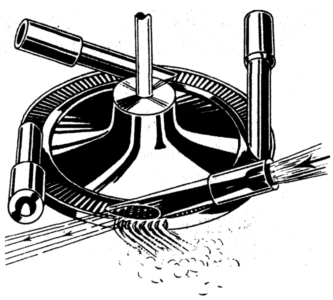


FIG. 1.—DE LAVAL WHEEL AND NOZZLES SHOWING DEVIATION OF THE STEAM JETS BY THE BUCKETS

Shortly after the turn of the century steam turbines began to replace steam engines as the principal prime mover in central station power plants. As a result developments were rapid and became associated chiefly with large companies rather than individuals. Improvement in both size and efficiency of units followed, leading to the commanding position now occupied by the steam turbine in the field of electric power generation.

Principal Components. — The principal components of a steam turbine are: (1) the rotor which carries the blading employed for converting energy of the steam into rotary motion of the shaft; (2) the casing or cylinder. inside which the rotor turns and which carries fixed nozzle passages through which steam is accelerated before being directed against the rotor blading; (3) the speed regulating mechanism by which the speed of rotation is governed;

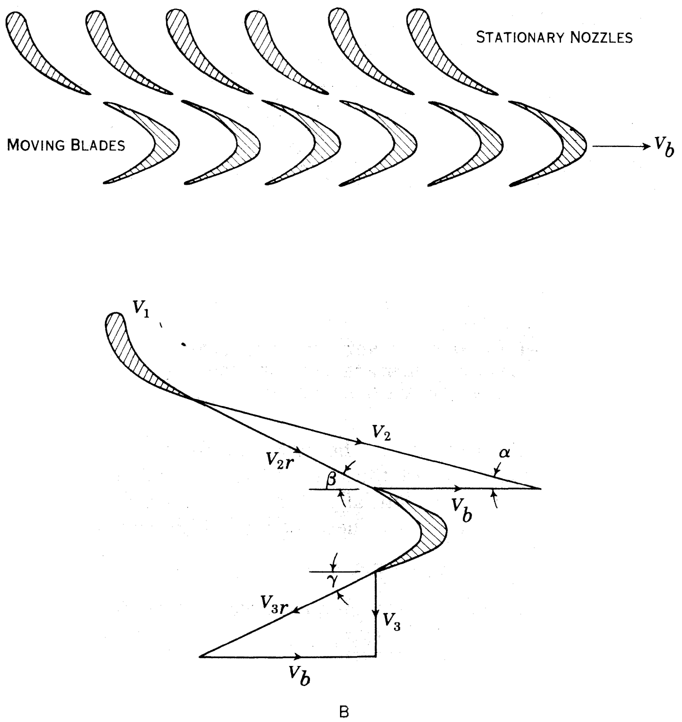
(4) the lubrication system for bearings and other apparatus associated with the turbine.

Of the various elements of the turbine, perhaps the most difficult to design properly is the blading, since it must have adequate strength and the correct aerodynamic shape to convert the energy of the steam into shaft work efficiently. Various types of blading and blading arrangements have been proposed but all are designed to take advantage of Newton's principle that when a given mass of substance suddenly changes its velocity, a force is exerted by the mass in direct proportion to the rate of change of velocity.

Two types of blading have been developed to a high degree of perfection. These are impulse blading and reaction blading.

The principle of impulse blading may best be illustrated by referring to fig. 1. This is a simplified diagram of a turbine rotor wheel showing four fixed nozzles directing high-velocity steam against blades mounted around the periphery. If there were no blades in the path of the steam, it would proceed in a straight line as indicated. However, the blades catch the impinging steam and turn it in the opposite direction, thus changing its velocity from a high value at entrance to a low value at exit. This decrease in velocity of the mass of steam produces a force on the rotor blading, causing the shaft, to which the blading is attached, to turn.

Proper operation of an impulse wheel similar to that illustrated in cross section in fig. 1 requires that the blading be of approximately symmetrical design and that it move past the nozzles with a speed approximately equal to one-half that of the steam issuing from the nozzles. A velocity diagram for such an arrangement is shown in fig. 2(B). In this diagram both magnitude and direction of steam velocity (V) at entrance and exit to the moving blades is indicated. When only a numerical subscript is employed, the velocity is relative to a stationary element of the turbine such as the fixed nozzles or casing. When the subscript r is added, the velocity is relative to the moving blades. Thus in fig. 2(B) the velocity of the moving blades is equal to V_b ft. per second while



BY COURTESY OF R. A. BUDENHOLZER

FIG. 2.— (A) ARRANGEMENT OF NOZZLES AND BLADING FOR A SIMPLE-IMPULSE TURBINE STAGE; (B) VELOCITY DIAGRAM FOR SIMPLE-IMPULSE TURBINE STAGE

that of the entering steam is equal to V_2 ft. per second. The relative velocity of the steam entering the moving blades is V_{2r}. Upon leaving the moving blades the steam has a relative velocity with respect to the moving blades equal to V_{3r} and a velocity V_3 with respect to the stationary elements of the turbine. It will be noted that V_2 is the vector sum of V_{2r} and V_b and that V_3 is the vector sum of V_{3r} and V_b. As indicated in the diagram, the blading turns the steam through a sharp angle, releasing it with about the same velocity, relative to the moving blades, as it had at entrance, but in the opposite direction. The result is that at exit the velocity component of the steam in the direction of the moving blades is approximately zero relative to the stationary elements of the turbine.

When reaction blading is employed the rotor is designed to turn at a speed approximately equal to that of the steam issuing from the nozzles, instead of half the velocity, as employed in an impulse stage. The steam thus enters the moving blades with almost zero relative velocity, as indicated in fig. 4(B). Also, the blades of the rotor of a reaction turbine are unsymmetrical and have a profile such that the space between blades forms nozzle passages. As the steam flous through these passages, it expands, thereby increasing its velocity relative to the blading. The acceleration of the steam creates a reactive force, turning the rotor in a direction opposite to that of the exit steam.

If the blading is designed to provide nozzle passages capable of building up an outlet relative velocity equal but opposite in direction to that of the moving blades, the steam will leave the moving blades with a component in the direction of movement approximately equal to zero relative to the stationary elements of the turbine.

It should be noted that with either type of blading, the over-all principle is the same, namely, that the velocity relative to stationary reference co-ordinates is first built up in the stationary nozzles, after which it is decreased in the moving blades. Energy stored in the steam is thereby first converted into kinetic energy and then into rotational shaft work.

Power Developed.—As already indicated, the magnitude and direction of steam velocity at entrance to and exit from the various passages in a turbine stage can conveniently be illustrated by means of a velocity diagram. With the aid of the velocity diagram illustrated in fig. 2(B) it is easy to compute the force of the steam acting on the blading of a simple-impulse stage. Employing Newton's law, one may write

$$F_b = \frac{w}{g}(V_{2r}\cos\beta + V_{3r}\cos\gamma) \tag{1}$$

where F_b is the component of force acting in the direction of the blade velocity, in pounds; w is the rate of flow of steam, in pounds per second; and g is the gravitational constant, in feet per second squared.

If the blading is symmetrical γ will equal β. Also, since the passages are not designed as nozzles, V_{3r} will equal V_{2r} and both may be replaced by $V_2\cos\alpha - V_b$, so that

$$F_b = \frac{2w}{g}(V_2\cos\alpha - V_b). \tag{2}$$

The power developed by the stage in foot-pounds per second will equal the force acting on the blading multiplied by the velocity with which the blades are moving. Hence,

$$P = F_b \times V_b = \frac{2w}{g}(V_2\cos\alpha - V_b)V_b. \tag{3}$$

To obtain the value of blade velocity resulting in maximum power output, equation (3) may be differentiated with respect to V_b and equated to zero. Thus

$$\frac{dP}{dV_b} = \frac{2w}{g}(V_2\cos\alpha - 2V_b) = 0. \tag{4}$$

Therefore

$$V_b = \frac{V_2\cos\alpha}{2}. \tag{5}$$

Substituting into equation (3) gives the maximum power of the stage

$$P_{\max} = \frac{wV_2^2\cos^2\alpha}{2g} = \frac{2wV_b^2}{g} \tag{6}$$

To express this in terms of horsepower, one need only divide by 550, the number of foot-pounds per second in one horsepower. Thus

$$hp_{\max} = \frac{2wV_b^2}{550g}.$$

To obtain greater power per stage with impulse blading the principle of velocity compounding may be employed. In this arrangement, the steam first passes through a row of nozzles and blades much as in the case of the simple-impulse stage but with a sufficient velocity to allow the steam to be redirected into a second row of moving blades as illustrated in fig. 3.

It can be shown by the use of Newton's law and trigonometric calculations similar to those carried out for the simple-impulse stage that a blade velocity equal to $\frac{V_2 \cos \alpha_1}{4}$ is required for maximum efficiency of this type of stage.

On this basis the maximum power obtainable is

$$P_{\max} = \frac{8wV_b^2}{g}. \tag{8}$$

This is four times as great as the power obtainable from a simple-impulse stage employing the same blade velocity. The reason for the increased power is that the velocity of the steam jet V_2 is tuice as great as for a simple-impulse stage. Its kinetic energy is therefore four times as great permitting the development of four times as much power.

It should be pointed out that although four times as much power is obtained with velocity compounding. four times as much thermal energy has to be expended in order to achieve this greater power. Velocity compounding, therefore, does not achieve more power for the same expenditure of thermal energy but merely permits a greater jet velocity for the same blade velocity. Since blade velocity is limited by the allouable centrifugal force, the use of velocity compounding permits a greater release of thermal energy per stage and hence fewer stages are required to accommodate a given thermal energy.

With impulse blading, an increase in velocity of the steam is achieved only in the stationary nozzle passages. In the case of reaction blading it is achieved in both the stationary nozzle passages and in the passages between the moving blades. This increase may be observed by referring to fig. 4(B), which is a velocity diagram for a 50% reaction-type stage. The term 50% reaction has reference to the fact that only 50% of the energy of the stage is released in the stationary nozzle passages, the other 50% being reserved for release in the moving blades. It will be noted from fig. 4(A) that both stationary and moving blades have the same profile. and that both form nozzle passages. This blading is in contrast with that of impulse stages in which the moving blades are symmetrical in shape and do not form nozzle passages.

In fig. 4(B) it will be noted that, just as in the impulse stage, the velocity in the stationary nozzles is built up to a value equal to V_2. However, since the blades are moving with the velocity V_b, the steam enters these with a relative velocity equal to V_{2r}, having no component in the direction of movement of the blades. In passing through the blading, the steam is accelerated to the velocity V_{3r}. In the ideal case V_{3r} is made approximately equal to V_2 so that the steam leaves the moving blades with a relative exit velocity component equal but opposite in direction to that of the moving blades.

Hence the velocity of the leaving steam, relative to stationary elements of the turbine, is V_4. This velocity has no component in the direction of rotation of the blading and is therefore correct to enter smoothly into the next row of stationary nozzles. In the reaction blading shown, the velocity component of the steam in the direction of rotation has been changed during passage through the moving blades from zero at entrance to $V_{3r} \cos \alpha = V_b$ at exit. This change creates a reactive force against the moving blades given by the equation

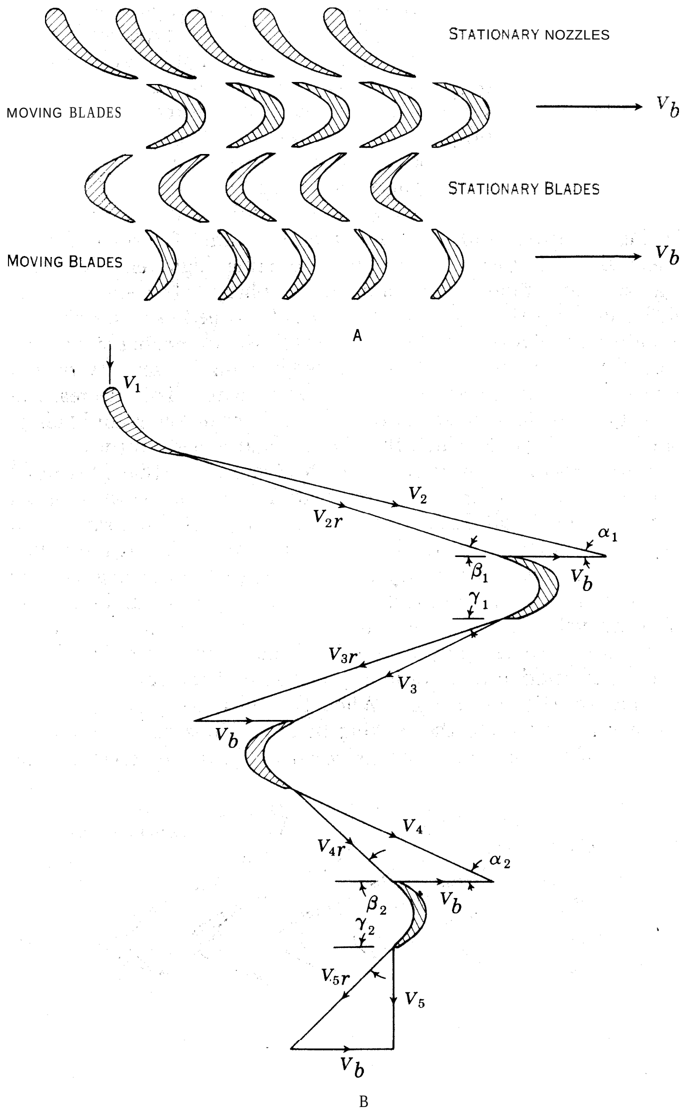
$$F_b = \frac{w}{g} V_b \tag{9}$$

where, as before, w is the flow through the blading in pounds per second. The maximum power developed by the stage will therefore be

$$P_{\max} = \frac{wV_b^2}{g}. \tag{10}$$

This is just half the power capable of being developed in a single-impulse stage having the same blade velocity and one-eighth that capable of being developed in a velocity-compounded stage of the same blade velocity.

Stage Efficiency.—The efficiency of a turbine stage may be defined as the power output divided by the energy expenditure required to produce that power. If it is assumed that between



BY COURTESY OF R. A BUDENHOLZER

FIG. 3.—(A) ARRANGEMENT OF NOZZLES AND BLADING IN A VELOCITY-COMPOUNDED IMPULSE TURBINE STAGE WITH TWO ROWS OF MOVING BLADES: (B) VELOCITY DIAGRAM FOR A VELOCITY-COMPOUNDED IMPULSE TURBINE

impulse stages the velocity of the steam is essentially zero. the velocity V, at the outlet of the nozzles must be achieved at the expense of thermal energy initially stored in the steam. The required energy is equal to the kinetic energy of the steam leaving the nozzles, $\frac{wV_2^2}{2g}$ ft.lb. per second.

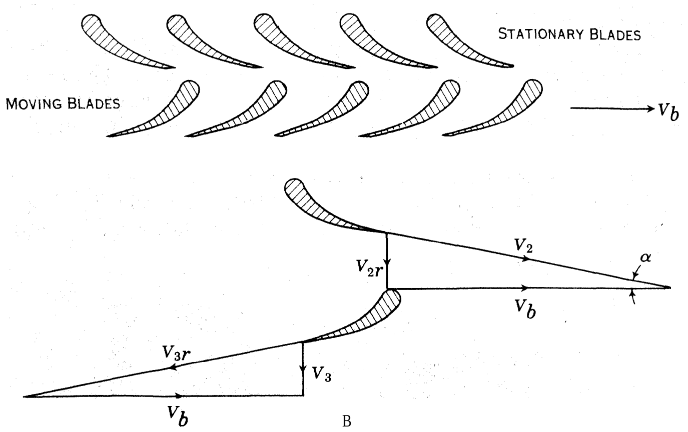
The maximum efficiency of a simple-impulse stage is therefore

$$e_s = \frac{P_{\max}}{\frac{wV_2^2}{2g}} = \frac{\frac{2wV_b^2}{g}}{\frac{wV_2^2}{2g}} = \frac{4V_b^2}{V_2^2} = \cos^2\alpha. \tag{11}$$

Similarly, for a velocity-compounded impulse stage the maximum efficiency will be

$$e_s = \frac{P_{\max}}{\frac{wV_2^2}{2g}} = \frac{\frac{8wV_b^2}{g}}{\frac{wV_2^2}{2g}} = \frac{16V_b^2}{V_2^2} = \cos^2\alpha. \tag{12}$$

In the 50% reaction stage the velocity V_2 must first be achieved by expansion through the stationary nozzles after which the velocity V_{3r} must be attained by expansion through the moving blades. Thus, two expansions are required at a sacrifice of stored



BY COURTESY OF R A BUDENHOLZER

FIG. 4.— (A) ARRANGEMENT OF NOZZLES AND BLADING IN A 50% REACTION-TYPE TURBINE STAGE; (B) VELOCITY DIAGRAM FOR A 50% REACTION-TYPE TURBINE STAGE

energy in the steam equal to $\dfrac{w(V_2^2+V_{3r}^2)}{2g}$ ft.lb. per second.

Since for this type of stage, V_{3r} is equal to V_2, the input is $\dfrac{wV_2^2}{g}$ and the efficiency is

$$e_s \equiv \frac{P_{\max}}{\dfrac{wV_2^2}{g}} = \frac{\dfrac{wV_b^2}{g}}{\dfrac{wV_2^2}{g}} = \frac{V_b^2}{V_2^2} = \cos^2\alpha. \tag{13}$$

It will be noted that the efficiency for all three types of stage is $\cos^2\alpha$, indicating that regardless of the type employed, the theoretical maximum efficiency is the same. In all types the smaller the angle α, the closer will the efficiency approach its maximum value of unity which occurs when a is zero. Normally the smallest value of a that will permit adequate flow through the blading is between 12° and 20°, making an efficiency of unity a physical impossibility. Also. in actual turbine stages there are numerous other losses such as wall friction, eddy current, turbulence and leakage losses. All serve to reduce the efficiency to well below $\cos^2\alpha$. Efficiency of turbine stages also varies nith the ratio of blade velocity to steam jet velocity. The manner in which this change occurs can be observed by referring to fig. 5 illustrating the variation of stage efficiency with velocity ratio for three different types of stage. The curves shonn are typical of actual stages and therefore incorporate the various losses mentioned above. It will be noted that the maximum efficiency of the velocity-compounded stage nith two rows of moving blades tends to be less than that of the simple-impulse stage, and that both tend to have a loner maximum efficiency than the reaction-type stage. In general, velocity-compounded stages are avoided except for the first control stage of turbines.

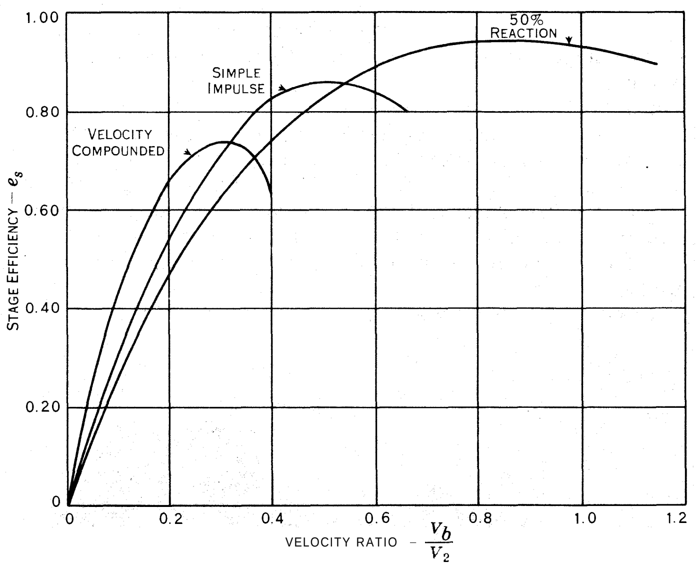
Turbine Staging.— In modern turbines a large number of stages arranged in sequence are required because the total energy release per pound of steam cannot be achieved in a single stage. There are several reasons for this, the most important of which are the folloning. (1) Steam in expanding through a modern turbine often enters under a pressure in excess of 2,000 lb per square inch and exhausts under a pressure below 1 lb. per square inch absolute. This means a several-hundredfold increase in volume of flon betneen entrance and exit. Such large expansions cannot be accommodated efficiently by a single stage because the cross-sectional area perpendicular to the flow would have to increase several hundred times through a single row of nozzle passages and one or two roms of moving blades. (2) By breaking the expansion into small steps, more efficient nozzle and blade passages can be designed. In this manner the proper velocity relationship can be realized to best accommodate conversion of energy in the steam into shaft work. (3) Centrifugal and other forces acting on the blading limit its maximum tip velocity to values that will not permit the efficient use of as few as one stage, even if all of the other factors were favourable to such an arrangement.

In modern steam turbines, three types of staging are often employed, either separately or in combination. These are velocity-compounded staging, pressure staging and reaction staging.

Velocity-Compounded Staging.— Velocity-compounded staging is well suited for small turbines in which the steam, after passing through the turbine, exhausts to a heating system or to some other use in which the pressure is atmospheric or higher. Such a turbine is illustrated in the cutaway view of fig. 6. This view clearly shows the admission valve which is controlled by a governing mechanism capable of rationing steam to the nozzles in accordance with power and speed requirements. The path of the steam through the admission valve, nozzles and turbine blading is clearly illustrated.

In addition to its use in small single-stage machines, velocity-compounded stages are frequently employed as the first of a number of stages in large industrial and central station type turbines. In this application the velocity-compounded stage serves as a control stage, and offers a powerful means of quickly changing the turbine output in response to the slightest change in steam flow as dictated by the governing mechanism. Velocity-compounded staging also permits a large drop in pressure and temperature before the steam enters the first moving blades of the turbine. This drop makes possible the use of higher initial temperatures and pressures without the use of special heat-resistant alloys that are very expensive and difficult to machine. In addition, the specific volume of the steam flowing through the blading is greater, allowing the use of longer blades, which results in lower frictional losses between the steam and the retaining walls of the blading and casing.

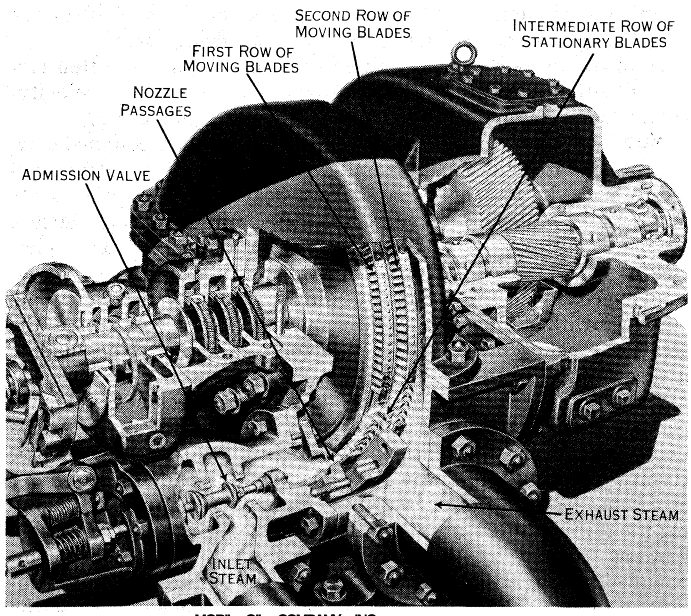
Pressure Staging.— The second type of staging mentioned, pressure staging, is simply the use of a large number of simple-impulse stages in sequence. Turbines using this principle employ a large number of stages, each contributing a small fraction to



BY COURTESY OF R A BUDENHOLZER

FIG. 5.— RELATIONSHIP OF STAGE EFFICIENCY AND VELOCITY RATIO FOR VARIOUS TYPES OF TURBINE STAGES

the total power output. A large central station turbine employing this type of staging is illustrated in fig. 7. The particular design shown is built in sizes from 50,000 to 100,000 kw. rated load, with steam inlet pressures ranging from 1,450 to 1,800 lb. per square inch gauge and temperatures ranging from 1,000° to 1,050° F. Typical of most modern machines, the turbine is equipped for return of the steam to the boiler for reheating after expansion through the first few high-pressure stages. Following reheat, the steam is again returned to the turbine where it continues its expansion through the intermediate-pressure section and on into



BY COURTESY OF SOCONY MOBIL OIL COMPANY, INC

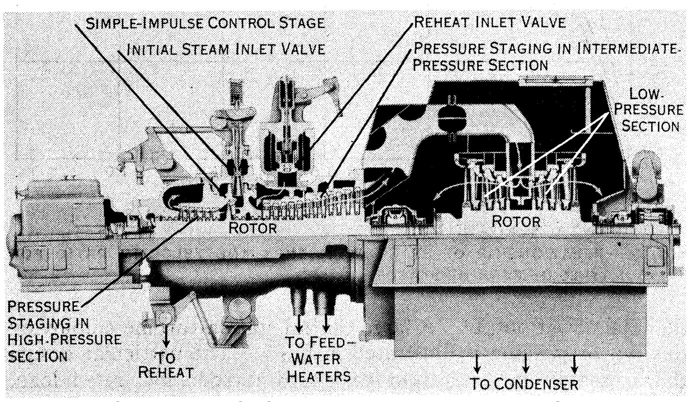
FIG. 6.—CUTAWAY VIEW OF A SINGLE-STAGE VELOCITY-COMPOUNDED TURBINE

the low-pressure section. Here it is divided into two paths, each flowing in opposite directions to opposite ends of the exhaust hood. From the exhaust hood the steam passes into a condenser where it is liquefied and returned to the boiler for re-evaporation into steam.

Reaction Staging.—Reaction staging is similar to pressure staging except that a number of reaction stages are employed in sequence. Turbines using this principle require about tnice as many stages as corresponding machines employing pressure staging. The cost, however, is about the same because blading for pressure staging must be stronger and therefore more rigidly constructed.

In fig. 8 is shown a sectional view of a reaction turbine with the various important parts designated. Also shown is a view of the exposed turbine rotor and another of the steam chest and multiple steam admission valves. It will be noted that in this machine the first stage is a velocity-compounded stage rrith two rows of moving blades. The two rows are clearly discernible in the exposed view of the rotor. This is a typical arrangement for turbines of this size.

Flow Characteristics.—In fig. 9 are presented blade cross sec-

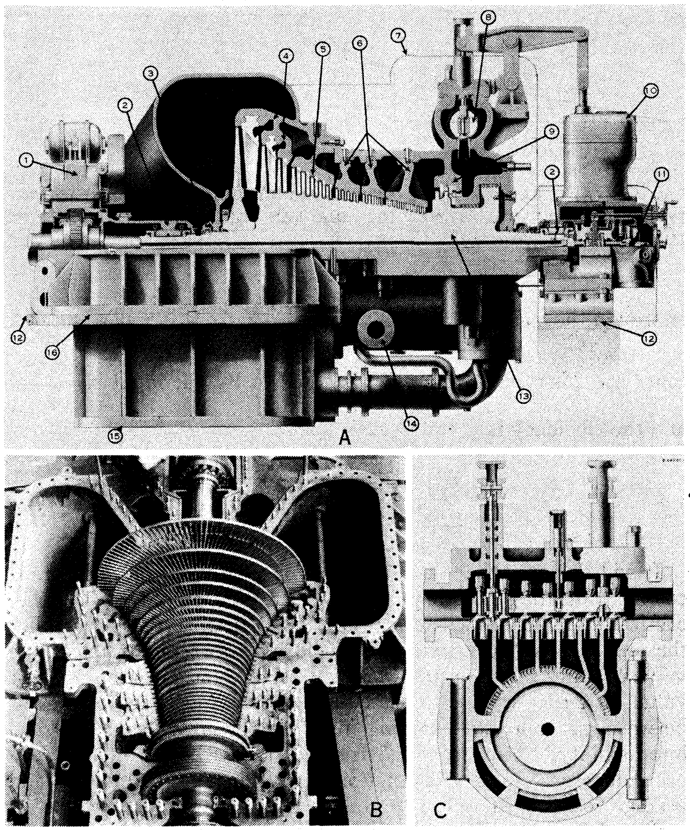


BY COURTESY OF GENERAL ELECTRIC CO AND CENTRAL ILLINOIS PUBLIC SERVICE CO

FIG. 7.—TANDEM-COMPOUND, DOUBLE-FLOW, REHEAT STEAM TURBINE

tions illustrating the variation of pressure, temperature, specific volume and velocity through the three types of staging discussed above. Each diagram is drawn employing the number of stages required to produce the same theoretical power output when using the same blade velocity. In every case ideal theoretical velocity ratios are employed and the same jet angle α is used.

Fig. 9(A) is a velocity-compounded stage in which the entire pressure drop occurs in the stationary nozzle passages. The result is a large drop in pressure and temperature and a large increase in specific volume and velocity. As the steam flows through the remainder of the stage its pressure. temperature and specific volume remain constant but its velocity is decreased in two steps as shown. In the first row of moving blades the velocity drops to about half its initial value. Through the stationary blading



BY COURTESY OF WESTINGHOUSE ELECTRIC CORP

FIG. 8.—TYPICAL REACTION-TYPE TURBINE

(A) Cutaway: (1) turning gear used for rotating turbine and generator rotor slowly when unit is off the line; (2) main bearings; (3) combination labyrinth and water seal glands; (4) moisture catchers; (5) turbine blading; (6) blade rings; (7) steel jacket; (8) multivalve steam chest; (9) first stage nozzles; (10) hydraulic governor servo motor; (11) turbine governor; (12) soleplate grouted to foundation; (13) turbine rotor; (14) extraction opening; (15) turbine exhaust flange; (16) low-pressure turbine casing. (B) Exposed turbine rotor. (C) Steam chest showing multiple admission valves

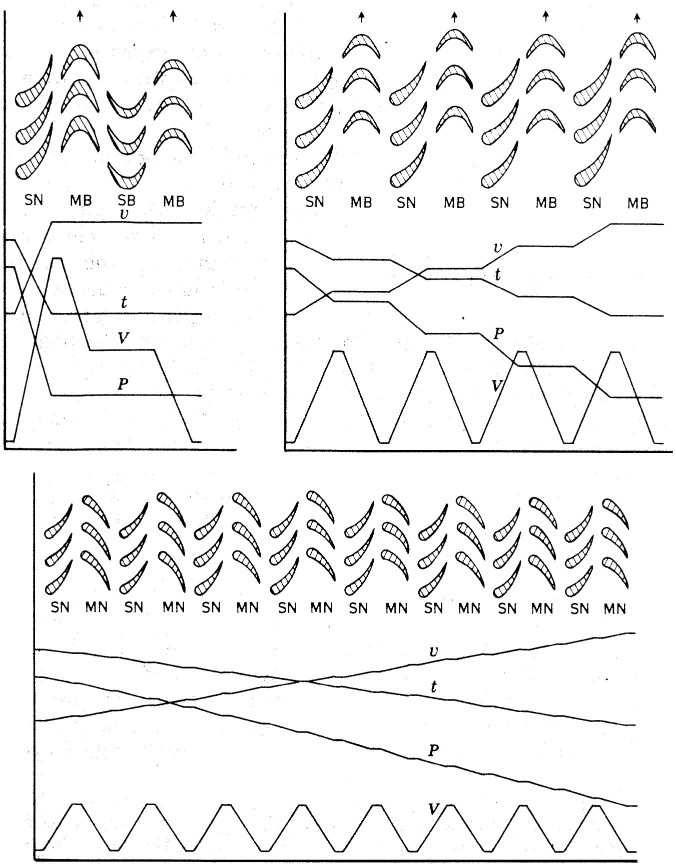
the magnitude of the velocity remains unchanged but its direction is altered.

After entering the second row of moving blades its value is decreased to almost zero at exit. Thus the kinetic energy stored in the steam, after leaving the stationary nozzles, is converted into work in two steps, each in a different velocity range. Hence the term velocity-compounded stage.

Fig. 9(B) is a diagram of the flow pattern through a group of four simple-impulse stages in series theoretically capable of developing the same power as the single velocity-compounded stage of fig. 9(A). In this case the velocity is built up in each row of stationary nozzles and reduced in each row of moving blades. As indicated, the over-all pressure and temperature drop and overall increase in velocity are the same as for the single velocity-compounded stage. It will be noted that the pressure drop occurs in four approximately equal steps, giving rise to the name pressure staging by which this type of arrangement is most commonly known.

A group of eight 50% reaction stages equivalent to the single velocity-compounded stage of fig. 9(A) or the four pressure stages of fig. 9(B) is illustrated in fig. 9(C). Here it will be noted that pressure and temperature drop occurs across the moving blades as well as the stationary nozzles. Although the specific volume increases, the velocity relationship of the moving blades relative to the stationary nozzle is such that the velocity relative to the stationary elements of the turbine is alternately built up and decreased as indicated. This alternation is true even though an expansion takes place relative to the moving blades as illustrated in fig. 4(B).

Performance Characteristics.— The performance of a steam turbine is measured in terms of the "turbine heat rate." which is a measure of the heat that must be supplied to the steam in order to produce a specified power output. For central station applications the turbine is always connected directly to an electrical generator and the combination is called a turbogenerator. The turbine heat rate for this type of machine is defined as the number of British thermal units (B.Th.U.) of heat that must be added to the steam in order to produce one kilowatt-hour of electrical power output.



SN= STATIONARY NOZZLES MB= MOVING BLADES P= PRESSURE V= VELOCITY
SB= STATIONARY BLADES MN= MOVING NOZZLES t= TEMPERATURE v= SPECIFIC VOLUME

FIG 9 — VARIATION OF PRESSURE TEMPERATURE. SPECIFIC VOLUME AND VELOCITY RELATIVE TO STATIONARY ELEMENTS OF THE TURBINE FOR THREE DIFFERENT TYPES OF STAGES

(A) Velocity compounded stage, (B) group of four simple-impulse stages (pressure staging), (C) group of eight 50% reaction stages. Each group develops the same amount of power

In the case of a turbine not connected to an electrical generator, the heat rate is usually expressed in terms of B.Th.U. per horsepower-hour output.

The turbine heat rate depends upon a large number of factors. the most important of which are the following: (1) pressure and temperature of the inlet steam: (2) exhaust pressure; (3) internal efficiency of the turbine, a measure of effectiveness with which the energy in the steam is converted into work; (4) exhaust loss, the kinetic energy loss associated with the high velocity of exhaust; (j) mechanical losses; (6) generator losses. With the exception of the first two factors. the above all depend to some extent upon the fraction of rated load being carried by the turbine.

In general. the turbine heat rate increases with decrease in load. This inverse relation means that more steam is required to generate a unit of output at low load than at high load.

A diagram illustrating the heat supplied to each pound of steam passing through a typical turbine. and its ultimate disposition. is shown in fig. 10. The diagram is plotted with the heat content per unit mass (enthalpy) of steam as ordinates and entropy as abscissas (see STEAM: Properties of Steam). The chart is commonly called a Mollier chart and has the advantage of showing heat and energy quantities in terms of length of lines measured parallel to the direction of the ordinate. Thus difference in enthalpy quantities are representative of heat and work insofar as operation of the turbine is concerned.

For simplicity, a turbine operating on the simple Rankine cycle (see STEAM: Steam *Power* Plants) has been chosen. In this type of cycle no steam is extracted from the turbine for heating feed water on its way to the boiler.

Referring to the diagram, various efficiencies of the turbine may be defined as follows:

$$\text{Generator efficiency} = \eta_g = \frac{\text{generator output}}{\text{mechanical output}} = \frac{h_1 - h_2''''}{h_1 - h_2'''}$$

$$\text{Mechanical efficiency} = \eta_M = \frac{\text{mechanical output}}{\text{mechanical input}} = \frac{h_1 - h_2'''}{hi - h_2''}$$

$$\text{Internal efficiency} = \eta_i = \frac{\text{steam output}}{\text{available energy}} = \frac{h_1 - h'_2}{h_1 - h_2}$$

$$\text{Engine efficiency} = \eta_e = \frac{\text{generator output}}{\text{available energy}} = \frac{h_1 - h_2''''}{h_1 - h_2}$$

$$\text{Thermal efficiency} = \eta_t = \frac{\text{generator output}}{\text{total energy input}} = \frac{h_1 - h_2''''}{h_1 - h_2}$$

It should be pointed out that in the above equations and in fig. 10 the symbols h_2''' and h_2'''' do not represent true enthalpies of the steam at the points indicated, but are energy quantities per pound of steam which can be used in lieu of enthalpy in order to make possible easy representation of the mechanical and generator losses both in the equations and on the Mollier chart. The quantity h_2'' represents the enthalpy which the steam exhausting from the condenser would have if its kinetic energy were converted into enthalpy and added to h_2'. The term h_2' is the enthalpy actually possessed by the steam exhausting to the condenser.

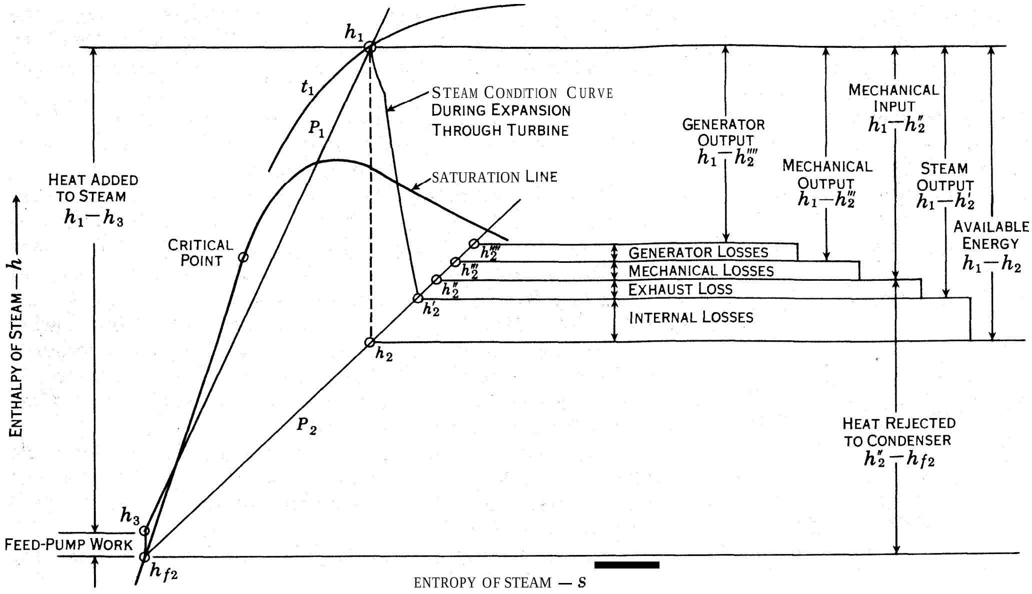
In turbines designed for central station power plants provision is made for withdrawing portions of the steam supplied to the turbine at several locations along the path of flow from inlet to condenser. This steam is used for feed-water heating. When steam is withdrawn in this manner the generator output per pound of throttle steam is obtained by summing up values of the flow between extraction points multiplied by the corresponding enthalpy drops between extraction points.

For central station steam turbines the following efficiencies are typical:

Generator efficiency	0.97–0.99
Mechanical efficiency	0.98–0.99
Internal efficiency	0.83–0.87
Engine efficiency	0.75–0.80
Thermal efficiency without extraction	0.25–0.35
Thermal efficiency with extraction	0.30–0.40

The heat rate of a turbogenerator may readily be found by dividing 3,413 by its turbine thermal efficiency. Thus for a turbine having a thermal efficiency of 0.30 the heat rate will be $\frac{3{,}413}{0.30} = 11\ 378$ B Th U. per kilonatt-hour.

Classification of Steam Turbines.— Turbines may be classified as condensing or noncondensing, depending upon whether or not the steam is exhausted to a condenser. Noncondensing turbines are those in which steam, after expsnding through the turbine, is exhausted to the atmosphere, to a heating system or to some other type of equipment. Their most frequent application is in industrial plants where steam is needed at low or intermediate



BY COURTESY OF R. A. BUDENHOLZER

FIG. 10.— DISTRIBUTION OF ENERGY IN A TURBINE OPERATING ON THE RANKINE CYCLE. ALL QUANTITIES ARE SHOWN IN B.TH.U. PER POUND OF STEAM

withdrawal of variable quantities of constant-pressure steam from one or more extraction points along the path of flow. regardless of how much load is being carried by the turbine. Such turbines are widely used in industrial power plants where steam is needed at one or more pressures for process work. Since it is desired to hold both extraction pressure and speed constant, regardless of power requirements, a complicated system of governing is required. This makes the turbines more expensive than either bleeder or straight-through turbines. Automatic-extraction turbines may be designed for either condensing or noncondensing operation.

Modern Trends.— The ever-increasing demand for electrical energy, together with the soaring cost of fuel. has stimulated the building of larger and larger turbines with higher and higher efficiencies. To secure the highest possible thermal efficiency, it is necessary to raise the pressure and temperature of the inlet steam to very high values.

During the decade 1930 to 1940, typical pressures and temperatures were around 1,200 lb. per square inch gauge and 900° F. In the following decade. 1940 to 1950, steam conditions of the order of 1,800 lb. per square inch became common, and temperatures as high as 1,050° F. were introduced. The decade 1950–60 witnessed the introduction of supercritical pressure plants, some operating with initial pressures beyond 6,000 lb. per square inch gauge and temperatures of the order of 1,100° F. These units are built with provisions for interrupting the flow of steam through the turbine and returning it to the boiler for reheat at least once and often twice during its passage from inlet to exhaust. In addition to reheat provisions, the turbines are also equipped with a large number of openings for extraction of steam for feed-water heating as required in a modern regenerative cycle plant.

pressures and where by-product power can be generated economically by inserting a noncondensing turbine between the steam generator and the equipment requiring steam.

Condensing turbines are those in which steam, after passing through the turbine, is exhausted into a condenser. Condensation is effected by the circulation of large quantities of cold water through the tubes of the condenser. The circulating water absorbs the latent heat of the steam and carries it away. The process of continuous condensation maintains a low pressure in the condenser, thus increasing the expansion ratio of the steam and the consequent efficiency and work output of the turbine. Because of the necessity of maintaining the highest possible efficiency, all central station power plants employ condensing turbines. These are connected directly to large electrical generators capable of generating power at high voltage. The power is carried by high-tension lines to substations where it is reduced in voltage and distributed to the consumer.

An additional classification of turbines may be made on the basis of whether or not a portion of the steam is extracted from the turbine during passage through the machine and in what manner the extraction takes place. On this basis turbines may be classified as (1) once-through turbines; (2) bleeder turbines; (3) automatic-extraction turbines.

Once-through turbines are those in which there are no bleed points and all steam supplied to the admission valves passes all the way through the turbine and out the exhaust. The energy breakdown contained in fig. 8 is for this type of turbine.

Bleeder turbines are those in which provisions are made for feed-water heating. This is accomplished by the withdrawal of steam at various locations along its path of flow through the turbine for the purpose of heating feed water on its way to the boiler. In bleeder turbines no attempt is made to control the pressure of the steam extracted. Because of this. extraction pressure automatically varies in almost direct proportion to the load being carried by the turbine. The principal advantage of a bleeder turbine over a once-through turbine is that steam bled from the turbine for the purpose of feed-water heating does not flow to the condenser. Its latent heat is therefore retained in the cycle. Another advantage is that the exhaust area of the turbine can be smaller because less steam flows to the condenser.

The use of bleed-point steam for feed-water heating is universal in central station power plants because it increases the thermal efficiency of a plant by 10% to 15%. In most cases the fraction of steam withdrawn is about 30% of the steam initially supplied at the turbine inlet.

Automatic-extraction turbines are machines designed for the

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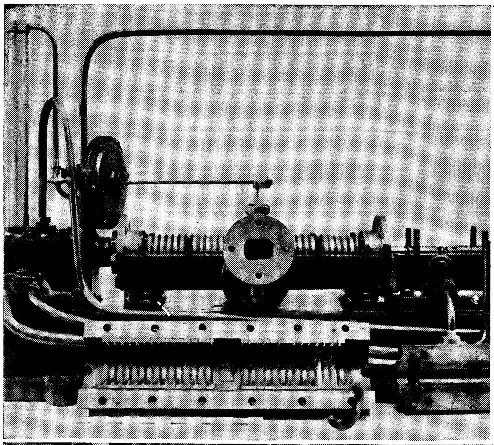
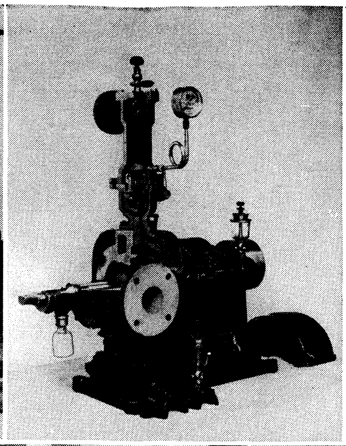
TURBINE: WATER. Modern hydraulic turbines may be divided into two classes, impulse, and pressure or reaction turbines. Of the former the Pelton wheel, and of the latter the Francis turbine or one of its modifications, are the only types used in recent important installations.

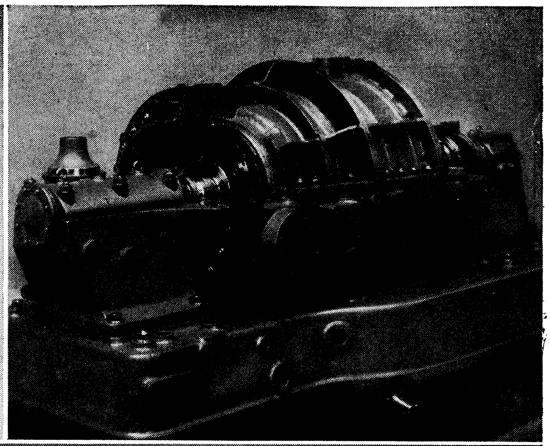
In an impulse turbine, the whole head of the supply water is converted into kinetic energy before the wheel is reached. The water is supplied to the wheel through a nozzle which delivers a high velocity jet at atmospheric pressure on to the vanes or buckets mounted on the periphery of the wheel.

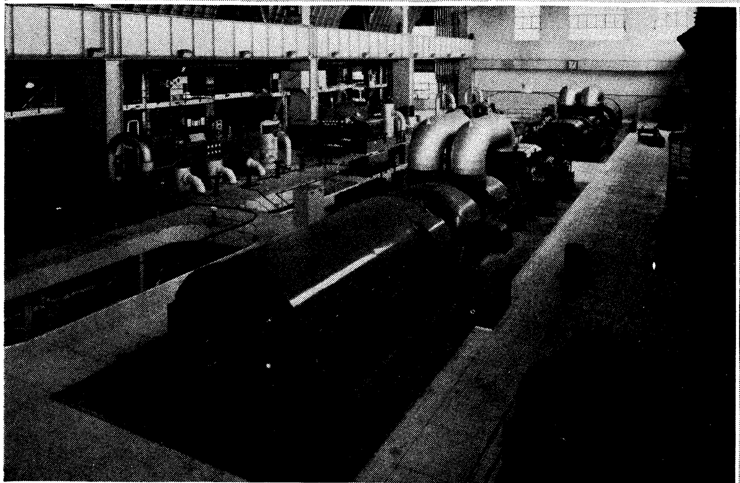
In the pressure or reaction turbine, the wheel or runner is provided with vanes into which water is directed by a series of guide vanes extending around the whole periphery. The water on leaving these guide vanes is under pressure, and supplies energy partly in the kinetic and partly in the pressure form. In its passage through the runner the pressure energy is utilized in increasing the relative velocity of flow between the vanes, and the water finally leaves the runner at the pressure obtaining in the discharge pipe or draft tube.

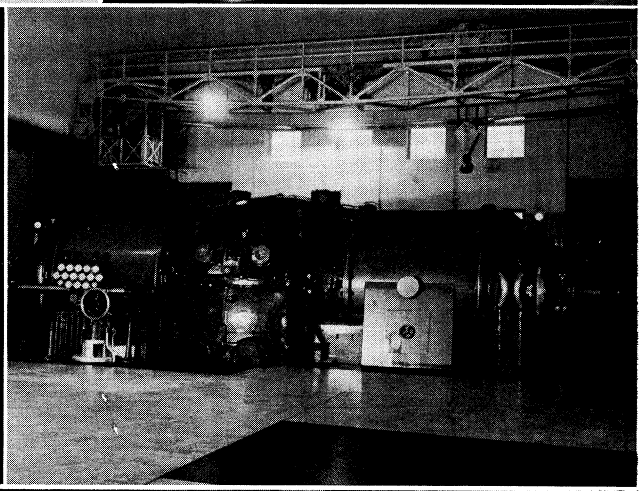
In the earliest of these turbines, the Fourneyron, the guide vanes were inside the runner, and the water flowed outward. This was followed by the Jonval turbine, in which the guide vanes are

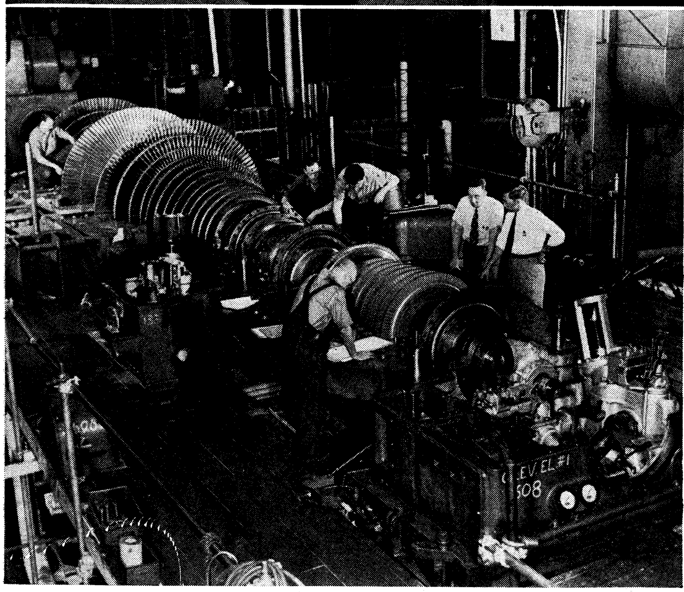


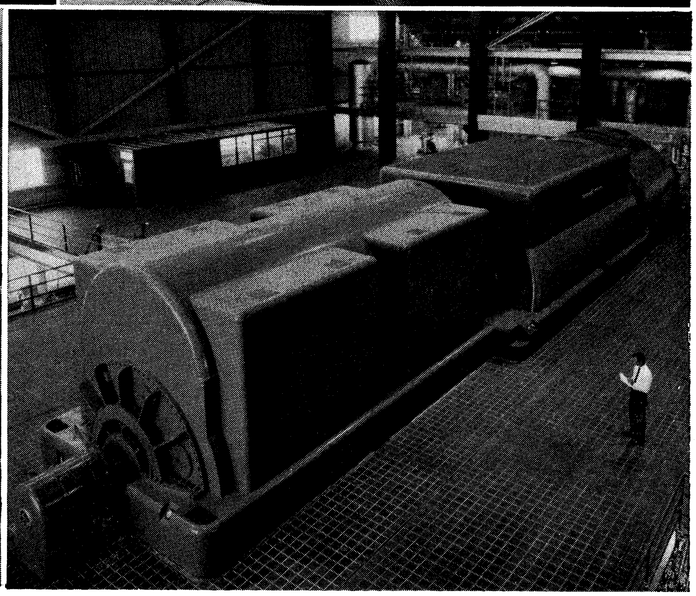












BY COURTESY OF (TOP LEFT) SIR CHARLES A. PARSONS K C B., F.R.S, (TOP CENTRE, TOP RIGHT) THE SCIENCE MUSEUM. LONDON. (CENTRE LEFT) METROPOLITAN-VICKERS ELECTRICAL COMPANY. LTD., (CENTRE RIGHT) SVENSKA TURBINFABRIKS AKTIEBOLAGET LJUNGSTROM. (BOTTOM LEFT. BOTTOM RIGHT) GENERAL ELECTRIC CO.

DEVELOPMENT OF THE STEAM TURBINE

Top left: Parsons' original 10-h.p. steam turbine with top of casing removed. The turbine was built in 1884 utilizing Parsons' principle of "pressure compounding"

Top centre: De Laval's steam turbine built in 1889. Sectional view reveals the single wheel, about 5 in. in diameter, which rotated at approximately 30,000 r.p.m.

Top right: Model of Rateau steam turbine built in 1896. Section shows internal construction

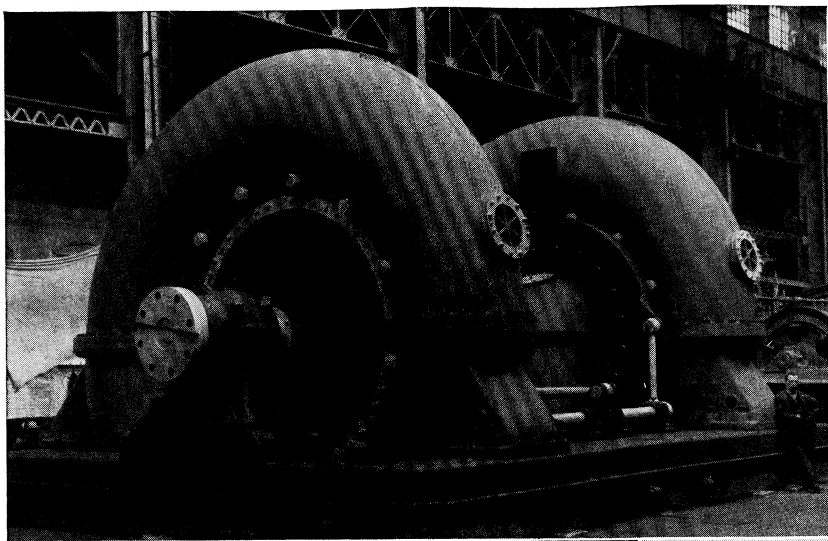
Centre left: Two 60,000-kw. Metropolitan-Vickers turbogenerators in the Littiebrook, Eng., "B" power station. Generators are hydrogen cooled

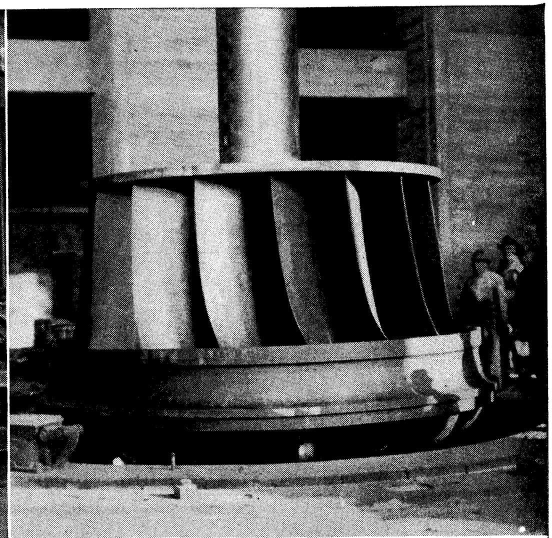
Centre right: 65.000-kw. S.T.A.L. turbine in the steam power station at Västerås, Swed.

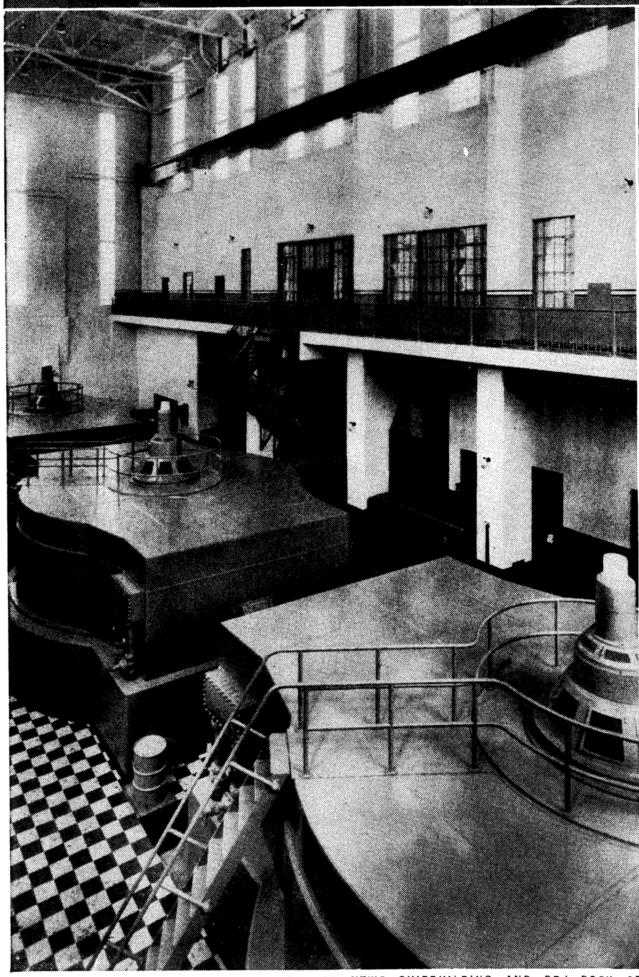
Bottom left: Tandem-compound triple-flow reheat steam turbine being assembled for test at General Electric turbine factory, Schenectady, N.Y. Capable of 3,600 r.p.m., the unit has a maximum rating of 125,000 kw.

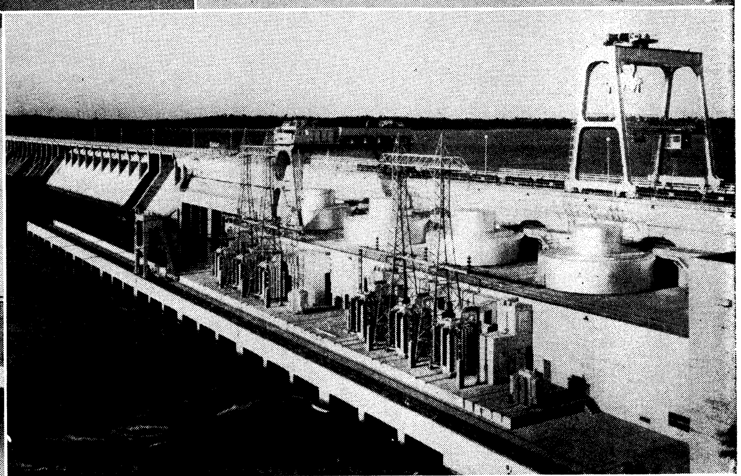
Bottom right: 291,000-kva. steam turbine-generator installed at the Eastlake plant of the Cleveland Electric Illuminating Co.

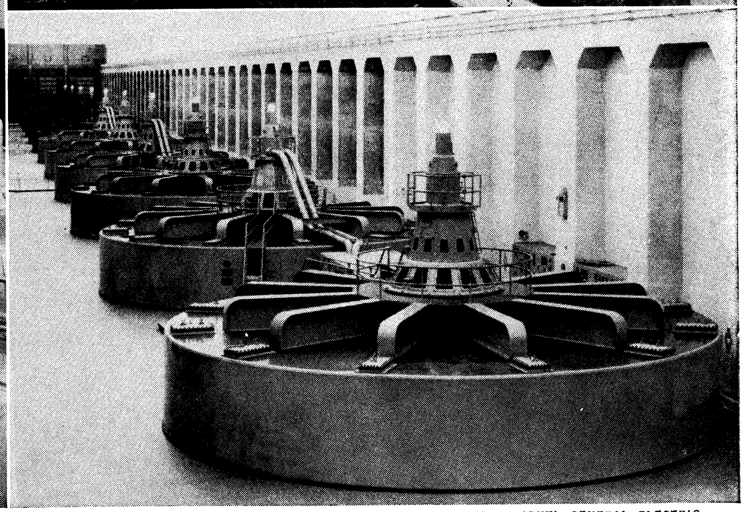
TURBINE: WATER











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U.S. WATER TURBINES

Top left: Twin horizontal medium-head 13,400-h.p. turbine with cast-iron spirals. Head, 180 ft.; speed, 187.5 r.p.m.

Top *right:* Rotor for 35,000-h.p. medium-head turbine at Muscle Shoals, Alabama. Head, 92 ft.; speed, 100 r.p.m.

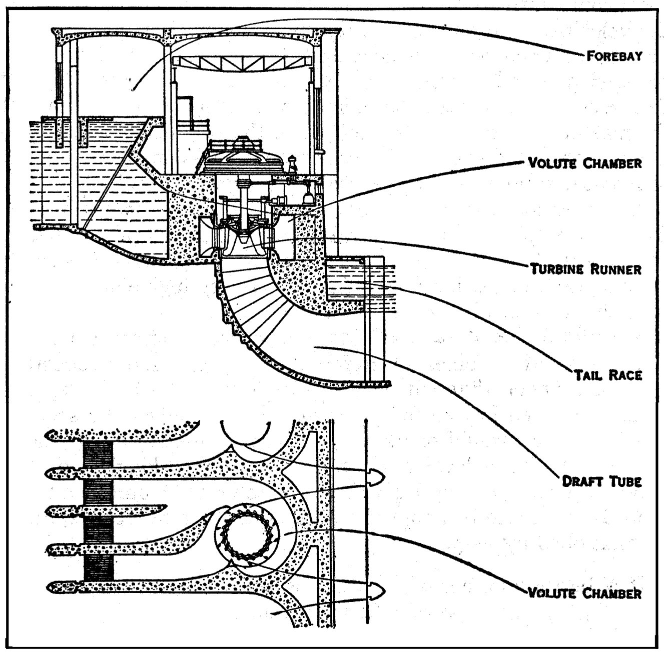
Bottom left: 25,000-kva. vertical water-wheel A.C. generators at Mansfield dam, Texas

Centre *right:* Hydraulic-turbine-driven A.C. generators at Wheeler dam, Alabama. Rated 36,000 kva., speed 85.7 r.p.m.

Bottom *right:* Vertical water-wheel A.C. generators at Bonneville dam, Oregon. Two in the foreground are rated at 48,000 kva., the others at 60,000 kva. Speed, 75 r.p.m.

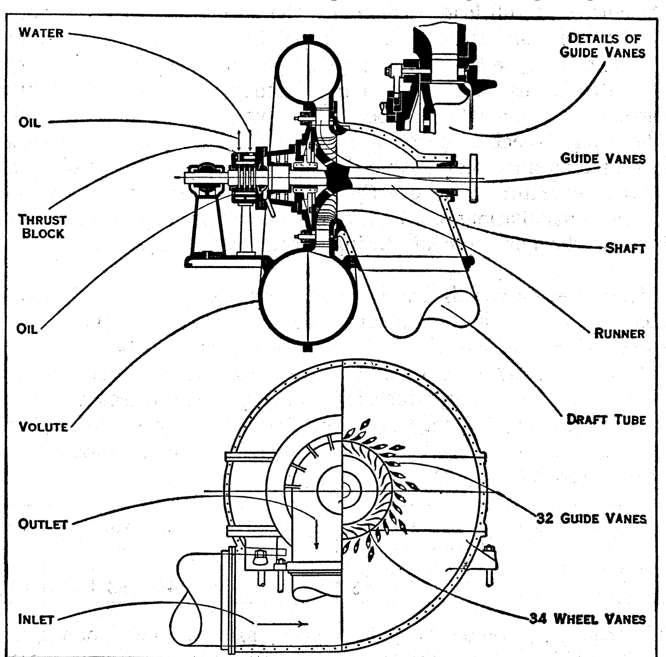
above the runner and the water flows axially into and through the wheel. Both types are now obsolete, and one or other modification of the Francis or inward-flow turbine, in which the guide vanes surround the outer periphery of the runner, is now in general use.

The supply of water to the runner depends upon the opening between the guide vanes. These are pivoted on stems which project through stuffing boxes in the turbine casing. Each stem carries a lever. These are all coupled to a regulating ring whose position is regulated by the governing mechanism, so that all the guide vanes are opened or closed simultaneously.



FROM GIBSON, "HYDRO-ELECTRIC ENGINEERING" (BLACKIE & SON)

FIG. 1.— PLAN AND ELEVATION OF LOW HEAD FRANCIS TURBINE AND SETTING; VERTICAL SHAFT MACHINE WITH ELECTRIC GENERATOR ABOVE TAIL RACE LEVEL



FROM GIBSON, "HYDRO-ELECTRIC ENGINEERING" (BLACKIE & SON)

FIG. 2.— DETAILS OF HIGH HEAD FRANCIS TURBINE WITH CAST IRON VOLUTE

In a low-head installation the turbine may be erected in the open forebay or supply canal. This method has the disadvantage that the guide-vane mechanism is submerged and cannot be inspected or repaired without draining the wheel pit, and in most recent installations, even of the low-head type, the guide-vane ring is surrounded by a spiral volute chamber, from which the pressure water is delivered with uniform velocity around the entire periphery of the guide ring. For heads not exceeding about 100 ft., modern practice favours the moulding of the volute chamber in the concrete of the substructure (fig. 1). For higher heads, considerations of strength necessitate a metal casing, to which the water is supplied through a pressure pipe line (fig. 2). The turbine runner is usually of cast iron, although where corrosion or erosion is to be anticipated, it may be made of cast steel if large, and of phosphor bronze if small.

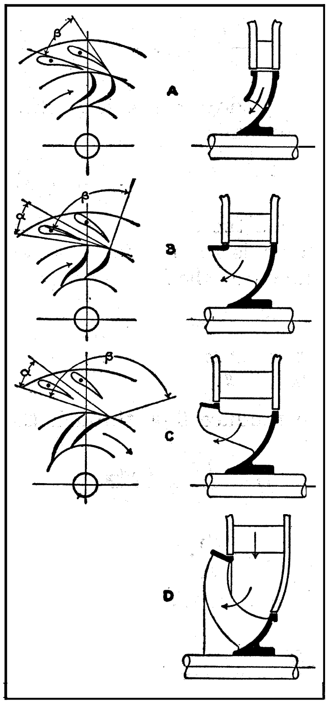


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FIG. 3.— TYPES OF TURBINE RUNNER

A. For high heads and comparatively low speeds. B. For medium heads and moderate speeds. C. For medium heads and high speeds. D. For low heads and high speeds

The general changes in the shape and proportions of the runner which have accompanied recent development of the low head high-speed turbine are indicated in fig. 3. The change has been generally in the direction of increasing the axial depth of the buckets, and at the same time of maintaining or increasing the ratio of the discharge area at exit to that at entrance. At the same time the width of the buckets in the direction of flow has been reduced. An extreme example is shown in fig. 3D, in which flow through the wheel itself is almost axial. In many recent low-head turbines the runners are of the propeller type. They are characterized by the fewness of the vanes, as few as three or four in many cases, and are in appearance very like the ordinary ship's propeller.

The Draft Tube.—In order to avoid the flooding of the turbine house by any raising of the tail race level in time of floods it is usually necessary to instal the turbines at some higher elevation, and if the turbines were provided with open discharge pipes, freely discharging into the atmosphere, the proportion of head represented by the elevation above tail water level would be lost. By arranging the discharge, or draft tube, so that the outlet is always submerged, it becomes possible, however, to place the turbine above tail water level without loss of head. The pressure at the point of discharge from the runner into the draft tube is now less than atmospheric by an amount which depends upon the elevation above tail water level.

The draft tube also, if well designed, serves a further purpose in that it enables a large proportion of the kinetic energy of discharge from the runner to be converted into pressure head, and so to be utilized. For this the tube must be designed with a gradually increasing diameter, so that the velocity is gradually reduced from v_1 to v_2 before discharge (fig. 4). The velocity of discharge from the draft tube should not exceed about 4 f.s.

Hydraulics of the Reaction Turbine. — In the following discussion let ω =angular velocity of the runner in radians per second ($\omega = 2\pi N \div 60$ where $N=$ revolutions per minute); $u=\omega v=$velocity of wheel at point indicated by a suffix; $v=$absolute velocity of water; $w=$tangential component of v; f =radial component of v; $v=$relative velocity of water and vane; $\alpha=$ guide vane angle; β =wheel vane angle at entrance; γ =wheel vane angle at exit; Q=flow in c.f.s.; W=weight of 1 cu.ft. of water; suffix (2) refer to inlet to wheel vanes; suffix (3) refer to exit from wheel vanes.

For entry without shock, the direction of the relative velocity of water and vane at the entrance to the wheel must be parallel to the vane tips, and a consideration of the diagram of velocities (fig. 4) shows that if the angles are correctly proportioned:

$$f_2 = w_2 \tan\alpha = (w_2 - u_2)\tan\beta;\ \therefore\ u_2 = w_2\left(1 - \frac{\tan\alpha}{\tan\beta}\right).$$

$$f_3 = (u_3 - w_3)\tan\gamma;\ 2v_r = f_2 \operatorname{cosec}\beta;\ 3v_r = f_3 \operatorname{cosec}\gamma.$$

The change of the moment of momentum in the wheel = turning moment $\left\{ -\frac{WQ}{g}(w_2 r_2 - w_3 r_3)\right.$ ft. lb.

$\therefore$ Work done per second on runner $= \frac{WQ}{g}(w_2 u_2 - w_3 u_3)$ ft. lb.

In an ideal wheel, with no friction or eddy losses, neglecting changes of level in the wheel, we should have

$$\frac{p_2}{W} + \frac{v_2^2}{2g} = \frac{p_3}{W} + \frac{v_3^2}{2g} + \text{work done per pound between (2) and (3).}$$

The efficiency will be a maximum when the energy rejected in the discharge is a minimum, *i.e.*, when v_3 is a minimum, or when w_3 is zero, in which case $v_3 = f_3$. Assuming the wheel to be designed for this state of affairs,

$$\frac{p_2}{W} + \frac{v_2^2}{2g} = \frac{p_3}{W} + \frac{f_3^2}{2g} + \frac{w_2 u_2}{g}.$$

Writing H as the head available to produce flow through the wheel, so that

$$H = \frac{p_2}{W} + \frac{v_2^2}{2g} - \frac{p_3}{W},\ \text{we have}\ H = \frac{f_3^2}{2g} + \frac{w_2 u_2}{g},$$

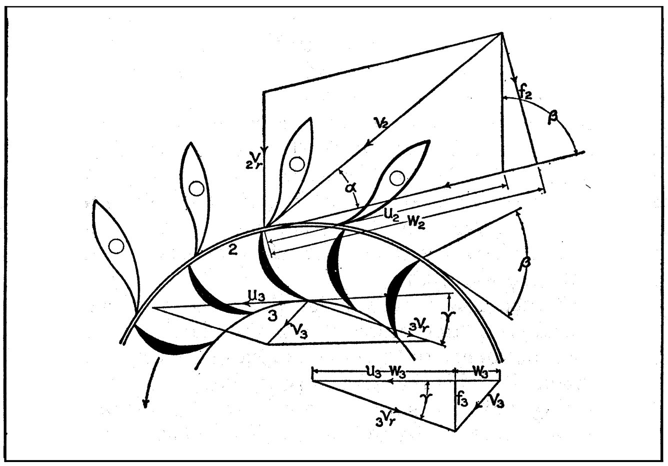
from which, writing $f_3 = f_2 \frac{b_2 r_2}{b_3 r_3} = w_2 \tan\alpha \frac{b_2 r_2}{b_3 r_3}$,

where b and r are the breadth and radius of the wheel, we get, on substitution,

$$w_2 = \sqrt{\left[\frac{2gH}{2 + \left(\frac{b_2 r_2}{b_3 r_3}\tan\alpha\right)^2 - 2\frac{\tan\alpha}{\tan\beta}}\right]}$$

while $u_2 = w_2\left(1 - \frac{\tan\alpha}{\tan\beta}\right)$, and $Q = A_2 f_2 = A_2 w_2 \tan\alpha$.

Thus in a wheel of given design, the peripheral speed for maximum efficiency, and the volume of discharge, each vary as $\sqrt{H}$,



FROM GIBSON, "HYDRO-ELECTRIC ENGINEERING" (BLACKIE & SON)

FIG. 4.— VELOCITY DIAGRAM FOR ENTRANCE AND EXIT OF FRANCIS TURBINE

while the output of the turbine, being proportional to the product QH, varies as $H^{\frac{3}{2}}$.

The hydraulic efficiency, $\eta = \frac{\text{work done per pound}}{H} = \frac{w_2 u_2}{gH}$.

By suitable adjustment of the vane angles α and β the, peripheral speed for a given head may be varied between wide limits. For high speeds the vane angle should be large. As β is increased the value of f_2 and hence the volume of water passing a wheel of given size diminishes, so that to obtain the same output the size of the wheel must be increased. If, as is usually the case in low-head plants, a high rotative speed is required, the inlet area is increased by increasing the depth of the runner. Such a turbine has a comparatively large ratio of inlet area to discharge area, and the velocities of discharge are relatively high. For high heads β may be between 60° and 90°, and, for medium and low heads, between 90° and 135°. Similarly, while the hydraulic efficiency decreases as α increases, the volume of flow increases with a , and the maximum output is obtained when the product of Q and η is a maximum. For high efficiency α should be as small as mechanical considerations permit, generally between 12° and 18°.

In one modern turbine, the Kaplan, the wheel vanes are not fixed but are pivoted on a central drum, and their leading angle β can be adjusted while running so as to suit any variations in the working head or discharge. In this way a very high efficiency may be maintained at all loads.

Specific Speed of a Turbine.— In order to afford a basis of comparison of turbines of different diameters and proportions operating under different heads, the term known as "specific speed" has been introduced. This may be defined as the speed at which a runner would operate if reduced geometrically to such a size that it would develop 1 h.p. under unit working head. The figures for specific speed given below refer to a unit head of 1 foot. If the metre be adopted as the unit, these figures require to be multiplied by 4.45.

If N be the number of revolutions per minute,
„ P „ „ horsepower of the turbine,
„ H „ „ working head in feet,

the specific speed $N_S = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$ revs. per minute.

The specific speed of a reaction turbine may be varied by varying the diameter of the runner, the angle of the guide vanes and the angle of the wheel vanes. By modifying the design as indicated in the sketches of fig. 3 it is possible, while maintaining high efficiencies at full load, to increase the specific speed from about 15, its minimum value with the type shown in fig. 3A, to about 125 with the type shown in fig. 3D. Specific speeds as high as 150 are possible with some sacrifice in efficiency, and it is probable that further developments will see the value increased still farther. These high specific speeds are extremely valuable for low-head installations since they enable the size and cost of the turbine and of the generator to be greatly reduced. In fact, many existing low-head installations would have been commercially impracticable but for the development during recent years of the high-speed turbine.

High specific speeds are, however, attended by some disadvantages. The part-gate efficiency in general falls off as the specific speed increases. Also if the speed is unduly high it becomes very difficult to avoid very high local velocities and centres of low pressure in the runner, which invariably give rise to severe corrosion. At the present stage of design, the maximum specific speeds to be used under normal circumstances with various heads are approximately as follows:

Head (feet)	20	40	60	80	100	150	200	300	400	600
Specific speed r. p. m.	125	100	85	75	65	50	43	33	30	25

The reaction turbine may be built either as a horizontal or vertical shaft machine. The latter type, having the weight of the rotating parts supported by a thrust bearing of the Michell or Kingsbury type, has been gaining in popularity of recent years.

The Pelton Wheel.— This is usually built as a horizontal shaft machine and consists of a runner carrying a series of buckets around its periphery on which impinge one—or in exceptional cases two—high velocity jets from a nozzle or nozzles at the end of the supply pipe line (fig. 5). The buckets are spoon shaped and have a central sharp ridge which divides the impinging jet into two halves which are deflected backwards by the buckets through about 165°. The modern Pelton wheel is always fitted with a circular nozzle, with an axial needle or spear for regulating the size of the jet. The maximum diameter of jet as yet adopted is about 12 inches. The axial position of the needle in the nozzle is regulated by the governing mechanism in all important installations.

The Pelton wheel, being essentially a high head turbine, is usually supplied through a comparatively long pipe line, and any

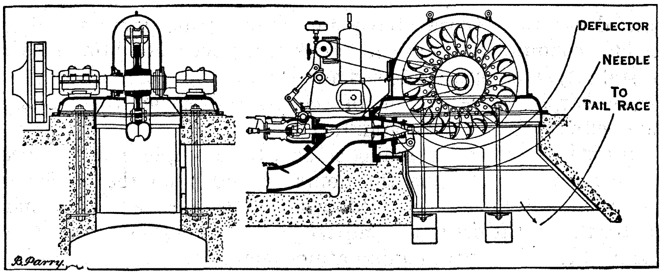


FIG. 5.— PELTON WHEEL WITH SINGLE NOZZLE

rapid closing of the nozzle such as might occur if the load were suddenly thrown off, would set up severe surges of pressure in the pipe line which would not only prevent close speed regulation but might be dangerous. To prevent this, modern Pelton wheels are also fitted with a jet deflector, consisting of a curved plate pivoted between the nozzle and the buckets, which is operated by the governor and which when in action cuts into the jet and deflects it either wholly or partially into the tail race. The governing mechanism is so arranged that when load is thrown off the wheel, the deflector at once comes into play, deflecting the jet from the buckets. The needle then begins to move slowly towards the closed position, and at the same time the deflector moves slowly back towards its idle position. Ultimately both come to rest with the deflector just clear of the jet, and with the diameter of the latter so adjusted as to give the required supply of water to the wheel.

Hydraulics of the Pelton Wheel.—If H be the pressure head behind the nozzle, in feet, the velocity of efflux is $C_v\sqrt{2gH}$ ft. per second, where C_v, the coefficient of velocity, in a well-formed needle nozzle is approximately ·99. Calling this velocity V_1, the horsepower of the jet is equal to

$$\frac{62{\cdot}4aV_1^3}{550\times 2g}$$

where a is the area of the jet in square feet.

Let u = peripheral speed of buckets at pitch circle, in ft. per second.
„ V_2 = final absolute velocity of water leaving the buckets.
„ ${}_1v_r$ = relative velocity of jet and bucket at entrance.
„ ${}_2v_r$ = relative velocity of jet and bucket at discharge.
„ α = mean angle between jet and tangent at point of contact.
„ γ = total angle of deflection of buckets.

Then the initial velocity of jet in direction of tangent at point of impact $= V_1\cos\alpha$.
The component, parallel to the tangent at discharge, of final velocity relative to bucket $= {}_2v_r\cos\gamma$.

∴ Absolute velocity in this direction at discharge $= u+{}_2v_r\cos\gamma$.

∴ Change of tangential momentum per second per pound

$$=\frac{1}{g}(V_1\cos\alpha-u-{}_2v_r\cos\gamma).$$

∴ Work done per pound of water per second

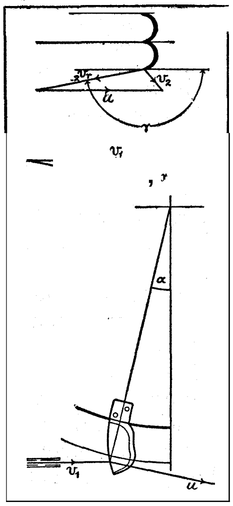
$$=\frac{u}{g}(V_1\cos\alpha-u-{}_2v_r\cos\gamma)\text{ ft. lb.}$$

∴ Efficiency $$=\frac{u}{gH}(V_1\cos\alpha-u-{}_2v_r\cos\gamma).$$

The loss due to friction and eddies in the buckets $=\dfrac{{}_1v_r^2-{}_2v_r^2}{2g}$ ft. lb. per pound, where ${}_1v_r^2=V_1^2+u^2-2V_1u\cos\alpha$.

The loss due to rejection of kinetic energy in the discharge $=\dfrac{V_2^2}{2g}$ ft. lb. per pound, where $V_2^2=u^2+{}_2v_r^2+2u_2v_r\cos\gamma$.

Tests show that in an average wheel ${}_2v_r$ may be as low as from ·5 to ·6 ${}_1v_r$. In a well-designed bucket, however, having a ratio of bucket width to jet diameter not less than about 3.3, this ratio approximates to ·75 or even ·8. If the angle of deflection were 180°, and if the buckets were frictionless, the value of the peripheral speed of the wheel for maximum efficiency would be $V_1\cos\alpha\div 2$, or approximately $V_1\div 2$, since α is small. When account is taken of the various losses and of the fact that γ is less than 180°, the best peripheral speed lies between ·44 and ·48V_1.



FROM GIBSON, "HYDRAULICS" (CONSTABLE & CO.)

FIG. 6.—VELOCITY DIAGRAMS FOR PELTON WHEEL BUCKETS

Comparison of Impulse and Reaction Turbines.— The peripheral velocity of a Pelton wheel for maximum efficiency is slightly less than one-half the velocity of the jet (usually approximately $\cdot 46\sqrt{2gH}$, where H is the head), while that of the reaction turbine varies from about $\cdot 65\sqrt{2gH}$ to $1{\cdot}05\sqrt{2gH}$, depending on the design. Because of this, the Pelton wheel is well adapted for very high heads, which may then be utilized with moderate speeds of rotation. On the other hand the relatively high speed of the reaction turbine enables reasonably high rotative speeds to be obtained with low heads.

The Pelton wheel cannot well be designed to utilize efficiently more than two jets on a single wheel, and as the maximum practicable jet diameter is not large, the volume of water which can be handled and the output of the turbine become small under low heads. The reaction turbine with its full peripheral admission on the other hand is well adapted for large volumes. It is not suited for small powers under high heads, since the volume of water is then small, the waterways are of very small sectional area and easily become choked by floating debris, and the fluid friction losses become relatively high.

The Pelton wheel cannot easily be adapted to the use of a suction or draft tube, and, where the tail-race level may vary appreciably, must be installed above the highest probable tail-water level with some sacrifice of head. The efficiency of the reaction turbine is not so sensitive to changes of head as that of the Pelton wheel, but if operated under constant head and at constant speed, the efficiency of the Pelton wheel does not fall off so rapidly at part loads as that of the reaction turbine. On the other hand, the modern reaction turbine has a slightly higher full-load efficiency, so that the average efficiency from half to full load is sensibly the same in a well-designed machine of either type. The following table shows typical values of the part-load efficiencies of modern turbines of both types of large size, installed under equally favourable conditions.

Proportion of maximum discharge	·2	·3	·4	·5	·6	·7	·8	·9	1·0
Efficiency of reaction turbine	·60	·70	·75	·79	·82	·87	·90	·91	·89
Efficiency of Pelton wheel	·70	·78	·82	·83	·84	·85	·86	·85	·83

The possibilities of accurate speed regulation are about equal in the two types.

For large units the reaction turbine is generally preferable for heads up to 400 feet. For heads above 750 ft. the Pelton wheel is more suitable, while between these limits the choice depends largely upon local circumstances and on the power required. The greater simplicity and accessibility of the parts requiring replacement due to natural wear and tear renders the Pelton wheel more suitable when the supply is taken from a stream carrying an appreciable amount of grit.

The reaction turbine has been built in units capable of developing 65,000 H.P. The most powerful Pelton wheel yet constructed develops about 30,000 H.P., but these outputs could be largely extended if necessary.

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(A. H. G.)

TURBOT *(Rhombus maximus)*, a flat fish of the Mediterranean and the Atlantic coast of Europe, is distinguished by a large terminal mouth, eyes on the left side, a very deep body and a naked skin, with conical bony tubercles scattered on the eyed side.

The brill, a related species, is not so deep and is scaly. The turbot is a valued food fish; it feeds mainly on other fishes; it attains a weight of 30 lb.

It has a longer larval life than most flat fishes; and specimens nearly an inch in length, with an eye on each side, may be found swimming at the surface.

TURBULENCE, ATMOSPHERIC. The motion of a fluid, whether liquid or gas, can be one of two main types: laminar, in which the individual particles of the fluid follow well-defined, smooth paths; or turbulent, in which the motion is extremely irregular and, in general, no two particles follow the same path. Most natural motion is turbulent, and this is especially true of the wind near the earth's surface, although even there, there is, on occasions, an approach to laminar motion, as will be seen below. The turbulence of the natural wind exhibits itself as a succession of gusts and lulls, with simultaneous random oscillations in direction, so that when speaking of the speed and direction of a wind one must necessarily refer to averages taken over a period of many minutes.

The amount of turbulence present in a wind varies considerably with the time of day, state of sky and the nature of the surface over which the air is passing. Meteorologists usually measure the turbulence of the wind by its gustiness, defined to be half the difference between the maximum and minimum speeds during a specified period divided by the average speed. Thus a wind whose average speed is 20 m.p.h. would have a gustiness of 0.25 if its speed varied between 15 and 25 m.p.h. during the period of measurement. Oscillations of direction are usually 15° or more on either side of the mean direction, but this figure also can vary considerably.

Mixing.—The importance of turbulence in meteorology lies in the fact that it is the agent that causes the atmosphere to be churned up and thoroughly mixed. In other words, turbulence is the main cause of the diffusion of water vapour, smoke and the lighter seeds. The evaporation of water from land and sea, and hence the hydrological cycle, depends very much on turbulence, which may be pictured as the irregular movements of small and large masses of air, usually called eddies, from one level to another. In this respect eddies may be likened to molecules whose incessant motion also causes diffusion, but eddy diffusion is on a vastly greater scale than molecular diffusion and takes place in a rather different way. As a consequence of these differences the mathematical theory of diffusion by turbulence is considerably more complicated and less exact than that of molecular diffusion. In particular, it is impossible to speak of the atmosphere having a definite "diffusivity"—that is, to associate with diffusion in the atmosphere a single quantity corresponding to the familiar diffusion coefficient encountered in molecular diffusion—although many attempts have been made to do so.

Lower Atmosphere.—In considering atmospheric turbulence it is essential to distinguish between conditions in the lower atmosphere, say within a few hundred feet of the surface, and those prevailing in the upper atmosphere, many thousands of feet above the ground. In the lower atmosphere the turbulence of the wind usually exhibits a marked diurnal variation. If the sky is clear, turbulence reaches a maximum in the hours around noon. This is because the surface of the earth is heated by the sun's rays, and masses of warm air continually rise and are replaced by cooler air from above.

This vertical motion, which is accompanied by a marked fall of temperature with height, called a lapse, together with disturbances in the wind caused by obstacles such as trees, houses and hills, keep the whole motion extremely irregular. Diffusion is at its highest level during lapse conditions, and smoke from domestic or industrial chimneys is quickly scattered.

As the sun sets, the earth cools rapidly because of radiation to space. As a result, the layers of air near the surface become more dense than those above and temperature increases with height, a condition known as an inversion. Such a condition makes for stability. and both the speed and the gustiness of the wind decrease sharply. The motion of the air approaches the laminar state, with marked effects on diffusion.

This is best seen by watching smoke, for example, from a weed fire in a garden. During the hours around noon the smoke is scattered in all directions by the vigorous turbulence of the wind, but after sunset it drifts in compact plumes that show little or no mixing with the surrounding atmosphere. The concentration of smoke, that is, the amount of smoke in unit volume of the air, is very much increased during the inversion period which lasts, on a clear night, until dawn. When the sky is overcast, the turbulence of the air remains at much the same level day and night. The cloud sheet reduces the intensity of solar radiation during the day and at night acts as a blanket which prevents the surface from losing heat to space.

Inversions of the type described above occur on every clear night and are usually confined to relatively shallow layers near the ground. On occasions, however, inversions may extend to 1,000 ft. or more above the surface. Such large-scale inversions are usually caused by the slow descent of air in an anticyclone. When this occurs there is a strong possibility that smoke-polluted fog (smog) will be formed, especially in winter, by the breakdown of the natural ventilation of the atmosphere. The outstanding example of such a smog is that which occurred in London in Dec. 1952, which was estimated to have caused the deaths of over 4,000 people from respiratory ailments such as bronchitis. Other examples of respiratory epidemics caused by pollution are those which occurred in Donora, Pa., in 1948 and in the Meuse valley, Belg., in 1930. It is clear, therefore, that turbulence is a valuable property of the wind, for without it life in great cities would not be possible.

Detailed studies of turbulence near the surface show that the oscillations of velocity have periods varying from a fraction of a second to many minutes, and that the gustiness of the wind depends very much upon the roughness of the surface. The difference between the total velocity at any instant and the mean velocity is called the eddy velocity; this has components in the average direction of the wind, across wind and vertically. Turbulence is also mainly responsible for the internal friction of the atmosphere. All motion of the air (wind) is caused by horizontal differences of pressure, but in the lower levels of the atmosphere the speed of the wind is considerably reduced by the friction of the ground. This frictional effect is spread upward by turbulence. The eddies in the wind, by mixing the slow-moving air near the ground with the faster-moving air from above, cause a general leveling out of velocity differences, with the result that over flat country the speed of the wind increases rather gradually from the surface value to that of the frictionless flow at about 2,000 ft

The stratum of air in which this transition occurs is usually called the friction layer of the atmosphere. Near the ground the cross-wind component of eddy velocity is considerably greater than either of the other components, but at heights exceeding about 100 ft. all three components are equal. Considerable attention has also been given to the cognate problem of the transfer of heat from the ground upward by the eddies in the friction layer.

In relation to atmospheric pollution, it has been established mathematically that the concentration of smoke at ground level from a typical industrial stack varies inversely as the square of the height of the stack, so that increasing the height of a stack from say, 100 to 200 ft., reduces the concentration of smoke at ground level by a factor of 4. It is therefore a considerable advantage to ensure that noxious fumes are emitted at as great a height as possible. These and other studies of turbulence in the regions of the atmosphere in which life is most abundant. that is, within a few hundred feet of the ground, are part of the science known as micrometeorology.

Upper Atmosphere.—At heights above 2.000 ft. or so over flat country, the frictional effect of the surface on the wind is greatly reduced, and much of the small-scale turbulence characteristic of the lower atmosphere disappears. However, although upper winds are usually much less turbulent than surface winds, they sometimes exhibit a degree of turbulence which is significant for aviation. In certain meteorological conditions, such as those which favour strong surface heating and high humidity, there is much upward movement of the air (convection) accompanied by the formation of cumulus clouds towering to considerable heights. In the vicinity of such clouds flying is usually rough or bumpy. The bumps are most severe in thunderstorms, in which upward currents of up to 100 ft. per second have been measured, and the interior of a thundercloud is a region of very intense turbulence. An aircraft flying through such rough air experiences severe vertical accelerations, sometimes sufficient to throw out of his seat a passenger who has not fastened his safety belt.

Pilots try to avoid cumulus clouds for this reason, but in recent years another type of turbulence, less easily forecast, has become prominent with the advent of high-speed aircraft operating at great heights. This is clear-air turbulence, which is only found in the high atmosphere. In many instances the sole effect on the aircraft is to give one the impression of riding in a solid-tired vehicle over cobblestones; but at times clear-air turbulence can be of sufficient intensity to strain the structure of the aircraft, especially at high speeds. This type of turbulence is often found near jet streams. the very high-speed winds which blow in narrow belts near the tropopause (30,000 ft. or above), but precisely how the wind becomes so violently disturbed at these great heights remains to be explained.

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TURDIDAE: see THRUSH.

TURENNE, HENRI DE LA TOUR D'AUVERGNE, VICOMTE DE (1611–1675), marshal of France, second son of Henri, duke of Bouillon and sovereign prince of Sedan, by his second wife, Elizabeth, daughter of William the Silent, prince of Orange, was born at Sedan on Sept. 11, 1611. He was educated in the doctrines of the Reformed religion and received the usual training of a young noble of the time; but physical infirmity, and particularly an impediment of speech (which he never lost), hampered his progress. though he showed a marked partiality for history and geography and especial admiration of the exploits of Alexander the Great and Caesar. After his father's death in 1623, he devoted himself to bodily exercises and in a great measure overcame his natural weakness. At the age of 14 he went to learn war in the camp of his uncle, Maurice of Nassau. and began his military career (as a private soldier in that prince's bodyguard) in the Dutch War of Independence. Frederick Henry of Nassau, who succeeded his brother Maurice in 1625. gave Turenne a captaincy in 1626

The young officer took his part in the siege warfare of the period and won special commendation from his uncle. who was one of the foremost commanders of the time, for his skill and courage at the celebrated siege of Hertogenbosch (Bois-le-Duc) in 1629. In 1630 Turenne left Holland and entered the service of France. Cardinal Richelieu at once made him colonel of an infantry regiment. He still continued to serve at frequent intervals with the prince of Orange, who was the ally of France. In 1635 Turenne served under Cardinal de la Valette in Lorraine and on the Rhine. The siege of Mainz was raised, but the French army had to fall back on Metz from want of provisions. In the retreat Turenne measured snords with the famous imperialist, General Gallas, and distinguished himself greatly by his courage and skill. The reorganized army took the field again in 1636 and captured Saverne (Zabern), at the storming of which place Turenne was seriously wounded.

In 1637 he took part in the campaign of Flanders and was present at the capture of Landrecies (July 26) and in the latter part of 1638, under Duke Bernhard of Saxe-Weimar (1608–39), he directed the assault of Breisach (reputed the strongest fortress on the upper Rhine), which surrendered on Dec. 17. He had now gained a reputation as one of the foremost of the younger generals of France, and Richelieu next employed him in the Italian campaign of 1639–40 under "Cadet la Perle," Henri de Lorraine, count of Harcourt (1601–66).

On Nov. 19. 1639, he fought in the famous rearguard action called the battle of the "Route de Quiers" and during the winter revictualled the citadel of Turin held by the French against the forces of Prince Thomas of Savoy. In 1640 Harcourt saved Casale and besieged Prince Thomas's forces in Turin, which were besieging in their turn another French force in the citadel. The latter held out. while Prince Thomas was forced to surrender on Sept. 17. 1640, a fourth army which was investing Harcourt's lines being at the same time forced to retire. The favourable result of the complicated operations of this campaign was largely due to Turenne, who had by now become a lieutenant-general.

He himself commanded during the campaign of 1641 and took Coni (Cuneo), Ceva and Mondovi. In 1642 he was second in command of the French troops which conquered Roussillon. At this time the conspiracy of Cinq-Mars (*q.v.*), in which Turenne's elder brother, the duke of Bouillon, was implicated, was discovered (see FRANCE: History).

The earlier career of Turenne was influenced by the relations of the principality of Sedan to the French crown; moreover his steady adherence to the Protestant religion was an element of difficulty in Turenne's relations with the ministers. Cardinal Richelieu nevertheless entrusted him with the command in Italy in 1643 under Prince Thomas (who had changed sides in the quarrel).

Turenne took Trino in a few weeks but was recalled to France toward the end of the year. He was made a marshal of France (Dec. 19) and was soon sent to Alsace to reorganize the "Army of Weimar"—the remnant of Duke Bernhard of Saxe-Weimar's troops—which had just been severely defeated at Tiittlingen (Nov. 24–25, 1643).

He was 32 years old at this time and had served under four famous commanders. The methodical prince of Orange, the fiery Bernhard, the soldierly Cardinal de la Valette and the stubborn and astute Harcourt had each contributed much to the completeness of Turenne's training; and he took the field in 1644 prepared by genius and education for the responsibilities of high command.

The work of reorganization over, Marshal Turenne began the campaign in June by crossing the Rhine at Breisach but was almost instantly joined by an army under the duc d'Enghien (afterwards the great Condé), who, as a prince of the royal house. took the chief command of the united armies of "France" and "Weimar." The four famous campaigns which followed brought to an end the Thirty Years' War (*q.v.*). The chief event of the first of these was the desperately-fought battle of Freiburg against Count Mercy's Bavarians (Aug. 3, 5 and 9, 1644), after which Philipsburg was successfully besieged. Before the capitulation Enghien withdrew and left Turenne in command.

The marshal opened the campaign of 1645 with a strong forward movement but was surprised and defeated by Mercy at Mergentheim (Marienthal) on May 2. Enghien was again sent to the front with the army of France, and Turenne's army was greatly increased by the arrival of a Swedish force and a contingent from Hesse-Cassel The Swedes soon departed, but Enghien was at the head of 20.000 men when he met the Bavarians in a battle even more stubbornly contested than Freiburg. Mercy was killed and his army beaten at Allerheim near Nordlingen (Aug. 3, 1645).

Ill-health forced Enghien to retire soon afterwards, and Turenne was for the third time left in command of the French army. He was again unfortunate against the larger forces of the imperialists, but the campaign ended with a gleam of success in his capture of Trier (Trèves). In the following year (1646) he obtained more decided successes and, by separating the Austrians from the Bavarians, compelled the elector of Bavaria to make peace (signed March 14, 1647). In 1647 he proposed to attack the thus weakened army of the emperor but was ordered into Flanders instead. Not only was the opportunity thus lost but a serious mutiny broke out among the Weimar troops, whose pay was many months in arrear. The marshal's tact and firmness were never more severely tried nor more conspicuously displayed than in his treatment of the disaffected regiments, among whom in the end he succeeded in restoring order with little bloodshed. He then marched into Luxembourg but was soon recalled to the Rhine, for in 1648 Bavaria had returned to her Austrian alliance and mas again in arms. Turenne and his Swedish allies made a brilliant campaign, which was decided by the action of Zusmarshausen (May 17), Bavaria being subsequently wasted with fire and sword until a more secure pacification was obtained.

The peace of Westphalia (1648) was no peace for France, which was soon involved in the civil war of the Fronde. (See FRANCE: *History.*) Few of Turenne's actions have been more sharply criticized than his adhesion to the party of revolt. The army of Weimar refused to follow its leader and he had to flee into the Spanish Ketherlands, where he remained until the treaty of Rueil put an end to the first war of the Fronde. The second mar began with the arrest of Condé and others (Jan. 1650), among whom Turenne was to have been included; but he escaped in time and with the duchesse de Longueville held Stenay for the cause of the "Princes"—Condé, his brother Conti and his brother-in-law the duc de Longueville. Love for the duchess seems to hare ruled Turenne's action, both in the first war and, now in seeking Spanish aid for the princes. In this war Turenne sustained one of his few reverses at Rethel (Dec. 1j, 1650); but the second conflict ended in the early months of 1651 with the collapse of the court party and the release of the princes.

Turenne became reconciled and returned to Paris in May, but the trouble soon revived and before long Condé again raised the standard of revolt in the south of France. In this, the third war of the Fronde, Turenne and Condé were opposed to each other, the marshal commanding the royal armies, the prince that of the Frondeurs and their Spanish allies. Turenne displayed the personal bravery of a young soldier at Jargeau (March 28, 1652), the skill and wariness of a veteran general at Gien (April 7), and he practically crushed the civil war in the battle of the Faubourg St. Denis (July 2) and the reoccupation of Paris (Oct. 21). Condé and the Spaniards, however, still remained to be dealt with, and the long drawn out campaigns of the "Spanish Fronde" gave ample scope for the display of scientific generalship on the part of both the famous captains. In 1653 the advantage was with Turenne, who captured Rethel, St. Menehould and Muzon, while Condé's sole prize was Rocroy. The short campaign of 1654 was again to the advantage of the French; on July 25, the Spanish were defeated at Arras. In 1655 more ground mas gained, but in 1656 Turenne was defeated at Valenciennes in the same way as he had beaten Condé at Arras. The war was eventually concluded in 1658 by Turenne's victory at the Dunes near Dunkirk, in which a corps of English veterans sent by Cromwell played a notable part (June 3–14); a victory which, followed by another successful campaign in 1658, led to the peace of the Pyrenees in 1659.

On the death of Cardinal Mazarin in 1661 Louis XIV took the reins of government into his own hands and one of his first acts was to appoint Turenne "marshal-general of the camps and armies of the king." He had offered to revive the office of constable of France (suppressed in 1627) in Turenne's favour if the marshal wonld become a Roman Catholic. Turenne declined. Born of Calvinist parents and educated a Protestant, he had refused to marry one of Richelieu's nieces in 1639 and subsequently rejected a similar proposal of Mazarin. He had later married a daughter of the Protestant Marshal de la Force, to whom he was deeply attached. But he sincerely deplored the division of the Christian church into two hostile camps. How closely both he and his wife studied such evidence as was available is shown by their correspondence, and, in the end, two years after her death, he was prevailed upon by the eloquence of Bossuet and the persuasions of his nephew, the abbé de Bouillon, to give in his adhesion to the Orthodox faith (Oct. 1668). In 1667 he had returned to the more congenial air of the "Camps and Armies of the King," directing, nominally under Louis XIV, the famous "Promenade militaire" in which the French overran the Spanish Netherlands. Soon afterwards Condé, now reconciled with the king, rivalled Turenne's success by the rapid conquest of Franche Comté, which brought to an end the War of Devolution in Feb. 1668.

In Louis XIV's Dutch War of 1672 (see DUTCH WARS) Turenne was with the army commanded by the king which overran Holland up to the gates of Amsterdam. The dikes were opened and the country round Amsterdam flooded. This heroic measure completely checked Turenne, whom the king had left in command. Turenne now fought a successful war of manoeuvre on the middle Rhine while Condé covered Alsace. In Jan. 1673 Turenne assumed the offensive, penetrated far into Germany and forced the Great Elector of Brandenburg to make peace; later in the year, however, he was completely outmanoeuvred by the famous imperial general, Montecucculi, who evaded his opponent, joined the Dutch and took the important place of Bonn. In June 1674, however, Turenne won the battle of Sinzheim, which made him master of the Palatinate. Under orders from Paris the French wasted the country far and wide. In the autumn the allies again advanced, and though Turenne was again outmanoeuvred, his failure on this occasion was due to the action of the neutral city of Strasbourg in permitting the enemy to cross the Rhine by the bridge at that place. The battle of Enzheim followed; this was a tactical victory but hardly affected the situation, and at the beginning of December the allies were still in Alsace. The old marshal now made the most daring campaign of his career. A swift and secret march in mid-minter from one end of the Vosges to the other took the allies by surprise. Sharply following up his first successes, Turenne drove the enemy to Turkheim, and there inflicted upon them a heavy defeat (Jan. 5, 1675). In a few weeks he had completely recovered Alsace. In the summer campaign he was once more opposed to Montecucculi, and after the highest display of "strategic chess-moves" by both commanders, Turenne finally compelled his opponent to offer battle at a disadvantage at Sassbach. Here, on July 27, 1675, he was killed by almost the first shot fired. The news of his death was received with universal sorrow. Turenne's most eloquent countrymen wrote his *éloges,* and Montecucculi himself exclaimed: "Il est mort aujourd'hui un homme qui faisait honneur à I'homme." His body was taken to St. Denis and buried with the kings of France. Even the extreme revolutionists of 1793 respected it; and, when the bones of the sovereigns were thrown to the winds, the remains of Turenne were preserved at the Jardin des Plantes until Sept. 22, 1800, when they were removed by order of Napoleon to the Church of the Invalides at Paris, where they still rest.

Turenne was one of the great captains whose campaigns Napoleon recommended all soldiers to "read and re-read." His fame as a general was the highest in Europe at a period when war was studied more critically than ever before, for his military character epitomized the art of war of his time (Prince de Ligne). Strategic caution and logistic accuracy, combined with brilliant dash in small combats and constancy under all circumstances of success or failure may perhaps be considered the salient points of Turenne's genius for war. Great battles he avoided. "Few sieges and many combats" was his own maxim. And, unlike his great rival Condé, who was as brilliant in his first battle as in his last, Turenne improved day by day. Kapoleon said of him that his genius grew bolder as it grew older; and a modern author, the duc d'Aumâle (*Histoire* des princes *de* la *maison* de *Condé*), takes the same view when he says: "Pour le connaitre il faut le suivre jusqua'à Sulzbach. Chez lui chaque jour marque un progrès." In his personal character Turenne was little more than a simple and honourable soldier, endowed with much tact, but in the world of politics and intellect almost helpless in the hands of a skilful intriguer or casuist. His morals, if not beyond reproach, were at least more austere than those prevalent in the age in which he lived. He was essentially a commander of regular armies. His life was spent with the troops; he knew how to win their affection; he tempered,a severe discipline with rare generosity and his men loved him as a comrade no less than they admired him as a commander. Thus, though Condé's genius was far more versatile, it is Turenne whose career best represents the art of war in the 17th century. For the small, costly and highly trained regular armies and the dynastic warfare of the age of Louis XIV, Turenne was the ideal army leader.

The most notable of the numerous portraits of Turenne are those of P. de Champagne at Versailles and of Senin (dated 1670) in the Jones collection at South Kensington, London. Of the older memoirs of Turenne the most important are those of "Du Buisson," *La Vie du vicomte de Turenne—the* author is apparently Gatien de Sandraz de Courtilz (Paris, the Hague and Cologne, 1688–95); Abbe Raguenet, *Histoire do viconzte de Turenne* (Paris 1741) and especially Ramsay, *Histoire d'Henri de la Tour d'Auvergne, vicomte de Turenne* (Paris 1735), the second volume of which contains the marshal's memoirs of 1643–58. These memoirs, of which the Prince de Ligne wrote that "ce ne sont pas de conseils, ce sont des ordres . . . 'faites' . . . 'allez,' etc."—were written in 1665, but were first published (*Mémoires sur la guerre, tirés des originaux*, etc.) in 1738, reprinted in Michaud, *Mémoires sur l'histoire de France*, 3rd series, vol. iii, and Liskenne and Sauvan's *Bibliothèque historique et militaire*, vol. iv (Paris 1846). A manuscript, *Maximes de M. de Turenne* (1644), exists in the Staff archives at Vienna; and of other documentary collections may be mentioned Grimoard, *Collections de lettres et mémoires trouvés dans le portefeuille de M. de Turenne* (Paris, 1782); *Recueil de lettres dcrites au viconzte de Turenne par Louis XIV. et ses ministres*, etc. (Paris 1779); *Correspondance inédite de Turenne avec Le Tellier et Louvois*, ed. Barthélemy (Paris 1874). *See* also the *Observations on the Wars of Marshal Turenne*, dictated by Napoleon at St. Helena (1823); Puységur, *La Guerre par principes et règles* (Paris 1748): Précis in *Bibliothèque internationale d'hist. milit.* (Brussels 1883); Duruy, *Histoire de Turenne* (Paris 1880); Roy, *Turenne, sa vie et les institutions militaires de son temps* (Paris 1884); Hardy de Périni, *Turenne et Condé* (Paris 1907); Neuber, *Turenne als Kriegstheoretiker und Feldherr* (Vienna 1869); Sir E. Cust, *Lives of the Warriors of the 17th Century* (London, 1867); T. O. Cockayne, *Life of M. de Turenne* (founded on Ramsay's work; London, 1853); G. B. Malleson, *Turenne. Marshal Turenne*, by "the author of the Life of Sir Kenelm Digby" (London 1907), is a valuable work by a civilian and is based in the main on Ramsay's work, the memoirs of Cardinal de Retz, James, duke of York, etc., and on Napoleon's commentaries. A remarkable parallel between Turenne and Condé, in Saint-Evremont's *éloge* of the latter, will be found in Carrion-Nisas, *Essai sur I'histoire général de l'art militaire*, ii, 83 (Paris 1824); C. G. Picavet, *Les dernières années de Turenne 1660–1675* (1910), p. 513; General Weygand, *Turenne* (1929). (C. F. A.)

TURFAN, the name of a remarkable depression in the Tarim region south of the Tien-shan, here over 10,000 ft. in height. This oasis lies 980 ft. below sea level at the lowest point. The'town of Turfan, just 30 mi. to the north, stands some 250 ft. above sea level, and the general level around the depression rapidly reaches over 2,500 feet. The depression is loess covered and would be fertile if it could be irrigated. The town of Turfan is a double settlement, part Chinese and part Turki, with a population of 15–20 thousand. In the depression, the temperature varies from 90° for July, calculated at Lukchun, to 13° in January and the daily fluctuations are very great.

TURGAI, a former province of Russian central Asia, now included in the Kazakstan (*q.v.*) A.S.S.R.; *see* also AKTUBINSK.

The Turgai strait, a narrow passage over the watershed separating the Tobol and the Irgiz, between the east of the southern Urals and the west of the plateau region of the Kirghiz steppe, is of great structural importance. Through it came the marine transgressions of previous geological epochs; the upper Cretaceous advanced into the southwest only, but those of the upper Eocene and Oligocene extended along the east of the Urals and the Lower Oligocene sea of Germany reached the Arctic ocean. During the age of the amber forests the Strait of Turgai was closed, and no sea again entered Siberia by that route. The course of the Tobol river marks the direction of the ancient marine connection. At a recent epoch the present Turgai river, which enters Lake Chalkarteniz and which receives the Irgiz as a tributary, flowed into the Sea of Aral, its volume being then much increased by tributaries which now lose themselves in the sand before reaching it.

See Suess *The Face of the Earth*, vol. III (1908).

TURGENEV, IVAN SERGEYEVICH (tōōr-gān'yĕv) (1818–1883), Russian novelist, was born at Orel of a family of provincial gentry. His father had married for money a woman older than himself, who made up for her thwarted affections by making herself a domestic tyrant to her children, as well as to her serfs. Turgenev was educated at home, at the Universities of Moscow and St. Petersburg and finally (1839–40) at Berlin, where, in contact with young Russian intellectuals, he became a Westernizer. In 1843 he published *Parasha*, a tale in verse, which was favourably reviewed by Belinsky. Turgenev deserted the civil service for letters and was infatuated with the famous singer, Pauline Garcia (Mme. Viardot); this caused a breach with his mother, who cut off his allowance. He lived as a Bohemian until her death (1850) made him a rich man. His lifelong affection for Mme. Viardot, who merely tolerated his presence, met with no response but left a deep impress on his work. Turgenev abandoned poetry for the drama (which he also abandoned after 1852) and for prose fiction. His first great success was *A Sportsman's Sketches* (started 1847, in book form 1852), in which the peasants appeared more attractive than their masters. It was received as a protest against serfdom. In 1852 Turgenev was exiled to his estate for a while because of his laudatory obituary on Gogol.

His masterpieces included short stories like *The Backwater, Asya, First Love* and the more ambitious novels *Rudin* (1856), *A Nest of Gentlefolk* (1858), *On the Eve* (1860) and *Fathers and Sons* (1862), in which the love plot was interwoven with current social issues. All were commented on at great length by the leading critics. His attempt, however, to draw a strong man in the person of the agnostic and materialist—"nihilist"—Bazarov was resented by the Radical press as a caricature. Turgenev, being sensitive to criticism, was embittered against his countrymen and settled abroad, and his later works are mainly retrospective. The two novels in which he tried to deal with actuality, *Smoke* (1867) and *Virgin Soil* (1877), only show the depth of his bitterness and his complete loss of touch with contemporary Russia. However, his last visit to Russia (1880) was a triumphant progress. He died in 1883, at Bougival, near Paris.

Turgenev was the first Russian author to be read and admired by Europe. During his last years he lived in close touch with the French literary world, contracted intimate friendships (especially with Flaubert) and was regarded as a master by younger men like Maupassant. He was very popular in this French circle, but much less so among his Russian compeers: Tolstoy, Dostoyevsky and Nekrasov all sooner or later came to detest him.

Turgenev is the most poetical (in the 19th century acceptance of the word) of the Russian realists. He had undergone the profound influence of Pushkin (as well as of Lermontov and George Sand). His novels are largely variations on the theme of *Eugene Onegin.* His character drawing does not depend on analysis and psychology but on a subtly-woven poetic atmosphere that accompanies the characters like an aura. This applies mainly to his women; they are invariably stronger and more attractive than his men, who (with the single exception of Bazarov) are neurasthenic weaklings. His style is marked by a careful simplicity and elaborate naturalness that answered to the highest ideals of 19th century taste. Delicately-drawn landscape passages are among its most outstanding features.

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TURGEON, PIERRE FLAVIEN (1787–1867), archbishop of Quebec, was born in Quebec on Nov. 12, 1787. He was ordained in 1810 and became director of the Quebec seminary in

1821 after visiting England and Rome, 1819–20. He was instrumental in obtaining settlement of the status of the Catholic church in Canada. After serving as administrator from Nov. 1849, he became archbishop of Quebec in Oct. 1850 and in that capacity brought about the organization of the province; and under him the first and second councils of Quebec convened in 1851 and 1854, respectively. He was the founder of Laval university, which opened on Sept. 1, 1852, and of La Maison du Bon Pasteur. He held office until 1855 when ill health compelled him to resign. He died on Aug. 25, 1867.

TURGOT, ANNE ROBERT JACQUES, BARON DE LAUNE (1727–1781), French statesman and economist, was born in Paris on May 10, 1727, the youngest son of Michel Étienne Turgot, "provost of the merchants" of Paris. He was educated for the church; and at the Sorbonne, to which he was admitted in 1749 (being then styled abbC de Brucourt), he delivered two remarkable Latin dissertations, *On the Benefits which the Christian Religion has conferred on Mankind* and *On the Historical Progress of the Human Mind.* In 1750 he decided not to take holy orders, giving as his reason, according to Dupont de Nemours, "that he could not bear to wear a mask all his life." In 1752 he became *substitut* and later *conseiller* in the parlement of Paris. and in 1753 *maîtres des requites.* In 1754 he was a member of the *chambre royale* which sat during an exile of the parlement; in 1755 and 17j6 he accompanied Gournay, then intendant of commerce, in his tours of inspection in the provinces and in 1760, while traveling in the east of France and Switzerland, visited Voltaire, who became one of his chief supporters. In Paris he frequented the salons, especially those of Mme. Graffigny—whose niece, Mlle de Ligniville, afterwards Mme. Helvétius, became his lifelong friend—Mme. Geoffrin, Mme. du Deffand, Mlle. de Lespinasse and the duchesse d'Enville. It was during this period that he met the leaders of the "physiocratic" school, Quesnay and Gournay, and with them Dupont de Nemours, the abbC Morellet and other economists. All this time he was studying various branches of science and languages, both ancient and modern. In 1753 he translated the *Questions sur la commerce* from the English of Josias Tucker and wrote his *Lettre sur la tolérance* and a pamphlet, *Le Conciliateur,* in support of religious tolerance. Between 1755 and 1756 he composed various articles for the *Encyclopédie* and between 1757 and 1760 an article on *Valeurs et monnaies,* probably for the *Dictionnaire du commerce* of the abbC Morellet. In 1759 appeared his *Éloge de Gournay.*

In August 1761 Turgot was appointed intendant of the *généralité* of Limoges, which included some of the poorest and most over-taxed parts of France; here he remained for 13 years. He was already deeply imbued with the theories of Quesnay and Gournay *(see* PHYSIOCRATIC SCHOOL) and set to work to apply them as far as possible in his province. He continued the work on the *cadastre,* or new official survey, begun by his predecessor Tourny in order to arrive at a juster assessment of the *taille;* he also obtained a large reduction in the contribution of the province. He published his *Avis sur l'assiette et la re'partition de la taille* (1762–70) and as president of the *Société d'agriculture de Limoges* offered prizes for essays on the principles of taxation. Quesnay and Mirabeau had advocated a proportional tax (*impôt de quotite'),* but Turgot, a distributive tax (*impôt de répartition*). Another reform was the substitution for the *corvée* of a tax in money levied on the whole province, the construction of roads being handed over to contractors. In 1769 he wrote his *Mémoire sur les prêts à intérêt,* in which the question of lending money at interest was for the first time treated from a scientific, not from a moral standpoint. Among other works written during Turgot's intendancy were the *Me'moire sur les mines et carrières* and the *Mémoire sur la ma-que des fers,* in which he protested against state interference and advocated free competition.

During the famine of 1770–71 he enforced on landowners "the obligation of relieving the poor" and especially the *métayers* dependent upon them and organized in every province *ateliers* and *bureaux de charité* for providing work for the able-bodied and relief for the infirm. Turgot made the *curés* the agents of his charities and reforms when possible. In 1770 he wrote his famous *Lettres sur la liberté du commerce des grains* addressed to the comptroller-general, the abbC Terray. Three of these letters have disappeared, having been sent to Louis XVI by Turgot at a later date and never recovered.

Turgot's best known work, *Réflexions sur la formation et la distribution des richesses,* written in 1766 for the benefit of two young Chinese students, appeared in 1769–70 in Dupont's journal, the *Ephémérides du citoyen,* and was published separately in 1776. After tracing the origin of commerce, Turgot develops Quesnay's theory that the land is the only source of wealth and divides society into three classes, the productive or agricultural, the salaried (*stipendiée*) or artisan class and the land-owning class *(classe disponible).* He advocates the *impôt unique; i.e.,* that only the *produit net* of the land should be taxed, and the complete freedom of commerce and industry.

On July 20, 1774, Turgot was appointed minister of marine through the influence of Maurepas; and on Aug. 24 he became comptroller-general. His first act was to submit to Louis XVI his guiding principles: "No bankruptcy, no increase of taxation, no borrowing." Turgot's policy, in face of the desperate financial position, was one of rigid economy in all departments. He contemplated a thorough-going reform of the *ferme générale* and, meanwhile, imposed certain conditions on the leases as they were renewed—such as a more efficient personnel and the abolition for the future of the abuse of the *croupes* (the name given to a class of pensions) and annulling certain leases, such as those of the manufacture of gunpowder and the administration of the *messageries,* the former of which was handed over to a company with Lavoisier as one of its advisers and the latter superseded by a better service of diligences which were nicknamed "turgotines." He also prepared a regular budget.

Turgot's measures reduced the deficit and raised the national credit to such an extent that in 1776, just before his fall, he was able to negotiate a loan with some Dutch bankers at 4%; but the deficit was still so large as to prevent him from attempting to realize his scheme of substituting for indirect taxation a single tax on land. He suppressed, however, a number of *octrois* and minor duties.

Turgot's edict for free trade in corn signed on Sept. 13, 1774, was strongly opposed in the *conseil du roi.* Turgot was hated by many in high places who had been interested in the speculations in corn and was opposed by Linguet and by Necker, who in 1775 published his treatise, *Sur la législation et le commerce des grains.* But Turgot's worst enemy was the poor harvest of 1774, which led to a slight rise in the price of bread in the winter and early spring of 1774–75 and to those extraordinary bread-riots known as the "guerre des farines." Turgot showed great firmness and decision in repressing the riots and was loyally supported by the king throughout.

Turgot's famous "Six Edicts" were finally presented to the *conseil du roi* (Jan. 1776). The two which met with violent opposition were, firstly, the edict suppressing the *corvées,* and secondly, that suppressing the *jurandes* and *maitrises,* the privileged trade corporations. Turgot announced in the preambles to these his intention to subject the noblesse to taxation and to establish as a principle the right of every man to work without restriction.

He obtained the registration of the edicts by the *lit de justice* of March 12; but by that time he had won the hatred of the nobles and the parlements, the court, the "financiers," the clergy, the rich bourgeoisie of Paris and others. The queen disliked him for opposing the grant of favours to her protégés, and he had offended Mme. de Polignac in a similar manner. Malesherbes and Maurepas ceased to support him, and Maurepas became reconciled with the queen and her party. About this time, too, appeared a pamphlet, *Le Songe de M. Maurepas,* generally ascribed to the comte de Provence (Louis XVIII), containing a bitter caricature of Turgot.

Before relating the circumstances of Turgot's fall it might be well to summarize briefly his views on the administrative system. With the physiocrats, he believed in an enlightened absolutism and looked to the king to carry through all reforms.

As to the parliaments, he opposed all interference on their part in legislation, considering that they had no competency outside the sphere of justice. He recognized the danger of the recall of the old parliament but was unable effectively to oppose it since he had been associated with the dismissal of Maupéou and Terray and seems to have underestimated its power. He was opposed to the summoning of the states-general advocated by Malesherbes (May 6, 1775), possibly on the ground that the two privileged orders would have too much power in them. His own plan is to be found in his *Mémoire sur les municipalités,* which was submitted informally to the king. In Turgot's proposed system landed proprietors alone were to form the electorate, no distinction being made between the three orders; the members of the town and country *municipalités* were to elect representatives for the district *municipalités,* which in turn would elect to the provincial *municipalités,* and the latter to a *grande municipalité,* which should have no legislative powers but should concern itself entirely with the administration of taxation. With this was to be combined a whole system of education, relief of the poor, etc. His large reforms amounted to a complete revolution and Louis XVI recoiled at the prospect.

Such a fundamental difference of opinion between king and minister was bound to lead to a breach sooner or later. Turgot's only choice, however, was between "tinkering" at the existing system in detail and a complete revolution; and his attack on privilege, which might have been carried through by a popular minister and a strong king, was bound to form part of any effective scheme of reform.

The immediate cause of Turgot's fall is uncertain. Some speak of a plot, of forged letters containing attacks on the queen shown to the king as Turgot's, of a series of notes on Turgot's budget prepared, it is said, by Necker and shown to the king to prove his incapacity. Others attribute it to the queen, and there is no doubt that she hated Turgot for supporting Vergennes in demanding the recall of the comte de Guines, ambassador to London, whose cause she had ardently espoused. Others attribute it to an intrigue of Maurepas. On the resignation of Malesherbes (April 1776), whom Turgot wished to replace by the abbé Véry, Maurepas proposed to the king as his successor a nonentity named Amelot. Turgot, on hearing of it, wrote an indignant letter to the king, in which he reproached him for refusing to see him, pointed out in strong terms the dangers of a weak ministry and a weak king and complained bitterly of Maurepas's irresolution and subjection to court intrigues; this letter the king is said to have shown to Maurepas, whose dislike for Turgot it still further embittered.

With all these enemies, Turgot's fall was certain; but he wished to stay in office long enough to finish his project for the reform of the royal household. This, however, he was not allowed to do. On May 12, 1776, Turgot was asked to resign. He retired to la Roche-Guyon, château of the duchesse d'Enville, returning shortly to Paris, where he spent the rest of his life in scientific and literary studies, being made vice-president of the Académie des Inscriptions et Belles Lettres in 1777. He died on March 18, 1781.

In character Turgot was simple, honourable and upright, with a passion for justice and truth. He was an idealist, his enemies would say a doctrinaire, and certainly the terms "natural rights," "natural law," etc., frequently occur in his writings. His friends speak of his charm and gaiety in intimate intercourse, but among strangers he was silent and awkward and produced the impression of being reserved and harsh. Many of the reforms and ideas of the Revolution were due to him; the ideas did not as a rule originate with him, but it was he who first gave them prominence. Oncken looks upon him as a bad physiocrat and a confused thinker, while Léon Say considers that "though he failed in the 18th century he triumphed in the 19th."

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TURI, a Shi'ah Moslem tribe which holds the Kurram valley in West Pakistan and enjoys increasing prosperity. Divided into five clans, all apparently of Turki origin, the Turis probably wrested the valley from the Bangash Pathans after 1700, distributing its lands as conquered so that every original settler's family now holds fields all over it. A sturdy race, whose "fathom" is reputed to be 6½ ft., they are distraught by faction but hospitable; and a Turi escort (*badragga*) is famed for its fidelity.

They threw in their lot with the Sunnite Pathans (1851–56) but in the second Afghan War furnished Sir Frederick Roberts with supplies and in 1890 accepted British protection.

TURIN (Ital. Torino), a city of Piedmont, Italy, and capital of the province of Torino. It is built upon alluvial soil 784 ft. above sea level and stands largely upon the left bank of the Po river, by its junction with the smaller Dora Riparia, 75 mi. S.W. of Milan. Turin was the capital of the kingdom of Sardinia until 1861 when it was made the capital of united Italy, and so remained until the removal of the seat of government to Florence in 1865. Pop. (1951) 717,245 (city); 719,300 (commune); (1957 est.) 889,249 (commune). The area of the commune is 50 sq.mi.

The streets and avenues of Turin, almost all of which are straight, intersect at right angles and many of them are arcaded. The Via Roma, almost bisecting the city to link the Porta Nuova railway station with the Piazza Castello, was imposingly rebuilt between 1931 and 1936. In general Turin has a modern aspect, but its regularity of form is derived from the ancient Roman town of *Augusta Taurinorum,* which formed its nucleus.

The cathedral of St. John the Baptist (the see became an archbishopric in 1510) is a cruciform Renaissance building, dating from 1492–98, by the Florentine architect, Baccio Pontelli, with Meo del Caprino as the contractor. Behind the high altar of the cathedral is the chapel of SS. Sudario or SS. Sindone, a brilliantly original baroque edifice built (1668–94) by Guarino Guarini as a royal burial place. The "sudario" from which it takes its name is asserted to be the shroud in which Joseph of Arimathea wrapped the body of Christ. La Consolata, another of Guarini's baroque works (1679) richly completed by P. Juvara (1714), has an 11th-century tower which belonged to the monastery church of S. Andrea, founded by monks from Novalesa in 942.

Other churches of note are La Gran Madre di Dio, erected to commemorate the return of the court in 1814, and S. Filippo (1672–1772), the largest church in Turin. The dome of S. Filippo fell in just as it was approaching completion under the hands of Guarini and was restored by Juvara. Waldensian church, the first Protestant church in Turin, was built in 1848.

The Palazzo Madama was built by William VII of Montferrat at the close of the 13th century on the Roman east gate of the town; remains of the gate towers were incorporated in it. It owes its name to the widow of Charles Emmanuel II, who added the west façade and the handsome double flight of steps from Juvara's design (1718). The extensive Palazzo Reale or royal palace was begun in 1646. Many of the baroque palaces have fine pillared courtyards; some of them are the work of Guarini. The tower of the citadel (1565) contains the artillery museum. The Castello del Valentino is partly in the French style of the 16th century. It contains the polytechnical schools, the geological, mineralogical and industrial museums and the university botanical garden.

The hill of Superga (Suporga, Soperga), about 3 mi. E. of Turin and 2,205 ft. above sea level, is crowned by a basilica, Juvara's masterpiece, erected for Victor Amadeus II in memory of the liberation of Turin from the French in 1706. King Charles Albert and other Savoy princes are buried in the crypt. The hill is ascended by a twisting road and by a funicular railway. From its summit in fine weather the visitor can look down on Turin across the river to the west, or at the wide semicircle of the snow-crested Alps that rise like a wall at a radius of 30 mi. or more and sweep from beyond the pyramidal Monte Viso on the southwest around to the massif of Monte Rosa to the north. In clear weather the mountains are visible from Turin itself. The summit of Superga, with its several restaurants, is a favourite excursion place of the Torinese. It is also the scene of football's first air disaster, when on May 5, 1949, the aircraft carrying the Torino team from a game in Lisbon struck the hill in a storm with the loss of all aboard.

Not far from Turin are the royal castles of Moncalieri, Stupinigi, Rívoli, Racconigi, Aglie, and Venaria Reale.

Besides Turin university, founded about 1405 by Louis of Savoy-Acaia, there are schools of agriculture, architecture, medicine and engineering and an institute of commerce and economics. The old university buildings, erected in 1713, contained the national library which was partially destroyed by fire in 1904. The academy of sciences, founded in 1757, is in a building erected in 1679 by Guarini. This building also houses a museum of local antiquities of Piedmont and of Egyptian treasures, some of which were excavated at Thebes and Assiut. The picture gallery has paintings by Dutch, Flemish and north Italian masters. There is a natural history museum in the Palazzo Carignano, another of Guarini's buildings. The Palazzo Reale contains the royal armoury (a fine collection begun by Charles Albert in 1833) and the Royal Albertine library with a rich manuscript collection and 20,000 drawings. Turin also contains the Museo Nazionale di Montagna, devoted to the history of mountaineering.

Turin is noted for many modern public monuments including those to Emmanuel Philibert (1838), Charles Albert (1861) and Pietro Micca (1834). The Mole Antonelliana, started by Alessandro Antonelli in 1863, is used for the Risorgimento museum. It is perhaps the highest (548 ft. including the Stella d'Italia) brick edifice in Europe; the dome is raised upon a hall with three galleries, one above the other. The newer parts of the city, extending toward the south beyond the stadium (1911) are well laid out.

Among the hospitals is that called by the name of its founder, St. Joseph Cottolengo (1786–1842), a vast institution providing for more than 7,000 persons.

Communications and Industries — Turin is the nearest railway centre to Mont Cenis in French Savoie, while the line through Cuneo over the Col di Tenda affords direct communication with the French Riviera. In the late 1950s there were plans for a Mt. Blanc and other tunnels. Lines connect Turin with Milan, Genoa and other Italian towns. At Caselle is a large airport.

After Milan, Turin is the chief industrial city of Italy. The industries comprise metallurgy, especially the making of precision tools and ball bearings; silk (exported) and cotton weaving; tanning and leather-working; the manufacture of synthetic fibres, plastics, matches, rubber, furniture, paper, cosmetics, glass; also damasks, velvets, woolen goods and ready-made clothing; chocolate, wines (exported), liqueurs and vermouth are other notable products. The manufacture of automobiles became of great importance in the 1950s; airplanes are also made as well as railway freight cars, bicycles, motorcycles, radios and television sets. Electric power is widely developed because of the proximity of the Alpine valleys; and the hydroelectric plants of Mont Cenis, the Val d'Aosta and the Toce valley all concentrate on Turin.

History. — The ancient Augusta Taurinorum (or Taurasia) was a city of Gallia Cisalpina and the chief town of the Taurini. The natural advantages of its site and its position with relation to the Mont Genèvre pass over the Cottian Alps (*see* COTTII REGNUM) made it important; though Hannibal, after crossing the Alps in 218 B.C., was able to take the town after a three days' siege. It was partly burned in A.D. 69, but continued to be prosperous.

The Roman town formed a rectangle 2,526 by 2,330 ft. (770 by 710 m.). This measurement was questioned by F. Haverfield, *Ancient Town-Planning* (Oxford, 1913), but was confirmed by an article by U. Savoia in *Town-Planning Review*, xii (Liverpool, 1927). The walls, which were 21 ft. high, 7 ft. thick at ground level and 3 ft. at the top, were standing until about 1600; and the north gate, the Porta Palatina, still remains. The interior of the town was divided by seven streets from east to west and eight from north to south into 72 blocks (*insulae*). The ancient pavement and the drains below it are frequently found under the streets of the central portion of the modern town, indicating that they follow the ancient lines. Remains of a theatre were discovered in the palace garden.

Turin was made the chief town of Piedmont by Amadeus, first duke of Savoy. (*See* SAVOY, HOUSE OF.) Between 1536 and 1562 Turin was occupied by the French, and in 1630 it lost 8,000 of its citizens by the plague. The French were masters once more from 1640 to 1706, and again from 1798 until 1815, when Piedmont was restored to the house of Savoy. The town was heavily bombed in World War II by the Allies, but by the latter 1950s the work of restoration was well advanced.

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TURINA, JOAQUIN (1882–1949), Spanish composer, was born at Seville on Dec. 9, 1882. He studied under Paul d'Indy, in Paris, 1905–14, where he wrote an encyclopaedia (*Enciclopedia abreoiada de la música*, Madrid, 1917). His principal works are: *Procesidn del Rocio* for orchestra; music for the morality play, La *adziltera penitente;* a dramatic work, *Jardín de oriente* (1923); a pianoforte quintet, a string quartet, *Escena Andaluze,* for viola, pianoforte and string quartet; *Poema de una Sanluqueña,* and songs. He died Jan. 14, 1949, in Madrid.

TURKESTAN: *see* TURKISTAN.

TURKESTAN (HAZRET, YASI), a town in the Kazakhstan Soviet Socialist Republic. in 43° 8′ N., 68° 18′ E., on the Orenburg-Tashkent railway 20 mi. E. of the Syr-Daria river. altitude, 833 ft. Population about 30,000. Its main industry is cotton, and it acts as a depot for the collection of hides and wool. It is an ancient town and in 1397 a Persian architect was commissioned by Timur (Tamerlane) to build a mosque in honour of the Kirghiz patron Hazret Yasavi.

TURKEY, a republic of the near east, with an area of 296,185 sq mi., comprising 9,068 sq mi. in Europe (Eastern Thrace) and 287,117 sq.mi. in Asia (Anatolia). The total includes 451 sq.mi. of swamps and marshes and 3,256 of lakes. A survey in 1955 established the area of the country as 301,380 sq.mi. It is bounded on the east by the U.S.S.R. (367 mi.) and Iran (Persia) (292 mi.); on the south by Iraq (235 mi.) and Syria (490 mi.) and the Mediterranean sea; on the west by Greece (127 mi.) and Bulgaria (124 mi.) and on the north by the Black sea.

Turkey in Europe is separated from Anatolia by the straits—the Bosporus. the Sea of Marmara and the Dardanelles—which form the only sea passage between the Black sea and the Mediterranean. It is bounded on the northeast by the Black sea, and on the southwest by the Aegean sea. The western frontier with Bulgaria and Greece was determined by the treaty of Lausanne (July 24, 1923). It runs from Ayastafanos on the Black sea along the valley of the small river Rezvaya, across the Istranca mountains and continues westward to the river Tundzha (Tunja), which it crosses about 15 mi. N. of Edirne (Adrianople). From this point it turns southwest to the river Maritsa (Meric) which it strikes about 15 mi. upstream from Edirne. There the frontier with Bulgaria ends and that with Greece begins. The border follows the Maritsa to Edirne (Adrianople), where on the right bank the suburb of Karagach (Karaagac) and a small part of the railway are included in Turkey; then the river is followed to its mouth near Enos (Enez).

The islands of Imroz (Imbros) and Bozcaada (Tenedos) off the Dardanelles belong to Turkey; otherwise the Aegean and the Mediterranean coast line is the boundary to a point just south of the mouth of the Orontes (Asi) river where the frontier with Syria begins. The line runs irregularly east and north through mountainous country, enclosing Antakya (Antioch) and its lake, to Meydaniekbez, where it turns east across the Baghdad railway, which it crosses again at Cobanbey (see *Communications,* below). It then runs about one yard south of the railway to Nusaybin (Nisibis), where it again crosses it and turns slightly north to Cizre (Jezirat ibn Omar) on the Tigris which it follows in a southerly direction to its confluence with the Khabur (Habur). The frontier with Syria, which ends at this point, was originally defined when the French withdrew from Cilicia in the Franco-Turkish agreement of Oct. 20, 1921, and was confirmed by the treaty of Lausanne (1923). Under the terms of this treaty the Antakya-Alexandretta district known as the sanjak of Alexandretta (Iskenderun) came within the French mandate for Syria but enjoyed a special administration by virtue of its large Turkish population. In 1939, when the grant of independence to Syria (*q.v.*) appeared imminent, the district was annexed to Turkey and became the Hatay province, the boundary of which, from the mouth of the Orontes to Cobanbey, became the western section of Turkey's frontier with Syria.

The question of the frontier with Iraq, in accordance with article 3 of the treaty of Lausanne, came before the council of the League of Nations and was defined in the Ankara convention of June 5, 1926. Delimitation was completed in 1928. The frontier starts from the junction of the Khabur with the Tigris about 80 mi. N.W. of Mosul, follows the Khabur and its tributary the Hazil Su northeastward into the mountains, then turns east and traverses the difficult Kurdish highlands to the Ruhar-i-Shin where it turns south across the Semdinan Su to the Rubar-i-Haji Bey and follows this river in a northeasterly direction to its source in the Persian watershed.

A frontier commission was delimiting the boundary between Turkey and Persia when World War I broke out in 1914. In order to put an end to frontier incidents which had occurred, an *accord* de *délimitation* was signed on Jan. 23, 1932, and a further rectification of the line in the neighbourhood of Paki and Eli was settled on May 27, 1937. From the junction with the Iraqi frontier the line runs in a general northerly direction in mountainous country to a point about 25 mi. S. of Mount Ararat (the Agri Dag), where it turns east for about 20 mi. and then north to enclose this mountain until the river Aras (Araxes) is reached. There the frontier with Iran ends and that with the U.S.S.R. begins.

The frontier with the U.S.S.R. was defined in an annex to the treaty of Moscow (March 16, 1921) and by article 4 and three annexes of the treaty of Kars (Oct. 13, 1921). From a point roughly east of Ararat the boundary line follows the Aras to its junction with the Arpa, which it then follows, skirting the Alagoz volcano, to a point about 10 mi. W. of Leninakan (Aleksandropol). There the line swings in a great bow, northwestward over the Transcaucasian mountains and then westward, enclosing Kars, Ardahan and Artvin; crossing the river Coruh (Chorokh), it reaches the Black sea less than 10 mi. S. of Batum.

Physiography. — Turkey has been described as a bridge between Europe and Asia. Though the western end of the bridge has been broken down toward the Aegean and is interrupted by the straits, the customary division into European and Asiatic Turkey is an arbitrary one derived from the strategical and political importance of the straits. European Turkey is no more than the western continuation of the northern coast land of Anatolia. The geological upheavals which determined the formation of the land surface had not ended in the 20th century, as the disastrous earthquakes of modem times testify.

Turkey in Europe, a rough triangle with its apex on the Bosporus, has a northern and southern fringe of mountains, the Istranca and Tekirdag ranges, and a central undulating plain through which run the valleys of the Maritsa and the Ergene, draining the landward slopes of both highlands. East of the Maritsa and Tundzha rivers the central lowland is the only avenue from the west to Istanbul. About 25 mi. W. of Istanbul, a transverse ridge 600 ft. high crosses the peninsula from Terkos lake to Buyuk Cekmeca. This ridge is the foundation of the defensive system known as the Chatalja (Catalca) lines.

Asiatic Turkey (Anatolia) is roughly rectangular in outline, almost three times as long from east to west (about 900 mi.) as from north to south (about 300 mi.). Its main features are: (1) a central plateau extending nearly 500 mi. eastward from the latitude of Istanbul; (2) a mountainous girdle encircling the plateau on north. west and south and (3) an almost entirely mountainous region which becomes progressively wilder and more rugged up to the frontiers of the U.S.S.R. and Iran.

The central plateau is elevated to an average height of 3,000 ft. above sea level. Most of it is semidesert or steppe with scanty pasture except where the rivers flow through it with strips of fertile land bordering them. There are numerous depressions where marshes, shallow lakes or mud flats have been formed. Some of these are brackish because of the solubility of the rocks over which the water has reached them. The largest of these basins is a salt lake, Tuz Golu, in the centre of the plateau, about 60 mi. S. of Ankara (Angora). West of Ankara much of the country is rolling upland, between 3,500 and 4,500 ft. above sea level, with a few rounded summits nearly 6,000 ft. high. To the south and east of the capital is a region of rolling uplands with the remains of extinct volcanoes and, particularly in the neighbourhood of Kayseri (Caesarea Mazaca), lava and ash from them. To the north and northeast toward Sivas the level of the plateau rises, falling again in the direction of Amasya (Amasia) and Chorum (Corum). Near Sivas the Kizil Irmak (Red river) is at about 4,500 ft., and the central plateau is enclosed by mountain ranges on the east, northwest and southwest.

The Black sea coast between the Bosporus and the Soviet frontier is about 750 mi. long and has, throughout most of its length, steep, broken country near the seaboard. The breadth of the coast land is less easy to define. There is no clear dividing line between it and the central plateau in the western part, though to the east the character changes and there is a sharp division between the high mountain ranges on the coast and the hinterland. There is a fertile plain, the delta of the Sakarya river, between the gulf of Izmit and Eregli. Between Eregli and Inebolu the mountains rise to 3,000 ft. close to the sea and peaks inland to more than 6,000 ft. The hills are well forested, and the valleys between them, running from north to south, with branches parallel to the coast, are extensively cultivated. Coal is mined between Eregli and Cide. East of Inebolu the coastal range rises steeply from the sea and then falls abruptly about 30 mi. S. of the coast. Inland of Sinop, at Bafra where the Kizil Irmak reaches the sea and also east of Samsun are areas of coastal plain. Generally speaking, the inland belt is well-wooded, and the rounded mountains form a series of plateaus with fertile depressions between them. From Ordu to the Soviet frontier the features are a coastal range about 20–30 mi. from the shore, between which and the higher volcanic ranges to the south run the Kelkit and Coruh valleys.

Western Anatolia may be defined as the region west of long. 30° E., which comprises the Aegean coastland up to the central plateau. The coast line is deeply indented and has many natural harbours. The country bordering the Sea of Marmara is relatively low with streams running north or south, for which the hills around Balikesir are the collecting ground. The valley of the Simav separates these hills from the higher country to the east in which the forest-clad Ulu Dag (the Mysian Olympus of the ancients) stands about 8,000 ft. above the fertile slopes around Bursa (Brusa); ranges average more than 5,000 ft. to the Egrigoz Dag (7,000 ft.), about 50 mi. to the south. The fertile coastal region of Bergama (the ancient Pergamum) lies between the Simav valley and the three east-west valleys of the Gediz and the Kucuk and the Buyuk Menderes (the Little and the Great Maeander). The region to the east of Izmir (Smyrna), which is watered by the last two rivers, is bounded by two semielliptical chains of mountains, the western one of which rises to an average of 4,000–5,000 ft. with peaks reaching more than 7,000 ft. Between this and the eastern range, 200 mi. inland at its furthest point, is a rich alluvial plateau. To the south are rugged highlands which end abruptly at the Mediterranean coast west of the Dalaman valley.

The southern edge of the central plateau is followed by the railway from Afyon (Afyon Karahisar), which traces a wide curve southeastward through Konya (Konia) to Karaman and then northeast to Kayseri. Between this line and the sea lie the Taurus mountains. From the Dalaman valley on the west to Silifke on the east a bundle of ranges, not always continuous and sometimes ill-defined, enclose the Adalia (Antalia) plain. The main Taurus, an irregular chain to the northeast, dominates the Seyhan and Ceyhan coastal plains in which lie Mersin and Adana. It is broken by the

Cakit gorge which leads to the famous Cilician Gates, the route from the central plateau to the sea. The Taurus, rising to more than 12,000 ft. southwest of this gorge, ends south of Kayseri, which is overlooked by the separate volcanic group. the Erciyas (the Mount Argaeus of the ancients). East of the Seyhan lowland is the narrow strip of lowland along the sides of the Gulf of Alexandretta, at the head of which a gap between two parallel ranges forms the ancient Amanus Gates, the Kalekoi pass between the Misis Dag on the west and the Gavur Dag (classical Amanus) on the east. Beyond the Taurus to the east is a group of seven ranges, the Anti-Taurus, all of which have a general trend to the northeast. The Kurt Dag, the Gavur and the Misis are the southernmost of the group, but none has an inclusive name. The central ranges are much cut up by tributaries of the Seyhan and Ceyhan rivers. There are numerous peaks with heights between 7,000 and 8,000 ft., and the Nuruhak Dag, southwest of Malatya, is 10,100 ft.

Southeastern Turkey may be defined as the belt bounded on the south by the frontiers with Syria and Iraq, on the east by the frontier with Iran and on the north by the mountain ranges which form the watershed of the Euphrates and the Tigris. The Euphrates basin, on the west, is an irregular strip through which the river runs between precipitous banks. Most of the villages are on tributaries well back from the river. Between it and the Tigris valley is a barren, undulating plain, north of which rise the rugged heights of the Kurdish Taurus. The Tigris rises near the Hasar lake, flows on an erratic course southeast to Diyarbakir and then east, fed by numerous tributaries on the way. It passes there between deep gorges turning south and then east to Cizre, where it meets the frontier with Syria.

East of the Tigris to the Iranian frontier lie the Kurdish mountains, with summits rising to more than 13,000 ft. On the west the country is wild, and rivers and their tributaries cut erratically between the crests. In the centre the ranges end in precipitous cliffs facing southwestward; further to the east the country is lower and becomes milder to the Iranian frontier. The Great Zab (Buyuk Zap Su), the tributaries of which drain the extreme southeastern comer of Turkey, passes through deep gorges in wild and difficult country and, cutting through the Cilu range, crosses the Iraqi frontier.

Eastern Turkey north of this region to the Kelkit and Coruh valleys is largely volcanic, with cones rising to 11,000 ft. or more surrounded by lava fields. Some ranges of nonvolcanic origin vary an otherwise monotonous landscape. The Murat Su, which rises north of Lake Van, almost in the shadow of Mount Ararat, crosses the area from east to west to join the Euphrates 250 mi. away. Lake Van, which lies at 5,643 ft. above sea level, is about 80 mi. long from east-northeast to west-southwest and about 35 mi. across at its widest point; it has no outlet. Mount Ararat, a volcanic cone rising to 16,916 ft., is the loftiest of the Agri Dag group on the frontier of Soviet Armenia, south of Erivan.

Climate.—The structure of Turkey—a central plateau surrounded by coastal belts of mountains—gives regional variations in climate which generally follow the divisions described above, although local differences due to latitude, altitude and topography occur. The central plateau has hot, dry summers and cold winters with rain or snow between November and May. The eastern part of the plateau is colder than the western in winter; the summers are cool in the north, but hot in the south. The change in climate is rapid from the Black sea coastlands to the plateau. In this region the winters are mild on the coast; the summers are hot and damp. Fog and mist are frequent throughout the year. Winter temperatures fall rapidly and rainfall increases from the coast to the mountain heights inland. In western Anatolia the change in altitude from coast to plateau is less abrupt and the climatic change is more gradual. The summers are hot and dry; the winters near the coast are mild and damp but become colder inland with frost and some snow. Rainfall is moderate (20–30 in.) on the coast and decreases inland. On the southern coastlands the temperature in winter is moderate, and this is the warmest part of Turkey. The summers are hot and, particularly in the eastern coastal lowlands, oppressive because of the high humidity. In the southeastern region the summers are extremely hot but the winters are milder than on the central plateau. Eastern Turkey has wide variations of temperature because of its mountainous character, and the northeastern district (Erzurum-Kars), where snow lies for four months of the year, has the coldest winter in Turkey. The summers are hotter in the south than in the north, but reliable records are scanty for this region. See Table I.

Table I.—Temperatures and Rainfall

Station	Absolute maximum and minimum recorded temperatures (degrees Fahrenheit)			Mean annual rainfall	
	Max.	Month	Min.	Month	Inches
Samsun . . .	96	September	22	February	28
Istanbul. . .	100	July	17	January	29
Edirne . . .	107	July	−2	December	22
Izmir . . .	111	June	12	February	25
Adalia . . .	110	July	24	February	42
Adana . . .	109	September	10	January	24
Konya . . .	100	July	−8	February	11
Ankara . . .	99	July	−13	December	14
Urfa . . .	111	July	19	December	16
Erzurum . .	89	August	−17	Jan. and Feb.	18
Kars . . .	91	August	−32	Jan. and Feb.	20

(K. C. B.)

HISTORY

The first appearance of the Ottoman Turks in history dates from the early 13th century. According to the official tradition of the Turkish historiographers, Ertughrul, the father of the first sultan, Osman, was a member of the tribe of Kayi, the most exalted branch of the Ghuzz (Oghuz) Turks, who had been driven from their home in central Asia by the advancing Mongols. He and his small band of tribesmen found their way into Anatolia, where the Seljuk sultan Ala ud-Din Kaikobad I, in gratitude for their timely intervention when he was hard pressed by a superior Mongol army, gave the gallant stranger a grant of lands around Soghut. Modern research (notably by Paul Wittek; see *Bibliography)* proved the greater part of this romantic story false. The weight of evidence is against Ertughrul's exalted Kayi genealogy. Nor was it tribal loyalty that held his followers to him, any more than it retained men's allegiance to his descendants for nearly seven centuries.

From at least the early 9th century, there are record: in the Moslem east of organizations of ghazis, (fighters for the faith), men sworn to wage ceaseless war on the infidel, through motives of religious zeal or greed for loot or both. Such were the followers of Ertughrul. Ertughrul was not the only ghazi leader to establish a dynasty; the beyliks (principalities) of western Asia Minor —Menteshe, Aidin (Aydin), Karesi, Sarukhan—were all founded by ghazis. So also was the Saffarid dynasty which ruled in Persia between 860 and 1000. When a ghazi organization settled down in a conquered territory, there was always a hard core of warriors who, remaining true to their purpose, refused to become peaceful citizens. These would naturally move on to any place where the fight against the infidel was still being fought. In this fact lies the reason for the extraordinary success of the line of Ertughrul; their field of operations was on the frontiers of Byzantium, where in fighting the Christian a ghazi might best fulfill his destiny. The Ottoman power was therefore perpetually strengthened by an endless stream of recruits from the more settled lands to the south and east.

In assigning to Ertughrul the lands around Soghut, the Seljuks were only recognizing a *fait accompli.* Soghut remained his headquarters. and when he died in 1281, at the age of 90, it was there that he was buried.

THE OTTOMAN SULTANATE

Osman I (1281–?1325).—Ertughrul was succeeded by his son Osman (b. 1258), the first sultan of the dynasty to which he gave his name ("Ottoman" is a barbarism for "Osmanli"). In 1284 he mas confirmed in his dominions by the Seljuk sultan Masud. He proceeded steadily with the work of enlarging his territories, taking Karajahisar in 1291, Bilecik and Yarhisar, and then Inegol in 1299. About 1308 the Seljuk sultanate came to an end, and the

Mongol Ilkhanids of Persia and Mesopotamia, to whom the Seljuks had been tributary, entrusted Anatolia to a Mongol prince, Timurtash. who tried with no great success to bring all the principalities under his sway. The main opposition to him came from the bey of Karaman, a powerful state which later gave the Ottomans a great deal of trouble. The fall of the Seljuks is generally regarded by Ottoman historians as marking the beginning of Ottoman independence, but it is known that Osman's successor continued to pay a yearly tribute to the Ilkhanids.

Toward the end of Osman's life, infirmity compelled him to depute his authority to his son Orkhan by 1324. By the time of his death (1325 or 1326), his dominions extended over the triangle contained by Hendek in the north, Eskisehir in the south and Lake Apolyon in the west.

Orkhan (?1324–62).—Orkhan had won the succession through his military ability, his elder brother Ala ud-Din being a man of pacific and scholarly temperament (he is generally identified, on no good authority, with the Ala ud-Din Pasha who served as vizier to the first two sultans). In 1.326 the Ottoman forces captured Bursa, which had been under siege since 1315. In 1329 a Byzantine army under the personal command of the eastern Roman emperor Andronicus III was defeated at Pelecanon (Maltepe); and Nicaea (Iznik) fell shortly afterward. In 1336 Orkhan profited by a dynastic quarrel in the neighbouring beylik of Karesi to annex a portion of its territory, including Pergamum. This acquisition placed a number of experienced seamen at the disposal of the Ottomans. The next year Nicomedia (Izmit) was wrested from the Greeks, and by about 1340 the Byzantine possessions in Asia Minor had been reduced to a few coastal towns near Constantinople.

A period of consolidation followed, until 1345, when dissension among the Greeks gave the Turks a bridgehead in Europe. In that year the usurper John Cantacuzenus appealed to Orkhan for aid against the rightful emperor John V Palaeologus. An Ottoman force was promptly dispatched which penetrated into the Balkans, inflicted a heavy defeat on the loyalists and returned laden with booty. John Cantacuzenus gave Orkhan his daughter in marriage; then, in 1352, as a reward for further help, he permitted the sultan to garrison the fortress of Chimpe on Gallipoli. He soon realized his mistake when the Ottomans advanced from this base to occupy the rest of the peninsula; his suggestion that Orkhan should sell Chimpe back to him and evacuate Gallipoli was not accepted. After the usurper's downfall in 1355, John Palaeologus was obliged to recognize Orkhan's territorial acquisitions in Rumelia. The sultan did not neglect his eastern frontiers; in 1354 an army commanded by his son Suleiman Pasha took Ankara from the son of Ala ud-Din Ertena, an Ilkhanid governor-general who had established himself at Sivas. Orkhan died in 1362 and was succeeded by his son Murad, Suleiman Pasha having predeceased his father by three years.

***Murad I* (1362–89).**—The reign opened brilliantly with the capture of Adrianople and Philippopolis by Lala Shahin Pasha. The efforts of the Greek emperor, in alliance with the doge of Venice, to expel the Turks from Europe came to nothing, in consequence of the Ottoman policy of settling nomads from Anatolia in the conquered territories. Although the exact date is not known, it was probably about this time that the corps of janissaries (*q.v.*) was founded, with Christian youths captured in the wars. In 1363 an allied army of Serbs, Bulgars, Walachians, Bosnians and Hungarians, headed by Louis I of Hungary, was routed on the Maritsa. Two years later Murad made Adrianople his capital and began to enrich it with palaces and mosques. By 1369 the conquest of eastern Thrace was completed. The Serbian ruler of Kyustendil, an important iron-mining centre, became tributary to the Turks in 1372, and Lazar I Hrebelyanovich of Serbia was soon obliged to follow his example. During the subsequent lull in hostilities the flow of Turkish settlers to the newly acquired lands continued and the foundations of Ottoman administration were firmly laid there.

The temporary peace did not interrupt the enlarging of the Ottoman territories. Murad married his son Bayezid to Devlet Khatun, daughter of the bey of Germiyan (Kermian), his southern neighbour. Her dowry consisted in the major portion of her father's lands, including the city of Kutahya. From this convenient base Murad intimidated the bey of Hamid into selling him a large part of his principality, contiguous to the frontiers of Karaman. Ali Bey of Karaman, probably in league with the ruler of Hamid, persuaded Stephen I Tvrtko, king of Bosnia, to attack the Turks in Rumelia and then took advantage of Murad's absence in Europe to occupy the former Hamidian provinces. Murad left Jendereli Khair ud-Din Pasha to deal with the situation in Rumelia and returned to Anatolia, with Byzantine and Serbian auxiliaries, to crush Ali Bey at Konia (1387). An Ottoman force under Timurtash Pasha invaded Bosnia but was totally defeated by a combined Bosnian and Serbian army. The princes and kings who had consented to pay tribute were encouraged to rebel by this success. Murad appealed for help to the Anatolian beys; some complied, including those of Germiyan and Hamid, but not Karaman. Murad then returned to Europe with a large force and sent Chandarlizade Ali Pasha northward; the fortresses of Shumla, Pravadi, Trnovo, Nicopolis and Silistria were taken by him. Ivan Shishman III, the rebel king of Bulgaria, was punished and his country once more subjugated. Ali Pasha then joined his master at Kosovo. There Lazar of Serbia had collected an army of 100,000 Serbs, Hungarians, Moldavians, Walachians and others. On Aug. 27, 1389, the greatest of the battles of Kosovo was fought. Lazar was captured and his army cut to pieces, but after the battle Murad was slain. Serbian tradition tells that he was assassinated by Milosh Kobilovich, a Serb who approached him on the plea of submission.

Murad was succeeded by his eldest son, Bayezid. His second son, Savji, had plotted with Andronicus, son of the emperor John Palaeologus, to dethrone their respective fathers. The attempt failed; Andronicus was ordered by his father to be blinded and Savji was put to death (1385).

Bayezid I* (1389–1403).**—After being proclaimed on the field of Kosovo, Bayezid ordered the execution of his remaining brother Yakub. There is some evidence that in killing his brother the new sultan was following the example set by his father on his accession. Lazar II, otherwise called Stephen, Lazar I's son and successor on the throne of Serbia, made haste to conclude peace with Bayezid; he acknowledged his suzerainty and gave him his sister in marriage. Turks and Tatars were settled between Nish and Uskub Skoplje. The sultan then returned to meet a grave threat in Anatolia. The bey of Karaman, on hearing of Murad's death, had roused the beys of Aidin, Sarukhan and Menteshe against the Ottomans. Independently of these, Yakub of Germiyan was resolved to take back the lands that had gone to make his sister's dowry. Bayezid acted with great promptness. In the winter of 1390 he overran Aidin and Menteshe and then marched east to occupy Germiyan. In his retinue was Manuel, son of the emperor John V Palaeologus. Kara Timurtash Pasha was appointed ***beylerbeyi (governor-general) of Anatolia, with his headquarters at Kutahya. In the spring of 1391 the Ottomans invaded Karaman. Hearing that the Walachians, in league with the dispossessed beys, were in revolt, Bayezid made peace with Karaman and, by a brilliant march to the Danube, put down the rebellion. Meanwhile Manuel Palaeologus, learning of his father's death, hastened to Constantinople to claim the throne as Manuel II, without obtaining leave from the sultan. Bayezid therefore blockaded the city. At the end of seven months, the new emperor not only agreed to pay an increased tribute but also consented to the building of a mosque in the capital and to the appointment of a kadi to judge between Moslems residing there. The reason for the sultan's willingness to lift the blockade was that Sigismund of Hungary, later western emperor, had, with Walacbian help, entered Bulgaria, capturing Nicopolis from the Turkish garrison. At the news of Bayezid's approach, Sigismund withdrew and the sultan returned to Anatolia to crush the turbulent ruler of Kastamuni (1392). At the end of 1394 Bayezid sent envoys to Egypt, requesting that the caliph should recognize him as sultan of Rum; and this was done.

In the same year Pope Boniface IX had proclaimed a crusade against the Turks. The attack came in 1396, when armies from many European countries assembled in front of Nicopolis. So elated were the allies by some minor initial successes that Sigismund even spoke of going on to the conquest of Jerusalem. The speed of Bayezid's advance was such that the crusaders at first refused to believe the reports of his proximity. Their over-confidence resulted in their annihilation. After this victory the siege of Constantinople was resumed, and about this time the fortress of Anadolu Hisari, on the Asiatic side of the Bosporus, was built. It seems that the Ottoman plan was to starve the city, rather than to take it by assault, but as the Turkish naval forces were negligible the Byzantines had no difficulty in obtaining supplies and reinforcements by sea. Bayezid overran Thessaly in 1397 and, until the spring of 1402, carried out a series of raids on the Morea, leaving colonies of Turks to hold the captured districts. In 1397 the sultan also took Konya after a siege and killed the bey of Karaman, who had attacked Ankara and captured Timurtash Pasha while Bayezid was fighting Sigismund at Nicopolis. The Ottoman territories were also extended in the northeast, to march with the empire of Trebizond.

Meanwhile Timur (Tamerlane) had started from Samarkand on his victorious career. After devastating Georgia in 1400 he marched against the Turks. Some of the dispossessed princes of Asia Minor had begged Timur to reinstate them. Bayezid replied to a request to this effect from Timur in terms which made war inevitable. An attack in force was postponed by Timur's activities in Syria and Mesopotamia. But in 1402 in a great battle near Ankara the Turks were defeated and Bayezid was taken prisoner. Eight months later he died at Akshehir. probably by his own hand. This disaster checked the Ottoman advance for more than a decade. Timur reached Bursa and looted it, although Suleiman, Bayezid's eldest son, who fled after the battle, had forestalled him in carrying off the Ottoman treasury. One after another the Anatolian cities of the Ottomans were seized and plundered by the Tatars. (G. L. L.)

Mohammed I (1413–21).—Timur had sent letters after the fugitive sons of Bayezid promising to confer on them their father's dominions and protesting that his invasion had been due merely to the insulting tone adopted toward him by Bayezid and to the entreaties of the dispossessed princes of Asia Minor. He did not cross into Europe, but moved eastward after capturing Smyrna and restoring the dispossessed beys. For some time further, disputes between the sons of Bayezid delayed the Turkish revival. However, Mohammed I (*q.v.*), the youngest, was recognized as sultan in 1413 and recovered nearly all his father's territories in his reign of eight years. Two years after his accession he compelled the prince of Karaman to yield up a number of his cities and then, turning northward, forced Mircea, voivode of Walachia, to pay tribute. The Turkish dominions in Asia Minor were extended, Amasia, Samsun and Janik being captured, and an insurrection of dervishes was quelled. In 1421 the sultan died. His services in the regeneration of the Turkish power were great. Amid the cares of state he found time for works of public utility and for the support of literature and art; he is credited with having sent the first embassy to a Christian power, after the Venetian expedition to Gallipoli in 1416. He was succeeded by his son Murad.

Murad II (1421–51).—Shortly after his accession the emperor Manuel, having applied in vain for the renewal of the annual subsidy, paid him by the late sultan for retaining in safe custody Mustafa, an alleged son of Bayezid (see MOHAMMED I), released the pretender. After ruling in Rumelia for more than a year he was defeated and hanged at Adrianople (1422), and Murad thereupon laid siege to Constantinople to avenge himself on the emperor. The siege was raised because the appearance of another pretender, in the person of Murad's 13-year-old brother Mustafa, under the protection of the revolted princes of Karaman and Germiyan, called the sultan to Asia. Mustafa, delivered up by treachery, was hanged (1424); but Murad remained in Asia, restoring order in the provinces, while his lieutenants continued the war against the Greeks, Albanians and Walachians. Constantinople withstood a siege in 1422, but by the treaty signed on Feb 22, 1424, shortly before his death, the emperor Manuel II, in order to save the remnant of his empire, agreed to the payment of a heavy annual tribute and to surrender all the towns on the Black sea except Selymbria and Derkos and those on the Struma (Strymon) river. Peace was also made at the same time with the despot of Serbia and the voivode of Walachia, on the basis of the payment of tribute. By 1426 the princes of Germiyan and Karaman had submitted on honourable terms, and Murad was soon free to continue his conquests in Europe. Of these conquests the most conspicuous was that of Salonika. Garrisoned by 1,500 Venetians, the city was carried by storm (March 1, 1430); the merciful precedent set by Mohammed I was not followed, the greater part of the inhabitants being massacred or sold into slavery and the principal churches converted into mosques.

By this time it was widely recognized that a further Turkish advance could be prevented only by the combined action of the northern peoples now definitely threatened. In 1442 a force of Slavs and Magyars under the voivode Janos Hunyadi (*q.v.*) drove the Turks from Nagyszeben (Sibin). In the following year they were expelled from Smederevo, which they had conquered a few years previously. Meanwhile, again confronted by a rebellion of the prince of Karaman, Murad had crossed into Asia and obtained his submission, granting him honourable terms in view of the urgency of the peril in Europe. On July 12, 1444, a ten years' peace was signed with Hungary, whereby Walachia was placed under the suzerainty of that country. Conscious of failure, Murad abdicated in favour of his young son Mohammed and retired to Manisa (Magnesia) in 1444. Pope Eugenius IV urged the king of Hungary to take advantage of this favourable opportunity, and 19 days after the truce had been concluded a large army headed by Wladyslaw I of Hungary, Hunyadi and Cardinal Cesarini crossed the Danube and reached Varna. In this emergency Murad was implored to return to the throne. After some hesitation he agreed and, crossing over with his Asiatic army from Anadolu Hisari, hastened to Varna and routed the allies. Murad is said to have abdicated a second time and to have been again recalled to power because of a revolt of the janissaries. In 1446 Corinth, Patras and the north of the Morea were added to the Turkish dominions. The latter years of Murad's reign were troubled by the successful resistance offered to his arms in Albania by Skanderbeg (*q.v.*). In 1448 Hunyadi, now governor of Hungary, collected the largest army yet mustered by the Hungarians against the Turks, but was defeated on the famous field of Kosovo. In 1451 Murad died at Adrianople, being succeeded by his son Mohammed.

Mohammed II the Conqueror (1451–81).—After suppressing a fresh revolt of the prince of Karaman, the new sultan gave himself up entirely to the realization of the long-cherished project of the conquest of Constantinople. After building in 1452 the Castle of Europe (Rumeli Hisari) Mohammed began the siege in 1453. Constantine XI Palaeologus, the last emperor, failed to obtain support from the west, the defenders of the city were vastly outnumbered by the Turks and on May 29, 1453, it was carried by assault. The sultan triumphantly entered the palace of the emperors, and the next Friday's prayer was celebrated in the church of St. Sophia.

Secure in his possession of Constantinople the sultan proceeded northward and entirely subdued the southern parts of Serbia. A siege of Belgrade was unsuccessful, because of the timely succour afforded by Hunyadi (1456). Two years later internal dissensions in Serbia brought about the conquest of the whole country by the Turks, only Belgrade remaining in the hands of the Hungarians. Walachia was next reduced to the state of a tributary province. Because Venice adopted a hostile attitude after Turkey's conquests in the Morea, greater attention was devoted to the fleet; Mytilene was captured and the entrance to the straits fortified. The conquest of Bosnia, rendered necessary by the war with Venice, was next completed, in spite of the reverses inflicted on the Turks by the Hungarian king Matthias Corvinus, the son of Janos Hunyadi. The Turks continued to press the Venetians by land and sea; Albania was overrun; and Venice was forced to agree to a treaty by which she ceded to Turkey Scutari (Shkoder) and Kroia, and consented to pay an indemnity of 100,000 ducats (Jan. 25, 1478). The Crimea was next conquered and bestowed as a tributary province on the Tatar khan Mengli Ghirai. Mohammed now endeavoured to strike a blow at Khodes, the stronghold of the Knights of St. John, preparatory to carrying out his long-cherished plan of conquering Italy. A powerful naval expedition was outfitted but failed, though a land attack on southern Italy at the same time was successful, Otranto being captured and held for a time by the Turks. In 1481, setting out on campaign, the sultan died at Gebze. He is said to have been of a merry and even jocular disposition, to have afforded a generous patronage to learning and art and to have been master of six languages.

Mohammed II was the organizer of the fabric of Ottoman administration in the form which it retained practically unchanged until the reforms of Mahmud II and Abdul-Mejid. He raised the regular forces of the country to a total exceeding 100,000. Under him the independent princes of Asia Minor were finally subjugated. Many educational and benevolent foundations were endowed by him, and it is to Mohammed II that the organization of the ulema, or legist and ecclesiastical class, is due.

Bayezid II (1481–1512).—Bayezid reached the capital before his brother Jem and ascended his father's throne. To win over the followers of his brother he paid an accession present to the janissaries: this became an established custom. Jem's attempts to seize the throne were defeated. He took refuge with the Knights of Rhodes, but they were paid to keep him in custody. He was removed to Europe and, after 13 years' captivity, died in Naples. He was said to have been poisoned by Pope Alexander VI, who received 300,000 ducats from Bayezid, but from *Taj-ut-Tevarih,* the most reliable history of the period, his illness sounds like erysipelas.

Bayezid was a man of peace by nature and quite incapable of directing the warlike tendencies of the young empire. He abandoned Otranto and exempted Venice from her yearly tribute by imposing instead a 4% customs duty on Venetian goods imported. In 1492 the armies of the Turks invaded Laibach in Carniola and Cilli in Styria. In 1494 they were driven out of Styria by the emperor Maximilian. While Bayezid was fighting against his brother's claims, Moldavians attacked Turkish territory in Walachia and he was forced to lead another Turkish army into Moldavia. The khan of the Crimea, Mengli Gherai, fought in this army, and through his influence political correspondence was opened between Russia and Turkey, and the first Russian ambassador, Mikhail Belsechev, arrived in Constantinople. Moldavia became a vassal state after two years of war. John Albert, king of Poland, invaded Moldavia in 1496; and this was followed by a counterinvasion of the Turks, but they were forced to return by the severe winter. In 1496 Hercegovina was annexed to the empire, and in 1500 the Polish wars ended with an armistice. Rome and the Italian states had encouraged the sultan to crush the Venetian republic. The Turks gained over Venice their first great naval victory at Lepanto on July 28, 1499, and concluded peace on Dec. 24, 1502; a part of Morea and a few islands passed to Turkey, Venice retaining Cephalonia. On the Asiatic side Ismail Safavi, the shah of Persia, inspired with religious zeal for the propagation of Shi'ite doctrines, raided the empire (1501). The sultan attempted a pacific solution but failed to restrain his warlike son Selim from fighting the Persians. Shah Ismail's propaganda rooted the Shi'ite doctrines so firmly in Anatolia that in spite of the sanguinary repressions during the reign of Selim I, and the republican law of 1925 abolishing the dervish orders, adherents of the Kizilbash and other Shi'ite sects remain there to this day. Bayezid had also to fight the Egyptian armies under the Mamelukes who had invaded Adana, and he drove them out.

Selim then turned upon his father and, having won the janissaries to his side with promises of conquest, forced him to abdicate. Bayezid died on his way to his retreat at Dimotika. The political influence of the janissaries on the frequent change of sultans dates from this episode.

Selim I the Grim (1512–20).—True to his promise Selim kept the janissaries in action throughout his reign. After defeating his brother's claims, he attempted to exterminate Shi'ism not only in Anatolia but in Persia which was its centre. In 1514 he annihilated Shah Ismail's forces at Chaldiran and conquered Azerbaijan and Kurdistan. His most important conquests were Syria and Egypt, which he added to the empire after defeating the Mamelukes in 1516 and 1517. According to most Turkish and western historians he obtained from the last of the Abbasid caliphs, Mutawakkil, the title of caliph. (After the fall of the caliphs of Baghdad in 1258, the descendants of the Abbasids took refuge in Cairo and enjoyed a purely titular authority under the protection of the Egyptian rulers.) But the important authority of the *Taj-ut-Tevarih* implies that Selim did not base his Pan-Islamism on the prestige of the caliphate, for the *Fetih-Name* (the declaration of conquest) of Selim himself, as there quoted, has no reference to caliph or caliphate. Another contemporary historian, Hasan Tulun, a Mameluke and an admirer of Selim, in his *History of Egypt,* also implies that Selim meant to realize Pan-Islamism through force rather than through the assumption of the title of caliph. He assembled the ulema in Egypt and, referring to the fact that the Mamelukes always had their sultan consecrated by the caliph, asked whether this was necessary: the ulema declared that the sultanate depended on force rather than on consecration. The sherif of Mecca, Abu'l-Baraka, sent his son with the holy relics and the keys of holy places to Selim. But though these relics are the emblems of the caliphate it is probable that Selim wished virtually to abolish it. Not until 1774 did a sultan claim also to be caliph.

An important revolt, led by Jelal who pretended to be the mahdi, broke out at Yozgad in Anatolia, but was at once suppressed and from this date *Jelali* came to be a general term for "rebel."

Selim, who died in 1520, never fought against the Christian west. Possessed by the ideal of uniting the Moslem east, he directed his campaigns accordingly. During his reign of eight years the empire nearly doubled its extent. Although he uprooted corruption and the people enjoyed a severe but just administration, his cruelty in executing eight grand viziers is alluded to in the popular saying: "May you be vizier to Sultan Selim." He was a distinguished poet, but wrote almost exclusively in Persian. His love of culture and learning was shown by his preference for the company of the learned. Although among his subordinates he punished small offenses with death, his sheikh ul-Islam, Ali-Jemali Efendi, who was fearless and outspoken, was able to make him desist from his plan of converting the Greeks to Islam by the sword if necessary, by reminding him of the conqueror's (Selim's grandfather's) firman, which gave religious freedom to the Greeks. At one time Selim tried to make Arabic the official language, to further his Pan-Islamic policy.

Suleiman I the Magnificent (1520–66).—Suleiman (Soliman) I, known as the "Magnificent" in the west and the "Lawgiver" in Turkey, being an only son, was saved from the wars of succession which his predecessors had to fight. He began his reign with the magnanimous act of freeing all the prisoners of war and restoring the goods confiscated from the merchants who traded with Persia in Selim's time. But this record is marred by the execution of two of his sons. That of the older, Mustafa, was thought due to the influence of his wife, the famous Khurrem Sultan, known as Roxelana (the daughter of a Russian priest), in order to leave her own sons without a rival. With her began the influence of women in affairs of state. She was also believed to have influenced the execution of the able grand vizier Ibrahim Pasha in order that his power might pass to Rustem Pasha, her son-in-law.

Suleiman's conquests were mostly in the west, though he had some Asiatic campaigns. He first marched into Hungary in 1521 ostensibly because his envoy had been slighted and because he received no congratulations on his accession. But actually he was resuming the northwestward march of his house that had been blocked by Hunyadi in 1456 He captured Belgrade, which remained a base throughout the Turkish wars in Europe. In 1522 Rhodes and Cos were conquered. In 1526 the Hungarians were severely defeated at the battle of Mohacs (*see* HUNGARY: *History*), their king. Louis II, killed and the greater part of Hungary including Budapest taken. The Turks appointed John Zapolya, the voivode of Transylvania, to be king of the Magyars. The sultan then left Hungary to put down a Shi'ite rising in Tabriz.

Ferdinand, the brother of the emperor Charles V, then claimed the Hungarian throne as the brother-in-law of Louis II, invaded Buda and drove out Zapolya, who naturally appealed to Suleiman. In 1529 Suleiman with Zapolya marched into Hungary, seized Buda and defeated the Austrians, and Zapolya was reinstated. Encouraged against Charles V by Francis I of France,, Suleiman laid siege to Vienna, but after three weeks was obliged to abandon it. Part of the Turkish army went as far as Regensburg in Germany. In 1532 Suleiman again marched against Charles V and approached Vienna, but in 1538 a truce was signed and Hungary was divided between Zapolya and Ferdinand.

During his Persian wars Suleiman retained the friendship of Ferdinand; but in 1540 Zapolya died and Ferdinand marched on Buda. Suleiman decided to uphold the claims of Zapolya's son and of his widow Isabella. He marched into Hungary, defeated Ferdinand and placed the young king on the throne under the regency of his mother. Suleiman refused all overtures of peace and war continued both on land and sea. In 1542 an alliance between Francis I and Suleiman led to a combination of the Turkish and the French fleets against Charles V. On land, Suleiman took Esztergom, Vizegrad, Szekesfehervar and a part of Hungary that became a Turkish province consisting of 12 sanjaks. On June 15, 1547, a truce of five years was signed in Adrianople between Suleiman, Charles V and Ferdinand which recognized the Turkish conquests and bound Ferdinand to pay a yearly tribute of 30.000 ducats to Turkey for the territory left to him. John Sigismund, the son of John Zapolya, was recognized as the independent prince of Transylvania and of the 16 adjacent Hungarian counties, Queen Isabella to act as regent during his minority.

The terms of the treaty were soon ignored. Ferdinand being in league with Frater Gyorgy (see MARTINUZZI, GEORGE) to free Transylvania from the Turkish suzerainty, Suleiman sent a large army under Sokollu Mohammed Pasha into Hungary. Lippa and Temesvar were taken but a victory of the Persians in the east forced Suleiman to sign an armistice in 1553 and invite Austrian delegates to Constantinople to negotiate for peace. The negotiations failed and war continued with atrocities on both sides till 1561. On June 1, 1562, peace was concluded between Suleiman and Ferdinand, who had been crowned emperor. Ferdinand undertook to pay all his arrears of tribute to Turkey and to continue a yearly payment of 30,000 ducats, to leave Temesvar and other towns to Suleiman, to recognize the independence of John Sigismund in Transylvania and to withdraw all his Habsburg claims to interference in Hungary.

In 1564 Ferdinand died and Maximilian II succeeded him. Maximilian attacked Tokay, which was in Turkish possession, and let the tribute fall into arrears. Sokollu Mohammed Pasha, the new Turkish grand vizier, desired to wipe out the disgrace of a naval defeat in Malta which had ended in the death of Adm. Torgut, and Suleiman in 1566 led an army into Hungary, although 72 years old. He died during the siege of Szigetvar, but his death was kept secret by Sokollu till the fortress fell. Thus Suleiman, after ruling 46 years in life, ruled 46 days after his death, until his son Selim ascended the throne and reached Belgrade.

On the Asiatic frontier in 1526 Shah Tahmasp of Persia had taken Tabriz from the Turks while Suleiman was fighting at Mohacs. On his return Suleiman set out for Persia with an army, conquered the Armenian plateau and joined another Turkish army commanded by Ibrahim Pasha which had already recaptured Tabriz. The Persians retreated without fighting and in 1534 Suleiman took Baghdad.

In 1536 the French ambassador, Jean de la Foret, negotiated a treaty between France and Turkey by which certain judicial and economic privileges were granted to France. This marks the beginning of the capitulations which, started when Turkey was a powerful empire, were at first regarded only as the means of procuring an easy market for Turkish goods in France. They led, however, to serious and enduring political complications and became the pretext for exploiting Turkey in her decadent days. In 1555 Suleiman concluded a treaty of peace with the Persians at Amasia after conquering Georgia, the Armenian plateau and Erzurum.

Murad II had begun the building of the Turkish navy but it was during Suleiman's reign that Turkey became a first-rate sea power. At no other time did Turkey have such a large number of famous admirals. Suleiman had conceived the idea of using the renowned corsairs who raided the Spanish and Irish coasts and he had engaged Khair ud-Din Barbarossa (see BARBAROSSA). Barbarossa was the son of a Turkish spahi, Yakub, a Macedonian, and his mother was Greek, his native place being Mytilene. He presented to Turkey Algiers, which he had personally conquered, and he formed what was called Garb Ojaklari (the states of Barbary). This was a military organization which administered Algiers, Tunis and Tripoli. Barbarossa took Tunis but was driven out by the fleet of Charles V, who devastated Tunis and destroyed mosques and valuable libraries because the Turks had converted churches into mosques in Hungary. Barbarossa's greatest naval victory was in 1538 when he defeated the combined fleets of the emperor, the pope and Venice under the command of Andrea Doria, off Prevesa. He took Castelnuovo and a few islands of the archipelago and he restored Morea to the Turkish empire. Torgut (known as Dragut in the west) was another famous corsair who had ravaged the Italian and Spanish coasts and was now engaged by Suleiman. He captured Tripoli from the Knights of Malta and was appointed its governor. He died in 1565, after an unsuccessful attack on Malta. Suleiman sent an expedition by sea to India in 1537, which conquered Aden on the homeward voyage. Piale Pasha, Piri Reis, Salih Reis, Seydi Ali Reis, were other renowned admirals of this period. Piri Reis and Salih Reis conquered the coasts of Yemen and Aden as far as the gulf of Basra. Piri Reis compiled a detailed sea atlas (Bahriye) of the Aegean and Mediterranean. He also conquered Muscat but was finally executed on the grounds that he had accepted bribes from the Portuguese to lift the siege of Ormuz. Seydi Ali Reis, a distinguished mathematician, succeeded him in the command of the fleet and was also defeated by the Portuguese. He escaped to the Indian ocean with three ships on which he lived for three years; then he landed and reached Turkey by land. He wrote his travels (*Mirat* ul-Memalik), a mathematical book on the astrolabe and a book called *Muhit* (Ocean) on the navigation of the Indian seas.

The Ottoman State in the 16th Century.—The Ottoman state evolved gradually from a society whose institutions were fundamentally nomadic. The power was divided between two classes: the military class representing force and the ulema representing religion. The judges belonged to the latter class, but their judgments were executed by the military. All executive power centred in the military. The sultan himself, whose autocratic person was the symbol of this power, was a soldier, as were the viziers, the leading administrators. During war the governing body accompanied the army, this being characteristic of a nomadic system. The most remarkable feature of the Ottoman state was that, down to the 18th century, the holders of almost every important post were slaves, most of them acquired by the impressment of Christian boys. The majority of the *kapikullari* (slaves of the Porte) were trained as janissaries in barrack schools. Those who showed promise of suitability for high office were sent to a school attached to the palace, where they were taught the Moslem humanities (Persian and Arabic), music and practical arts and crafts. (See Barnette Miller, The Palace School of Muhammad the Conqueror [1941].)

Suleiman's administration was one of the best of his time. The Christian population in Morea preferred the Turkish rule to that of the Venetians, and some Hungarian villages chose Turkish rule of their own accord. Financially Turkey was in a good position; it had been enriched by the addition of prosperous lands, the revenue was 183,000,000 aspres (though expenditure was 6,000,000 more) and no new tax was levied during this reign. The countries belonging to the empire were administered in two different ways. One part was ruled by the central government and consisted of 24 vilayets (provinces), 4 of which were in Europe and 20 in Asia and Africa. The second part was more or less self-governing under the suzerainty of the sultan and consisted of the kingdoms of Hungary and Transylvania, the principalities of Moldavia and Walachia, the khanate of Crimea and the sherifate of Mecca, which was ruled by the descendants of the prophet. The *Garb Ojaklari* (the states of Barbary), consisting of the provinces of Tripoli, Algiers and Tunis, had semi-independent governors who selected their own administrative bodies and later were empowered to make independent treaties.

After the conquest of Constantinople and the transfer of the capital to the imperial city, the Turkish system was somewhat influenced by that of the Byzantine empire. The affairs of state were discussed at the imperial divan over which the sultan presided until the reign of Mohammed the Conqueror, after which the sultans thought it more in keeping with their imperial dignity to hear the proceedings from behind a grating. The permanent members of the imperial divan consisted of three or more viziers (pashas with three horsetails), the grand vizier being the chief of these and invested with supreme power by the signet of the sultan. He held the title of *serdar-i-ekrem* (generalissimo) when in command of the army, in which case one of the other viziers remained behind as *kaymakam* (lieutenant). The viziers in the divan were called *kubbe vezirleri* (viziers of the dome), because of the nature of their meeting place. Their deliberations were attended by the following dignitaries: the *kazaskers* of Rumelia and Anatolia (the two highest judges of the empire); the *kadi* (judge) of Istanbul; the *defterdar* (minister of finance); the *nishanji* (keeper of the great seal); the *yenicheri aghasi* (commander of the janissaries); the *kaptan pasha* (lord high admiral) and the *reis ul-kuttab* (chief secretary, later the foreign minister).

Each vilayet was governed by a pasha (two horsetails) called a *beylerbeyi*. These provinces were divided into *sanjaks*, each being governed by a pasha (one horsetail) called *sanjakbeyi*. The *sanjaks* were divided into *kazas*, each being governed by a *kadi*.

The Turkish army during Suleiman's reign probably numbered between 200,000 and 300,000, and was one of the best disciplined and best equipped of the time. The main elements of the army were the janissaries and the spahis, the latter comprising feudal cavalry and standing cavalry divisions. Other important units were the *jebeji* (armourers), the *topju* (artillery) and the *bostanji* (originally gardeners, later police).

The land was divided into several categories: *vakuf*, *yurtluk-ojaklik*, *timar*, *ziamet* and *khas*. The revenues of vakuf-lands provided for the upkeep of mosques, schools, hospitals and other pious purposes. *Yurtluk-ojakliks* were lands in frontier districts, the revenues of which went to the frontier guards. The other three terms denoted fiefs whose revenues amounted to 2,000–20,000 aspres, 20,000–100,000 aspres and more than 100,000 aspres respectively. Some of these fiefs provided incomes for members of the imperial house and for successive holders of the great offices of state, while others were assigned to spahis. Only the latter sort were hereditary.

Selim II (1566–74).—Selim II, after pacifying the janissaries with payments, tried to undermine the power of Sokollu, the grand vizier, but finally found himself obliged to let the country be ruled by that great statesman. The conquest of Samos was completed and the risings is Yemen suppressed by Sinan Pasha. In 1568 the peace between Austria and Turkey was renewed for eight years. With the idea of joining the rivers Don and Volga by canal so that a fleet might be sent to the Caspian sea, Sokollu attacked Astrakhan but failed in his project. Turkish historians credit him also with the intention of opening a Suez canal. Cyprus was invaded by the Turkish army under the command of Lala Mustafa Pasha, who violated the capitulations of Famagusta (1571) by executing the Venetian commander Marco Antonio Bragadino, and aroused strong feeling against the Turks. Venice, Spain and the pope united in a holy league against Turkey and their combined fleets under the command of Don John of Austria severely defeated the Turkish fleet at Lepanto (1571). A year later the advance of a new Turkish fleet commanded by Kilij Ali Pasha caused Venice to break from the league and conclude a treaty with the Turks (March 7, 1573). In 1574 Sinan Pasha and Kilij Ali Pasha recaptured Tunis and ravaged Sicily. Selim died in 1574.

Murad III (1574–95).—Murad, Selim's eldest son, opened his reign by murdering his five younger brothers. He also tried to undermine Sokollu's power and in spite of his advice opened a war with Persia which lasted 12 years. The Turks conquered Shirvan, Tiflis and Daghistan and peace was concluded when Abbas, the successor of Tahmasp, was firmly established as shah of Persia. Sokollu's efforts to build an observatory in Istanbul were opposed by fanatical opinion; and his assassination, which soon followed, is said to have been ordered by the sultan. This threw the country into disorder, for there was no man who had Sokollu's strength and authority to oppose the harem intrigues and corruption. The janissaries, refusing to accept a debased coinage that was called "Jewish money," mutinied throughout the empire. This mutiny had scarcely been suppressed when in 1593 the uncertain peace between Austria and Turkey degenerated into a regular war which is known as the "long war." This began when Hasan Pasha, the governor of Bosnia, raided the Austrian frontiers and attacked Sisak. The Austrians and the Hungarians together routed the Turks in Kulpa with great slaughter. Sinan Pasha, the grand vizier, marched on Hungary with a large army, and war continued for 14 years. Bribery, which had become widespread in the country, corrupted the army as well, and there was no office which was not susceptible to the bribe of the highest bidder. Shemsi Pasha, one of Murad's counsellors, openly boasted of having made a sultan take bribes for the first time. Veszprem and Gyor were conquered by the Turks but the Moldavian and Walachian revolts checked further victories. The sultan's Venetian wife, Safiye Sultan (Baffo), ruled for many years as his only wife, accepted bribes and interfered in state affairs, influencing the Porte's relations with Venice, although in later years she had rivals. Murad, who died in 1595, is said to have had 130 children. The capitulations with France were renewed in 1581, those with Venice in 1589. Capitulations were signed with the grand duke of Tuscany for the first time in 1578, and with Great Britain for the first time in 1580. The first British ambassador sent to Turkey was William Harborne. Elizabeth I in her letter to the sultan urged as a special claim to his friendship their common mission to fight the "idolaters," an interesting example of diplomacy.

Mohammed III (1595–1603).—Safiye Sultan, who had wielded such a strong influence as wife, continued to do so as mother during this reign. The new sultan began by murdering 19 of his brothers. The war in Hungary became chronic and intrigues bet een Sinan Pasha and Ferhad Pasha for the position of grand vizier led to frequent changes of command in the army, with disastrous results. Sinan persuaded the sultan to command the army in person, with good results at first, for in 1596 the Turks recaptured Eger (Erlau) and in three days defeated the allied armies at Keresztes. Because the sultan was anxious to return to his easy life in the capital and because the undue severity of Chighala Sinan Pasha was causing the Anatolian troops to desert, the Turks did not gain much by their victory. Ibrahim Pasha, Safiye Sultan's favourite, became grand vizier through her influence and she sold by proxy all the high offices of state. In 1598 Gyor, Tata, Veszprem and Papa were lost by the Turks. In 1599 overtures for peace were made by all sides without result. The unique military achievement of this campaign was that of Tiryaki Hasan Pasha, who in 1600 captured Kanizsa. A year later the attempt of the archduke Ferdinand to retake it at the head of 30,000 men was defeated. Military mutinies and Jelali insurrections broke out in the interior and Shah Abbas marched on Tabriz and Erivan. The sultan died in 1603.

Ahmed I (1603–17).—Ahmed I succeeded his father at the age of 14. The war with Persia continued fitfully during his reign. The Turks recaptured Esztergom in Hungary. Transylvania passed to the suzerainty of Turkey of its own accord; Stephen Bocskay, a member of its own aristocracy was appointed king. But the continual mutinies of the janissaries and the reverses in Persia forced Turkey to sign for the first time at Zsitvatorok a treaty of peace on terms of equality with Austria. Austria was freed from future tribute to Turkey by paying 200,000 ducats down, and for the first time the emperor was referred to as *padishah* in the official Turkish documents. A treaty of peace was also concluded between Turkey and Persia in 1611, Persia giving to Turkey as indemnity 1,000,000 lb. of silk. Kuyuju ("pitman") Murad Pasha, so called because he threw the bodies of rebels into pits, suppressed the Jelali risings in Anatolia. Friendly relations with Poland were restored.

Ahmed I was of a religious disposition, and left the affairs of the state to his grand vizier. In this reign it was decided to relax the custom of killing the brothers of every new sultan. They were, instead, to be confined each in a separate pavilion enclosed in a walled garden, known as kafes (cage). The evil result of this humane decision was that when a sultan was succeeded by a brother and not by a son the new ruler was inevitably a man with no experience of the world or of state affairs. At Ahmed's death his sons were minors and, as it was contrary to custom for a minor to succeed, his brother Mustafa became sultan (1617).

Mustafa I and Osman II (1618–22).—Sultan Mustafa being an imbecile was after three months declared incompetent to rule and Osman II, son of Ahmed, ascended the throne. Sokollu's idea that friendship with Persia would be politically to the advantage of the empire was adopted by the sultan and peace was concluded with that country. Moldavia revolted and joined the Poles, and Osman marched on Hotin. The expedition was a failure and diminished the prestige of the sultan. From his contact with them he knew how utterly degenerate and useless a body the janissaries had become and decided to discipline and reform them. He pretended to go on a pilgrimage to Mecca with the intention of marching back to the capital with a loyal and well-disciplined army which he hoped to raise in Syria and Arabia. When a rumour of this reached the janissaries they revolted. After marching the sultan through the streets of Istanbul and exposing him to ignominious insults they killed him.

Mustafa I (1622–23), Murad IV (1623–40), Ibrahim I (1640–48).—Mustafa I was once more dragged to the throne by the janissaries but he soon abdicated in favour of his nephew Murad IV, still a minor. Till the sultan was of age the empire was in the hands of his mother, Kosem Sultan, who had to cope as well as she could with the mutinous army and the corrupt state. The army chose the grand viziers and massacred them when it wanted a change. Kosem Sultan had to open the treasury to appease these revolts, which depleted the finances still more. When Murad IV was of age he restored order by one of the bloodiest reigns of history. Marching on Baghdad and Erivan he recaptured them from the Persians, repeating the atrocities which the Persians themselves had committed. He concluded a peace with Persia which fixed the Turko-Persian frontiers. On his return he murdered all his brothers with the exception of Ibrahim and continued to terrorize his officials by frequent executions. He died in 1640.

The decline in the Ottoman power continued during the reign of Murad's eccentric brother and successor, Ibrahim I. Ibrahim devoted himself to pleasure and was ruled by the women in the palace while his mother Kosem Sultan once more took the reins of power. It is not surprising that complete anarchy reigned throughout the empire, the capital included. A campaign against Crete, which belonged to the Venetians who had burned some Turkish ships, began during this reign, but continued for 25 years. For the first time the Dardanelles were closed by Venetian ships, which caused a famine and led to a revolt. Ibrahim wanted to massacre the Christians, but the ulema were able to restrain him. The change of the residence of the ambassadors from Istanbul to Pera dates from this event. Ibrahim was dethroned during a mutiny and killed.

Mohammed IV (1648–87).—Mohammed IV, the seven-year-old sultan, succeeded his father and for another eight years the affairs of state were in the hands of Kosem Sultan, his grandmother. The janissaries had supreme power, monopolizing everything, even the sale of bread. Mohammed's mother, Turhan Sultan, tried to get the power into her hands and the period of anarchy and mismanagement was prolonged by the struggle between the two women, each depending on a different military party. Turhan Sultan accused her mother-in-law of trying to poison the boy sultan and one evening she contrived that her party should invade the palace and surprise Kosem Sultan in her room. Kosem Sultan's great oratorical powers, which had enabled her to control janissary risings, failed to save her life and she was strangled with the cords of her bed curtain. Turhan Sultan now put Kuprili Mohammed into power as grand vizier, the first of five from the same family of Kuprili (*q.v.;* properly Koprulu) who did much to restore the empire. He restored order in the srmy by very drastic measures, rebuilt an efficient navy, defeated the Venetians and recaptured the island of Lemnos and other islands, The improved condition of the army led to the pacification of Transylvania which was in revolt. Kuprili Mohammed Pasha died after being in officefive years and his son Ahmed became grand vizier. In 1663 disturbances in Transylvania caused the Turks to attack the Austrians. At first Turkish arms were victorious; but the French, who had been alienated by the haughty demeanour of the Kuprilis, sent help to the Austrians under Raimando Montecucculi, the Austrian general, and the Turks were defeated at the battle of Szent Gotthard abbey. They lost little in the treaty of Vasvar (Aug. 10, 1664), by which a truce of 20 years was agreed upon. Transylvania was evacuated but remained tributary to Turkey. The Turks retaliated on the French by depriving those Catholics who were under French protection of some of their privileges in the holy places and granting them instead to the Orthodox church. The Cretan campaign was still in progress and the French were helping the Venetians, but the Turks took Candia and a treaty was signed in 1669 between the Venetians and the Turks which left Crete in the possession of Turkey while the island fortresses of Suda, Spinalonga and Grabusa remained Venetian.

Events in the Ukraine led Turkey into war with Poland in 1672. The Turks captured Kamenets, Lemberg and Lublin. The Poles sued for peace and a treaty was signed in 1672 at Buczacz whereby Podolia was ceded to Turkey and the Ukraine left to the Cossacks; Poland consented to pay Turkey an annual tribute of 22,000 sequins. But John III Sobieski, who ascended the Polish throne, refused to abide by the terms of this treaty and war was renewed and continued till 1676, when the treaty of Zurawno was signed, both parties abrogating the tribute clause.

Kuprili Ahmed having died, Kara Mustafa succeeded him as grand vizier. A man of great military ambitions, he led Turkey into a series of unnecessary wars. The first was against the Russians, and although the Turks were successful at the beginning, their losses were so great that they signed a treaty at Radzin (Jan. 8, 1681) ceding the disputed territory to Russia. The internal disputes in Austria caused by Protestant persecution caused Kara Mustafa in 1683 to violate the truce signed by Kuprili Ahmed and lead a vast army against Austria which laid siege to Vienna. The emperor and his court fled from the capital, but John Sobieski of Poland saved the Austrian cause by attacking the Turks in the rear and defeating them. The failure at Vienna marks clearly the beginning of Ottoman decline. It kindled the crusading spirit in Europe against Turkey and an alliance between Austria, Venice, the pope, Poland, Russia, Malta and Tuscany was formed. The Austrians made conquests in Hungary, the Venetians in Greece, the Russians in Crimea and the Poles in Podolia. Turkey tried in vain to get France to join it against this general alliance. The janissaries mutinied and Mohammed IV abdicated.

Suleiman II (1687–91), Ahmed II (1691–95), Mustafa II (1695–1703).—Mohammed's brother Suleiman II succeeded to the throne. Kuprili Mustafa was made grand vizier, and true to the tradition of his illustrious family, he restored order in the army and in the fleet, and by wise and tolerant administration won the sympathies of the non-Moslem subjects. The Austrians captured Erlau, entered Transylvania and reached Belgrade and Uskub, but Kuprili Mustafa drove them out and recaptured Belgrade. He also defeated the Russians in Crimea. Mustafa went as far as to distribute seeds for the crops of the people of the recaptured countries. In 1691 while the Turkish army was fighting in Morea Suleiman II died and was succeeded by his brother Ahmed II.

The Turks were defeated at Slankamen (Szalankemen) in Croatia in Aug. 1691 and Kuprili Mustafa was slain on the battlefield. An attack on Petrovaradin was equally a failure and the Venetians captured the island of Chios. In 1695 Ahmed died and was succeeded by his nephew, Mustafa II, Mohammed IV's son, who resumed leadership in the field of war.

Chios was recaptured and the war with Austria continued. The Turks conquered Lippa and defeated the Austrians and the Austrian field-marshal Friedrich von Veterani was killed. But the Russians took Azov and in 1697 the Austrians under Prince Eugene defeated the Turks at Zenta on the Tisa (Tisza). The war was ended, on the pressure of Venice, Holland and England, by a series of treaties with Austria, Poland and Venice concluded at Karlowitz (Jan. 1699). By the terms of these treaties Turkey retained the Banat; Austria kept Transylvania; Poland restored the places captured in Moldavia but retained Kamenets, Podolia and Ukraine; Venice retained the Morea and Dalmatia and a two years' truce was signed with Russia. In 1700 Azov was ceded to Russia by a separate treaty. During this time Husein, another Kuprili, was grand vizier, but his efforts to introduce order into the country were frustrated. He was driven out of office and a fresh revolt of the janissaries forced the sultan himself to abdicate. He was succeeded by his brother Ahmed III.

Ahmed III (1703–30).—Ahmed began his reign by conceding the demands of the janissaries and accepting their chosen grand vizier. Charles XII of Sweden, having been beaten by the Russians at Poltava, took refuge in Turkey and was invited to reside at Bender. This involved Turkey in another war with Russia, which had already sent troops across the frontiers in pursuit of Charles XII (1710). Baltaji Mohammed, grand vizier in command of the Turkish army, was induced by diplomacy to grant the tsar Peter a peace less to Russia's disadvantage than his army's defeat on the Pruth merited (1711). By this peace Azov was left to Turkey, Russian fortresses on Turkish frontiers were razed, Russia consented to the return home of Charles XII and renounced all claims over the Tatars in Crimea and in Polish territory. Because the hospodars of Moldavia and Walachia had assisted Russia during the campaign they were punished, and Phanar Greek notables (see PHANARIOTES) governed these principalities till the Greek insurrection of 1821. Venice was next to be punished for having incited the Montenegrins to revolt, invaded Bosnia and captured Turkish ships in the Mediterranean. In 1715 Turkey declared war against Venice, quelled the Montenegrin revolt, captured Modon and Coron and with its fleet took the islands of Tinos and Cerigo, as well as the remaining Venetian fortresses in Crete. Austria intervened, urging Turkey to cede to Venice certain places in Dalmatia as compensation for its losses in Morea. This led to a declaration of war against Austria in 1716. The Turkish army was routed near Petrovaradin and pursued by the Austrian army led by Prince Eugene, which took Belgrade and overran the Banat (1717). The Turkish army then retreated to Adrianople. By the mediation of England and Holland the treaty of Passarowitz was signed on July 21, 1718: Belgrade, a part of Walachia and Banat passed to Austria, and strongholds in Albania and Dalmatia to Venice. This treaty was signed by the grand vizier Ibrahim Pasha, who is accused of having betrayed Turkey by accepting it. The craze of the time in the capital was the cultivation of tulip gardens and has given to this period of Turkish history the name of the "tulip period." It created a definite literary school under Nedim, the greatest Turkish lyric poet. But popular murmurings against these costly pleasures became such that the grand vizier had to seize the occasion of the Persian defeat by the Afghans to annex several parts of Daghistan in Persia in order to appease the bellicose spirit of the janissaries. This led to a complication with Russia, but the intervention of France resulted in the treaty of Constantinople between Russia and Turkey (June 30, 1724) which allotted Baku and Derbend on the Caspian coast to Russia.

The news of the defeat of the Turkish army by the Persian army under Nadir Kuli Khan led to a rising of the mob under the leadership of Patrona Khalil. a bath waiter. The grand vizier was killed and the sultan forced to abdicate (1730). His nephew, Mahmud I, Mustafa II's son, succeeded. This was the only Turkish rising which did not originate in the army. The printing press first came into use in Turkey at this time.

Mahmud I (1730–54).—Patrona Khalil was killed and his followers dispersed after the accession of Mahmud I. The war continued with Persia, and Nadir Kuli Khan, after his successes in Iraq and Erivan, seized the Persian throne. In 1736 a Turco-Persian treaty was signed whereby all territory conquered since the reign of Murad IV was returned to Persia. Russia also returned the Persian territory it had annexed, thus laying the basis of a Russo-Persian alliance against Turkey.

The question of the Polish succession once more led Turkey into war. France had put forward as its claimant to the Polish throne Stanislas Leszczynski, while Austria and Russia supported the claims of Augustus III (the elector Frederick Augustus II of Saxony) although Russia had bound itself by the treaties of 1711 and 1720 to abstain from interfering with Poland. The Russian candidate was forced upon Poland (1733), whereupon France declared war on Russia and Austria and then urged Turkey to join it. Turkey had a grievance in that Russia had refused to allow the Crimean troops to march through Daghistan during the Persian campaign, so Turkey declared war in spite of the joint efforts of England and Holland. Before waiting for a declaration of war a Russian army under Marshal B. C. Münnich stormed the isthmus of Crimea, devastated the peninsula and captured Azov and Kilburun in 1736 and Ochakov the next year. The sea powers of the west mediated to restore peace and the representatives of the belligerents met in Niemirow in 1737 to arrange terms. Austria, however, put forward new claims to the principalities and the Balkan peninsula which were refused by Turkey, whereupon Austria revealed the existence of a secret alliance with Russia and threatened to fight for its new claims. Accordingly Austria's army marched on Bosnia and Walachia, capturing Nish in Serbia. But the tide of war turned against both Russia and Austria when Ochakov and Kilburun were recaptured by one Turkish army while another crossed the Danube and penetrated as far as the Banat. In 1739 Turkey consented to negotiate peace and a conference opened in the camp of the grand vizier who was marching on Belgrade. The preliminaries were signed under the mediation of the French ambassador, Louis Sauveur Renaud, marquis de Villeneuve, for whose services the Porte reaffirmed the capitulations which France had already obtained. After the entrance of the grand vizier into Belgrade the definitive treaties of peace were concluded with Austria and Russia (Sept. 18, 1739). Austria gave up Belgrade and the rest of the territory south of the Save which it had gained by the treaty of Passarowitz. The treaty with Russia provided that the forts of Azov should be razed and that Russia should have no warships on the Sea of Azov or on the Black sea. The Kabardias were to remain independent as a buffer state between Turkey and Russia. Turkey consented to discuss the question of recognizing the tsar's claim to the imperial title of padishah and admitted his right to send representatives to Constantinople.

Two years after the treaty of Belgrade, war broke out with Persia because of Nadir Kuli Khan's attempt on Mesopotamia. It continued from 1743 to 1746 with varying fortunes, and when peace was signed Turkey retained the frontier fixed at the time of Murad IV and Persia procured a few privileges for its pilgrims to the Holy Places. Turkey refrained from taking part in the War of Austrian Succession in spite of the efforts of France, and maintained a peaceful attitude during the disorders which followed the death of Nadir Kuli Khan in Persia. The sultan died in 1754 and was succeeded by his brother Osman III (1754–57). The only noteworthy events of the latter's reign were the first Wahhabi rising and the issuing of the first order for veiling women's faces.

Mustafa III (1757–73).—Koja Raghib, the grand vizier at the accession of Ahmed III's son, Mustafa III, sent an envoy to Berlin, and a treaty of friendship and commerce was signed on March 12, 1761. While he was alive Koja Raghib kept the sultan out of war. He controlled Turkey's foreign affairs while the sultan, who was of a fanatical disposition, concerned himself with the dresses and the veils of women. He projected an alliance between Turkey and France; but since France and England had differences over the Indian possessions such a treaty might have affected the English interests among the Moslems, and in consequence Sir James Porter, the British ambassador in Istanbul, used his influence against it.

Before long, events in Poland drew Turkey into war in 1768. Catherine II of Russia tried to put her favourite, Stanislas Poniatowski, on the Polish throne on the death of Augustus III.

The Poles complained to the Porte and urged Turkey to fight Russia. The sultan at first contented himself with protests, but Russia had violated the neutrality of the Kabardia, while in Serbia, Moldavia and Montenegro the Russian monks carried on seditious propaganda against Turkey. Turkey issued an ultimatum to Russia demanding that Russia withdraw its army from Poland. On Russia's refusal war was declared. Turkey procured the neutrality of England, Holland and Sweden in this war, and Austria undertook to remain neutral in return for certain privileges. Nevertheless Turkey had entered the war without preparations. The Turks were first defeated by the Russian forces in Georgia. Crimea and Kabardia and on the Dniester; the Russian Baltic fleet under Alexis Grigorievich Orlov reached Morea, and incited the inhabitants to revolt. In 1770 the Turkish fleet was burned near Cheshme (Cesme, west of Smyrna) by the Russian fleet under the direction of a Scottish admiral. The Turks were defeated in Bessarabia, and the Russians invaded the principalities and reduced the fortresses on the delta of the Danube and on the Dniester. In 1771 the Crimea was conquered by the Russians. Although the Austrians had undertaken to mediate and to assist the Turks, they preferred to take a share in the partition of Poland. After a fruitless conference at Focşani, the Russian representative at the conference of Bucharest (1773) issued an ultimatum demanding the free navigation of the Black sea and the Aegean sea for Russian trading vessels and warships, the cession of Kilburun and the right to protect the Orthodox subjects of the sultan. Turkey refused these terms, and the war continued, the Turks fighting hard in Silistria and Varna. Mustafa died in 1773 and was succeeded by his brother. Abd ul-Hamid I.

Abd ul-Hamid I (1774–89).—Abd ul-Hamid had been kept in seclusion for 43 years and was weak in his mind. The abuses and disorders in the army and the palace were at their worst, and the situation at home gave no hope of retrieving the external misfortunes of the state. Turkey refused the mediation of Prussia, but when the Russian army reached Shumla it was forced to negotiate peace. The treaty of Kuchuk Kaynarji was signed on the anniversary of the treaty of Pruth (July 21, 1774) which had been disastrous to Russia. This was the most humiliating treaty the Turks had yet signed. The treaty was the first political manifestation of the Eastern Question (*q.v.*). The Tatars from Poland to the Caspian sea were given their independence, the sultan merely retaining his religious leadership as caliph. Russia retained Kilburun, Kerch and Yenikale, while Akkerman, Ismail, Ochakov and Bessarabia were restored to Turkey. Moldavia and Walachia became semi-independent states under Turkey, Russia, however, having the right to intervene in the appointment and dismissal of the hospodars. The imperial title of padishah was definitely conceded to the Russian tsars. The Black sea and the Mediterranean were made free for commerce and navigation to both countries, and Turkey was to pay an indemnity of 15,000 purses to Russia. The most important clause from the Turkish point of view was that which gave Russia the right to protect the Orthodox subjects of Turkey. Originally this treaty only accorded to Russia the right to build a church in Constantinople and the right of making representations for the protection of the officials of this church. and Turkey undertook to protect the Christians (article 7). This clause was later interpreted as an inclusive protection of the Orthodox Christians and played a disastrous part in the subsequent history of Turkey. Poland, the original cause of the war, was not mentioned, having been partitioned for the first time in 1772.

Turkey took advantage of the respite to strengthen its frontier defenses and to reform the janissaries. Russia soon tried to annex Crimea, but a rupture was averted by French mediation and also by the fact that Turkey was not ready for war. Turkey signed the convention of Ainali-Kavak, March 10, 1778, whereby the Russian partisan Shahin Gherai was recognized as the khan of Crimea, and the terms of the treaty of Kaynarji reaffirmed. Five years later Russia annexed Crimea and Kuban, and Turkey was forced to sign the convention of Constantinople on Jan. 8, 1784, the stipulations as to the independence of the Tatars in the treaties of Kaynarji and Ainali-Kavak being abrogated. Catherine II's triumphant entry into the Crimea and her interview with her ally the emperor Joseph II to discuss the partition of Turkey, together with the seditious Russian propaganda in Moldavia, Walachia and Morea created a war party in Constantinople which was sustained and encouraged by the British and Prussian ambassadors. War was declared. The Austrians joined the Russians but were driven back from Mehadia by the Turks, who overran the Banat (1789). The Russians captured Hotin and Jassy and Ochakov, all of whose inhabitants were massacred, including the women and children, by the order of Gen. Alexander Suvorov. The news affected Abd ul-Hamid I so deeply that he died.

Reform had become so urgent and inevitable that of the two young sultans who succeeded Abd ul-Hamid I, one gave up his life for it and the other had to carry out his designs for westernization by the most sanguinary measures. The ignorance, the despotism or the weakness of most of the sultans disorganized both the autonomous and the centrally governed provinces. Between the treaty of Karlowitz and the treaty of Kaynarji, the absence of discipline among the janissaries and their interference in the internal policy of the state upset the administrative machinery. The partially self-governed states of Barbary (Tripoli, Tunis, Algiers) had become almost independent, keeping only a nominal connection with the empire and choosing their own chiefs, called *dayi*. The Mamelukes who were allowed to stay in Egypt by Selim the Grim had become stronger and, with the help of the janissaries, were taking up a hostile attitude to the Porte. The pashas in Baghdad did the same. The recurrence of the Jelali insurrections brought forward headstrong governors who ruled the country like feudal lords. In European Turkey the locally elected notables, called *ayan*, interfered in the administration. This general disorganization had been partially remedied by the grand viziers belonging to the Kuprili family, but it continued worse than ever after them. The system of land tenure of the time of Suleiman was violated. The *khas, timar* and *ziamet* were seized by the central government, apportioned to the favourites of the sultans or the viziers and sometimes even sold to the highest bidder and to people who were not able to cultivate them or to perform the military duties of the former spahi fief holders. The number of the officials increased, and their short terms of office led to continual disorder.

During the "long war" of the time of Murad III the army increased disproportionately, but its individual units were no longer trained in the barracks and their military value was next to nothing. The sultans isolated themselves in their palaces and led lives of pleasure, thus losing contact with the army. They appointed incompetent commanders and executed them if they were defeated, which paralysed the initiative of those with a genuine ability to command. As the supply of provisions and ammunition was also in disorder, many deserted from hunger and lack of munitions. Although the army decreased in numbers after the treaties of Karlowitz and Passarowitz, the leaders of the janissaries would mark any man in the street as a regular soldier, register his name and put the pay in their own pockets, while the man himself went on with his own work. All attempts so far had failed to remedy these abuses. To make matters worse, the frequent change of sultans, often brought about by the janissaries themselves, meant accession presents which at times depleted the treasury. Then the treasury was refilled by debasing the coinage.

Science and industry which were far advanced at the time of Suleiman had taken no part in the progress of the 17th and 18th centuries but had remained hopelessly mediaeval. The official class was mostly illiterate, and the *kadis* who meted out justice were ignorant. The Turks refused to learn any European languages and knew very little of what was going on in the world. When necessity arose they used Christians and Jews as interpreters and became correspondingly dependent on them. Few books on philosophy, mathematics and history were printed in Ahmed III's reign. Only literature, especially poetry, flourished during this decadent age, and many of the great Turkish poets were of this time. Textile industries, being patronized by the sultans, also flourished. The manufacture of implements of war and ammunition continued, partly because of the artisans who inherited their craft and partly because of the experts who were brought from the west for the purpose.

Selim III (1789–1807).—Selim III, the son of Mustafa III, was the only Turkish prince of the last centuries who had not been caged, which gave him an opportunity of greater knowledge and a more normal view of the world. A passionate admirer of French culture, he wanted Turkey to be equal with the western powers in every branch of progress. It was in Selim's mind that the new Turkey originated, and with him the struggle for reform and progress began seriously, at the price of so many Turkish martyrs. He hoped to bring the war to a victorious end and so acquire the necessary prestige for his reforms. When the news of the Russian victory of Kalas reached Constantinople, he called a council, enumerated the causes of defeat and disaster and proposed internal reform as the only remedy. He insisted that the people should elect their own *kethudas* (mayors) and *ayans* (notables) without the interference of the governors, that an end should be put to the unlawful tribute which the *rayas* were made to pay, that the army and the administration should be organized on a western basis.

In the meantime one Austrian army defeated the Turks in Serbia and captured Belgrade, while another in conjunction with the Russian army captured Focşani. On Aug. 4, 1791, the new Holy Roman emperor, Leopold II, who was unfavourable to the Russian alliance, made a peace with Turkey at Sistova through the mediation of England, Prussia and Holland, by which Belgrade was restored to Turkey. But Russia, after defeating the Swedes, who were Turkey's allies with Prussia, was free to carry out its policy of extension in Turkey, and the war continued. It was about this time that William Pitt in England proposed the policy of preserving the integrity of the Turkish empire. It appeared first in the form of friendly advice to Russia to make peace with Turkey, which was rejected by Catherine II. Turkey, after several reverses on the field, made peace with Russia in 1792 at Jassy, the Dniester becoming the Turkish frontier in Europe.

Selim continued his reforms, especially in the army. He formed a new corps, but in order to disarm the jealousy of the janissaries he affiliated the new corps to them. Military schools were opened, the fleet reorganized, and instructors brought from Europe. But his progress was interrupted by the war with France (1798). Bonaparte attacked Egypt, more as a move against England than against Turkey, as his aim was to open a French route to India. Turkey fought against France in alliance with England and Russia. Napoleon was beaten in Syria, the French feet destroyed by Nelson at Aboukir, and the Ionian islands captured by the Turkish and Russian fleets. Peace was concluded with France in 1802. The reactionary governors whose interests were injured by the new reforms continued to cause disorder in every part of the empire. Pasvanoglu, the governor of Vidin, drove the peaceful *rayas* to revolt by his persecutions, and the insurgents chose Karageorge (George Petrovic) as leader and succeeded in taking Belgrade. An army was sent to punish Pasvanoglu, without result. The revolt of the Wahhabis in Nejd became another source of anxiety which continued till the time of Mahmud II. A marked renewal of trouble broke out with Russia over the principalities. Constantine Ypsilanti and Alexander Murusi, hospodars of Walachia and Moldavia, two instruments of Russia, had caused risings against the Porte which had led Turkey to dismiss them without the consent of Russia, thus violating the agreement of 1802. Russia and England protested, and the two were replaced. But, encouraged by the French ambassador, H. F. B. Sébastiani, Turkey declared war against Russia, although the British ambassador threatened to join Russia against Turkey (Nov. 6, 1806). The British fleet passed the straits, anchored off Constantinople and delivered an ultimatum, ordering Turkey to dismiss the French ambassador within 24 hours and to make peace with Russia. The Porte, encouraged by Sébastiani and by popular indignation at the presence of the ships, decided to resist. The entire population of Constantinople helped to range a thousand guns along both sides of the Bosporus in one day. The British fleet retired considerably damaged.

In the meantime the reforms and the progress of the new army were leading the janissaries and the corrupt officials to make desperate efforts in opposition, and they were supported by most of the reactionary governors. In 1807 the garrisons on the Black sea rose, under Kabakjioglu, and killed their officers and all those who were known to be reformists. The rebellion became general and the abolition of the new troops was demanded. The concessions made by the sultan in the hope of preventing further bloodshed only encouraged the rebels to make greater demands, and finally they dethroned him. Sébastiani is charged by the Turkish historians with inciting the janissaries.

Mustafa IV (1807–08).—Selim's successor Mustafa IV, son of Abd ul-Hamid I, abolished all the reforms, and anarchy continued during his reign of 14 months. In 1807, during the negotiations between Tsar Alexander I and Napoleon at Tilsit for the partition of Turkey, Napoleon undertook to mediate peace between Russia and Turkey if Alexander would withdraw his troops from Walachia and Moldavia. An armistice was signed in Aug. 1807, the Turkish army retiring to Adrianople. In the winter of 1807 a committee composed of the adherents of reform in Ruschuk (Russé), persuaded Bairaktar Pasha, who had distinguished himself in the Russian war, to march on Constantinople with an army of 20,000 Kirja-Ali troops with the object of reinstating Selim and his reforms. Selim was killed by the janissaries before Bairaktar's army could enter the palace (1808). His nephew, Mahmud, Mustafa IV's brother, a youth brought up in the tradition of reform, was saved by Jevri Kalfa, a woman in the palace who threw ashes in the eyes of the murderers and enabled the future sultan to escape by the roof. Mustafa IV was dethroned and Mahmud II, the last survivor of his line, ascended the throne.

Mahmud II (1808–39).—Mahmud II appointed Bairaktar grand vizier and issued a royal proclamation ordering him to treat the people and their *rayas* with justice and to re-establish order. As the Russian question was not settled and the principal governors were all trying to instigate revolts by declaring the reforms to be antireligious and thereby exciting fanatical resistance, Mahmud II based his arguments on religious grounds and demonstrated the necessity of education and reform in the name of Islam. Bairaktar Pasha called a council in Constantinople to which he invited notables and influential men from all over the country. The council decided that the new troops, under European instructors, were to be re-established under the name of *seymen-i-jedid;* that the janissary organization was to be retained but reformed, those only nominally on the register and receiving pay without serving to be dismissed; and that the authority of the sultan was to be permanent. The new grand vizier managed to restore comparative order and began his reforms seriously, but while the Kirja-Ali troops who were loyal to him were on their Bairam leave the janissaries attacked his home at night. He pretended to parley with them asking to have his womenfolk removed to a safe place, after which he promised to give himself up. But when the women had been removed he opened fire on the rebels from his windows and fought them to the last shot, after which he blew himself up in the powder magazine under his house. The janissaries, once more masters of the situation, resumed their massacres of the new troops and forced the sultan to cancel all the reforms.

The truce signed with Russia in 1807 had had no result,, and the war continued fitfully. France had encouraged the Porte to resume the Russian wars but the misfortunes of these wars aroused public opinion in Turkey against France and turned it in favour of England. On June 5, 1809, a treaty was signed in Chanak between England and Turkey, the British representative being Sir Robert Adair. A peace with Russia was also concluded on May 28, 1812, in Bucharest by the mediation of Stratford Canning, who later as Lord Stratford de Redcliffe, British ambassador, played a great part in Anglo-Turkish friendship. The treaty gave Hotin, Bender and Akkerman to Russia and confined the eastern frontiers of Turkey to the lines of the Prut river. The clause which restored Serbia to Turkish suzerainty was vague and gave rise to disputes. The Turkish army marched into Serbia and appointed one Milosh Obrenovich as the governor of his district; he, however, raised a successful revolt against Turkey and ruled Serbia in semi-independence. Karageorge, who had returned, was killed by him, and in 1817 he was designated hereditary prince of Serbia.

During the war with Persia, Russia had acquired the right from

Turkey to use temporarily the road from the Black sea to Tiflis by way of the valley of the Rion-Phasis. Russia desired to have this district ceded to it by a secret clause in the treaty of Bucharest, and the sultan had refused to ratify it. But within a few years Russia acquired the high land between the Caspian and the Black sea and the low lands along the coast between Xnapa and Poti, which were nominally under the suzerainty of the sultan.

Such was the situation when a European guarantee of integrity of Turkey was proposed at the congress of Vienna, in the belief that breakup of the Turkish empire would endanger the world's peace. It was decided, with the consent of the tsar Alexander, that England, France and Austria should trace clearly the frontiers of the Turkish empire, whose integrity the powers would undertake to guarantee. The Porte, deeming the proposal to be a humiliating foreign intervention, refused. The return of Napoleon threw the question into the background and the Turkish empire thus remained outside the European concert. This Eastern Question (*q.v.*) which occupied the political history of the 19th century can be summed up as the result of the conflict of the following desires: Russia's and Austria's desire to reach the Mediterranean; the British desire to prevent Turkey from obstructing the route to India and the desire of the non-Moslem Turkish subjects for independence, which was often concealed under the demands for reform.

Mohammed (Mehemet) Ali Pasha, the governor of Egypt, who had become known during the war with Napoleon, had proved his strength in 1811 by destroying the Mamelukes. His successful expedition against the Wahhabis in Hejaz had made him a popular hero as the saviour of the holy places. Another Ali Pasha of Janina (*see* ALI, called the Lion of Janina), originally from Tepeleni. nho kept order for a time in Greece and Albania, but who became rebellious, was slain in 1822.

The Greek Rising. — The Greeks found this an opportune moment to realize their ideal of national independence. Their hopes had begun at the time of Peter the Great and were considerably strengthened by the attitude of Catherine II (*see* GREEK INDEPENDENCE, WAR OF). Their secret revolutionary society, the Hetairia, was founded in Bucharest by the Greek poet and patriot, Constantine Rhigas; and, four years after his arrest and execution in 1798, it was revived in Odessa. The society passed into action with the help of Alexander Ypsilanti. son of hospodar Ypsilanti, a Greek who had become a general in the Russian army and used his forces to support insurgents in Moldavia in 1821. The emperor Alexander's aversion to supporting a revolutionary, even against the infidel Turks. together with the preference of the population of the Danubian principalities for the Turkish rule rather than that of the hated Phanariotes. considerably weakened the cause of the insurgents. This, the first serious rising was put down at the battle of Dragashani on June 19, 1821. The Greek rebels in Morea, however, had massacred almost to extermination the native Moslems and the sultan retaliated by executing the Greek patriarch in Constantinople on the charge of having instigated the slaughter. Russia, taking this up as an insult to the Orthodox Church, broke off relations with Turkey. The European powers used every effort to avert a Russo-Turkish conflict. Metternich hoped that with time and the moral and material assistance of European peoples the Greeks would of themselves achieve national independence. On March 2j, 1823, however, George Canning induced England to recognize the Greek insurgents as a belligerent party. The Russian emperor, jealous of this new influence in favour of the Orthodox Christians of the east, called as a counterpoise a conference in St. Petershurg in April 1824. Neither the Turks nor the Greeks would abide by its decisions and the sole outcome of the conference was an offer of the joint mediation of Austria and Russia, which the Porte refused. The sultan, finding himself unable to put down the Greek revolt, asked the aid of Mohammed Ali Pasha, the governor of Egypt, promising him the general governorships of Morea, Syria and Damascus in return. The well-disciplined Egyptian fleet and army approached the Morea under the command of Ibrahim Pasha, the son of Mohammed Ali. The Greeks were defeated in June 1827. Athens once more was in the hands of the Turks, and Ibrahim Pasha was sending crowds of Greeks as captives to Egypt and replacing them by the fellahin (Egyptian peasants). An isolated Russian intervention, for which Russia was concentrating in the south, was prevented by the death of the tsar Alexander in 1825. Canning persuaded the new tsar Nicholas I to call another conference in St. Petersburg on April 4, 1826, as a result of which England was empowered to offer Turkey a settlement of the Greek question based on the establishment of Greece as a vassal and tributary state. In case of refusal the two powers. whether separately or in common, would take the earliest opportunity of enforcing a settlement. Russia, meanwhile, issued a separate ultimatum to the Porte for the satisfaction of its other grievances. The Porte, though it resented new demands being made before the others were dealt with, was unable to resist and signed the convention of Akkerman accepting the Russian demands which were: the confirmation of the treaty of Bucharest; the opening of the navigation of the Black sea to Russian ships; seven years' term of office for the hospodars of Walachia and Moldavia, as well as the consent of the Russian ambassador in Constantinople before they could be dismissed and the recognition of the autonomy of Walachia and Moldavia, where no Moslem was to reside except in the fortresses.

Mahmud II, by a wholesale massacre on June 15, 1826, had crushed the janissaries, and the defense of the empire was now in the hands of the new army. Helmuth von Moltke was to be among the large number of French and Prussian instructors engaged for it. Mahmud also abolished what remained of the feudal system in the provinces. The taxes were to be gathered by the central government. The execution of individuals by the viziers without trial and the confiscation of the property of wealthy persons deceased, or of persons executed by the state, was forbidden by new regulations. Mahmud II himself discarded the turban and adopted the fez and European costume, and ordered all officials to do the same. The fez remained the official headgear of the Turks till the passing of the "hat law" by the Turkish republic in 1925.

The Greek question was still unsettled. In 1826, the Greeks formally asked for the mediation of England. Canning's objection to intervening unasked having thus been removed, he invited the co-operation of Russia in making representations to the Porte which should be based on the protocol of St. Petersburg and suggested measures of coercion in case of refusal; the tsar consented to this. The coercion was to take the form of a pacific blockade of Morea, so as to force Ibrahim Pasha to evacuate the country by cutting off his supplies. Austria and Prussia, in the conference of the five powers of the Grand Alliance in London in 1827, protested against coercion of the Porte for revolutionary purposes and withdrew. On the suggestion of France, however, the protocol was made into a treaty and, as the treaty of London, was signed by the three powers on July 6, 1827. By its public articles the powers agreed to secure the autonomy of Greece under the suzerainty of the sultan without any breach of friendly relations with Turkey. But by additional secret articles it was agreed that in the event of the Porte's not accepting the offered mediation, consuls should be established in Greece and an armistice proposed to both belligerents and enforced by the powers.

The armistice. accepted by the Greeks, was refused by Ibrahim Pasha, pending instructions from Constantinople, though he consented to keep his ships in the harbour of Navarino. In the meantime the Greeks destroyed a Turkish flotilla off Salona, and Ibrahim, taking this as a breach of the convention, set sail from Navarino northward. The Russian and French fleets joined the British fleet at Navarino and, on Oct. 20, attacked the Turkish and Egyptian fleets and destroyed them (*see* NAVARINO, BATTLE OF). Turkey broke off diplomatic relations with the three powers concerned. and the sultan issued a proclamation denouncing the cruelty and perfidy of the European powers and summoning the Moslems to a holy war. Canning had died and England had gone back to its policy of preserving Ottoman integrity, so the struggle that followed was restricted to Russia and Turkey. Russia declared war on Turkey April 26, 1828, England disapproving and France agreeing. Although Turkey was in the midst of confusion because of the destruction of the janissaries and the new army

PHOTOGRAPHS (TOP, BOTTOM LEFT) CLAUDE JACOBY FROM PIX, (CENTRE LEFT) PHILIP D. GENDREAU, (CENTRE) CHRIS WARE FROM F.P.G., (CENTRE RIGHT) EUROPEAN (BOTTOM RIGHT) RALPH MANDOL FROM F.P.G.

VIEWS OF TURKEY

Top: Partial view of Istanbul, showing the Galata bridge leading across the Golden Horn to the old city

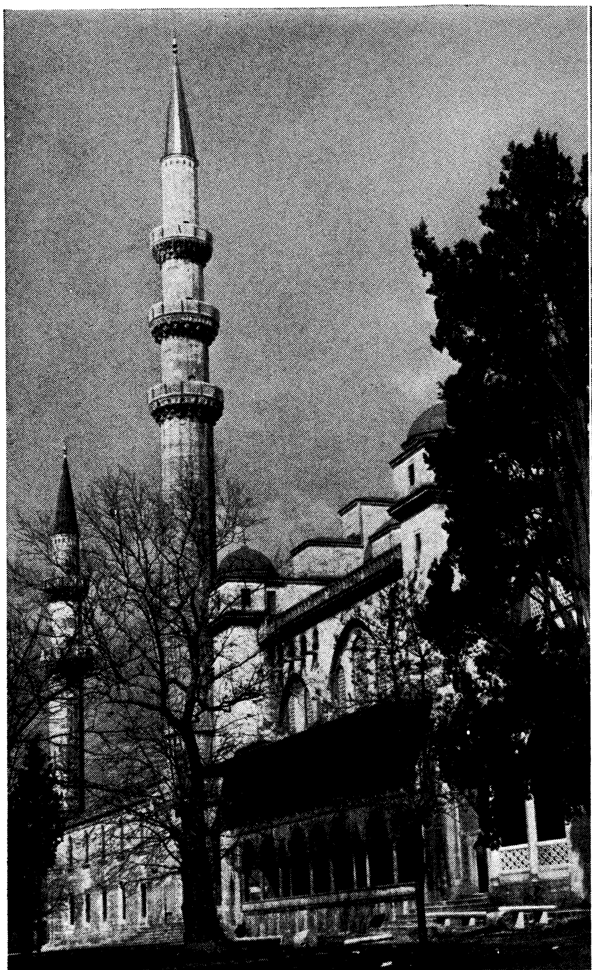
Centre left: Kurdish woman of southeastern Turkey

Centre: Vegetable seller in the streets of Ankara, capital of Turkey

Centre right: Woman weaving rugs in the town of Isparta

Bottom left: The church of St. Sophia, founded in A.D. 532 under the emperor Justinian the Great

Bottom right: Monument in Istanbul to Mustafa Kemal Ataturk, Turkish soldier and statesman



PHOTOGRAPHS, (TOP LEFT) RALPH MANDOL FROM F.P.G., (TOP RIGHT) EUROPEAN, (CENTRE RIGHT) PHILIP D. GENDREAU, (BOTTOM) CLAUDE JACOBY FROM PIX

SCENES IN TURKEY

Top left: The "Blue mosque" of Sultan Ahmed I, 17th century, in Istanbul
Top *right:* Modern hotel overlooking the Bosporus in Istanbul
Centre right: Camel and mule train in southern Turkey
Bottom: Dolma Bahce palace, located on the Bosporus, the president's official residence while in Istanbul

was small and hardly formed, the resisting power of the Turks was raised to its utmost by the attitude of the powers. Russia had to fight two very hard and difficult campaigns before Gen. H. von Diebitsch could dictate terms of peace at Adrianople (Sept. 14, 1829). A protocol at London on March 22 had proposed boundaries for an autonomous Greece. The treaty of Adrianople between Turkey and Russia provided that the Danubian principalities were to become practically independent; that the districts of Anapa and Poti were to be ceded to Russia; and the Greek question was to be settled according to the terms of the protocol of March 22. But in order that Russia should not enjoy the prestige of having emancipated Greece unaided, the other powers decided to give further concessions to Greece, and this was expanded into the treaty of London of May 7, 1832, by which Greece became an independent kingdom under the Bavarian prince Otto (see RUSSO-TURKISH WARS; GREECE: History).

The Egyptian Revolt.—Turkey suffered a series of serious internal revolts after the reverses had reduced her prestige. Bosnia and Albania revolted. In 1830 the French occupied Algiers. Mohammed Ali Pasha, the governor of Egypt, was found to have intrigued in the revolt of Albania and in Damascus. He was recalled and replied by open revolt, sending his army under his son Ibrahim Pasha to invade Syria. Mohammed Ali Pasha's hope was to seize the sultanate and to start a new dynasty—a hope which seemed feasible when, after capturing Damascus and Aleppo and defeating the Turkish army in Konya, Ibrahim invaded Kutahia. As France was supporting Egypt, Turkey endeavoured to draw England into an alliance against Egypt. Palmerston refused in spite of the efforts of Stratford Canning, and Mahmud II in desperation asked for help from Russia. The treaty of Unkiar Skelessi (Hunkiar Iskelesi) was signed July 8, 1833, and the Russian army came to the Bosporus to help the Turks against the Egyptian army which was now threatening to march on the capital. England and France, suspicious of Russia, now mediated. They forced Mohammed Ali to stop the march of the Egyptian army and made the sultan accord the hereditary governorships of Adana, Crete. Tripoli and Damascus to him. This put a temporary end to the war. The treaty of Unkiar Skelessi had included clauses which permitted: (1) Russian warships to pass through the straits and to land troops if necessary and (2) the closing of the straits to warships of all the other powers. These clauses seemed to place Turkey in the power of Russia. After securing peace under these humiliating conditions Mahmud once more began to prepare his army while Mohammed Ali increased his with recruits from the provinces which had been given him. In 1839 Mahmud sent a Turkish army against the Egyptians in Syria but was badly beaten by the forces of Ibrahim Pasha at Nezib in the north of Syria. Mahmud died in Constantinople while the battle was actually in progress (July 1, 1839).

Internal Affairs.—Mahmud II's reign opened seriously the period of westernization in Turkey. In addition to the army reforms already mentioned. medical schools were opened by experts from Europe, and the civil service was organized on a modern basis. A number of students were sent to Europe for the first time, a newspaper and the first official printing press were established. The ministry of foreign affairs and the ministry of the interior were organized as well as the ministry of public works and the supreme council of legal affairs. The naval and military schools and the school of engineering founded by Selim III were reorganized, and in 1838 a council of public instruction was formed. The basis of compulsory elementary education was laid down by a royal proclamation which forbade children who had had no elementary education to take up any craft. And the pious foundations (evkaf) were unified and organized into a ministry.

Abd ul-Mejid I (1839–61).—Abd ul-Mejid succeeded his father at the age of 16 when Mohammed Ali Pasha of Egypt seemed on the verge of seizing Turkey and the empire seemed about to dissolve into its elements. The army, the government and the sultan were helpless and the Turkish fleet was handed over to Mohammed Ali Pasha by the treachery of Adm. Ahmed Pasha. But to prevent Russia from using the treaty of Cnkiar Skelessi for its own purposes the great powers decided to intervene in the Turko-Egyptian conflict and called a conference in London. France, who had supported Mohammed Ali Pasha, took no part in the final settlement. but Russia for the purpose of breaking the entente between England and France waived its claims under the treaty of Unkiar Skelessi and joined the concert. By the protocol de *clôture*, which was signed on July 15, 1840, the governorship of Egypt became hereditary in Mohammed Ali's family without undermining the sovereign rights of Turkey; Egyptian claims to Crete, Syria and the Holy Cities were abandoned. A year later, on July 15, 1841, five powers signed the protocol des *détroits*, by which the sultan was to close the straits to warships of all the powers.

The schemes for reform which Selim III and Mahmud II had only been able partially to realize were to be more fully worked out under Abd ul-Mejid I. Mustafa Reshid, the Turkish foreign minister and ambassador to London, returned. He was the greatest statesman and westemizer of the reform period, and he personally prepared a tanzimat or vast plan of reforms and made the sultan sign and issue it under the name of *Gulhane-hatti-humayouni* (royal decree of Gulhane). From this decree dates the fundamental change of Turkey from the old system based on nomadic principles to that of a modern state. Like the preceding decrees, in order that it might disarm fanatical opinion, it also emphasized that all progress was in accordance with Islam. It undertook to issue laws conforming with the age; to establish security of life, property and honour (no one was to be punished without trial); to remodel every branch of the administration and to accord perfect equality to all Ottoman subjects of whatever race or creed. This meant a great difference for the Christians. Though they had religious and communal freedom by the firman of the conqueror, the political complications caused by the separatist tendencies and the massacre of the Moslems in Morea by the Greeks had aroused intense hatred and made their position difficult and even dangerous. The attempt of the *tanzimat* to establish them as equal citizens helped to unite them with the ruling race and before long the Christians shared all the offices in the administration, even up to the rank of cabinet minister. Mustafa Reshid with a few convinced and westernized men around him made gigantic efforts to enforce the new principles in every department. The announcement of reforms, however, regularly ran far ahead of their performance.

Mahmud's military organization was extended by engaging more foreign instructors and opening more military schools. The most important change was the recruiting law, which reduced military service, hitherto for an indefinite time, to a limited period. The Christians were exempted from military service upon payment of a special tax. A body of gendarmerie was instituted.

In addition to the only existing educational institutions, that of the ulema and the schools maintained by private donations, with studies based on the Koran, the council of education founded and multiplied both primary and secondary state schools, and tried to unify and centralize education by sending superintendents to the provinces to carry out the state system. Commercial courts were opened. As the civil and penal cases were sent to the Sheria courts, a school for judges was opened and attached to the office of the sheikh ul-Islam.

Permanent ambassadors were appointed from among the best statesmen and sent to European capitals; this helped to create friendly relationships with the western powers. The promise of the reforms, which without resorting to terrorist methods appeared to be forming a centralized and efficient government, naturally aroused great sympathy for Turkey and hope for its future. The only international controversy arose when in 1848–49 Turkey, true to its traditions, refused to give up the Polish and Hungarian refugees. Turkey had England's support in this act. The difference with Persia over the frontier question was settled for the time being by the treaty of Erzurum (1848) by English and Russian mediation.

The Holy Places and the Crimean War.—The possibility of a strong and reformed Turkey made Russia uneasy. Since the time of Peter the Great and Catherine II it had considered itself the rightful heir to most of the lands of the declining Turkish state. Nicholas I, who went to London in 1844, proposed to England the partition of Turkey, which he called a "sick man." England was to receive Crete and Egypt, Constantinople was to be a free city, and the Balkan states were to be autonomous under Russia. Suspicious of the Russian designs, England refused to solve the Eastern Question by so drastic a measure. But the question came up again in 1850 through a quarrel between the Catholic and Orthodox monks about the Holy Places in Palestine.

The capitulations signed on May 28, 1740, by Mahmud I, according certain rights to the Roman Catholic (Latin) ecclesiastics in the Holy Places, had placed the French pilgrims, together with the pilgrims of the other Catholic nations, under the protection of the French flag. This stipulation of the treaty had fallen into desuetude during the French Revolution. In the meantime every advance of Russia had been marked by encroachments of the Orthodox Church on the Roman Catholic Church. The quarrels of the monks of the two churches would have passed unnoticed if Louis Napoleon had not in 1850 seized the opportunity to win over to his side the clericals in France: the French ambassador handed to the Porte a formal demand for the restitution to the Catholics of all their rights. The Ottoman government proposed a mixed commission of inquiry. and France agreed with the condition that no documents later than 1740 should be admitted as evidence. As this suggestion excluded the treaty of Kaynarji, the tsar demanded that nothing should be altered in the status quo. This was a contest between Russia and France for paramount influence in the east: England was inevitably involved and took the side of France and Turkey. The Porte arrived at a compromise in March 1852 by issuing a firman which accorded privileges to both sides, taking on itself the right of "protection." Neither France nor Russia accepted this as neither desired a settlement. Louis Napoleon, who became emperor as Napoleon III in Nov. 1852 and whose new title had been recognized only equivocally by the tsar, wanted a war for dynastic reasons, and the tsar thought the moment opportune to drive out the infidel from Europe. The tsar renewed the proposals of partition made in 1844.

In 1853 Prince Alexander Sergeievich Menshikov was sent to present the Russian ultimatum to Constantinople. He demanded the recognition of the status quo in the matter of the Holy Places end of the tsar's right under the treaty of Kaynarji to protect the Orthodox subjects. The Porte turned for advice to Lord Stratford de Redcliffe, the British ambassador, who was both popular and influeritial. He grasped the situation at once and persuaded Menshikov to present the two demands separately. On April 22, the question of the Holy Places was settled by the British, Russian and French ambassadors. Then when the question of the Russian protectorate over the Christians was raised, Menshikov found himself opposed by the ambassadors of the other powers. Menshikov demanded that the Porte should give a note reaffirming the Russian rights, and this the Turkish cabinet seemed inclined to accept. But that cabinet fell; Mustafa Reshid came into power and, advised by Lord Stratford de Redcliffe, refused the Russian demand. Menshikov left Constantinople on May 22. On June 22 the Russian army under Prince Mikhail Dmitrievich Gorchakov entered the Danubian principalities. It was explained, however, by a circular that this was not with the purpose of attacking Turkey but in order to obtain material guarantees for the enforcement of the existing treaties. In August a conference of the four powers assembled in Vienna, but the settlement proposed conceded everything to Russia except the protectorate, and the Porte would not agree to it. In October Turkey presented an ultimatum to Russia demanding the evacuation of the principalities, and the French and English fleets passed the Dardanelles. Lord Aberdeen, hoping to keep peace, informed Russia that as long as it abstained from crossing the Danube or attacking a Black sea port there would be no *casus belli*. But Russia bornbarded Sinop on the Black sea coast and destroyed a Turkish squadron (Nov. 30), and the French and English fleets entered the Black sea and demanded that the Russian fleet should retire.

The conflict at Sinop had been more like a slaughter than a battle, and the excellent behaviour and initial successes of the Turkish land forces aroused sympathy and admiration throughout Europe. The belief in the rejuvenation of Turkey seemed justified. On March 27, 1854, Great Britain and France declared war on Russia, with the strong support of public opinion; they were later joined by Sardinia. Austria put pressure on Russia to withdraw from the Danubian principalities and occupied them itself in agreement with Turkey. (See EASTERN QUESTION.)

The main operations of the Crimean War (*q.v.*) were confined to the Crimea. The allied troops landed on Sept. 14, 1854, and the campaign lasted till Dec. 1855, when the threatened intervention of Austria forced Russia to accept terms which were ultimately embodied in the treaty of Paris (March 30, 1856). Russia abandoned its pretensions to protect the Christians in Turkey and renounced her right of exclusive interference in the Danubian principalities, to which a fragment of Bessarabia was restored; the navigation of the Danube became free under the supervision of an international commission; the Black sea was to be open to commercial ships of all countries and closed to all warships except a limited number of small warships belonging to Turkey and Russia; Turkey was admitted to the European concert and the contracting parties were to respect its independence and the integrity of its territory; the tanzimat was reaffirmed and enlarged by a decree of the sultan called the *Hatt-i* Humayun, which was included in the treaty under insistence from the powers.

The new era following the Paris conference opened with several outbursts against the reforms. It is noteworthy that the Christians, even the clerical class, were opposed, either for fanatical reasons or at the instigation of Russia, which did not want Turkey to be strengthened. In 1859 the Danubian principalities, encouraged by France and Russia, united and, choosing Alexander John Cuza as their ruler, formed the principality of Rumania. (See RUMANIA.) In 1860 a disturbance in Lebanon involving the Druses and the Christians led to a French occupation, which Fuad Pasha, seconded by Ahmed Vefik Effendi, the Turkish ambassador in Paris, contrived to restrict and to terminate as soon as possible. A *réglement* was signed in Constantinople on June g, 1861, instituting an autonomy for Lebanon under a Christian governor to be chosen by the powers with the consent of the Porte. This agreement lasted till World War I.

Toward the end of Abd ul-Mejid's reign a secret committee was formed in Constantinople to propagate the idea of a constitutional regime for Turkey.

Abd ul-Aziz (1861–76).—Abd ul-Aziz became sultan on his brother Abd ul-Mejid's death in 1861 and reaffirmed by decree the principles of the *tanzimat*. Pan-Slavism, which had its centre in the University of Moscow, began to penetrate Montenegro and Hercegovina, which rose in revolt. These revolts were put down but the Serbs also revolted, demanding the expulsion of the Moslems who lived in the fortresses. In 1862 this revolt was pacified by ceding a few more fortresses to the Serbs; and five years later, through the mediation of England and Holland, the Turkish troops were withdrawn altogether. The Cretans, aided by Greece, revolted and declared their union with Greece. Thereupon Ali Pasha, the grand vizier, went to Crete with an army and quelled the revolt; the episode led to a diplomatic rupture with Greece and in 1869 a conference of ambassadors in Paris accorded local autonomy to Crete under Christian governors. Meanwhile, Ismail Pasha, who became governor of Egypt in 1863 and was a man given to unrestrained expenditure, had obtained loans from France and England, bribed a large number of influential men in the Porte and made the sultan agree to the establishment in Egypt of a succession from father to son, which he did by issuing the firman of May 27, 1866, and June 8, 1867, the latter according to the governor of Egypt the title of khedive. Abd ul-Aziz yielded so easily because he was desirous of bringing about the same alteration in the succession in Turkey in favour of his eldest son. Also, the introduction of a regular budget system for the first time revealed the deplorable state of the treasury. New loans, internal and external, had to be raised in order to pay the interest on the old debts.

The regime of Midhat Pasha, the father of the Turkish constitution, as the governor of Nish, was so popular with all races and creeds that his methods were introduced into other Rumelian vilayets. The people elected their provincial councils, and criminal and civil courts were first opened in those provinces. On March 10, 1870, a firman instituted the Bulgarian exarchate, thus severing the Bulgarian Church from the jurisdiction of the Greek patriarch of Constantinople. In 1871, Russia. taking advantage of the weakened state of France, declared itself no longer bound by the treaty of Paris, which had restricted the number of Russia's warships on the Black sea. An international conference which met in London in 1871 recognized this by abrogating the restrictions on both Russia and Turkey. The passage of the straits remained interdicted to warships.

A law promulgated on June 18, 1867, for the first time allowed foreigners to hold landed property throughout the empire except in Hejaz on condition of their being divested of their right to the protection of their own authorities concerning such property. The grand vizier, Ali Pasha, also made the first amendment to the capitulations by inducing the powers to accept Turkish jurisdiction over small cases for their subjects who lived at a distance from consular towns. In 1866 a Bulgarian insurrection, instigated by Russia, broke out in Trnovo on the pretext that the reforms promised by the firman quoted in the treaty of Paris had not been carried out. Although Midhat Pasha pacified the rising, its real motive, which was nothing less than a desire for national independence, remained unaltered. After the death of such able statesmen as Ali Pasha and Fuad Pasha, Abd ul-Aziz became despotic and began to exile people without trial. The palace expenses increased and financial conditions became worse. The world-wide depression which began in 1873 ended the process of borrowing to cover extravagance and meet deficits. Recourse was had to increased pressure for taxes, which were still payable in kind. Mahmud Nedim Pasha was obliged to declare that the government could pay only a 50% annuity on its debts; whereupon Europe considered Turkey bankrupt, and the state began to lose the prestige gained after the reforms. The agrarian conflict between the Moslem landowners and the Christian peasantry in Hercegovina now spread to the Serbs and Bulgars. A revolt of the latter people was punished with traditional Turkish severity. The Bulgarian atrocities committed by the Turks in the summer of 1876 turned public opinion in the west against Turkey still more.

A secret revolutionary society, formed at the time of Ali Pasha and called the Young Ottomans, was spreading its ideas and influencing public opinion. The great Turkish poet and patriot Namik Kemal Bey and another poet and satirist, Zia Pasha, fled to Paris and published pamphlets inciting the people to demand a constitutional government and succeeded in smuggling them into every part of Turkey. Midhat Pasha, who shared the opinions of the Young Ottomans, succeeded in winning over other members of the cabinet for constitutional change and obtained a *fetva* for the deposition of Abd ul-Aziz, who was accordingly dethroned on May 30, 1876, with the purpose of establishing a constitutional regime. A few days after his deposition he' committed suicide. His nephew Murad V, Abd ul-Mejid's son, who ascended the throne, became insane after reigning three months and was deposed. Murad's brother Abd ul-Hamid, believed to be liberal, but actually reactionary, was placed upon the throne (Aug. 31).

Abd ul-Hamid II (1876–1909).—In the autumn of 1876 Russia made preparations looking toward war with Turkey. With the hope of settling peacefully the Bosnian, Serbian and Bulgarian questions, the British government of Disraeli took the initiative in calling a conference at Constantinople. After assembling on Dee. 12, the conference appeared to be making progress, proposing that the Bosnian and Bulgarian areas should be given substantial autonomy under a governor-general named by the sultan and approved by the powers. But on Dec. 23 the sultan proclaimed a constitution, mainly modelled on the French system, which had been prepared by Midhat Pasha. The defeated conference dragged on for four weeks and then disbanded. Two weeks later, on Feb. 5, 1877, the sultan dismissed and banished Midhat Pasha. Russia in exasperation declared war on Turkey on April 24. The Rumanians joined Russia and Austria declared its neutrality. Public opinion in Europe was anti-Turkish, especially in England, because of the financial repudiation and the sanguinary repression of the Bulgarian revolt, and not a single voice was raised in favour of Turkey. The Turks were defeated both in Europe and in Anatolia (*see* RUSSO-TURKISH WARS), and the Russian army reached Adrianople where both a truce and the preliminaries of peace were signed on Jan. 31, 1878. A treaty was concluded in San Stefano on March 3, 1878. Rumania and Serbia were to become independent, while Bulgaria was to become a vast principality, its frontiers reaching both to the Mediterranean and the Black sea. The provinces of Kars, Ardahan and Bayazid were to be given to Russia as a war indemnity. England objected to the treaty as violating the terms of the international treaty signed in Paris and proposed a new congress. At first only Germany, France and Italy agreed, but when Austria, which was in a position to endanger the retreat of the Russian army, came in, Russia was obliged to do likewise. Turkey contracted a defensive alliance with England on June 4, 1878 at the price of leasing to that country the island of Cyprus.

On July 13, 1878, the congress of Berlin (*q.v.*) ended the Russo-Turkish conflict. It modified the treaty of San Stefano; recognized the independence of Rumania, Serbia and Montenegro; reduced the frontiers given by the treaty of San Stefano to Bulgaria and further divided the territory into two parts, one of which became a self-governing Turkish province named Eastern Rumelia. Turkey had the sanjak of Bayazid in Anatolia restored but was to pay an indemnity of 300,000,000 roubles to Russia. The most important clause of the treaty was the formal engagement of Turkey to introduce reforms in the Rumelian provinces as well as in the eastern provinces which had Armenian minorities.

Abd ul-Hamid II, who immediately after the congress engaged a number of European experts on the pretext of reorganization and reform, before long dismissed them. Apart from the occupation of Egypt by England (1881), (*see* EGYPT), the chief interest of Turkish history now lies in the steps by which Abd ul-Hamid secured his predominance. The power of the Porte was slowly transferred to the palace through the machinations of Said Pasha, the first secretary of Abd ul-Hamid, who before long was an absolute monarch. Midhat Pasha, the veteran reformer, was lured back by a free pardon and appointed governor of Smyrna. Before long he was arrested, charged with the death of Abd ul-Aziz, condemned, reprieved, exiled and finally executed in prison. Since the finances had become worse after the war and the payment of debts was falling into arrears, Said Pasha, now grand vizier, founded the Ottoman Public Debt administration which gave the control of the payment of debts to European delegates. By the decree of Muharrem, Dec. 1881, several categories of Turkish revenue were assigned to this administration, which exercised a weighty influence in Turkish finance until 1914.

In 1885 a rising took place in the province of Eastern Rumelia, which was united to Bulgaria. Turkey appointed Prince Alexander of Battenberg (the prince of Bulgaria) governor of Eastern Rumelia, a diplomatic way of accepting the annexation. Revolts in Crete had been in progress since 1890, and Greece hoped to annex the island. The series of independent non-Moslem governments which had been founded in succession within the empire raised the hopes of all the other national minorities. The Armenians in the eastern vilayets, who enjoyed freedom of education in their schools, succeeded in permeating all the Armenian communities with the desire for national independence. Two revolutionary Armenian committees, called Hinchak and Dashnaktsutiun, who were in close touch with European centres, were formed. Abd ul-Hamid's foolish patronage of the Kurdish communities encouraged them to persecute the Armenians. This, as well as the severity with which the taxes were collected, gave the Armenians two pretexts to rise in revolt in 1894. These revolts were repressed with such sanguinary measures that England and France prepared a program of reforms for the eastern vilayets and forced Turkey to accept it. No effect was given to the Turkish promises, and in 1896, when Lord Salisbury tried to enforce reform on those vilayets, the other powers would not agree to the coercion of Turkey. The Armenian revolutionaries in despair adopted a form of revolt which would force the attention of European political circles: they seized the Ottoman bank, a European institution in Istanbul. The repression was once more sanguinary.

On the ground that Greece had inspired the revolts in Crete, the

Porte declared war on April 17, 1897, and the Turkish army, after inflicting a severe defeat on the Greeks, marched on Domokos. The powers, becoming anxious, intervened and ended the war. A peace was concluded which involved a slight rectification of the frontier and the payment of an indemnity of £T4,000,000 by Greece. Crete was put under international control, en *dépôt,* and much of the capitulations which benefited Greek citizens was cancelled. In 1898 Prince George, the son of the king of Greece, was appointed governor of Crete and a national assembly called. The refusal of Austria and Germany to take part in the anti-Turkish settlement of the Cretan question emphasized a new attitude of Germany toward Turkey. As a result of its apparent pro-Turkish policy Germany obtained a concession to construct the Anatolian railway and in 1899 the Baghdad line. Abd ul-Hamid's preference for Germany was partly because of the friendly attitude of the German kaiser and partly because he feared the liberal influence which France and England would have over the intellectuals in Turkey.

During the latter part of Abd ul-Hamid's reign the Macedonian question became most important. The independent Balkan states carried on anti-Turkish propaganda among their own races in the Turkish Balkans and it is through this movement that the *comita*djis appeared in the Balkans. *Comitadjis* were armed bands of political partisans, such as have at various times worked in the Balkan peninsula. Their activities caused risings and slaughter, which were avenged by equal if not greater ferocity, thus adding to Turkish ill-repute in Europe. In 1903 after the Bulgarian insurrection in Macedonia, Turkey accepted the Miirzsteg program, which was prepared by Austria and Russia: the three vilayets of Salonika, Monastir and Uskub (Skoplje) were placed under a Turkish inspector general (Husein Hilmi Pasha) who in turn was under the supervision of Russian and Austrian civil agents. The gendarmerie was given an Italian commander, and French, English, Austrian, Russian and Italian instructors. In spite of these reforms Macedonia could not be pacified and the work of the comitadjis went on.

Rise of *the* Young Turks.—The Young Turks were the successors of the Young Ottomans, who after the closing of the first parliament had worked in secret for the restoration of the constitution by means of publications and secret societies both in Europe and in Turkey, mostly among the students in the military and medical schools. From 1882 onward Abd ul-Hamid had put the press under a strict censorship and by an elaborate network of spies had abolished freedom of speech. The obscurantist educational system was preventing the spread of modern ideas, the Christian schools alone not being affected by this system. Under these conditions Talaat Bey, a chief clerk of the Salonika post office and a student of law, and Rahmi Bey, a local notable, together with a few others, had formed the Secret Society of Union and Progress on the model of the Freemason lodges, to restore the constitution. The Turkish revolutionary societies in Europe were affiliated to the Salonika society through their leader Nazim. Then, provoked by reports that Edward VII of England and Nicholas II of Russia had planned the partition of Turkey at their meeting in Reval in June 1908, the officers of Macedonia such as Niazi, Enver, Mustafa Remal and Jemal Bey joined the society, bringing to it the command of an active force in the Macedonian army. In July 1908, Maj. Niazi first led an armed rising in Resna and the other conspirators followed. The revolt shot through the cities of the empire, and Abd ul-Hamid was informed that he had no alternative but to restore the constitution, which he did on July 24. This bloodless revolution aroused enthusiasm even among the Serbian, Bulgarian and Greek *comitadjis* and among the Armenian revolutionaries. Representatives of nearly all these came to Salonika and joined the Union and Progress, which ceased to be secret after the proclamation of the constitution. It seemed for the minute as though all the different racial elements of the empire would really unite in a constitutional Turkey. But the separatist and nationalist ideals of the different races were too deeply rooted to be swept away by momentary enthusiasms. The restoration of the constitutional regime postponed the Reval program. But both Austria, which thought Turkey an obstacle to its expansion toward the Aegean sea, and Russia, which found a strong Turkey a hindrance to its plans of expansion, felt uneasy. On Sept. 15, 1908, the Austrian and Russian foreign ministers A. L. von Aehrenthal and A. P. Izvolsky (*qq.v.*) met at Buchlau and agreed on a partition program by which the straits were to be in the Russian zone and Bulgaria a Russian sphere of influence; Macedonia was to be in an Austrian zone and Serbia an Austrian sphere of influence; Albania was to be in an Italian zone and Greece an Italian sphere of influence. Three weeks after this meeting Austria annexed Bosnia and Hercegovina (Oct. 5, 1908), and Bulgaria declared its complete independence. Turkey recognized the Bosnian annexation, for which Austria paid £2,200,000 and evacuated the sanjak of Novi Pazar. For Turkey's recognition of Bulgarian independence, Russia cancelled £5,000,000 of the Turkish indemnity of 1878, expecting to recover the greater part from Bulgaria. Before long these foreign blows were followed by the recrudescence of internal conflicts. The Albanians revolted against the new regime in Macedonia, and the Kurds attacked the Turks, the Armenians and the Nestorians in eastern Anatolia. In Adana the reactionaries attacked the Armenians, and Yemen rose in revolt. Izzet Pasha was sent to pacify the Yemen which he was able eventually to do by a friendly agreement with the imam Yahya (1912). The reactionary opposition in the capital incited fanatical opinion against the new regime. Finally the movement passed into a military revolt on April 13, 1909. Some officers and adherents of the new regime were massacred, and parliament was raided. Abd ul-Hamid pardoned the leaders of the revolt and formed a new cabinet. In reply an army under Mahmud Skevket, sent by the Young Turks from Salonika, marched on the capital and punished the insurgents. The evident desire of Abd ul-Hamid to restore absolutism led parliament to procure his dethronement by a fetva. His brother Mohammed V took his place.

Abd ul-Hamid had tried to revive the political influence of the caliphate in the hope of retaining the non-Turkish Moslem elements of the empire. This Pan-Islamic deal was favoured by the German emperor William II who, during his visit to Jerusalem in 1898, spoke of himself as the friend of the "caliph of three hundred million Moslems." Abd ul-Hamid constructed the Hejaz railway to further the same ideal.

Mohammed V (1909–IS).—Now that the government of the Young Turks was firmly established, the Committee of Union and Progress became a political party and efforts were made to stop the interference of the army in internal politics. In spite of the great losses of territory the empire over which the Young Turkish party was to rule extended from the Adriatic to the Indian ocean and from Mt. Ararat to Tunis. Thirty-three years of mismanagement under the despotic reign of Abd ul-Hamid had reduced Turkey to such a state that in any case a new government had a difficult task; and although the Young Turks were full of patriotic zeal and well versed in western culture, they had had no experience in governing. The army was put under intensive German instruction, the navy was put under instructors led by Adm. Sir Douglas Gambles. A French expert, Charles Laurent, was engaged for the financial department, though it was Javid Bey, the minister of finance, who first succeeded in establishing a finance department on European lines. A great change took place in public works through the concessions given to European companies, which brought foreign capital into the country. In every branch a serious and fruitful activity began.

The evacuation of Crete in 1909 by the four controlling powers led to an acute difference between Turkey and Greece. In 1910 the Cretans elected deputies to the Greek parliament in Athens, but Eleftherios Venizelos refused to admit them, an act which prevented war.

The Italian and Balkan Wars.—The Italo-Turkish War (*q.v.*) began in 1911. Italy, having been assured of the neutrality of the powers, gave the Porte an ultimatum of 24 hours on Sept. 28. On its rejection the Italian navy bombarded Preveza, and Italian troops landed at Tripoli and in Cyrenaica. Without a strong navy Turkey was unable to defend Tripoli, but Enver and Fethi Beys organized a defense by the natives, who were thoroughly roused and the invaders were confined to the coast. Rhodes and the Dodecanese were occupied in May 1912. The outbreak of the First Balkan War forced Turkey to make peace at Ouchy on Oct. 15, 1912. Tripoli and Cyrenaica were left to Italy, but the sultan was permitted to send a representative, called *naib-i-sultan.* The fate of the Dodecanese islands was not to be decided until the Lausanne conference of 1922–23.

In Aug. 1912, a faction in the army, opposed to the Union and Progress party, had brought about a change of government, and the cabinet formed was composed mostly of the members of the old regime, including Kiamil Pasha, the well-known Hamidian grand vizier. Russia offered to help Turkey in case of an attack on the Dardanelles on the condition that the Russian fleet be allowed to pass the straits. The Porte refused.

To stamp out the *comitadjis,* Turkey had embarked on an attempt to disarm the people in the Balkans. Greece, Serbia, Montenegro and Bulgaria in reply reconciled their conflicting interests in the Balkans and formed an alliance against Turkey (March–Oct. 1912). Turkey was unaware of this alliance for a long time, but on Oct. 8, 1912, Montenegro declared war on Turkey; and on Oct. 14, Greece, Serbia and Bulgaria issued ultimatums demanding reforms and the demobilization of the Turkish army in the Balkans. Turkey declared war on Serbia and Bulgaria on Oct. 17, and Greece declared war on Turkey the next day. The political dissensions which affected the command and the organization of the army proved disastrous to Turkey, and the army was defeated, though it made a fine and prolonged defense of Scutari (in Albania), Janina and Adrianople. Adrianople was still in the hands of the Turks when the advance of the Bulgarian army was stopped at the last defenses of Constantinople, the Chatalja lines. The Turkish cruiser "Hamidie," under the command of Rauf Bey, escaped through the lines of the Greek fleet at the straits and wandered in the Adriatic, Aegean and Mediterranean, bombarding enemy ports, hampering their transports and raising Turkish morale. At the beginning of the war the powers had declared that whatever the military results of the war might be the territorial *status* quo would be maintained in the Balkans. Turkey hoped that this declaration would apply as much in the event of Turkish defeat as of Turkish victory. The powers called a conference in London after the Turkish defeat. But since the status quo was clearly going to be changed in favour of the Balkan states, in spite of the declaration of the powers, and since Kiamil Pasha's government was about to cede Adrianople even before that city had fallen, the Young Turks determined to seize power again. They raided the Sublime Porte and forced Kiamil to resign. A Young Turkish cabinet was formed under Mahmud Shevket. Although at first the new cabinet refused the terms of peace of the London conference, the intervention of Russia and Austria and the fall of Adrianople enforced their acceptance by treaty at London on May 30, 1913. This brought the Turkish frontiers in Europe to the line Midia-Enos.

A month later the Second Balkan War broke out, with Greece and Serbia fighting Bulgaria over the division of territory. The Rumanians, with the purpose of annexing the Dobruja, also marched on Bulgaria. This moment was seized as opportune by the Turkish army to march on Adrianople, which was recaptured. A treaty of peace was signed with Bulgaria in Constantinople on Sept. 29, by which Adrianople passed to Turkey. On Nov. 13 peace was concluded with Greece, by which it was given Crete and the rest of the Aegean islands except Tenedos and Imbros and the Dodecanese islands, the latter of which were still under Italian occupation. On March 14, 1914, peace was signed with Serbia. The net result of the series of treaties contracted with the Balkan states was the loss to Turkey of all its possessions to the west of the Maritsa river. (See BALKAN WARS.)

Young Turkish Policy.—Mahmud Shevket Pasha then attempted a settlement of differences with England and France. Hakki Pasha, ex-grand vizier, was sent to London to come to an understanding over the Persian gulf controversy and to negotiate for the modification of the financial capitulations. Javid Bey, ex-minister of finance, was sent to France to settle the railway questions, to modify the financial capitulations and to raise a loan. But during these negotiations the opposition (the Liberal Union) murdered Mahmud Shevket, and the Young Turks passed repressive measures. A new cabinet was formed under Said Halim Pasha. A military mission was brought from Germany under Gen. Otto Liman von Sanders, who was also appointed commander of the army corps in Constantinople. The navy was under the Englishman, Adm. A. H. Limpus. A detailed program of reform for the eastern vilayets was prepared. As the powers refused to provide experts, inspectors were engaged from Sweden; the ministry of the interior, however, employed British inspectors.

The policy of the Young Turks had begun by being a policy of "Ottomanism," which aimed at uniting all the racial and religious elements of the empire. The risings in Macedonia had proved that the nationalism of each element, encouraged by outside powers, could not be assimilated by such a weak state as Turkey. Turkey through the Balkan War lost its Albanian, Bulgarian, Serbian and most of its Greek subjects, and the Arabs, incited by France, also manifested separatist tendencies, although to give the right to use Arabic officially in the courts in Arabia was the only decentralizing measure the Young Turks had taken. The failure of Ottomanism was followed by the revival of Abd ul-Hamid's Pan-Islamist policy, a decision encouraged by the sympathy which the Indian and the Egyptian Moslems had shown during the disasters of the Italian and Balkan wars. It was this Pan-Islamism which later led the Young Turks to proclaim jihad (holy war) in the hope of influencing the Moslem combatants in the Allied armies during World War I. This revival was led by Enver Pasha; it was opposed, in the name of pure nationalism by a larger group led by Ziya Gokalp, the poet and philosopher, who was helping the cultural-nationalist institutions called the "Turk Yurts" and the "Turk Ojaks" (opened 1912). The influence of Turkish refugees from Russia caused the nationalism of the Union and Progress party to take a Pan-Turanianist form.

The disagreement between England and Germany over the Baghdad railway and that between France and Germany over their respective railway spheres were settled by two agreements signed in Feb. 1914 between France and Germany and in June between England and Germany.

World War I.—In 1913 Enver Pasha, formerly Enver Bey, became minister of war. His policy was to give the high commands in the army to younger men. The military organization continued to be under the German mission. There were secret negotiations between Germany and Turkey known only to the grand vizier Prince Said Halim Pasha, Talaat Bey and Enver Pasha. A secret alliance was signed on August 2, 1914, when war was breaking out between Germany and Austria on one side and England, France and Russia on the other. Turkey declared its neutrality but mobilized at the same time. There were war and antiwar factions in the party. The antiwar faction tried to come to an understanding with the Allies, declaring that Turkey would remain neutral if the financial capitulations were modified and a loan granted. Javid Bey, the minister of finance, was at the head of the antiwar faction. The Allies made no promises, but they demanded the dismissal of the German commanders and the expulsion of the crews of two German cruisers which had taken refuge in the Dardanelles. The British government commandeered the two Turkish dreadnoughts which were then being constructed in England with the money raised by popular subscription, an act which, though legal, caused surprise and resentment. And when Germany offered the warships "Breslau" and "Goeben" to the Turkish navy the antiwar faction was weakened. The war faction argued that Turkey had lost by its political isolation since the Crimean War, that it should join Germany who was fighting against the hereditary enemy of Turkey, tsarist Russia, and that should Turkey become victorious, it might become free from the capitulations and even regain some of its lost territories. On Sept. 8, 1914, Turkey declared the capitulations abolished, which raised protests from all the powers, including its ally Germany. When the two German warships, which had become units of the Turkish navy though still under German command, attacked Russian ships and ports in the Black sea, Russia declared war, and England and France did the same. Turkey thus found itself at war with the

Allies on the Egyptian, Mesopotamian and Caucasian frontiers as well as at the Dardanelles (see DARDANELLES CAMPAIGN; MESOPOTAMIA, OPERATIONS IN; PALESTINE, OPERATIONS IN). The Dardanelles were successfully defended by Turkey, but the Russians took Trebizond, Erzurum and Erzinjan and marched toward Sivas; while Turkey failed in its attack on the Suez canal and the British took Mesopotamia including Baghdad. During the Turko-Russian battles on the Caucasian front, the Armenians created disturbances behind the Turkish lines and threatened to cut the lines of communications. The Turkish government began early in 1915 a general deportation in which atrocities were committed on a large scale. When Gen, Antranik, the Russo-Armenian general, entered eastern Anatolia, the Armenian soldiers under his command (so-called "Christian Army of Revenge") replied by similar atrocities, though on a far smaller scale. As Turkey had mobilized to its utmost limit it became almost impossible to sustain the army; the civil population suffered privation hitherto unknown; martial law was proclaimed everywhere. The Communist Revolution led Turkey and its Allies to conclude a peace treaty with Bolshevik Russia at Brest-Litovsk, March 3, 1918, by which all its lost territory was restored to it (even those districts which it had ceded to Russia in 1877). But the Arab nationalists, supported by England, drove out the Turks from Hejaz, except from Medina. The British army occupied Syria. On Oct. 30, 1918, an armistice was signed at Mudros, on the British warship "Agamemnon," between Adm. S. A. G. Calthorpe and Rauf Bey, the Turkish minister of marine. Although the armistice aimed at ending World War I, it did not end yet for Turkey who had to fight for four years more actually against Greece though virtually against the Allies themselves.

During the war secularization in education and other departments had taken place. The university had been extended and its principal chairs were occupied by German professors. The Sheria courts were taken from the sheikh ul-Islam and given to the ministry of justice. A family law issued in 1916 reformed marriage and divorce regulations. Women, who already had equal education with men, now filled public posts, and the university opened its doors to them.

Mohammed VI (*1918–22*).—Mohammed V had died in July 1918 and had been succeeded by his brother Vahid ed-Din, who took the name of Mohammed VI. In the early months of the reign the Turks welcomed the armistice as being the end to the great suffering of long years. But they soon forgot this suffering in the humiliation and persecution to which they became exposed. The Allied fleets and armies occupied the straits, Istanbul and even places outside the armistice line, and the terms of the armistice were stretched to the point of violation. Under these conditions the Turks had a bitter foretaste of the peace that they would receive at the hands of the Allies. Both in Istanbul and in the provinces, officers and intellectuals met in secret and began to discuss how to secure a tolerable peace, and as the nationalists appeared in the forefront of the general reaction against the Allies this agitation received the general name of the "nationalist movement." Meanwhile the Allies could not come to an agreement among themselves over the Turkish peace. Finally, on May 15, 1919, the Greek army was landed in Smyrna under the protection of the British, French and U.S. fleets, and the Greeks inaugurated their occupation by massacres committed in full view of the Allied fleets. (Italy, having retired from the peace conference for the moment, did not take part. By the interallied agreement of St. Jean de Maurienne in 1917, Smyrna and Adalia had been apportioned to Italy, and Italy had landed troops in Adalia in April 1918.) The Greek landing in Smyrna aroused general indignation in Turkey which ended in the national determination to resist to the last, even if this meant total disintegration. Mass meetings in Istanbul were the first manifestation of this feeling.

The National Pact.—Meanwhile Turkey was in a state of anarchy. The responsible leaders of the Union and Progress party had escaped to Germany, and the party was dissolved. Mohammed VI, a personal enemy of the Young Turks, forced Izzet Pasha's cabinet, which to some extent was able to keep order, to resign, and the Liberal Union came into power, Certain nationalist leaders wanted to save the country from disintegration by cooperating with the sultan and using his prestige as sultan-caliph. Among these was Mustafa Kemal Pasha. But Mohammed VI preferred to sacrifice the existence of his nation to his personal security, and this he did by bringing Damad Ferid Pasha into power and, through him, giving the reins of the government to the high commissioners of the Allies. In western Anatolia organizations for a national defense against the Greek invasion were rapidly arising. In eastern Anatolia, especially in Trebizond and Erzurum, associations, under the guidance of Kiazim Kara-Bekir Pasha, were preparing to oppose any attempt of the Allies to create an Armenia out of the territories which, even before the deportations and atrocities, they claimed to have been predominantly Turkish. The sultan with the Allies' assent, in order to control these organizations and disperse them if necessary, sent Mustafa Kemal Pasha to eastern Anatolia as the military inspector general. Kemal reached Samsun four days after the Greek landing at Smyrna. But as he was already in correspondence with these organizations, he met Rauf Bey, Ali Fuad Pasha and Col. Refet at Amasia on his way to Erzurum and signed the Amasia protocol on June 19, 1919; Kiazim Kara-Bekir Pasha also signed by telegram. This protocol is the first document that formally declared the national determination to resist both the Allies and the sultan, as the instrument of the Allies. A national congress assembled in Erzurum, on July 23, 1919, and Mustafa Kemal Pasha, having resigned from the army, presided. Another congress assembled in Sivas on Sept. 4, 1919, to which the national associations of western Anatolia sent representatives. This congress reaffirmed the decisions of the Erzurum congress, added plans for the defense of Eastern Thrace and chose a representative body to control the movement in Anatolia. No president was chosen. but Mustafa Kemal Pasha's leadership was generally recognized. This manifestation of the national will forced the sultan to dismiss Damad Ferid Pasha. A new cabinet with nationalist tendencies came into power. In Jan. 1920 a new parliament assembled in Istanbul, containing a nationalist majority. The parliament issued the national pact as accepted by the two congresses.

This national pact formulated the demands which the nationalists made during the whole struggle, and which they obtained eventually at Lausanne. It proposed self-determination for the Arab provinces south of the armistice line; it agreed to the opening of the straits to commerce and it proposed to grant to non-Turkish minorities the same rights as they had secured in Europe under various postwar treaties. The pact also demanded, either explicitly or implicitly, that Turkey should retain all territories inhabited by non-Arab Ottoman Moslem majorities, which meant not only Anatolia but eastern Thrace and the Mosul vilayet; that Istanbul should be given military security; that the capitulations should be abolished and that there should be a reasonable settlement of the public debts.

The Allies were watching with some anxiety the nationalist activities, which consisted mostly of smuggling in arms and ammunition and organizing the defense. Mustafa Kemal Pasha stayed in Anatolia to conduct these activities. The Allies, in conjunction with the sultan and the Liberal Union party, decided to strike at the nationalist movement through the persons of the leading deputies and intelligentsia in Constantinople. On March 16, 1920, the Allied forces in the capital seized a large number of nationalists, including Rauf Bey, the leader of the nationalist party in parliament, and Kara Vasif Bey, the head of the nationalist organization in Constantinople, arresting them in the parliament house itself. Parliament was then closed by the orders of the sultan. Some deputies and a few of the intelligentsia escaped to Ankara, which had become the nationalist centre.

The *Ankara* Government.—Mustafa Kemal Pasha had issued a proclamation inviting Anatolia to elect its deputies for a new assembly, which was opened in Ankara on April 23, 1920. Mustafa Kemal Pasha was elected president both of the assembly and of the government. Thus came into existence a new Turkish government over all territories not under foreign occupation. A new temporary constitution, known as the Law of Fundamental Organization, proclaimed the sovereignty to belong to the nation without restriction, and the great national assembly to be the sole and lawful representative of the nation, exercising sovereignty in its name. But Mustafa Kemal Pasha tried to make use of those who were still loyal to the sultan by declaring in his speeches that the sultan-caliph was a prisoner in the hands of the Allies and that he would be restored after the realization of the national ideal. The government of Istanbul, controlled by the Allies, condemned the leading nationalists to death by extraordinary courts and issued a fetva denouncing them as outlaws. The Anatolian government retaliated similarly. The sultan's government sent forces under the name of the caliphate army and roused counterrevolutionary outbreaks around Ankara, tvhich, however, were put down by the nationalists. When the Allies found themselves embarrassed by the nationalist success, they accepted the offer of Venizelos that the Greek army should advance beyond the area allotted to it in order to deal with the nationalists. In the months of June and July 1920 the Greek army occupied eastern Thrace and marched on to Bursa and Ushak. On Aug. 10, 1920, the Allies concluded the treaty of Sèvres with the sultan's government in Istanbul which aimed at destroying the independence of Turkey. In Europe, eastern Thrace nearly as far as the Chatalja lines, including Gallipoli, was assigned to Greece; and provisionally Greece was also given Smyrna and a zone around it. A tripartite agreement between England, France and Italy laid out French and Italian spheres of influence in parts of those Anatolian territories which under the peace treaty were nominally left to Turkey. The outlines of the Armenia which was to be formed in eastern Anatolia were left to Pres. Woodrow Wilson to define. The treaty strengthened the nationalist cause by arousing unanimous indignation. The British forces in Eskisehir withdrew under the pressure of Ali Fuad Pasha's forces. In Cilicia and Aintab the nationalist forces were struggling successfully against the French army.

The continual raids by the Armenians of the Armenian republic on the Turkish frontier villages, as well as the necessity for a direct route to Russia, led Turkey to attack the Armenian republic. The Turkish army captured Kars and Alexandropol, and a victorious peace was concluded with Armenia at Alexandropol on Jan. 3, 1921. A Turkish delegation sent by the Ankara government signed a treaty of friendship with Russia by tvhich Russia became the first country to recognize that government. The Menshevik government of Georgia was overthrown, and Turkey with the consent of Georgia occupied Ardahan, Artvin and Batum. When the Caucasian republics were federated to Russia, a treaty signed in Kars Oct. 13, 1921, between Russia, the government of Ankara, and the three Caucasian republics, left Kars, Ardahan and Artvin to Turkey and restored Batum to Russia.

The defeat of Venizelos in the general elections in Greece and the return of King Constantine alienated the Allies, especially France. The Greek army in Anatolia started a new offensive, but was twice checked by the Turkish army at Inonu (January–April 1921). The Allies called a conference in London to which representatives of both the government of the sultan and the government of Ankara were invited (January–February 1921). At this conference it became clear that the Allies realized the necessity of amending the treaty of Skvres: the Ankara delegates initialled agreements with the French and Italian governments which were not accepted by Ankara. These agreements nevertheless were the first signs of the difference of opinion between the Allies on the Turkish question. The Allied high commissioners at Istanbul as a result of this dissension announced the neutrality of their governments on May 18, 1921, and designated neutral zones forbidden to the belligerents on each shore of the Bosporus and the Dardanelles. On July 10, 1921, the Greek army once more passed to the offensive and drove the Turkish army east of the Sakariya. At the suggestion of a commission of inquiry sent by the great national assembly to the front, Mustafa Kemal Pasha was now appointed generalissimo. He fought during 20 days the decisive battle of the Sakariya, after which the Greeks retired westward. As a reward he was made marshal and was given the title of *ghazi* by the great national assembly.

Henri Franklin-Bouillon was delegated by France to negotiate an agreement which was signed in Ankara on Oct. 20, 1921. It recognized the Ankara government and traced the Turko-Syrian frontier, as later reaffirmed in the Lausanne treaty. On March 24, 1922, the Allies intervened in common to propose a truce between Turkey and Greece, but the Turks declared that they could only negotiate after the evacuation of Anatolia. However, the Ankara government sent to Europe first Yusuf Kemal Pasha, the commissary of foreign affairs, and then Fethi Bey, the commissary of the interior, to seek a peaceful solution. Fethi Bey arrived in London with especially conciliatory proposals, but during his three weeks' stay was not received by any cabinet minister. The Ankara government concluded that the question could be settled only by force of arms. The Greeks, to raise their morale, demanded permission to occupy Istanbul, which the Allies refused. On July 30, 1922, Aristeides Sterghiadis, the Greek high commissioner in Smyrna, proclaimed the autonomy of the Anatolian territory under Greek occupation, apparently with the intention of continuing the Anatolian war in the guise of a local Greek national movement, in case the Greek army should be compelled by diplomatic pressure to evacuate Anatolia. The Allies proclaimed their neutrality for the second time on August 10, 1922, by the decision of the supreme council of war.

The Turkish offensivebegan on Aug. 26 and the Greek army was completely routed. On its way from Ushak to Smyrna, it burned to the ground the most prosperous towns in the west of Turkey, and atrocities were committed on a large scale. Nearly a million people were made homeless. The Turkish army entered Smyrna on Sept. 9, and masses of the native Christians left the town in great disorder. The central part of the town was burned on Sept. 13.

The annihilation of the Greek army produced a dangerous situation. At first England and France agreed to act in concert in case of necessity by opposing any Turkish violation of the neutral zones. On Sept. 16, David Lloyd George further announced that the British dominions, Yugoslavia and Rumania had been asked to promise military support for maintaining the freedom of the straits. This announcement incited the Turks to action, both by its threatening tone and because it contained no reference to the nationalists' territorial demands in Eastern Thrace. In consequence the Turkish army advanced toward the neutral zone. France and Italy withdrew their troops, and Franklin-Bouillon was sent to Smyrna from Paris to mediate with Mustafa Kemal Pasha-and so arrest the march of the Turkish army. The British troops remained alone. On Sept. 23, Lord Curzon came to an agreement with M. Poincaré which accepted the British view regarding the temporary question of the neutral zones and the French view regarding the definitive peace terms. On the same day, in accordance with this agreement, the principal Allied powers invited the Ankara government to a peace conference on two bases: that Turkish sovereignty should be restored in Thrace up to the river Maritsa; and that during the interim period, pending the negotiations and entry into force of the peace treaty, the inviolability of the neutral zones should be maintained. Meanwhile the Turkish cavalry had advanced almost up to the British wire at Chanak, and only the tact and firmness of Gen. Charles Harington, as well as his desire to prevent war, averted a disaster. The nationalists accepted the Allied invitation and suggested a preliminary conference on Sept. 29. On Oct. 13 a military convention was signed at Mudania between the Ankara delegates, the Allied generals in Istanbul and Greek representatives.

The Allies had also invited the sultan's government to the peace conference. Tewfik Pasha, the last grand visier of the Ottoman empire, wrote to the great national assembly proposing joint action, and this made it necessary for the assembly to face the dilemma of having two governments in one country. In consequence the caliphate was separated from the sultanate; the sultanate was abolished, and the sovereignty of the nation without any restriction, already inserted in the new constitution, was reaffirmed on Oct. 1, 1922. It was decided, however, to keep the caliphate in the house of Osman. The governmental departments in Istanbul then passed to the Ankara government, tvhich formality was accomplished by Refet Pasha, that government's high commissioner for Thrace. Thus the house of Osman, which had reigned for seven centuries, came to an end through the treason of its last sultan, Mohammed VI, and for the first time in its history Istanbul was no longer the capital of the state to which it belonged. On Nov. 17, 1922, Mohammed VI took refuge in the British warship "Malaya" and escaped to Malta. The commissary of Sheria deposed the refugee caliph by a *fetva* and elected Prince Abd ul-Mejid. the son of Abd ul-Aziz, as caliph. The new caliph recognized the sovereignty of the great national assembly and gave up his claims to the sultanate by a written document. This was the last time the Turks used the *fetva*.

The Treaty **of Lausanne.**—The Lausanne conference met on Nov. 20, 1922, and after a recess from Feb. 4 to April 23, 1923, signed a peace treaty on July 24. By it the Turks procured the demands they had put forward in the national pact, except that concerning Mosul. The capitulations were abolished. To realize racial unity in new Turkey the Orthodox Greeks in Anatolia were to be exchanged for the Moslem Turks in Greek Macedonia; the Greeks of Istanbul and the rest of the Christian minorities were to have the same rights as were secured to other minorities in Europe under the postwar treaties. The tracing of the frontier with Iraq was to be discussed between England and Turkey at a future date and if necessary to be submitted to the League of Nations. Turkey also concluded treaties with the U.S. and Poland which restored diplomatic relations with these countries.

(**A. A. A.;** G. L. L.)

THE REPUBLIC

The Ottoman empire, which had tried to end the war in 1918 by the armistice of Mudros, was no more. The Turks, principal element of the defunct empire, had created a new independent Turkish state. The new Turkey had abolished the capitulations and contracted treaties with all the other states. Released from external troubles, it was free to begin a new era of progress and reconstruction. The new constitution was not complete, and the position of the president of the national assembly, who was the head of the state at the same time, was vague. Taking advantage of this, during a difficulty in forming a new council of commissaries, Mustafa Kemal Pasha proposed a constitutional amendment by which Turkey would become a republic (Oct. 29, 1923). This amendment was accepted, and Mustafa Kemal Pasha was elected the first president of the Turkish republic. Ismet Pasha, his right hand man, formed a cabinet.

Mustafa **Kemal's** Presidency.— Mustafa Kemal Pasha accepted the clause in the new constitution which declared the state religion to be Islam. But there was a growing conviction that radical reform would be possible only after freeing the state from religion. Turkey after adopting the republican form of government was determined to complete the partial secularization of the preceding regime and to prevent all interference by religious influence, which was regarded as having been the principal obstacle to modernization. The clause in the constitution declaring Islam the state religion and the position of the *fainéant* caliph were accordingly the first objects of attack. On March 3, 1924, the great national assembly passed three laws at one sitting: (1) expelling the Ottoman dynasty; (2) abolishing the caliphate, the commissariat of *sheria* (the recognized office for the religious affairs) and *evkaff* (pious foundations) and (3) attaching all the educational and scientific institutions, including the *medresses* (religious colleges), to the commissariat of public instruction. By these laws the Turkish republic put an end to Pan-Islamism in Turkey and also paralyzed the Khilafat movement in British India. The most important step in secularization was the clause of one of the three laws which withdrew the civil transaction section of the *sheria*, which so far had dominated the Turkish code through the *mejelle* (Turko-Islamic code). The dispatch of all concerns and cases which related to dogma and religion passed to an office called the presidency of religious affairs. Thus for the first time Turkey tried to separate religion from the state. Of the two classes, the ulema and the military, which had dominated the Turkish state, the ulema were no more. The military, from the time of the *tanzimat*, had nominally ceased to interfere in internal politics. But in spite of this the deposition of Abd ul-Aziz (1876), the re-establishment of the constitution (1908) and the nationalist movement (1918) were all brought about through the army. And although during the last and most important changes of regime, including state secularization, military influence was not obvious, the force behind the throne in the Turkish state was still the army. A month before the passing of these laws Mustafa Kemal Pasha assembled the commanders of the army in Smyrna and discussed these questions with them, thus diplomatically shifting the responsibility to the shoulders of the army in case of any public opposition. A new constitution which was extremely democratic in form was adopted on April 20, 1924. To win over the peasantry, who constituted the majority and who did not regard these radical measures favourably, the tithes, which lay heavily on the agricultural classes, were abolished and military service was reduced to 18 months. The deficit in the revenue resulting from abolition of the tithes was met by a heavier taxation of the urban population.

Although constitutionally the natural sovereignty was in the hands of the national assembly, Mustafa Kemal Pasha, through his personal prestige won in the field and through his hold over the army, showed decided tendencies toward a personal dictatorship. This created an opposition under Rauf Bey and Kiazim Kara-Bekir Pasha, which attempted to keep the republic on a democratic and liberal basis and was called the Republican Progressive party (Nov. 1924). Ismet Pasha's cabinet fell and Fethi Bey, a liberal and moderate statesman, formed a new cabinet. The Kurdish provinces revolted because they resented the extreme centralization and the harsh measures of the government in carrying out new reforms and because of the separatist tendencies of some of the leading chiefs. Mustafa Kemal Pasha seized this as a pretext to strike at the opposition. Pretending that the liberal clause in the Progressive program which advanced liberty of conscience had encouraged this rising, he forced the Fethi Bey cabinet to resign, on the ground that it had refused to carry out drastic measures in the peaceful parts of Turkey. Ismet Pasha formed a cabinet for the second time. The law of maintenance of order was passed.

With the passing of this law, the tribunals of independence, which had functioned during the nationalist struggle against the antinationalists, were revived. The opposition party was suppressed. The freedom of speech. which the new constitution had accorded to the Turkish nation was evaded through the very vague terms of the law. Mustafa Kemal was able to establish his dictatorship, despite a very democratic assembly, by the absence of any clause in the constitution which would place the president of the republic above parties. Therefore he, as the active president of his own party, could wield unbounded power. The Kemalist party (People's party), like Abd ul-Hamid and the Committee of Union and Progress, believed that the Turkish nation was not yet ready for a liberal regime. Although the Kurdish insurrection was put down by tribunals and military operations, the disturbances continued in Van, Bitlis and Diarbekr and led the republic to begin a partial deportation of the Kurds. The religious orders were abolished and the *tekkes* (monasteries) were closed as having influenced the Kurdish rising. A decree ordered the army to adopt a kepi and the civil servants to wear hats. A law passed in Nov. 1925 abolished the fez and obliged everybody to wear hats (women were not included). This law provoked several counterrevolutionary risings in the eastern provinces, which the tribunals suppressed by death sentences and imprisonments. On Feb. 17, 1926, the assembly adopted a new civil code which was almost a translation of the Swiss. By the adoption of this code Turkish legislation was wholly freed from Islamic influence. The laws concerning marriage, divorce and inheritance, which had been totally different from those of the west, were altered, and polygamy was legally prohibited. This radical secularization led the non-Moslem minorities to renounce of their own accord the minority rights which they had procured at the Lausanne conference. The secular republic had now only two points of contact left with religion: the clause in the constitution which stated that the religion of the state was Islam, and the law which attached the presidency of religious affairs to the prime minister's office. The former of these was broken on April 9, 1928, by an amendment to the constitution.

On the pretext of a conspiracy against Mustafa Kemal Pasha's life, "discovered" in the summer of 1926, all the members of the suppressed opposition party, both in and out of the assembly, as well as the leading members of the Union and Progress party, were arrested by the tribunal of independence. At the trial political opponents were assumed to be conspirators by the mere fact of their being in the opposition. Kiazim Kara-Bekir Pasha, Ali Fuad Pasha and Refet Pasha were acquitted by the pressure of the army. Several members of the assembly, whose parliamentary immunity was violated and who had been in the forefront of the nationalist movement, were executed. Javid, the foremost Turkish financier, Shukri, Nazim and Janpoulant, all ex-ministers of the Unionist regime and some of them deputies, were also executed. The ex-prime minister Rauf, who was in Europe at the time, was condemned to ten years' imprisonment.

A decree of 1928 discarded the Arabic alphabet for the writing of Turkish and imposed the Roman instead. This change was in accordance with the policy of modernizing the language itself and freeing it from its dependence on Arabic and Persian.

The year 1930 saw two advances in Turkey's political life: women received the vote for municipal elections; and on Aug. 13 the former prime minister, Fethi Bey, formed an opposition group, the Liberal Republican party. In the municipal elections of the same year his party polled about 25% of all votes, women were for the first time elected, and the Greek, Armenian and Jewish minorities presented their candidates. But by the end of the year the opposition party was dissolved.

Turkey did not escape the economic depression of the early 1930s. But that adversity did not arrest—although it curtailed—the economic reconstruction of the country. This was fostered by the formation of a number of state banks, to each of which was delegated the establishment and control of state industrial and mining enterprises and public utilities. A long-term credit of $8,000,000 was negotiated with the Soviet government for the acquisition of Russian cotton-spinning machinery. Many occupations, until then mostly exercised by foreigners, were reserved for Turks—partly to promote their education in trade and commerce. In 1932 a five-year industrial plan was promulgated and an important program of economic and educational reforms was launched. The metric system was adopted; and English replaced French, Arabic or Persian as the principal foreign language to be taught in the schools.

On Dec. 6, 1934, the great national assembly changed the constitution so that all Turkish men and women were henceforth entitled to vote in legislative elections as soon as they had reached the age of 23 and to become elected at the age of 31. At the same time it was also decided that the president was to be elected from among the deputies, his term of office being identical with the life of the assembly. During 1935 women were for the first time elected to the great national assembly. The international women's congress met at Istanbul in April of the same year. Sunday was introduced (in place of Friday) as the weekly rest day. The old Turkish titles—such as pasha—were abolished; and family names were introduced, as in the west. Mustafa Kemal received the surname of Ataturk;' the premier Ismet, that of Inonii. On Feb. 5, 1937, the assembly accepted the six principles of the Republican People's party—republicanism, nationalism, democracy, evolutionism, separation of state and religion and state supervision of the principal industries, public utility services and means of communication.

In Oct. 1937 Ismet Inonu, who had been prime minister for almost 15 years, resigned and was replaced by the former minister of economic affairs Celal (Jelal) Bayar. After the death of Kemal Ataturk on Nov. 10, 1938, at the age of 58, Inonii was elected president of the republic.

Foreign Affairs.—On May 19, 1924, a conference assembled in Istanbul to trace the Turko-Iraqi frontier, which had been left over by the Lausanne conference. No result was achieved and in accordance with the decision of the Lausanne conference, England and Turkey submitted the question to the League of Nations. On Dec. 16, 1925, the League decided to give most of the vilayet of Mosul to Iraq. To this the Turks would not at first consent. A treaty of mutual neutrality was concluded on Dec. 17 for three years with the U.S.S.R. Turko-Soviet relations, which had become distant since the Lausanne conference, once more became very close. The *Türk Ojaks* (national clubs) issued a declaration, stating that Turkish nationalism was cultural and local and had no Pan-Turanian aims. Finally in the early summer of 1926, the British, Turkish and Iraqi representatives met in Ankara and signed a treaty on June 5, which ceded the vilayet of Mosul to Iraq with a slight rectification of the frontier in favour of Turkey: for a period of 25 years from the coming into force of the treaty, the Iraqi government was to pay Turkey 10% on all royalties it received from the exploitation of the Mosul oil. On April 22, 1926, a treaty of neutrality had been concluded with Persia. A treaty of perpetual peace and friendship was signed with Afghanistan on May 27, 1928, and a treaty of nonaggression and arbitration with Italy on May 30.

In 1930, after an exchange of populations, treaties of friendship and arbitration were signed with Greece, initiating an era of co-operation between Greece and Turkey. Cordial relations were also maintained with the Soviet Union; and in Oct. 1931 the second Balkan conference met in Istanbul, with more than 150 delegates from Albania, Bulgaria, Greece, Yugoslavia, Rumania and Turkey attending. In July 1932 Turkey joined the League of Nations, and at about the same time initiated a rapprochement with Britain and France. A further step in Turkish policy was taken on Feb. 9, 1934, when under Turkish leadership the Balkan entente—which included Rumania, Yugoslavia, Greece and Turkey (but not Bulgaria) was established. In Nov. 1935 the existing treaties with the Soviet Union were prolonged for a further ten years. The treaties with Iran, Iraq and Afghanistan were consolidated by the signing, at Saadabad on July g, 1937, of an Asiatic pact of nonaggression with those states.

The rapprochement with Great Britain became more marked in 1936. Turkey promised to co-operate with Great Britain in case of a conflict with Italy in the Mediterranean; and a conference at Montreux removed (with British support) the limitations imposed upon Turkey by the treaty of Lausanne in respect of the militarization of the straits. The visit of King Edward VIII to Istanbul still further strengthened Anglo-Turkish relations.

By an agreement with France of July 3, 1938, the district of Alexandretta was established as an autonomous part of Syria, but conforming in most respects to the order prevailing in Turkey. It received the name Hatay, after the ancient Hittites, regarded by the modern Turks as their ancestors. In less than a year Hatay was ceded wholly to Turkey, at the signing of the declaration of mutual assistance with France.

World War II.—As president; Ismet Inönü followed, on the whole, the constructive and cautious policy of his predecessor. But his cabinet was soon faced with the imminence of war in Europe. In view of this crisis Turkey signed declarations of mutual assistance with Great Britain (May 12, 1939) and France (June 24), aiming at the maintenance of peace in the eastern Mediterranean.

Turkey's position seemed secure because of its friendship with the western democracies on the one hand and with the Soviet Union on the other. Turkey might indeed have become the connecting link between these two camps, both of which were then opposed to German aggression. But the pact of friendship between the Soviet Union and Germany of Aug. 1939 profoundly altered Turkey's position. Turkey tried to maintain its friendship unchanged, and the Turkish foreign minister visited Moscow in the autumn, but without result. On Oct. 19, therefore, Turkey concluded a treaty with Great Britain and France, and a series of staff talks between the general staffs of the western democracies and Turkey began. Turkey was unable however, to transform the Balkan entente into a military alliance.

Italy's entrance into the European war in May 1940 extended the area of the conflict into the eastern Mediterranean and thus created for Turkey a *casus* foederis. But the downfall of France and the complete uncertainty of the future of Great Britain made Turkey hold back. Although Turkey made every effort to increase the strength of its army it was largely a bayonet army, inadequately equipped with modern aircraft and armour. President Inonii, therefore, adopted a policy of neutrality. Nevertheless, although Turkey did not enter the war as an active ally of Great Britain. it continually stressed its solemn intention of remaining faithful to the alliance.

It was expected that Turkey would enter the war actively if the security of the straits or of the near eastern oil fields were threatened, or if Bulgaria and the Greek region of Salonika—which Turkey regarded as her security zone—were invaded. Accordingly, in Jan. 1941, Anglo-Turkish staff talks were held in Turkey and the British foreign secretary Anthony Eden visited the country. But fear of German military superiority kept the Turks inactive when the time for action came. Thus, when the German army occupied Bulgaria at the beginning of March, Turkey did not move, nor did it come to the help of Greece and Yugoslavia when they were attacked by Germany. The German conquest of Greece and the occupation of the Greek islands in the Aegean sea in the spring of 1941 isolated Turkey strategically and made its participation in the conflict impossible for the time being. By the end of 1941 the war had come near to Turkey on all sides. Bulgaria was in it on the side of the axis. Greece was completely occupied by Bulgarian, Italian and German forces. Greek and Italian islands held by the axis were being equipped for fighting. Syria, Iraq and Iran were thoroughly controlled by Great Britain, Free France and the U.S.S.R. The Balkan entente and the Asiatic pact had gone, and the Anglo-Franco-Turkish treaty for mutual aid was uneasily asleep. Turkey sat alone—a small neutral buffer state in the midst of mighty antagonists.

In general Turkey had nothing to lose and everything to gain by a policy of neutrality. It held no colonial territory and desired no extension of boundaries. Its economic surpluses were eagerly sought by both sides. Participation in the war would have meant heavy expense and renewed depletion of its manpower. During almost five years of World War II, therefore, Turkey maintained a firm and scrupulous neutrality. No concealment, however, was made of a determined intention to resist with all resources any invasion of its territory. The danger of invasions by axis forces was certainly great: in fact, Hitler's choice in June 1941 to attack the U.S.S.R. rather than to overwhelm the middle east probably saved Turkey from terrible disaster. A German drive might have rolled with comparative ease across Turkey to Egypt and the Persian gulf, to join forces with Japan in southern Asia. This danger was averted, but it was not removed so long as Germany was active in North Africa and advancing toward the Caucasus and Iran. But the resounding defeats of El Alamein and Stalingrad remove the "pincers" threat, and after Jan. 1943 Turkish fear of Germany diminished rapidly.

Under the circumstances Turkey's neutrality was convenient to both sides. The Germans, while fighting in the U.S.S.R., could feel secure against a thrust from the southeast. The Allies on the other hand possessed a neutral barrier on the north while they strengthened themselves in Egypt and improved the roads across Iran for transporting supplies to the Soviet Union. In particular, Turkey protected the Anglo-Iranian oil fields, which were of vital consequence to the whole eastern war.

In the midst of its tribulations the Turkish government had thought best to sign a two-year nonaggression pact with Germany on June 18, 1941, only four days before the German attack on the U.S.S.R. This was followed on Oct. g, after much haggling, by a commercial treaty: products to the value of £T100,000,000 on each side were to be exchanged during 1943 and 1944; Germany was to deliver to Turkey war material to the value of £T18,000,000, and in exchange Turkey agreed to provide Germany with 90,000 tons of chrome ore per year. Great Britain and the United States offered counter proposals: on Dec. 3, lend-lease advantages were promised to the Turks, and in March 1942 a first large shipment arrived. During the course of the war the Anglo-Saxon countries continued to provide Turkey with war material, naval vessels, locomotives, railway cars, wool, cotton yarn, mining machinery and foodstuff (military preparedness had caused shortages of foodstuffs by removing men from the farms). The supplies entered Turkey mainly at Mersine and Alexandretta, ports which were improved by wharves and jetties. While the western nations steadily increased their support of Turkey, Germany was less and less able to fulfill its promises and was reported to have received only 25,000 tons of chrome ore during 1943, paying four times the prewar price for it.

Relations with the Soviet Union were disturbed after an attempt in Feb. 1942 to assassinate the German ambassador Franz von Papen. Among 50 persons arrested five were Russians. Two of the latter—employees of the Soviet consulate in Istanbul—were convicted on June 17.

In July Shukru Saracoglu, who had long served successfully as Turkish foreign minister, became premier. In Feb. 1943 a new great national assembly was elected. Meeting in March, it re-elected Ismet lnonii as president for four years. The president confierred at the end of January with the British prime minister Winston Churchill at Cairo. He returned there in December to meet Churchill and Pres. Franklin D. Roosevelt. Both conferences appeared to be very cordial, but no visible changes of Turkish policy ensued.

The heavy war expenditure strained Turkish finances seriously. To meet the deficit a law of Nov. 11, 1942, created a form of capital levy tax called the *varlik vergisi;* the penalty for nonpayment was forced labour in the eastern provinces. The tax was fairly levied upon Moslem Turks and foreigners but it was unjustly and ruthlessly applied in the case of Jews, Greeks and Armenians of Turkish nationality—against whom considerable feeling had been aroused because of their alleged war profiteering. Within six months more than £T300,000,000 had been collected.

The year 1944 brought increasing successes to the Allies and discomfiture to the axis; and Turkish policy responded cautiously to the change. In January the Japanese Domei correspondent was expelled. In May a Pan-Turanian and fascist plot was uncovered in Istanbul; many arrests were made and martial law was proclaimed. In March, however, relations with Great Britain became strained because Turkey was still shipping chrome ore and other products to Germany and manifested no intention of joining in the war. Great Britain, therefore suspended shipments to Turkey of munitions and foodstuffs. In justification of its inaction Turkey claimed that it had not received the quantity of war material which had been promised.

Not until Aug. 2, 1944, did Turkey yield to pressure from the United Nations to fulfil its treaty obligations, and then it only broke off relations with Germany. Promptly thereafter German representatives left Turkish soil and commercial exchanges came to an end. Turkey, however, still refused to declare war and join in the final grand assault in Germany. It did not, indeed, make the formal declaration until Feb. 23, 1945 after the Allies had announced that only those states which had done so would be invited to take part in the United Nations conference at San Francisco.

Internal Affairs after World War 11.—The collapse of the Nazi regime and the close association of Turkey with Great Britain and the U.S. were bound to weaken Turkey's attachment to the one-party system established by Kemal Atatiirk. It came to an end in Jan. 1946 when the Democratic party—an opposition party founded by Celal Bayar, one of Turkey's most eminent statesmen—officially came into existence. The new party received the blessing of the president, the government and the press. The first election under the two-party system was held in July 1946, and resulted in a sweeping victory for the government. The opposition leaders charged the government agents with irregularities. The result, however, would probably have been much the same if the votes had been properly counted.

The great national assembly took westernization of its parliamentary system in its stride. The Democratic party followed the maxim that it was the duty of the opposition to oppose. It constantly criticized the government, and its effectiveness was out of proportion to its numbers. It continued to gain strength in the country, but it refused to contest any of the by-elections of 1948 and 1949 on the grounds that the amendments to which the government had consented in the electoral law had not gone far enough. Early in 1950, however, a new electoral law was passed by the assembly which provided all the safeguards demanded by the opposition (secret ballot, public counting, judicial supervision, etc.); and on May 14, a general election was held. It resulted in an overwhelming defeat for the Republican People's party, which had been in power continuously since 1923. The Democratic party won 408 seats against 69 for the Republican People's party, one Nationalist and 9 Independents. Celal Bayar was elected president of the republic. He invited Adnan Menderes to form a cabinet. A distinguished historian and university professor, Fuat Koprulu, became minister of foreign affairs.

Despite Republican and Nationalist attacks on the government (so vitriolic that modifications of the laws against libel and slander were made), the Democratic party again won a decisive victory at the general election in May 1954, securing jo3 of the 541 seats.

The Democratic party drew its leaders mainly from the middle class. Its domestic policy might be described as liberalism plus the nationalization of railways, power, coal, steel and other large-scale activities, but greater scope was promised for private enterprise.

Communism did not appear to be a serious problem in Turkey after World War II. Its doctrines would not ordinarily appeal to a prosperous Moslem peasantry, and the fact that it was sponsored by Russia, the historic enemy of Turkey, handicapped Communist agents and propaganda. Nevertheless, the government decided to prohibit Communist organizations. In 1946 out of jj suspects arrested, 44 were convicted of being members of an illegal organization, and several professors were dismissed from Ankara university for Communist sympathies. Further arrests were made in 1951. Despite Turkey's apparent prosperity, there was considerable internal discontent during 1954–55, caused by inflation resulting from overinvestment and also by the bitterness of the strife between the political parties and repressive government policy. Underground organizations took advantage of this, and the riots of Sept. 6–7, 1955 (*see* below), were evidence of unrest. At a special meeting of the national assembly (Sept. 12) martial law was imposed for a period of six months in Istanbul, Izmir and Ankara.

One of the most important measures adopted by the great national assembly was the land reform bill of 1945. It aimed at converting Turkey into a country of smallholders by distributing state and ecclesiastical lands, reclaimed and uncultivated lands and privately owned lands of more than 450 ha. among landless peasants and immigrants. The dispossessed owners were to receive 4% state bonds for their property, and the agricultural bank was to grant loans to the peasants, free of interest and repayable over 25 years, to assist them in stocking and equipping their farms. The bill also had provisions against the splitting of holdings through inheritance. After protracted discussions, the great national assembly decided in 1948 to introduce the teaching of Islam—but only in the two highest classes of the primary schools and outside the regular school hours.

Foreign Relations.—Until the establishment of the republic, Russia and Turkey had engaged in a succession of wars for nearly 300 years. Russia. therefore, came to be regarded by the Turks as the inveterate enemy. the inevitable aggressor, whose aim. down the centuries, remained the same: to possess Istanbul and the straits. In 1925, however, cordial relations were established by Lenin and Kemal, which endured until the signature of the Soviet-German "nonaggression" treaty of Aug. 23, 1939. Although the Soviet-Turkish treaty of friendship of Dec. 17, 1925, still remained in force, Turkey suspected (not without reason, as was subsequently proved) that the U.S.S.R. was bargaining with Germany at Turkey's expense.

The estrangement was no less pronounced on the Soviet side since Turkey continued to maintain its attitude of nonbelligerency, keeping the straits closed to Soviet and Allied warships. The ancient hostility was revived, and with it the ambition—dormant since the Russian Revolution—of gaining control over the straits. Early in 1945 Moscow launched a war of nerves against Turkey, which was not mitigated by Turkey's belated declaration of war against Germany. The subsequent denunciation, therefore, by the Soviet government on March 20, 1945, of the Soviet-Turkish treaty of friendship (due to expire on Dec. 17, 1945) did not come altogether as a surprise in Ankara. This was followed by a Soviet demand: (1) for a revision of the Montreux convention of 1936 which would permit the U.S.S.R. to share in the defense of the straits and (2) for the return of the old Turkish provinces of Kars and Ardahan, which had been annexed by Russia in 1878 and ceded back to Turkey by the treaty of Brest-Litovsk of March 3, 1918 (cession confirmed by the treaty of Kars of Oct. 13, 1921).

These demands were clarified by exchanges of notes in which the Soviet government proposed: (1) that the straits always be open for the passage of merchant vessels of all countries; (2) that they always be open for the passage of warships of the Black sea powers only; (3) that the passage of warships of non-Black sea powers not be admitted, except in special cases; (4) that the regime of the straits be the joint responsibility of the Black sea powers with Turkey; and (j) that the defense of the straits be carried out jointly by Turkey and the U.S.S.R. Turkey intimated in its replies that it might agree to the first three proposals, but pointed out that the regime of the straits was governed by the Montreux convention, which could not be revised except by its signatories. It refused to consider the suggestion that the U.S.S.R. be alloued to share in the defense of the straits, pointing out that this would mean granting bases on Turkish territory to a foreign power, which would be an infringement of Turkish sovereignty and a menace to its independence.

Great Britain and the United States supported Turkey on this issue. The visit in the summer of 1946 of the battleship "Missouri" to Istanbul aroused enthusiasm in Turkey and was followed by visits of successive squadrons of U.S. warships. These fleet movements were unmistakable hints to the U.S.S.R. that the United States would not tolerate any offensive move against Turkey. On March 12, 1947, Pres. Harry S. Truman recommended the employment of U.S. funds and military and civil equipment to assure the independence and economic stability of Turkey. Thereafter the United States pursued a policy of full support for Turkey's military. naval and economic strength. War material poured into Turkey. Important naval and military missions arrived from the United States, and U.S. experts were soon studying and preparing plans for the development of Turkey's agriculture, irrigation, coal, oil, banking, transport system, education, electrification and foreign trade. By 1950 work had begun on a number of schemes, and equipment had begun to arrive. In addition hundreds of U.S. technicians were engaged and hundreds of Turks went to the U.S. to receive military or technical instruction. In the spring of 1948 military aid alone was stated to have reached the value of $100,000,000. (A. A. A.; A. H. L.; A. C. Es.)

In its foreign policy Turkey remained steadfast through all changes of government. It resolved to play its full part in international organizations in favour of peace by mutual aid and felt disappointment that it was not allowed to be an original member of the North Atlantic treaty of April 4, 1949.

After the Communist aggression in Korea Turkey was first to announce its decision to join the U.S. armed forces there, and a brigade disembarked at Pusan in Oct. 1950. The Turks fought brilliantly at Kunuri, in Nov. 1950, under Brig. Gen Tahsin Yazici. The Turkish casualties during the Korean campaign amounted to 717 dead and 2.156 wounded—fourth largest casualties after those of South Korea, the United States and the United Kingdom.

The accession of Turkey to the North Atlantic Treaty organization was. on the initiative of Turkey itself, proposed to the other NATO powers by the United States on May 1j. 1951. The United Kingdom. though initially favouring a separate Mediterranean or middle eastern treaty, gave its support to the proposal. At its meeting at Ottawa, Ont., in Sept. 1951, the NATO council recommended to the member governments that an invitation be extended to Turkey (and Greece) to accede to the treaty, and a protocol was agreed to change the text of the treaty accordingly.

The Soviet government announced on May 30, 1953, that the Georgian and Armenian Soviet republics had renounced territorial claims to Kars. Ardahan and Artvin, and that, in consequence, "the Soviet Union had no territorial claims whatsoever on Turkey." The note also recalled that, at the time these territorial claims had been presented, the Soviet government had also raised the question of "the removal of the possible threat to the security of the U.S.S.R. from the side of the Black sea straits." The Soviet government had, however, reconsidered its opinion on this question and now deemed it possible to ensure the security of the U.S.S.R. on conditions acceptable alike to both countries.. In its reply the Turkish government expressed satisfaction that the U.S.S.R. had renounced all territorial claims on Turkey and pointed out that the question of the Bosporus and the Dardanelles was regulated by the Montreux convention of 1936.

Improved relations between Greece and Turkey reached a climax on Feb. 28, 1953, when a treaty of friendship and co-operation was signed at Ankara between Turkey. Greece and Yugoslavia. This was transformed into a military alliance by a treaty signed at Bled on Aug. 9, 1954. It was suggested that Italy should also become a signatory. but the alliance was seriously weakened during 19jj by the new relationship established between Yugoslavia and the U.S.S.R. by the Soviet leaders' visit to Belgrade in May and June; and by the crisis in Turko-Greek relations over Greek support for the movement toward self-determination for Cyprus. At the London conference on Cyprus (Aug. 29–Sept. 7, 1955) the Turkish foreign minister insisted that if Great Britain were to give up Cyprus) the island must revert to Turkey, its former owners. On Sept. 6–7 serious anti-Greek rioting. said to be Communist-inspired, broke out in Istanbul. Izmir and Ankara.

Progress was made, however, with the formation of a middle eastern defense system. On Feb. 19, 1954, an agreement was signed between Turkey and Pakistan, and on Feb. 24. 1955, a Turco-Iraqi defense treaty was signed at Baghdad. This was joined by Great Britain in April, by Pakistan in September and by Iran in November.

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Population. — The earliest invaders of the present Turkey probably came from the Eurasian steppes around the Black and Caspian seas. The Hittite empire was established in Mesopotamia and in Anatolia by 1800 B.C., and the Turks of today take great pride in their Hittite ancestry. The Hittite empire on its fall gave place to Phrygian invaders and to refugees from Greece, who overran western Anatolia. They were followed by the Persians, by the Macedonians under Alexander, by Celtic tribes from the middle Danube (Galatians). by the Romans. by the Arabs (Saracens) and, by the Seljuk Turks. (See TURKS OR TURKIC PEOPLES.)

The history of the country is reflected in the variety of types found in modern Turkey, though generally the people are muscular and well-built, round-headed, with high cheekbones. brown eyes, square jaws and large, somewhat aquiline noses. The majority has Mediterranean colouring, but there is a fairer strain.

TABLE II.—*Population, 1927–60*

Date of Census	Total	Urban	%	Rural	%	Density per sq.mi.
1927 .	13,648,270	3,305,879	24.2	10,342,391	75.8	46
1935 .	16,158,018	3,802,642	23.5	12,355,376	76.5	54
1940 .	17,820,950	4,346,249	24.4	13,474,701	75.6	59
1945 .	18,790,174	4,687,102	24.9	14,103,072	75.1	62
1950 .	20,947,188	4,593,261	21.9	16,353,927	78.1	70
1955 .	24,064,763	6,927,343	28.8	17,137,420	71.2	80
1960 .	27,809,831	...	...	...	...	92.3

TABLE III.—*Population of Chief Towns*

Town	1927	1940	1945	1950	1955	1960
Istanbul .	690,857	793,949	860,558	983,041	1,268,771	1,931,910
Ankara .	74,553	157,242	226,712	288,536	451,241	646,151
Izmir . .	153,924	183,762	198,396	227,578	296,559	370,923
Adana. .	72,577	88,119	100,780	117,642	168,628	230,024
Bursa . .	61,690	77,598	85,919	103,812	128,875	153,574
Eskisehir .	32,341	60,742	80,030	120,092	120,092	153,190

It was estimated that the present people of Anatolia owe about 75% of their ancestry to the original inhabitants and 25% to the Seljuk Turks. The Kurds, living mainly in the eastern and south-eastern provinces, are differentiated from the rest of the people by their height (average j ft. 7 in.) and very long heads and by the high proportion with fair hair and blue eyes.

The growth of the population between 1927 and 1955, and the extent to which industrialization produced a shift from rural to urban population are shown in Table II. Growth of the chief towns during the same period is illustrated by Table III.

The greater part of the population lives near the coast, where

TABLE IV.—*Population by Main Mother Tongtte*

	Turkish	Kurdish*	Arabic	Greek	Armenian	Circassian	Spaniol (Jewish)
1927 .	11,777,810	1,184,446	134,273	119,822	64,745	95,901	68,900
1955 .	21,792,255	1,504,482	346,404	81,799	46,934	90,738	29,207

*Those claiming Kurdish as a mother tongue should not be confused with those who would describe themselves as Kurds. Estimates of the latter are twice the figures shown in the table.

Source: Turkish Central Statistical Office.

TABLE V.—*Population by Religion*

	Moslem	Greek Orthodox	Armenian (Gregorian)	Roman Catholic	Protestant	Jewish
1955 .	13,269,606	109,905	.	39,111	6,658	81,872
1955 .	23,862,162	84,759	55,403	22,337	10,488	40,585

Source: Turkish Central Statistical Office.

agricultural activity is most intense and where the trading centres are located. There the density varies from 75 to 100 per square mile. In the central plateau and in the mountains of eastern

TABLE VI.—*Population by Occupation, 1927–50*
(In 000s)

Occupation	1927	1935	1945	1950
Farming, forestry, fishing . . .	4,368	6,480	7,425	10,745*
Industry, handicrafts . . .	299	656	674	946
Commerce, banking, insurance. .	257	218	280	238
Transport and communications .	15†	122	140	114
Administration, public service, professions‡	290	398	693	423
Domestic and personal service . .	122	46	30	155
Without occupation or unreported .	5,169	8,236	11,164	4,045

*A disproportionate increase, caused partly by changed basis of census information whereby rural population over six years of age were registered as farmers in 1950, instead of as without occupation.

†Telecommunications workers only.

‡Before 1950 military men were classified under administration; in 1950 they were classified according to civil profession.

Turkey. the density is from 1 to 25 per square mile. On the edge of the plateau, in western Turkey and in the southern coastlands the density varies from 25 to 75 per square mile.

Population groupings according to language and religion are shown in Tables IV and V respectively.

The distribution of the population by occupational groups is shown in Table VI.

Education.——Primary education is, in theory, compulsory for both sexes between the ages of 7 and 12. Among the problems of primary education in the 1950s was the lack of teachers. Although great expansion had taken place, there was probably still a considerable number of children in the provinces receiving little or no education. The secondary schools provide a three-year course which may be followed by a three-year or four-year course at a *lycée.* Parallel with the secondary schools are the boys' technical schools, with three-year, five-year or six-year courses, where engineering, building and other trades were taught; girls' institutes giving training in home management, cooking, hygiene, etc.: and commercial schools in which general as well as commercial subjects are studied.. Technical and commercial instruction may be continued in a small number of *lycées* specializing in these subjects. Evening trade schools are also provided for men and women who have not had more than a primary education; the number of these in the mid-1950s was still small. The Istanbul Technical university, reorganized in 1941, is designed to give instruction, both practical and theoretical, in engineering subjects. The course lasts four years. With it is associated a technical department, with a two-year course in civil or mechanical engineering. Other universities include one at Istanbul. with faculties of law, medicine, science, letters and economics; one at Ankara, with faculties of languages, history and geography, science, medicine and law; and the University of the Aegean in Izmir (opened in 1955), with faculties of agriculture and medicine.

An interesting and successful experiment was the establishment of village institutes (koy *enstitülari*), at which boys and girls who have had primary education are given general and vocational training designed to fit them as teachers in village schools or as farmers able to apply modern agricultural methods to their work. The rural atmosphere is maintained in these institutes and the training is severely practical. A boy returning as a village schoolmaster is expected to be able not only to teach but to build and maintain a schoolhouse of a standard pattern, if necessary.

Education is free in all government schools; but board and lodging, where this is necessary, are not always provided, though many scholarships that cover all expenses at school or university are awarded. A number of Turkish private schools exist, as well as the schools for the minorities (Greek, Armenian or Jenish) and the foreign schools (of which the U.S.-supported Robert college in Istanbul is the best known). The Turkish government's insistence on the secularization of education throughout the country raised serious difficulties for the foreign schools. and some were forced to close. In 1947 the ban on religious instruction was relaxed, and Moslem schools were permitted to open in addition to, but not in replacement of the secular state schools.

The spread of education was enormously assisted after the Arabic alphabet was superseded by the modified Latin alphabet, introduced in 1928 by a nation-aide campaign in which Kemal Ataturk himself took a prominent part. At the same time efforts were made to reform the Turkish language by the substitution of pure Turkish words for Arabic or Persian words in general use. This led to some confusion and the effort was allowed to slacken.

Adult education was still much needed at mid-century. Apart from stationary and mobile schools for the illiterate, vocational and professional training schemes with day or evening classes had been developed. To help in filling the need for adult education, "people's houses" (*halkevleri*) were established all over the country; activities include language and literature, fine arts, drama and history. Libraries and museums were also established.

Table VII shows the increases in the number of schools and students between 193j and 1952, illustrating particularly the great importance attached to technical training. The budget allocation for the universities was trebled between 1950 and 1955.

TABLE VII.—*Education*

Year	Number of schools	Number of students	Primary schools	Secondary schools	*Lycées*	Vocational schools	Higher schools and faculties
1935–36	6,614	770,600	6,275	191	66	44	18
1945–46	14,615	1,522,400	14,010	252	83	196	31
1948–49	16,858	1,632,466	16,119	321	88	257	33
1951–52	18,324	1,816,200	17,417	440	93	298	33

GOVERNMENT AND ADMINISTRATION

Before the Kemalist revolution, a "Turk" was generally taken to mean a Moslem subject of the sultan. In 1924 the meaning was established in article 88 of the organic law as follows:

The people of Turkey, regardless of religion and race, are Turks as regards citizenship.

The organic law, adopted on April 20. 1924, was a concise document showing the influence of U.S., French and British examples. It contained six chapters: (1) fundamental provisions; (2) legislative powers; (3) executive powers; (4) judicial powers; (5) general rights of Turkish citizens and (6) miscellaneous, containing articles relating to the administration and to the conditions for amendment of the constitution itself. Article 2 later underwent important amendments; in 1928 the provision that Islam was the religion of the state was deleted, and in 1937 the six principles of the People's Republican party (at that time the only political party) — republicanism, nationalism, state socialism (*étatisme*), sovereignty of the people, secularism and revolution — were inserted. These were regarded as fundamental principles and were accepted by all parties, though interpretation of them varied. "Nationalism" was not aggressive but looked inward with an educative and humanitarian aim; "state socialism" was designed to build up economy and industry on a Turkish foundation and to encourage social and cultural progress; "revolution," an expression of reaction to the slow and ineffective reforms of Ottoman times, signified the will to reform methodically the life and institutions of the country. Other important modifications to the organic law were the extension of the suffrage to women (1934); the alteration in the system of voting in parliamentary elections from indirect to direct (1946); and the introduction of the secret ballot (1948). Other important provisions were: that sovereignty belongs without restriction to the nation; that the grand national assembly is the sole and real representative of the nation: on whose behalf it exercises the right of sovereignty; that the legislative authority and executive powers are concentrated and manifested in the grand national assembly and that the grand national assembly exercises its executive authority through the person of the president of the republic, elected by it, and through a council of ministers chosen by the president. Under chapter 5 it was laid down that "Every Turk is born free and lives free. Liberty consists of any action which is not detrimental to others . . . All Turks are equal before the lams . . . Personal immunity, freedom of conscience, of thought, of speech and press, the right to travel. to make contracts, to work, to own and dispose of property, to meet and to associate, form part of the rights and liberties of Turkish citizens."

The assembly's term is four years, and it meets annually on November 1 without a summons; it must remain in session for at least six months every year, and the annual budget must be presented at the beginning of the session. The functions of the assembly include: the making, amending, interpreting and abrogation of laws; concluding treaties; declaring war; examining and ratifying laws drafted by the commission on the budget; coining money and accepting all contracts and concessions involving financial responsibility.

The president of the republic is elected by the members of the assembly from their own number for the four years of their own office. He is eligible for re-election. He may preside over the assembly on ceremonial occasions and, if he deems it necessary, over the cabinet. But he may take no part in debates or cast a vote. He is bound to publish laws passed by the assembly within a period of ten days; however, he may return for reconsideration with an explanation of his reasons laws of which he does not approve, except organic and budget lams. The president is the supreme commander of the army, personifying the assembly in which the office is vested. He selects the prime minister from the members of the assembly; other ministers are chosen by the prime minister and presented to the assembly after the president's approval.

Members of the council of ministers are responsible individually and collectively to the assembly for the policy and conduct of the department of state. The prime minister decides the number of ministers (usually 15) in charge of the following departments: justice! national defense, interior, foreign affairs, finance, education, public works, economy, health and social assistance, customs and monopolies, agriculture, communications, commerce, labour and state enterprises. In addition there is a minister of state who is deputy prime minister.

The council of state is both an advisory body and a judicial authority in administrative matters. It is attached to the office of the prime minister. and its members are chosen from prominent citizens with administrative and judicial experience. It may advise on draft laws submitted to it by the government.

The country is divided into 63 provinces (*ils,* formerly *vilayets).* Provinces are divided into districts *(ilces,* formerly *kazas)* and districts into communes *(bucaks,* formerly *nahiyes).* The highest administrative official in each is the *vali,* the *kaymakam* and the *bucak muduru.* The *vali,* who is appointed by the president of the republic on the recommendation of the minister of the interior, is the chief administrative officer of the province, representing all the departments (except those of war and justice) and co-ordinating their work in his province. He corresponds directly with each ministry and has a staff of advisers, who also form an administrative council under his chairmanship. The organization of the district *(ilce)* under the *kaymakam* and of the commune *(bucak)* under the *bucak muduru* follows the same pattern. The commune comprises a number of villages each of which has a headman *(muhtar)* and a council of elders, numbering from 5 to 12, according to the size of the village. A provincial council, elected for four years, debates questions of local administration, and its resolutions have legal effect; the *vali,* who is president of the council, may however refer proposals of which he does not approve to the council of state. In every headquarters town of a province or district and in all other towns of 2,000 inhabitants or more there is a municipality *(belediye).* At the head of the municipality is the mayor *(belediye reisi),* who is assisted by an elected municipal council and a committee composed partly of officials and partly of persons chosen by the council for a year's term of office.

Justice, Police and Gendarmerie. — Under articles 8–54 of the organic law, the courts of justice were made entirely independent of the assembly and the government. The highest court is the court of cassation in Ankara, which has civil, penal, commercial and bankruptcy chambers, each divided into special sections. Each court chamber has its president; the chambers together iorm the quorum of the court of cassation which has its own president and forms the highest court of appeal. Lower courts are: (1) peace courts, (2) courts of first instance, (3) central criminal courts and (4) commercial courts.

The most sweeping of the changes made by the revolution was the abolition oi the religious courts and the Moslem Shari code and the adoption, in 1926, of the Swiss civil code, the Italian penal code and a commercial code based on several European models.

The minister of the interior is responsible for the maintenance of order and the internal security of the country. He exercises his powers through the director-general of security and the general commanding the gendarmerie and, in case of necessity, by calling on the armed forces, although a decision of the council of ministers is necessary before the army can be employed. The police are divided into three groups: administrative (prevention of crime, maintenance of law and order, etc.), in which they are under the orders of the civil authorities; judicial, in which they are under the public prosecutor, and political (*i.e.,* for matters concerning the internal security of the state). In the capital the police are organized under a director-general. In the provinces the police subdivisions are attached to the valis, kaymakams or *mudurs.* A law of 1930 established the gendarmerie as a military force, administratively under the minister of the interior, which reinforces the police mainly in rural districts and is subject to the same local authorities, administrative or judicial. The gendarmerie is formed from men serving with the colours and is primarily a military formation, its training and instruction being supervised by the general staff.

Defense. — From Feb. 1952 Turkey was a full member of NATO. The result was the formation of the southeastern Europe command, the headquarters of which were fixed near Izmir (Smyrna). At the end of 195j it was estimated that Turkey had 427,000 men in the armed forces.

The ground forces, 375,000 in all, were organized into three armies (Istanbul, Izmir and Erzurum), 16 partly motorized infantry divisions, 3 cavalry divisions and 6 armoured brigades (two in each of the three armies). Each armoured brigade comprised 50 M-47 Patton tanks, a battalion of artillery mith 12 pieces (105-mm. and 1jj-mm. howitzers) and a battalion of motorized infantry.

The air force (29,000 strong) was responsible for 12 combat squadrons equipped with U.S. jet aircraft, assigned to the NATO Izmir command. The navy (23,000 strong) included one cruiser ("Yavuz," a modernized German battle cruiser), 10 destroyers and 12 submarines. Military service was compulsory for a period of 24 months.

Social Welfare. — The basic law relating to labour and social insurance was passed in 1936 and regulated conditions of employment (health and safety arrangements, hours of work, etc.) in establishments employing ten or more persons. It also prohibited strikes and lockouts. In 1946 a ministry of labour was established to supervise the laws relating to labour and social insurance; supplementary laws were passed in 1946, 1947 and each year from 1950 to 1954. Of the 300,000 persons covered by the law in 1949 about 74,000 were members of the 83 trade unions. Any trade union representing the majority of workers in an industry could, on the written demand of one-fifth of the total number of workers, initiate collective bargaining with an employer. Any employer wishing to make mass dismissals had to give a month's notice to the ministry of labour.

Insurance measures were introduced in 1946. They applied to all persons covered by the basic law of 1936, and others could be included. Workers and employers each contribute 4% of the wage paid, and men and women receive a pension at the age of 60, from £T400 to £T3,000 annually, according to the piemiums paid. In heavy industries the pensionable age is 55 and premiums are higher. Sickness and maternity benefits were provided under a law of 1951.

Although thought was given to the care of the sick during the middle ages, apparently even the elementary service of those days was allowed to decay, and it was not until the middle of the 19th century that any attempt at reorganization was made. Under the constitution of 1908 some reforms were introduced, but progress was slow and the government of the republic faced a formidable task when it established the ministry of public health and welfare in 1923. At that time there were only 54 hospitals and 30 provincial dispensaries to serve the needs of the whole country. In 1952, however, there were 328 hospitals with 27.366 beds, administered as follows: ministry of health, 96 (15,437 beds); provincial administration, 47 (3,500 beds); municipalities, 1; (2,268 beds); others (including those belonging to foreign organizations, minority communities, charitable associations and private doctors), 80 (5,2jr beds). There were also 90 health centres with 910 beds.

Campaigns against malaria, trachoma and syphilis were vigorously conducted with considerable success. Great efforts were made to reduce the very high infant-mortality rate (120–350 per 1,000 live births in 1918), but the shortage of nurses and midwives made this difficult.

Each province (il) has a director of health services, with doctors in the districts (ilces) and communes (*bucaks*) who not only supervise sanitary conditions but, in the bucaks, are the local medical practitioners, giving free advice and treatment. Each large town has its own municipal health organization. The state-controlled factories, moreover, have their own hospitals and staff.

ECONOMICS

Agriculture. — Agriculture is Turkey's most important industry, providing a livelihood for 75–80% of the population, largely on small farms. For some years the republic spent relatively small sums on the scientific development of agriculture in comparison mith its expenditure on industrial projects, but after World War II great efforts were made in soil conservation, irrigation, cattle breeding, and the improvement of farming methods and transportation facilities. U.S. aid enabled excellent results to be obtained.

Turkey's principal crops were cotton, tobacco, cereals, fruit (fresh and dried), nuts, oilseeds, olives, pulses and vegetables (see Table VIII). Besides grapes and figs (see Table IX), other fruits (*i.e.,* citrus fruit, apples, pears, quinces, peaches, apricots, melons and strawberries) grew in abundance. Only dried fruit (figs and raisins) was exported in quantity in the 1950s.

Olives are grown in western Anatolia and in the south. Although the country ranked fifth among world olive producers in the 1950s, most of the crop was used for domestic consumption. Turkey rose to first place in world production of raisins.

TABLE VIII.—*Principal* Crops: Areas and *Yield, 1934–54*

(In 000s)

Crop*	1934–38		1946–50		1954		1955	
	Area (ha.)	Crop (tons)	Area (ha.)	Crop (tons)	Area (ha.)	Crop (tons)	Area (ha.)	Crop (tons)
Wheat	3,197	3,423	4,206	3,630	6,556	5,010	7,225	7,016
Barley	1,775	1,931	1,806	1,725	2,500	2,400	2,600	2,985
Maize	449	567	j66	6jj	720	914	700	855
Rye	353	338	441	405	613	440	650	650
Oats	229	224	283	257	348	325	370	356
Rice	35	66	24	54	79	110	...	102
Cotton†	249	55	301	95	582	142	...	...
Tobacco‡	56	72	124	78	156	98	156	109
Sugar beet	34	394	4 6	718	70	1,065	98	1,497

*Cereals are grown principally in the central plateau, except maize, grown on the Black sea coast, and rice in the hdana-Iskenderun district and in southeastern Turkey.

†The cultivation of cotton is concentrated in the Aegean and Adana regions.

‡Most of the tobacco is grown in the Aegean district but there are important areas also on the Marmara coast and on the Black sea coast near Samsun

Hazelnuts, walnuts, pistachios, almonds and peanuts were grown, but only the hazelnut was exported in any quantity. Grown on the Black sea coast near Samsun, the yearly exports averaged nearly 30,000 tons. The pistachio crop rose to 10,000 tons in 1954.

The principal kinds of oilseeds grown included sunflower, linseed, cotton, sesame: poppy, peanuts and olives. Excluding the last two, the 1953 crop of oilseeds was aboyt 446,000 tons, of which more than one-half was cottonseed.

Vetches of various kinds came into increased use as fodder in the 1950s. Haricot, broad beans, lentils and chickpeas are plentiful, and potatoes are widely grown. Onions, garlic! leeks, eggplant, artichokes, tomatoes, cabbage, lettuce, cucumbers, carrots and turnips are extensively grown for local consumplion.

Tea growing mas started in 1931 in the Rize district on the Black sea coast. The approximately 7,800 ac. under cultivation in 1949 had grown to 9,500 by 1952. Production in the factory at Rize, a govern-

TABLE IX.—*Dried* Fruit: Tonnage and *Value* Exported*

*No reliable figures of total production were available in the early 1950s. The white seedless grape, *sultaniye*, grows in the valleys in western Anatolia. The best figs are grown in the Aydin district of western Anatolia and near Izmir (Smyrna).

ment monopoly, was 159 tons in 1949; by 1955 tea production amounted to about 700 tons.

Forestry.— The forests of Turkey, according to official statistics published in 1953, occupied about 40,200 sq.mi., or 13.4% of the total area of the country. Forests, however, had been diminishing for many years as a result of neglect, indiscriminate cutting, and destruction by goats. At mid-century a scheme of reafforestation was being carried out by which it was intended to increase the forest area to about 60,000 sq.mi. The principal species are pine and fir (western Anatolia and the Black sea coast), beech (Marmara region, western Anatolia and Black sea coast) cedar (southern coastlands) and oak; valonia oak grows only in western Anatolia. There are fringes of oak scrub on the Black sea, Marmara and Mediterranean coasts.

Livestock and Fisheries.— Except for a few state farms the care and feeding of livestock remained poor in the mid-1950s, and a large proportion of the grazing land (artificial pasture being almost non-existent) was bad. Sheep and goats are the most common stock since they can exist on poor grazing. The sheep are mostly oi the Karaman, fat-tailed variety; there are large numbers of ordinary goats, and the Angora goat, which thrives on dry, elevated plateaus, is bred extensively. Cattle are still largely used as draught animals, the Turkish gray cattle being especially suitable ior this. Crossbreeding with Swiss cattle was tried with some success after World War II. The horses are mainly oi Turkish origin, but breeding irom Hungarian stock was introduced on a small scale; the five government stud farms breed mostly English thoroughbred and Arab race horses. There are many fowl.

In 1952 the government set up the Et ve Ralik Kurumir organization to regulate the meat and fish industry and trade.

TABLE X.—*Livestock*

(In 000s)

	1937* (estimate)	1945* (estimate)	1951	1953	1955
Sheep	21,725	23,386	24,833	27,600	26,808
Goats, ordinary . .	11,050	12,222	16,531	17,000	...
Goats, Angora . .	4,959	4,026	4,370	5,000	...
Hens.	17,666†	17,800	20,300	21,159	...
Cattle	8,766	9,810	10,396	12,000	...
Donkeys. . . .	1,761	1,706	1,823	1,843‡	1,827
Horses . . .	1,058	977	1,173	1,216‡	1,214
Water buffaloes . .	904	848	967	1,013‡	1,171
Camels	119	106	108	96%	...

*No official census was taken before 1948. †1939. ‡1952.

Annual production of wool was about 36,000 metric tons in 1954. Production of mohair (from the Angora goat) amounted to about 7,500 tons; about one-half of this was exported.

Dairying was only a minor industry. Cow's milk was used to some extent in the cities; goat, sheep and water buffalo milk were more common in villages. Large quantities of yogurt and cheese and smaller amounts of butter were made. In 1955 a model dairy farm was established near Istanbul by Turkish and Danish interests.

The main fishing industry is in the Sea of Marmara and the Bosporus, but fishing is carried on in various forms all around the coasts. Bonito, tunny, swordfish, mackerel, herring and sardines constitute the principal catch. The only inland fishing centre is Lake Van though trout, pike, carp, eels and coarse fish are common in inland waters. About one-third of the catch of fish is consumed in the country, the remainder being exported salted, canned, dried or fresh.

Mining.—Turkey's principal minerals are coal, lignite, iron ore, chrome, copper, manganese, lead, zinc and emery, but only coal, lignite, iron and chrome are extensively produced, though important increases in production of copper, manganese and sulfur took place after 1950.

The Petroleum law of 1954 abolished the state monopoly in the exploitation of oil deposits and leading foreign companies began work by the end of the year. First drilling for petroleum took place under government auspices in 1947 at Ramandag in southeast Anatolia. A refinery at Batman. 40 mi. away, started production in 1955; the ultimate capacity was about 300,000 tons a year.

The only bituminous coalfield is around Zonguldak on the Black sea coast, about 150 mi. E. of Istanbul. Although output increased from about 700,000 metric tons in 1924 to nearly 6,000,000 metric tons in 1954 it did not keep pace with the internal demand, and there was no export trade in coal. Deposits of lignite are widespread; it is most abundant in western Turkey. The principal mines worked are at Soma, Degirmisaz and Tuncbilek. Other extensive coalfields, both bituminous and lignite, are known to exist but lack of transport facilities and power prevented their exploitation. Some progress was made possible by Marshall plan aid after World War II.

Industry.— The policy of *étatisme,* or state exploitation, had never necessarily involved 100% control of any particular industry, and "a very free interpretation was practised. Statism begins where private initiative stops." (A. Bonné, Stale *and Economics in* the *Middle* East, see Bibliography.) The Sumer bank was created in 1933 to take over some existing industries and to establish and administer new ones. It became responsible for some or all of the factories making cotton and woolen textiles, artificial fibres, iron and steel, paper and cellulose, cement and firebricks, and leather, shoes and glue. The Eti bank was founded in 1935 to exploit mineral resources and develop and control electrical power. Tobacco and cigarettes, alcohol and alcoholic drinks, matches and salt became state monopolies, but the manufacture of beer and w-ine and the import oi whisky and champagne were freed in 1955. Much of the beet sugar industry was developed by the state. Industrial development was slowed down during World War II, but the prospect of foreign credits and U.S. aid made possible large-scale plans ior development afterward. At the same time. the government adopted a more liberal policy toward private enterprise and foreign capital, particularly after 1950. The Industrial Development bank to help private enterprise was iounded in 1950 with the participation of private individuals, banks, the government, the International Bank ior Reconstruction and Developmect, and Marshall plan counterpart funds. In 1951 and 1954 further encouragement was given to foreign capital investment. (See Table XI.)

Textiles.—The principal cotton products in 1955 were cabot, white sheetings, prints. low-grade shirtings and cambrics. The "cottage industry" produced rough cotton fabrics on hand looms. In 1955 there were about 1,000,000 spindles and 19,000 looms. In addition to five woolen mills owned by the Sumer bank there were nearly 40 privately owned mills, some of them very small. There was a total of 199,000 spindles and 2,610 looms in 1955. There mas also a rayon factory producing about 450 tons annually. The long-established silk-weaving industry at Bursa was entirely in private hands. Production in 1948 was 200 tons of yarn and 1,500,000 m. of silk fabric.

Iron and Steel.—The iron and steel works at Karabuk were formerly operated on behalf of the Sumer bank. The iron ore was brought by rail from Diurigi, formerly an Eti bank enterprise (600 mi. away), and coal from Zonguldak. Plans to double the output were considered in the mid-1950s and a site ior a second iron and steel plant was sought. A new company to take over the whole industry was formed in 1955.

A sulphuric acid plant, installed at Karabuk by a German firm during World War II, produced about 11,000 tons of acid in 1949. The raw material is imported.

Paper.—The paper industry controlled until 1955 by the Sumer bank. centred at that time around two paper mills at Izmit, with yearly capacities of about 11,000 and 12,000 tons. In 1955 plans were made for the construction of a third mill at Izmit; all three mills were to be a part of the newly established Turkish Cellulose and Paper Factories enterprise. The Aegean Paper industry at Izmir, a joint effort of Turkish and U.S. investors, was also established in 1955.

Cement.—In 1949 six iactories produced 375,000 tons. Rapid expansion took place in the following years and in 1954 a Cement Industries company financed by private and government capital planned the building of additional plants which were expected to have a total capacity of 2,500,000 tons by 1958.

Sugar.—Before 1951 four factories controlled by the Sugar Monopoly organization, met domestic needs. Between 1950 and 1954 seven new factories were built. The total capacity of refined sugar was raised to 375,000 tons in 1956.

Tobacco.—In 1955 production was estimated at 22,010,000,000 cigarettes and 2,402 tons of processed tobacco. Tobacco and tobacco products were among Turkey's leading exports in value.

Electric Power.— Expansion of electric power capacity, both thermal and hydroelectric, was planned in the 1950s; it was designed to give 3,000,000,000 kw.hr. Production was 312,000,000 kw.hr. in 1938 and 1,452,200,000 kw.hr. in 1955. In 1953 industry used 64.3% of the output, and domestic customers 14.6%. Per capita consumption of electric power rose from 22 kw hr. in 1940 to 54 kw.hr. in 1953.

TABLE XI.—*Industrial Production*

(In 000s of metric tons)

Year	1938	1945	9 4	1951	1954	1955
Pig iron . . .	13*	70	100	153	196	201
Steel . . .	38†	64	102	135	169	188
Coke . . .	85	336	396	432	636	672‡
Cement . . .	287	298	345	396	707	816
Paper . . .	9	14	18	23	38	47
Cotton yarn . .	19		29	30	23%	26§
Cotton fabrics .	16		20	21	132§‖	146§‖
Wool yarn . .	4	7	8	8	10	4§‖
Wool fabrics . .	3	6	6	5	4§‖	5§‖
Sugar (refined) .	43	90	118	186	186	...

*1939. †1940. ‡Estimate. $Government establishments only. !.I?millions of metres.

Communications.—*Railways.*—Before the constitution of the republic, Turkey was badly served by railways, nearly all of v hich were owned by foreign companies; their total length was 2,536 mi. The republican government put in hand a program of extensions which added 1,238 mi. in its first ten years. By the end of 1949 517 mi of line had been transferred to the state by conventions and treaties, 2,000 mi. had been bought from foreign companies and 2.250 mi. had been constructed by the government since 1923, bringing the total length of lines to 4,767 mi. During World War II the rate of construction had been slowed down because of rising costs and difficulties in the supply of materials. In 1947 a plan was worked out under which it was intended to add a iurther 1,435 mi. to the system by 1965. Between 1945 and 1954 rail traffic increased from 51,000,000 to 62,000,000 passengers, and from 7,000,000 tons to 11,000,000 tons of freight. Some diesel-electric units were imported, and locomotives were converted from coal to oil burning for use in eastern Turkey.

The directorate-general of the Turkish state railways (Devlet *Demir Yollari*), iormerly operated under the general control of the ministry of communications, became a state corporation in 1953. The office of railroads and ports, a division of the ministry oi public works, oversaw technical planning and construction.

Roads.—In 1923 the roads, surfaced and unsuriaced, amounted to only 8,073 mi. During the next 15 years an average of £T7,300,000 a year was spent on building and reconstruction. By 1935 the total length had almost been doubled, and in 1939 a comprehensive program was announced under which 19,872 mi. of modern roads were to be built in ten years at a cost of £T120,000,000. World War II put a stop to this work, and development was slow until, in 1948, an agreement was signed between the American Mission for Aid to Turkey and the ministry of public works, in which a nine-year program for the construction, reconstruction and improvement of a national highway system of 13,437 mi of all-weather roads was announced. The length of stabilized roads was increased from 9,578 to 16,875 mi. in 1950–54.

Ports and Shipping.—The railway administration was made responsible for the maintenance and exploitation of the terminal ports of Haydarpasa (Istanbul), Derince, Iskenderun (Alexandretta). Mersin, Samsun, Alsancak (Smyrna), part of the quays at Sirkeci (Istanbul) and the quays at Bandirma and Edrcmit. Istanbul, which handles 30% of Turkey's foreign trade, suffered from congestion. Improvements to it and extensive works at Samsun, Mersin Alsancak (Izmir) and Iskanderun were in progress in the mid-1950s.

In 1951 the state shipping lines were converted into a corporation under the Maritime Bank (*Denizcilik* Bankasi) but in 1955 this administration was superseded by an independent organization, the *Denizcilik Nakliyat* to manage a fleet of 30 passenger and cargo ships. The total commercial fleet, including vessels in private ownership, amounted in gross tonnage to 553,900 tons (passenger vessels. 110,500 tons) in 1955. There were also state-owned ferryboats and auxiliary craft.

Civil Aviation.—The state airlines operated an extensive network of internal services in the mid-1950s with services to Athens and Cairo also. The main civil airports were at Istanbul and Ankara. Civil air agreements were concluded by Turkey with the United States, Sweden, France, Italy, Denmark, Czechoslovakia, Greece, the Netherlands, Great Britain, Iraq, Brazil, Iran. Egypt. Israel and Yugoslavia.

Posts, Telegraphs and *Telephones.*—The republican administration claimed that the number of post and telegraph offices in Turkey increased from 688 to 2,216 by 1954. Work on the expansion of telephone and telegraph interurban services was begun in 1947, and a wide-scale training program to fit the staff to cope with new technical problems was initiated. In 1934 broadcasting was taken over by the government from a semiofficial body, its supervision being vested in the director-general of the press, publication, broadcasting and tourism. Three transmitting stations were operating in 195j, Radio Ankara, the main station on 1,648 m., 19.79 m., 16.48 m., 31.7 m. and 19.7 m., with 120 kw.; Radio Istanbul, on 428 m. and two short-wave transmissions. with 150 kw.; and Radio Izmir, a regional station of low power, on 45.53 m. Programs in Urdu, Serbian, Arabic. Persian, German, Bulgarian, Greek, Rumanian, Polish, French and English were being broadcast from Ankara. Receivers registered in Turkey numbered 990,000 in 1955, compared with 38.428 in 1938. The cost of broadcasting was met entirely from a grant out of the budget allocation for the director-general of the press.

Finance.—Continuous adverse trade balances caused the value of the Turkish pound (LT or TL.) to depreciate between 1923 and 1930, when the £ sterling reached the value oi £T11.00. Action by the Turkish government brought the rate to £T10.30, at which it remained until Great Britain went off the gold standard in Sept. 1931. From that date the Turkish pound was kept pegged to the French iranc at 12.06 ir. per £T1. In 1936 the iranc was devalued, and the Central bank, which had started operations in *1931*, maintained the old gold parity and exchange rates so that the pound sterling equalled £T5.20. This. however, was only a theoretical rate. as exports enjoyed a premium and imports suffered a surcharge. This situation was regulated in 1946. when the Turkish currency was devalued. When sterling was devalued in 1949, the old rate with the dollar mas retained. (Sea Table XII.)

Reduction in imports and competitive buying by the belligerents during World War II resulted in a considerable rise in Turkey's gold reserves and foreign-exchange assets betu-een 1939 and 1945. But when manufactured goods became more easily available and exports were artificially restricted, these balances were rapidly dissipated. The Marshall plan aid came to Turkey's rescue (1948), and further sub-

TABLE XII.—*Exchange* Rates of the Turkish Pound
(In £T, official)

	1930	1931	1936	1938	1945	1946	1947	1949 (Sept.)	1956
£ sterling=	10.32	10.24	6.25	6.16	5.28	5.28	11.29	7.90	7.84
Dollar=	2.12	2.11	1.26	1.26	1.31	1.31	2.80	2.80	2.80

stantial assistance was given under the European Recovery plan, as well as both financial and technical help from the U.S. under the auspices of the Economic Cooperation administration.

The state budget and those of the para-statal bodies (state railways, steamship lines, etc.), and of the state-owned mining and industrial enterprises may be said to interlock in so much as some are subsidized or subsidize others. The final accounts of state finances showed deficits in all except two years between 1936 and 1950–51; with the exception of the Monopolies administration (tobacco and alcoholic liquors), deficits were also shown by the state-owned undertakings. The monopolies' profits could be regarded as the equivalent of excise duties in other countries. The financing of deficits was difficult since there was no organized capital market and the public became unwilling to subscribe to internal loans. In 1951, when 37% of the revenue was derived from direct taxes and 56.7% irom indirect taxes, the government promised to 'do its best to improve the state of affairs. The reformed income tax laws that came into force in 1950 had, moreover, failed to provide the expected amount of revenue because, it was believed, of evasion and ialse returns. (See Table XIII.)

Table XIV shows the more important departments' expenditures.

TABLE XIII.—*Budgets, 1948–1956*
(In 000,000s of £T)

	1948	1950–51	1952–53	1953–54	1954–55*	1955–56†	1956–57†
Revenue	1,494.7	1,448.8	2,360.4	1,955.8	2,381.4	3,091.3	3,362.8
Expenditure	1,431.7	1,508.5	2,231.3	2,126.5	2,381.3	3,091.3	3,362.8

*Approved budget. †Draft budget.
Source: Ministry of Finance, Ankara.

TABLE XIV.—*Main* Expenditures*
(In 000s of £T)

	1947	1949	1951	1953	1955
Health	42,185	51,600	68,164	117,263	149,672
Education	132,093	204,234	209,298	269,051	425,950
Social security	79,023	95,296	147,899	173,984	202,547
Defense	422,919	535,932	529,776	635,000	810,721
Economic development	177,171	252,607	361,718	568,186	862,515
General administration	227,620	218,613	231,098	315,968	505,418
Public debt	121,059	83,625	105,165	126,473	135,391

*Totals of current and investment expenditures.
Source: Ministry of Finance, Ankara, *Memorandum on the Budget Bill for Fiscal Year, 1955*.

The Ottoman public debt, which had been contracted to meet the serious financial situation during the latter half of the 19th century, was administered by an international council until Turkey entered World War I in *1914*; payments under existing arrangements then ceased. By the treaty oi Lausanne (1923) part oi the indebtedness was transferred to the territories then detached from the Ottoman empire. Turkey remained responsible for a sum of £T84,590,000. Agreements with the bondholders were revised in Turkey's favour in 1928, 1933 and 1936, and the Turkish government assumed the liabilities and took over the management of the debt in 1940.

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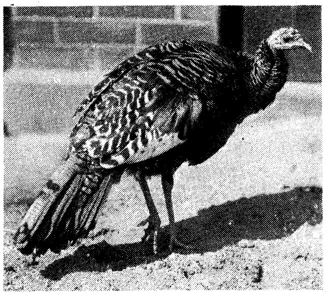
W SUSCHITZKY

FIG. 1.—DOMESTICATED NORTH AMERICAN TURKEY (MELEAGRIS GALLOPAVO)

TURKEY. Either of two species of gallinaceous (chicken-like) birds that, along with chickens, peafowl, pheasants, guinea fowl, quail, megapodes, curassows and guans, comprise the order Galliformes. Within this order the turkeys form the family Meleagrididae.

One species is *Meleagris* gallopavo, the North American turkey, which originally was native to the southwestern, midwestern and eastern United States, southern Ontario, Can., and nearly all of Mexico. This species is the source of all domesticated turkeys which are now found in almost all countries of the world.

The other living species is the ocellated turkey, *Meleagris ocellata* (or *Agriocharis ocellata*), of the tropical lowlands that make up the Yucatán peninsula of Mexico and adjacent parts of Guatemala and British Honduras. No subspecies of *ocellata* are knonn. The ocellated turkey is one of the most colourful of birds, displaying iridescent green, gold and reddish-copper bronzing over nings and back, with a purplish-blue ocellus (eyelike spot) in the tips of the gray-and-black-penciled main tail feathers and tail coverts. Males and females look alike and neither has a beard or breast tuft. *Ocellata*'s maximum weight is reported to be 18 lb. It has not been domesticated.



BY COURTESY OF NEW YORK ZOOLOGICAL SOCIETY

FIG. 2.—OCELLATED TURKEY (OCHARIS OCELLATA)

Turkey males are called toms or gobblers, the females are called hens and the young turkeys are called poults. The sparsely feathered head and upper neck of males are heavily caruncutated and are bright red, changeable to white overlaid with bright blue. The females are less heavily caruncutated and lack the blue colour. There is a single large throat wattle, or dewlap, in both sexes and a single fleshy head appendage, the snood. The beard is a tuft of coarse, black, hairlike feather structures in the centre of the crop region of all males and a few females of the North American species.

Wild Turkeys.—The North American wild turkey has produced seven distinct subspecies. The most widespread subspecies was the turkey of the Pilgrims, the Eastern wild turkey, *Meleagris* gallopavo *silvestris*, which became the U.S. symbol of Thanksgiving. This turkey originally ranged the United States and Canada south and east of a line extending approximately from Portland, Me., through Mitchell, S.D., and south to Houston, Tex., excepting southern Florida. The Florida wild turkey inhabited the lower three-fourths of that state. The Rio Grande turkey lived in south central Texas and northeastern Mexico. The Merriam turkey inhabited the mountains of Arizona, New Mexico, southern Colorado, southwestern Texas and north central Mexico. The Central Mexican, or Gould's, turkey ranged the mountains of central Mexico. The South Mexican turkey, *Meleagris gallopavo gallopavo*, was native to the mountains of southern Mexico from Michoacán through Oaxaca. Moore's turkey has been discovered on the western slopes of the Sierra Madre mountains of northwestern Mexico at elevations of 2,500 to 8,500 ft.

All these subspecies intergraded with each other where their ranges adjoined, and all have the same general colour pattern but differ from each other in details of plumage colour. The basic colour is black with red-green surface iridescence, copper-coloured bronzing on wings and tail, and black-and-white barred wing feathers. The lower body and tail feathers of both sexes and the breast feathers of females have chestnut-brown tips in the Eastern and Florida turkeys, cinnamon to buff tips in the Rio Grande and Merriam turkeys and almost-white to white tips in the three Mexican subspecies.

The North American turkey still exists in the wild state over most of its original Mexican range. In the United States it is found in varying numbers in about 21 states, including all those south of the Ohio river, as well as Pennsylvania, Maryland, Illinois, Missouri: Arkansas, Louisiana, Oklahoma. Texas, Colorado, New Mexico and Arizona. In certain states wild turkeys may be hunted legally.

Wild turkeys subsist on nuts. seeds, grasses, legumes, roots, tubers, leaf buds, fruits and insects along with occasional small amphibians, crustaceans and mollusks. They roost high in trees, preferably evergreens. When alarmed they may fly as far as a mile and at speeds estimated to be as high as 55 mi. per hour. The males, both wild and domesticated, practise gobbling and strutting, mostly during the breeding season, to attract the hens. Turkeys are polygynous but harems of more than six hens are rare in the wild state. The females build nests on the ground and their brown-speckled eggs are incubated for 23 days.

Domesticated **Turkeys.**—Turkeys had been domesticated by the Aztec Indians of southern Mexico prior to the European discovery and were taked to Spain about 1519. From Spain the stocks spread throughout Europe, reaching England about 1541. Some of these European turkeys were taken to North America by the early colonists and served as foundation stock, along nith the native wild turkeys, in the development of the six long-established standard varieties of the United States—Bronze. Narragansett, White Holland, Bourbon Red. Black and Slate.

Up to about 1935 turkeys were bred mainly for perfection of plumage colour, and some exquisitely beautiful exhibition strains were produced in the U.S. Emphasis then changed to meat qualities and some exceptionally well-meated strains. were produced. Large. heavily fleshed Bronze turkeys of Englis origin aided in this development.

These new strains! called Broad Breasted Bronze, dominated the turkey inarket in the U.S. and Canada by 1913'. Adult males of this variety commonly weigh 50 lb., or, rarely, up to 65 lb. The Beltsville Small White, a small broad-breasted turkey developed by the U.S. department of agriculture, became popular in the U.S. and was made a seventh standard variety in 1951. State experiment stations and private breeders developed a number of large. broad-breasted white strains. These strains rapidly achieved popularity until by the late 1950s about 18,000.000 were raised annually in the United States, compared to 48,000,000 large Broad Breasted Bronze. 15,000,000 Beltsville Small Whites and possibly 1,000,000 of all other varieties and crosses.

The turkey industry of the United States produced a gross annual income as high as $356,000,000 during the 1950s. The Canadian turkey industry is of sizable proportions; those of Mexico, Argentina! Brazil, most European countries and Australia are smaller but of measurable economic importance.

See also POULTRY AND GAME PREPARATION ; POULTRY AND POULTRY FARMING.

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TURKIC LANGUAGES are considered to be related to the Mongolian and Tungusic languages in what is known as the Altaic group. In fact the links between the Turkic and other so-called Altaic languages are somewhat tenuous. Taken by themselves. the Turkic languages present a remarkable uniformity and interresemblance, only Chuvash and Yakut being strongly aberrant. They have changed little from the language in the earliest extant Turkish inscriptions, those found near the Orkhon river in the Mongolian People's republic and the Yenisei river in the U.S.S.R., which date from the 8th century A.D.

Classification.—The Turkic languages may be classified according to either the historical-geographic or the phonetic data. The former system, being the most generally accepted, is given below:

1. Old *Turkish:* The Turkish of the Orkhon and Yenisei inscriptions ; Uigur.

2. *Middle Turkish*: (a) *Western Group*: Kuman. Kipchak; (b) *Eastern Group:* Kara-khanid, Khwarezmian, Chagatai.

3. *Modern Turkish: a. Southwestern* (*Turkmen*) *Group:* (1) Pre-Ottoman. Ottoman, the Turkish of modern Turkey, Ottoman dialects of Anatolia and the Ealkans. Crimean Ottoman, Gagauz Turkish (of Rumania), Turkish dialects of Bulgaria, Bosnia and

Macedonia, and Chuvash; (2) Azeri (Azerbaijani), spoken in the Azerbaijan Soviet Socialist republic (S.S.R.), and in northwestern Iran; (3) Kashgai, Ainalu and Baharlu, spoken in southern Iran; (4) Turkmen, used in the Turkmen S.S.R. and extending into the Kara-Kalpak Autonomous Soviet Socialist republic (A.S.S.R.), the Uzbek S.S.R., Kazakh S.S.R., Iran and Afghanistan. Small groups of Turkmen are also found in Anatolia, Syria and Transcaucasia.

b. Southeastern (Ckagatai or Uzbek) Group: Eastern Turkistan (Turki) dialects are spoken in the Sinkiang Uigur Autonomous region; various dialects of Uzbek are used in the Uzbek S.S.R., the southern part of the Kara-Kalpak A.S.S.R., in the eastern part of the Turkmen S.S.R., in the northern and western parts of the Tajik S.S.R. and in the southern part of the Kazakh S.S.R. as well as in northern Afghanistan; the Chagatai literary language also belongs to this group.

c. Northwestern (Kipchak) Group: (1) Kirghiz, which is used in the Kirghiz S.S.R., overlaps into Chinese territory and is also found in Afghanistan, is, of all the languages of this group, most similar to Oirot and Teleut of the northeastern group and with them may form a subgroup linking the northeastern and northwestern groups; (2) Kazakh is used in the Kazakh S.S.R., in the Kara-Kalpak A.S.S.R. and to some extent within the Mongolian People's republic; (3) Kara-Kalpak, which is hardly more than a Kazakh dialect, is used in the Kara-Kalpak A.S.S.R., and also by the Kara-Kalpaks living in Afghanistan; (4) Nogai is spoken in three dialects—White Nogai, which is used in the Karachai-Cherkess Autonomous oblast (A.O.) and differs markedly from the other two, and Black Nogai and Central Nogai, which are used in the Dagestan A.S.S.R.; (5) Kumyk is also spoken in the Dagestan A.S.S.R.; (6) Bashkir is used in the Bashkir A.S.S.R.; (7) the Volga Tatar dialects such as Kazan Tatar are spoken in the Tatar A.S.S.R. and a number of other languages are used by Tatar elements in the Urals, Tobol and Irtysh river areas.

d. *Northeastern (Uigur) Group:* (1) Tuva (Uryankhai), spoken in the former Tannu Tuva republic (now Tuva A.O.), and Karagass, spoken on the northern slope of the Sayan mountains (the language of the Orkhon and Yenisei inscriptions and the old Kirghiz language are also sometimes placed in this group); (2) the languages and dialects spoken in the Abakan and Yüz steppes (most of them in the Khakass A.O.), and also Sarig Uigur (Sari Yogur) spoken in China; (3) the language spoken in the Baraba steppe and the languages spoken in the northern Altai and in the Altai proper, chiefly in the Gorno-Altai A.O., *i.e.,* Altai proper (now called Oirot), Teleut, Teleng, Tölös, Yakut. Further research is still required on the grouping of these languages.

Turkish is the primary language of approximately 60,000,000 people, of whom 25,000,000 are in the Republic of Turkey. 19,000,000 in the Soviet Gnion, 8,000,000 in China and 8,000,000 in Iran and Afghanistan.

Characteristics. — Phonetics. — The outstanding phonetic characteristic of the Turkic languages is vowel harmony. The vowels are of two kinds — "front vowels," produced at the front of the mouth (e, i, o and *ü*), and "back vowels," spoken from the back of the mouth (a, *ı* [like the *i* in the English "hit"], o and u). Purely Turkish words can contain only front or back vowels and all suffixes and infixes must conform to the vowel of the syllable preceding them in the word. Thus, ev "house:" evler "houses," *evlerim* "my houses," evlerime "to my houses"; but at "horse," atlar "horses," atlarzm "my horses," *atlarıma* "to my horses." The principle of vowel harmony has to some extent broken down in a few Turkic languages, notably in certain dialects of Uzbek, and it is usually not applied to foreign words incorporated into Turkish.

Although in their old form Turkic languages probably had both long and short vowels, long vowels are now rarely found except in loanwords from such languages as Arabic and Persian. Only Turkmen and Yakut have to a great extent preserved the original length of vowel sounds.

There are certain changes of consonants which are peculiar to Turkic languages; some consonants change when they are followed by a vowel. In particular, *p, ç* ("ch"), t and k change to b, c ("j"), d and **g** (*e.g.,* varlik to *varliği*). Certain consonants change by what is known as progressive assimilation when they follow certain other consonants. Thus in the Turkish of modern Turkey the past tense of gelmek ("to come") is geldi, but that of gitmek ("to go") is gitti. Initial 1 and r are not found in purely Turkic words.

Morphology and Syntax. — The morphology and syntax of the Turkic languages are governed by agglutination. *i* e., the expression of grammatical concepts by suffixes and infixes which themselves have no intrinsic meaning, rather than by independent words. Since the plural is expressed by a special suffix, case endings are not affected by number. The result is a remarkable regularity and facility of analysis. For example, the word *evlerimde* ("in my houses") is composed of: *ev* "house," ler = plural suffix, *im* = possessive suffix of first person singular and de = locative suffix "in." Attached to a word with back voweling, *e.g.,* oda "room," these suffixes change their vowels according to the law of vowel harmony to odalarzmda ("in my rooms").

The syntax of Turkic languages, although logical and regular in itself, presents many difficulties to the English-speaking student. This is due principally to the absence of any relative pronoun and a great wealth of participles and verbal nouns. Thus the sentence "I know that the person who had come went away" is rendered in Uzbek: Kelgan *kishining* ketganini *bilaman* (literally "Having-come person's having-gone-his know I").

Of the various parts of speech which present peculiar features, the Turkic verb deserves special mention:

1. One or more infixes may be inserted between the verbal stem and the grammatical suffix to indicate passivity, causation, reciprocity, negativity and impossibility. So the word *sevmek* ("to love") can be enlarged to *sevdirilememek* ("to be impossible to be caused to love"), with *-dir-* showing causation, *-il-* passivity, *-e* + me- negative possibility and *-mek* the infinitive suffix.

2. All Turkic languages have an unusually large number of tenses and combinations of tenses to express fine shades of meaning. However, future tenses hardly exist or are used at all except in the Turkish of modern Turkey.

3. In a sentence containing a series of verbs in the same tense and time, differing only in their stems, the requisite verbal suffixes are affixed only to the final verb in the series, while to the other stems the abbreviating suffix (*-ip* in the Turkish of Turkey) is affixed in their place. So *gelip, görüp, gittim* ("I came, I saw, I went") are written, instead of *geldim, gördüm, gittim.*

4. A characteristic of many Turkic languages, though only traces are found in the Turkish of Turkey, is the expression of a verbal concept by two or more successive verbs. Thus the concept "to bring" is expressed in Uzbek by two verbs meaning "having taken, come" (alib kel), but in the Turkish of Turkey by a single word.

Writing and Literary Languages. — The Orkhon and Yenisei inscriptions of the 8th century were written in the Turkic runic script, according to the description of Vilhelm Thomsen, who deciphered it in 1893. This is thought to have been derived from the Aramaic alphabet through the old Sogdian alphabet. It was eventually replaced by the Uigur script derived from one of the northern Semitic alphabets through Sogdian. This in turn was largely replaced by the Arabic alphabet in the 9th and 10th centuries, although it was used until the 15th century by the Golden Horde and by the Timurids for writing the Kipchak and Chagatai languages.

The Arabic script was generally used by all Turkic peoples writing Turkic languages until 1924, when a Latin script was introduced in Soviet Azerbaijan. After 1928 this Latin script was extended to most of the other Turkic languages in the U.S.S.R. in a modified form known as the unified Turkic Latin alphabet. But after 1939 it was replaced by modified forms of the Cyrillic alphabet. A different Latin script was officially adopted in Turkey after 1928, so since that time the Arabic script has not been officially used by any Turkic people.

Distinct Turkic literary languages did not begin to develop until the 14th and 15th centuries. The most important was Ottoman Turkish, which developed from the literary language of the Seljuk period and included heavy accretions of Arabic and Persian uords. It persisted in upper-class Ottoman society until it was gradually supplanted by the Turkish of modern Turkey in the 20th century. Second in importance was Chagatai, ahich had its origin in the literary language in the domains oi Chagatai, the second son of Genghis Khan, during the 13th century. It persisted from the 15th century until the emirate of Bukhara was incorporated into the U.S.S.R. in 1920, when it was replaced by the Uzbek literary language.

Of the other literary Turkic languages current in Russia before the Revolution the most important were Turkmen, Azeri and Crimean and Kazan Tatar, all of which used the Arabic script A limited amount of writing was done in Kazakh, Kirghiz and a few other languages, mostly in the Arabic script. After the Revolution about 18 literary languages were developed for most of the Turkic languages spoken in the U.S.S.R.

Outside Turkey and the U.S.S.R. a certain amount of writing in the Arabic script is done by Turkic communities such as those in Iranian Azerbaijan and the Sinkiang Uigur A.O. The Cypriot Turks use the Latin script of Turkey.

Linguistic Policies. — The people of the Turkish republic and the Soviet Union were subjected to official linguistic policies whose widely varying object, nature and scope tended to produce different results.

The Turkish policy, initiated by Mustafa Kemal Atatiirk in 1928, aimed at modernizing the language by adapting a Latin script and by replacing words of foreign origin—chiefly Arabic and Persian—with words of Turkish origin or at least formed according to the principles of Turkic morphology. This policy was only partially successful and the more familiar Arab and Persian words remain in use, especially for official administrative terms and abstract concepts. On the other hand the Soviet adoption of the Cyrillic script after 1939 was aimed at the cultural separation of the Soviet Turkic peoples from those of Turkey. It was designed to facilitate the introduction of Russian loanwords and to promote the study of Russian in order to assimilate the Turkic peoples into the Russian community. Whereas in Turkey the tendency was to draw on pre-Ottoman words to express new and particularly political concepts, the Soviet authorities preferred to draw on Russian. Thus; for the Arabic word *inkilap* ("revolution") an attempt was made in Turkey to substitute *devirme* ("a turning round"), while in the U.S.S.R. it was replaced by *revolyutsiya*. In addition to reforms of alphabets and vocabularies both Turkish and Soviet policy aimed at modification of syntax and phonetics, the former toward a simplified Turkish purged of Arabic and Persian accretions, the latter toward the Russian systems. *See* also TURKISH *LANGUAGE.*

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(S. J. S.)

TURKISH LANGUAGE. By this term is generally understood the language of modern Turkey, the offspring of Ottoman Turkish. With the tongues of Azerbaijan and Turkmenistan, it forms the southwestern or Turkmen group of the Turkic family.

Morphology. — It is an agglutinating language, adding suffixes to invariable roots to make words which may be the equivalent of a whole English phrase or sentence. Thus *parasızlıklarından,* "because of their poverty," is composed of: *para,* "money"; *-sız,* "-less"; *-lık,* "-ness"; *-ları,* "their"; *-n-dan,* "from."

A peculiarity of Turkish is a lack of grammatical gender even more complete than in English: the same pronoun *o* does duty for "he," "she" and "it."

The noun has five case endings: a definite accusative, a genitive, dative, ablative and locative; *e.g., deniz-i gördük,* "we saw the sea"; *deniz-in,* "of the sea"; *deniz-e,* "to the sea"; *deniz-de,* "on/in the sea"; *deniz-den,* "from the sea." The plural suffix *-ler/-lar* precedes these endings.

The verb has a present, an aorist, a future and two past tenses, one for facts and one for hearsay. Thus from *yapmak,* "to do": *yapıyor,* "he is doing"; *yapar,* "he does"; *yapacak,* "he will do"; *yaptz,* "he did/has done"; *yapmış,* "he is said to have done." The simple past *yaptz* has a special set of personal endings which it shares with the conditional mood; the other tenses are compounded by adding the present of the verb "to be" to the tense base, which is identical with the third-person forms given above. Additional tenses are formed with the past tense of the verb "to be." Thus *yapar* means "habitually doing." and this, with the addition of *-ız,* "we are." or *-dık,* "we were." gives respectively *yaparzz,* "we do," and *yapardık,* "we used to do."

Negative. passive, reflexive. reciprocal. causative, potential and necessitative suffixes may be added to the verb stem: *gel-me-di,* "he did not come"; *yap-zl-dz,* "it was done"; *yıka-n-dım,* "I washed myself"; *sev-iş-irler,* "they love one another"; *sev-dir-dim,* "I caused to love"; *gel-ebil-irsiniz,* "you can come"; *gel-meli-siniz,* "you ought to come."

The cardinal numbers are as follows: 1 *bir,* 2 *iki,* 3 *üç,* 4 *dört,* 5 *beş,* 6 *altz,* 7 *yedi,* 8 *sekiz,* 9 *dokuz,* 10 *on,* 11 *on bir,* 19 *on dokuz,* 20 *yirmi,* 30 *otuz,* 40 *kırk,* 50 *elli,* 60 *altmış,* 70 *yetmiy,* 80 *seksen,* 90 *doksan,* 100 *yuz,* 1000 *bin.*

Phonology. — Turkish is written in a Latin-based alphabet, whose letters have much the same values as in English, with these differences: *c* is pronounced like English *j; ç* like *ch; ğ* lengthens a preceding vowel; *j* is pronounced as in French; *ş* is pronounced like English *sh.* Undotted *ı* is like *i* in "Cyril"; *o* and *u* are pronounced as in German; the remaining vowels as in Italian.

Of fundamental ımportance in Turkish phonology is the vowel harmony based on the distinction between the back vowels *a, ı, o, u* and the front vowels *e, i, o, ü.* As a rule, all the vowels of a word belong to the same class: *sargz,* "bandage"; *sergi,* "exhibition"; *dolu,* "full"; *köprü,* bridge; *kolay,* "easy"; *borek,* "pastry." The vowels of suffixes vary according to the class of the root. Thus 1st, *birinci;* 3rd, *üçüncü;* 9th, *dokuzuncu;* 40th, *kırkıncı.*

Apart from this phonetic variation, the language has a regularity which at first sight seems almost artificial. this impression is heightened when we learn that the verb "to be" is anomalous and that there is one lone irregular noun.

Syntax. — The chief syntactical feature is the use of nouns as qualifiers, by adding the possessive suffix of the third person to the qualified word. *Türkiye Cumhuriyet-i* ("Turkey Republic-its"), "Turkish Republic"; *hava yollar-ı* ("air ways-its"), "airways."

The main part of a statement comes at the end of the sentence, preceded by ıts modifiers and qualifiers. English prepositions are represented in Turkish by postpositions. Thus *İngiltere konsolosluğuna yakzn otelde oturan arkadaşımız dun evimize geldi,* literally "England consulate-its-to near hotel-in living friend-our yesterday house-our-to came," means "Our friend who lives in the hotel near the British Consulate came to our house yesterday."

History. — From the time of the wholesale conversion of the Turks to Islam in the 10th century, their language was subjected to invasion by a stream of Arabic words, not only religious and ethical terms but also the whole vocabulary of Arab science and civilization. In the 12th century, when Persian became the literary language of western Asia, a second invasion began. Turkish writers felt themselves free to draw on Arabic and Persian and also to employ grammatical constructions peculiar to these languages. The imposition of vast numbers of Semitic and Indo-European nords on the basic Turkish stock resulted in Ottoman Turkish, a language as hybrid as the culture which gave it birth, but expressive, flexible and possessed of a rare majesty. It was, however, a purely administrative and literary language, used by fewer than one in ten of the population.

The beginnings of Turkish journalism, just after the middle of the 19th century, led to a simplification of the written language, and this trend was accelerated in the second decade of the 20th century by the nationalist and Pan-Turkish policies.

Cnder the republic. it became almost a matter of dogma that the language should be purged of alien elements. The first casualty in the ensuing campaign was the alphabet. The Arabic script, which had been adopted by the Turks at the time of their conversion to Islam, distinguishes only three vowels. Turkish has eight.

The consonants of the two languages are also dissimilar. In 1928 the Arabic alphabet was replaced by the Latin letters described above. Despite certain shortcomings, this new alphabet, which is now in full use, is far better suited to express the sounds of Turkish.

In 1932 Mustafa Kemal founded a Turkish Linguistic society, whose chief purpose was to find genuine Turkish substitutes for every single Arabic and Persian word in the language. The application of this principle often led the society to absurd lengths. We might sympathize with an English purist who urged us to say "beginning" instead of "commencement," but we should certainly balk at having to say "wapentake" instead of "constituency"; analogous suggestions by the Turkish language reformers cost them much popular support. They modified their policy and stopped advocating the abandonment of well-established words of foreign origin.

The Democratic party, which came to power in 1950, withdrew governmental support from the language-reform movement. But all the years of nationalist propaganda, the increase in literacy and the great expansion of popular journalism had left their mark on the written language. Arabic and Persian grammatical constructions had been almost entirely eliminated and there was a growing disinclination to use Arabic or Persian words for which Turkish synonyms exist. On the other hand, the westernization of Turkish life was subjecting the language to a third foreign invasion: the literary man who makes an adaptation of a work scorns to describe it by the Arabic term *iktibas*, preferring to call it an *adaptasyon*.

The attempt to reform by decree had been abandoned; further development depended on the good taste of the people using Turkish.

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TURKISH LITERATURE. Three main periods can be discerned in the history of Turkish literature: first, the period before the conversion of the Turks to Islam, covering approximately the 8th to 11th centuries A.D.; secondly, the period of Islamic culture, extending from the 11th to the mid-19th century; and thirdly, the modern period, dating from the accession of Sultan Abdul Mejid in 1839, in which the influence of western thought and literature, following the reforms of that reign, became predominant.

THE PRE-ISLAMIC PERIOD

The oldest literary legacy of the pre-Islamic period is to be found in the Orkhon inscriptions (*q.v.*) in northern Mongolia, carved in 735 in the Turkish runic alphabet on two large stones, in memory of the Turkish prince Kiil (d. 731) and his brother King Bilge (d. 734). They relate in epic and forceful language the origins of the Turks, the golden age of their history, their subjugation by the Chinese and their liberation by Bilge Kagan. Their polished style suggests considerable earlier development of the language (see D. Ross, "Orkhon Inscriptions," Bulletin of the School of Oriental and African Studies, 1929). Excavations carried out in Chinese Turkistan have brought to light important specimens of writings of the Uigur Turks from the 9th to the 11th centuries. Mahmud Kashgari's comprehensive dictionary (1071) contains specimens of old Turkish poetry in the typical form of quatrains (*dörtlük*), representing all the principal genres, epic, pastoral, didactic, lyric and elegiac. They echo vividly the life and customs of the people, contrasting with the later, Persian-inspired, stylized and mannered poetry (see C. Brockelmann, "Alttiirkestanische Volkspoesie," Asia Major, i and ii, 1924).

THE ISLAMIC PERIOD

With the conversion to Islam, the Turks gradually adopted Arabo-Persian poetical metres and literary traditions. The first known work of Islamic Turkish literature is Kutadgu *Bilig* ("Knowledge That Gives Happiness"; 1069) by Yusuf Has Hacib, chamberlain to the sultan of Kashgar. An allegorical poem of more than 6,000 couplets on the art of government, it consists of a series of conversations between the prince, the vizier, his son and a friend, who symbolize justice, good fortune, reason and contentment. Many traditions of pre-Islamic Turkish poetry survive in this work.

Later in this period Turkish literature divided into three branches according to the three main dialects: Chagatai, Azeri and Anatolian or Ottoman.

Chagatai.—This, the literary language of the eastern Turks, was used mainly in central Asia by the Golden Horde (*q.v.*), in Egypt and in the Indian courts of the Mogul period. Lacking a political and literary centre, it was influenced by local spoken dialects. Alishir Nevai (*q.v.*), the Mogul emperor Baber (d. 1530) and Ebulgazi Bahadur Han (d. 1663), the author of *Shecere-i Türk* ("Genealogy of the Turks") are three of the great classical writers of this dialect. Baber's memoirs, the Babur-nama describing his adventurous life in a vivid and colourful style, are the masterpiece of eastern Turkish prose (see A. S. Beveridge, The *Babur-nama*, Eng. trans., 2 vol., 1922).

Azeri.—This, the literary dialect of eastern Oguz (a term denoting the Turks in western Persia, Iraq and eastern Anatolia before the Ottoman conquest) is very similar to Anatolian Turkish. Nesimi is its first outstanding representative. An enthusiastic mystic, he was executed for heresy (*c.* 1420). His poems have rare beauty and profound religious feeling.

Shah Ismail (d. 1524), founder of the Safawid dynasty of Persia and known by his pseudonym, Hatai, had a lasting influence on popular religious literature in Anatolia. His poems, a blend of religious emotion and political propaganda, preach the Shi'ite doctrine. Fuzuli (*q.v.*), the greatest representative of the classical school, influenced Azeri and Ottoman poets of all succeeding generations. Azeri has also bequeathed to posterity the *Oguzname* ("The Legend of Oguz Kagan"), the only surviving example of the old Turkish epic. It relates the conquests and exploits of the legendary Turkish king Oguz and his sons. Another important Azeri work which contains elements of the old Turkish epic is the *Kitab-i* Dede Qorqut. This consists of 12 epic tales named after the sage who appears in each. They have only a superficial trace of Islamic culture and relate the life and battles of the Oguz Turkish tribes in northeastern Anatolia during the 13th and 14th centuries. The repetition of certain rhyming or alliterative word sequences suggests that parts of old poems have been incorporated into the tales. Slightly altered versions of some of the tales still live on in modern Turkish folklore.

Anatolian **or** Ottoman. — This was the language of the Anatolian Seljuks and of the Ottoman empire after the 13th century.

Preclassical Period. — In this period, which spans the 14th and 15th centuries, the influence of the Persian classics was paramount. They provided the inspiration for Turkish lyrics and romances, and Turkish poets strove to adapt their language to the Arabo-Persian metrical system, However, the most prominent figure of the period is Yunus Emre (*q.v.*), a great mystic poet and saint, who wrote in simple language, using the traditional syllabic metre. Sultan Veled (d. 1312) also wrote in a simple style. Other representative figures of the period are Ashik Pasha (d. 1332), author of the mystic and didactic poem Garibname, and Ahmed Dai, whose narrative poem Chenkname discovered in recent times is most original.

Ahmedi (d. 1413), a court poet, wrote several romances in verse and a vast epic on the life of Alexander the Great, containing the earliest known chronicle of the Ottoman empire. Sheyhi (d. 1428) continued the work of Ahmedi, assimilating with greater inspiration Persian poetic forms. He wrote a romance, *Hüsrev ü Shirin*, and the famous humorous satire Harname. Suleyman Chelebi (*q.v.*) composed the popular verse panegyric on Mohammed, Mevlid, a masterpiece of religious literature.

The prose of this period is mainly represented by translations of religious or popular stories and semiepic accounts of battles.

The Classical Period. — From the middle of the 15th century onward, with the establishment of the Turks in Istanbul, the golden age of Turkish letters began. The Persian classics were no longer mechanically imitated, but fully assimilated, and this enabled Turkish poets to evolve a genuine classical poetry which bore the imprint of their own individuality. A price had to be paid, however, for this assimilation of Persian poetic forms. The Turkish language lost some of its purity by accepting a large number of Persian and Arabic words and constructions. A result of this was that Turkish literature was restricted to a small educated class and was largely isolated from the mass of the people. Outstanding poets of this period include Ahmed Pasha (d. *c.* 1497) who improved the technique of classical Turkish prosody; Necati (d. 1509), a more inspired poet and author of lyrics and elegies written in a refined and original style, which greatly influenced later poets; Zati (d 1546). author of the poem *Shem ü Pervane;* Tashlicali Yahya (d. 1573) who wrote a romance, *Yusuf ve* Zulehya, the story of Joseph and Potiphar's wife, and a famous elegy on Prince Mustafa, the son of Suleiman the Magnificent; Ruhi of Baghdad (d. 1605), remembered especially for his famous Terkib-i bend, a sarcastic satire on bigotry, hypocrites and flatterers; Fuzuli (*q.v.*); and Baki, known as the "king of poets."

In the 17th century Yahya, the sheikh ul Islam, with his gay and polished lyrics, forms a link between Baki and Nedim. Nef'i (*q.v.*) and Naili (d. 1668) were both influenced by the "Indian school" of Persian literature. Naili, with his delicate style and fresh and colourful images tinged with melancholy, introduced a new note into the hackneyed poetry of the established tradition. The refined and flowing verse of Nabi (d. 1712), very popular in his time, echoes eastern wisdom and has a stronger appeal to the intellect than to the emotions.

The prose of the classical period shows great variety with folk tales; half-religious, half-epic narratives; belles-lettres written in a rather heavy and artificial style; and particularly the work of the chroniclers, who were also masters of Turkish classical prose. The chronicles of Ashikpashazade (d. 1485) and Neshri have an epic character and are written in simple Turkish. Ibn Kemal (d 1535) and Hoca Sadeddin (*q.v.*) wrote in a flowery style. Other chroniclers of this period were Mustafa Ali (d. 1606), also author of many treatises; Pechevi (d. 1650), who is particularly interesting when he relates events he himself witnessed; Katib Chelebi (*q.v.*); Silahdar (d. 1723); and Mustafa Naima (*q.v.*), greatest of all Turkish historians. These all wrote in a comparatively straightforward style, free from the mannerisms of official documents. The same can be said of the style of the Seyahatname written by the great traveler Evliya Chelebi (*q.v.*) and of Kochi Bey's famous reports to Murad IV and to Ibrahim recommending reforms for the empire.

The Postclassical Period.—The 18th century witnessed a refreshing revival of classical poetry. During the first half of the century, Nedim (*q.v.*) sang in colourful, vivacious and gay poems of the Tulip age of Istanbul under Ahmed III. In the second half of the century Galib Dede (*q.v.*), the last of the great classical authors, wrote the original mystic romance *Hüsu ü Ashk.*

Prose, on the other hand, was in decline. After Naima, most prose writers gradually moved away from natural, spontaneous narrative and adopted a pompous and flowery style.

Folk Literature.—Apart from the poets of the learned classes there were a number of folk poets. The greatest of these was the 17th-century minstrel Karacaoglan who told of the life of the people in simple language in the old syllabic metre.

THE MODERN PERIOD

The Impact **of** the West.—In the 19th century the introduction of western reforms into Turkish life generally had its effect on literature. Mainly under French influence, pioneers like Shinasi (1826–71). his disciple Ziya Pasha (1825–80), Namik Kemal (*q.v.*) and Abdulhak Hamid (*q.v.*) began, from the middle of the century, to adopt and adapt western literary art forms, such as the novel. the drama and the essay, nhile the rigid forms and attitudes of classical poetry gradually went out of fashion.

About the end of the century, the novelist Halid Ziya (*q.v.*) and the poet Tevfik Fikret (*q.v.*), together with their friends, founded a literary school associated with the name of the periodical *Servetifünün.* They were more western in technique and conception than their predecessors, but they indulged in an overloaded and precious style. These mannerisms were eschewed by the novelist Huseyin Rahmi (*q.v.*) and the essayist Ahmet Rasim (1864–1932), who described Istanbul life at the turn of the century with power and realism. The same reaction in favour of simplicity and realism is to be seen in the poetry of Mehmed Emin (1869–1944) and of Riza Tevfik (1868–1949). After the revolution of 1908 the younger generation of writers, headed by the symbolist Ahmed Hashim (d. 1933), grouped themselves into the short-lived *Fecr-i* Ati ("Dawn of the Future") literary school.

Independent Trends.—At this time the neoclassicist Yahya Kemal (*q.v.*) began to exercise great influence upon the younger generation, while the popular Pan-Islamist poet Mehmed Akif (1873–1936) remained an independent figure. Author of the Turkish national anthem, Akif achieved a mastery of classical prosody while using mainly the everyday Turkish idiom. A fervent Moslem, he wrote mainly didactic poetry but reaches the heights of lyricism when he is inspired by great religious or national events.

Nationalist Literature.—The *Türk Yurdu* ("Turkish Hearth") movement? based on the review of that name which became the official organ of the Young Turks, and the sustained striving of the Salonica periodical *Gench Kalemler* ("Young Pens") for simplified language were followed by the evolution of a distinctively Turkish literature largely under the leadership of Ziya Gokalp (*q.v.*), who sought to base literature on the ideals and aspirations of Turkish nationalism and to give it inspiration by a study of the Turkish past. Writers looked for new subjects in the country and its people. The outstanding prose writers of this period are Fuad Köprülü (*q.v.*), who wrote on Turkish literary history and folklore; Omer Seyfeddin (1884–1920), language reformer and author of popular short stories; Yakup Kadri (*q.v.*); Halide Edib (*q.v.*); Refik Halid Karay (1888–). whose novels and short stories gave the first realistic glimpses of life in Anatolia; Falih Rifki Atay (1894–), a brilliant journalist and essayist; and Reshat Nuri Guntekin (*q.v.*), popular novelist and language reformer.

In poetry, Faruk Nafiz Chamlibel, whose unsophisticated, romantic poems on emotional and patriotic themes made him the most popular poet of the 1920s, Necib Fazil Kisakurek (1903–), a modern mystic, and a host of others wrote in the Turkish syllabic metre.

Literature Under the **Republic.**—Nazim Hikmet Ran (*q.v.*) introduced free verse and "unorthodox" poetry in the early 1920s, but his influence only began to be felt in the late 1930s. Poets who, without ignoring the conventions, also enriched Turkish poetry were A. H. Tanpinar (1901–) who, mainly concerned with form, achieved unusual musical effects in syllabic metre by his choice of words and delicate imagery; A. M. Dranas; and C. S. Taranci (1910–56) who, writing in a warm and flowing style, dwelt on the themes of human sorrow and melancholy.

Orhan Veli Kanik (*q.v.*) pioneered the new school of poetry, reintroducing free verse and widening the range of theme. Such was his influence that most poets of his generation adopted his language and technique. The greatest name, however, in 20th-century Turkish poetry is Fazil Hüsnü Daglarca (1912–), whose books have given a continuous revelation of his versatile poetic genius. His lyrics and epics express his unquiet spirit in a delicate, fresh and original style.

The outstanding prose genre of the republican period is the short story, developed as never before in Turkish literature. Themes vary, but the emphasis is on social problems. the life of simple people, workers and peasants, although there are also subjective, autobiographical, psychological and descriptive types of story. In the early 1930s Sebahattin Ali (1907–49) drew superficially realistic sketches of Anatolian peasant life, but it was Sait Faik (*q.v.*), a poet by nature, who pioneered the ne school in the short story, widening its scope and using slang and dialect.

Although of the preceding generation it was not until the 1940s that Abdulhak Shinasi Hisar (1888–) produced his best work. His stories recall the early days of the century. In the late 1940s most prose writers turned to the novel, a genre which had been long neglected. The life and problenis of the peasantry and small townsmen were successfully treated in both short stories and novels by Samim Rocagoz, Kemal Bilbashar and especially by

Orhan Kemal (1914–) and Kemal Tahir (1908–). Other leading modern writers include Haldun Taner, Salah Binsel, Sabahattin Batu, Nezihe Merich and Mahmut Makal (1930–) whose Bizim Koy, a powerful sketch of a central Anatolian village, made a sensation when it appeared in 1949. In Ince Memed (1956), another outstanding novel, Yashar Kemal Gokcheli (1922–) tells the story of a landowner's cruelty and its results.

Nurallah Atach (1898–1957), the language reformer, was the outstanding literary critic of his day. His flair for discovering talent launched many young poets and writers on their careers.

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TURKISTAN (TURKESTAN), a name that has been conventionally employed to designate the regions of central Asia lying between Siberia on the north and Tibet, India and Afghanistan on the south, the western limit being the Caspian sea and the eastern limit Mongolia and the Gobi desert. Etymologically the term was intended to indicate the regions inhabited by Turkic peoples; however, the regions called Turkistan not only contained peoples who were not Turkic but excluded some who were; *e.g.,* the Turks of the former Ottoman empire. What was formerly commonly called Eastern (Chinese) Turkistan became mainly the southern portion of the Chinese province of Sinkiang (*q.v.;* see also TARIM); the former Western (Russian) Turkistan was included in the soviet socialist republics of Uzbekistan, Turkmenistan, Kazakhstan, Kirghizia (Kirghizstan) and Tajikistan (*qq.v.*). See also ASIA: Ethnology; TURKS OR TURKIC PEOPLES.

TURKMENISTAN. A soviet republic of west-central Asia, which in 1924 was separated from the former Russian Turkistan. It is bounded on the west by the Caspian sea, on the north and northeast by Uzbekistan, on the southeast by Afghanistan and on the south by Iran.

Physical Geography. — Turkmenistan consists largely of desert plains and low plateaus rising southward to the Kopet Dagh. The Ust Urt plateau projects into the republic in the north as an area of semiarid tablelands, containing some sandy and alkalifloored depressions, and giving way southward to the Kara Kum (Black Sands) desert. The latter area of vast desert lowlands comprises perhaps 90% of Turkmenistan. Of the several rivers which descend into the Kara Kum from the south, only the Amu Darya maintains sufficient volume to traverse the desert.

The shrinking Caspian sea, its surface 86 ft. below open sea level, bears witness to the region's aridity. The Gulf of Kara-Bogaz-Gol acts like a great evaporating pan, 30 ft. deep. drawing water from the Caspian to further concentrate its salts so that sodium sulfate, gypsum and sodium chloride may be extracted industrially. During the Pleistocene Age the Caspian and Aral seas were connected at a level *c.* 245 ft. above that of the present Caspian, and their waves cut widespread benches at this height. A system of disused channels links the lower Amu Darya and the Caspian. Just north of Khiva oasis, the Kunya Darya runs westward into the Sarykamysh basin and still occasionally carries flood water from the Amu to feed lakes in the basin. Only when the Aral sea stood about 12 ft. above its present level could its waters have joined the Caspian through the lowest gaps in the rim of the Sarykamysh basin. As the level of the Caspian progressively diminished, such water cut the Uzboi channel (now dry) for more than 800 mi. to the Balkhan gulf.

Extensive areas of the Kara Kum are covered with sand derived from the alluvium of former and present rivers. A good deal of it is fixed by vegetation. L. S. Berg described the various forms taken by the sand: crescentic *barkhans* up to 30 ft. high; the more stable "mound sands" of compacted sand bearing an appreciable cover of plants; the "ridged sands," possibly "fossilized" Pleistocene dunes, lying in elongated parallel north-south ridges. 80 yd. apart and up to more than 60 ft. high and separated by *takyrs,* troughs of clay and saline deposits; and the sandy plains, generally held by vegetation, which cover large areas east of the Murgab (Murghab) river in the south. Southward Kara Kum merges into a loess-covered piedmont plain 300–400 ft. above sea level, across which flow many small mountain streams which have built up alluvial fans along the mountain front. Only the Tedzhen and Murgab push any distance out into the desert.

Finally, forming the frontier with Iran and Afghanistan, the Kopet Dagh range belongs to the Alpine-Himalayan structural system. Within the republic the Kopet Dagh attains more than 9,650 ft., yet the Turkmenian slopes are so dry that only minor streams descend from it. Toward the Caspian the range is lower and more broken, ending possibly in the isolated Little Balkhan. The structures of the Great Balkhan (5,600 ft.) appear to be due to an earlier (Mesozoic) phase of mountain building.

Apart from the Kara-Bogaz-Gol salts, most of the useful minerals of the republic are found in the south. Petroleum in the region of Nebit Dagh, Vyshka and the Cheleken peninsula is the most important. Others include ozocerite, barites, witherite and bentonite, all in the Caspian coastal belt, and copper and salt in the eastern corner of the republic.

Turkmenistan has a continental desert climate. Winters are cold in the north (January mean 25° F.) to cool in the south (35°), but summers are very hot (July mean 90°) in the south and practically cloudless. In the lowland the rainfall amounts to only 4–8 in., while even on the most favourable mountain slopes the total is but 16 in. A spring maximum is the rule.

Natural vegetation is limited to drought-resisting types. Everywhere the spring rains produce a short-lived cover of grass and herbs. The semidesert vegetation of the Ust Urt differs only in density from that of the Kara Kum. In both there are plants that can tolerate the various saline areas; *e.g.,* boyalych shrubs (*Salsola* arbuscula), biyurgun (Anabasis salsa j, various Artemisia and black saxaul. More sandy areas bear plants adapted to a shifting soil and which can find moisture at depth; *e.g., juz-gun* (*Calligonum*) and white saxaul. Climbing into the foothills a thicker cover of desert sedges gives place to dry grass steppes. Pistachio thickets are found southwest of the Tedzhen. River courses, notably the Amu Darya, are lined by saline meadows and tugay jungle, including poplars, willow, tamarisk and Russian olive. The fauna include many species adapted to a sandy environment: lizards, jerboas, etc. Wild ass and antelope are becoming rare! but the tugay forests still contain Turkistan tigers. (B. L. C. J.)

History. — The Turkmens or Turkomans arrived in Transcaspia in the 11th century, as Seljuk Turks. They were, in fact, not eastern but western Turks, separated from the main stem geographically but not linguistically. Since they had always lived as nomads, they did not form a state. They often became subject to one of the neighbouring states, Persia, Khiva or Bukhara, but this dependence was limited to only a few oasis cities of the area. Like their forefathers who had built the Turkish state in Anatolia, they are good warriors, as the Russians discovered in the second half of the 19th century when they had decided to annex the land of the Turkmens to the governor-generalship of Turkistan. To conquer Kokand; Bukhara and Khiva the Russians had to start their progress from the north, because the western approach was barred by the desert of Kara Kum and by the Turkmens. Advancing from Krasnovodsk, the Russians took Kyzyl Arvat in 1877 and two years later stormed the Turkmen fortress of Geok Tepe but suffered a defeat. Lt. Gen. M. D. Skobelev took Geok Tepe on Jan. 24, 1881, No quarter was given, and about 8,000 persons were slaughtered.

After the Russian victory, Ashkhabad was occupied three days later and in March the leaders of the Turkmen *ulus* ('(tribes") declared their submission. Merv (Mary) was occupied without fighting on March 18, 1884, and the Transcaspian province (*oblast*) of Russian Turkistan was formed.

During World War I, when the tsarist government tried to conscript the Turkmen for auxiliary services, they revolted in Oct. 1916 under the leadership of Aziz Chapykov. Two years later, when a Turkish army under Nuri Pasha, coming to the help of Azerbaijan, captured Baku from the Red army, the British sent a small force to Turkmenistan and for a time Merv was occupied by a detachment under Gen. Sir Wilfrid Malleson. This was not meant to be an intervention in Russian affairs, but an operation to prevent a German-Turkish thrust in the direction of Afghanistan and India. By the end of 1920 the Red army occupied the Transcaspian province.

In the summer of 1919 a Bureau of Turkistan Moslem Communist Organizations, or Musburo for short, was formed in Moscow. It expressed the opinion that the Uzbeks. Kazaks. Kirghiz and Turkmens, as well as the Bashkirs, Tatars and other Turkic peoples of Russia, were members of one Turkish nation and should form one republic within a Soviet federation. The Moscow council of people's commissars was cautious enough not to agree to that, but also not to reject such a wish too abruptly. A Turkistan Autonomous Soviet Socialist Republic was formed within the Russian federation, but J. V. Stalin, the people's commissar of nationalities, started preparing the partition of Turkistan into five republics, allegedly according to the principle of nationalities. He did not want a single Turkish nation within the U.S.S.R. According to him, the crux of the matter was that the Turkic peoples had no industrial proletariat. Speaking to the 12th congress of the All-Union Communist party (April 23, 1923), Stalin said that conditions now existed enabling these peoples to establish. with the aid of the Russian proletariat, their own centres of industry. The master plan was to prepare a massive interpenetration of the Turkic peoples through industrialization.

On Oct. 27, 1924, Turkmenistan became a Soviet Socialist republic and on Jan. 29, 1925. it was accepted as a member of the U.S.S.R. The Musburo was disbanded in 1934. In Turkmenistan, as in other Turkic-speaking republics, the vigilant Russian political police discovered many "bourgeois nationalists," such as N. Aitakov, chairman of the supreme soviet of the Turkmen S.S.R., who was shot in 1937.

PRINCIPAL CITIES AND RAILWAYS OF TURKMENISTAN

Population.—The area of Turkmenistan, according to official Soviet sources?is 188,417 sq.mi. Between 1926 and 1939 its population increased from 998.154 to 1,253,985, and in 1959 it was 1.520.000. There were 811,769 Turkmens in the U.S.S.R. in 1939. and 1,004.000 in 1959. In Turkmenistan proper there were an estimated 762.300 (61%) in 1939 and 924,000 (61%) in 1959. The percentage of Russians during that period was 18%. The progress of industrialization was apparent in that the percentage of urban population, 13.7% in 1926, had risen to 33.2% in 1939 and to 46% in 1959.

The population of Ashkhabad, the capital, rose from 51.593 to 126,580, and that of Chardzhou from 13.950 to 54,739. In 1959 the population of Ashkhabad was 170.000. In 1959 Merv had a population of 48,000 and Krasnovodsk of 50.000. The Turkmens are Sunni Moslems. (See TURKS OR TURKIC PEOPLES,)

Education.—While before World War I about 99% of Turkmens were illiterate: by 1953 there mere 1,226 schools with 218,500 pupils: including 30 secondary vocational schools and 6 institutions of higher education with a total of 13,000 students. Journals and books are printed in Turkoman as opposed to the literary Turkish language. Between 1925 and 1928 the Arabic script was replaced by a Latin alphabet, not only in Turkmenistan but also in other Turkic-speaking republics. The idea of this reform was to isolate the Turkic-speaking peoples of the U.S.S.R. from the cultural influences of Turkey which was still using the Arabic script. But in 1928 Mustafa Kemal Atatiirk introduced the Latin script in Turkey and Moscow was faced with the potential danger of a cultural unity of all Turkic-speaking peoples. To build a new barrier, the Soviet government decided that a new "alphabetic revolution" was necessary. In 1938 the compulsory teaching of Russian in all non-Russian schools was introduced, and in 1939–40 the Cyrillic alphabet replaced the Latin in all Turkish-speaking areas. In Turkmenistan this created a barrier between the Russian Turkmens and those of Iran (c. 400,000 in Khurasan), but this was considered in Moscow a lesser evil.

Economy. — Before World War I Turkmenistan was a typical land of nomadic herdsmen. By the mid-20th century nomadism had been replaced by a settled way of life. Cotton growing and an oil industry were developed. In 1934 there were 138.800 head of cattle in the republic, 721,200 sheep and goats and 54,200 horses; *i.e.,* about one-quarter of the livestock there had been in 1914. By 1942 the livestock figures were 260,100 head of cattle, 2,213,300 sheep and goats, 56,500 horses, 133,100 mules and asses and 74,900 camels.

The area under cotton in the Murgab and Tedzhen valleys was increased between 1925 and 1945 from 151,000 ac. to 264,000 ac.; *i.e.,* from 25% to 31% of all arable land. Production of unginned cotton increased during this period from 44,730 metric tons to 171,600 tons, which was about 7% of the total Soviet production. The main ginning plants were at Chardzhou and Tashauz.

Petroleum was discovered in the country before World War I and the 1913 output was 129.500 metric tons; by 1941 the output amounted to 690,300 tons, and in 1953 to 3,255,000 tons. After Baku, the Bashkir, Tatar and Kuibyshev areas Turkmenistan was by the mid-20th century fifth in importance among the oil-producing areas of the U.S.S.R.

Soviet planners had given much attention to irrigation works in Turkistan in general and in Turkmenistan in particular. On Sept. 11, 1950, the decision was taken to construct the Great Turkmenian canal across the Kara Kum desert. linking the lower Amu Darya to the Caspian sea. The canal was to be 684 mi. long, and it was to irrigate nearly 3,200,000 ac. When completed it would permit the transport of cotton and other raw materials from Uzbekistan and Turkmenistan to central Russia and of grain and industrial goods in the reverse direction. This project would have restored in a modern setting the situation which existed until the mid-16th century, when the Amu Darya flowed into the Caspian. It was not known if construction of this canal was ever begun. but if so, the work was abandoned in 1953 and thereafter the Soviet press kept silent about the project.

See UZBEKISTAN: Bibliography. (K. SM.)

TURKOMAN (TURKMEN), the name of a people belonging to the southwestern or Oguz branch of the Turkic linguistic group. They live for the most part in Soviet Turkmen S.S.R. and in neighbouring parts of Soviet Central Asia (Kazakhstan and Uzbekistan). A large body live in Iran, especially in the north and in northeast and northwestern Afghanistan. Small pockets of Turkomans are found in northern Iraq and Syria. Larger groups live in central Anatolia, Turkey. The Turkomans speak a Turkic language most closely related to the Turkish of Turkey, Azerbaijani, Crimean Tatar, the Turkic dialects of the Balkans and Kashgai of Iran.

The territory of the Turkomans is almost. invariably arid. ranging from dry steppe to semidesert to desert. Turkmenistan proper is one of the most arid places in the world. Agriculture is possible only under conditions of intensive irrigation and artificial fertilization of the soil. The Turkomans were by tradition a nomadic pastoral people, an economic type well adapted to the arid conditions of their habitat, and lived in tent villages which were not fixed in one place. They raised sheep. goats, horses, camels. asses and cattle. Their nomadism was an annual round of movement from winter camp to summer pasture, and in the spring out onto the desert to give the herds and flocks access to the ephemeral desert plants. Most of their terrain is waterless;

most of their lakes are salt or brackish. With the help of irrigation and fertilization, the Turkomans of the Soviet Union have taken up agriculture; their stock-breeding is no longer nomadic but is based upon a fixed-village and permanent-dwelling pattern. The Turkomans of the countries outside the Soviet Union continue their traditional nomadic pastoral life. An important adjunct to the Turkoman economy is their manufacture of rugs.

The social organization of the Turkomans is heavily patiilineal. Genealogies, marriage, family life and inheritance of tangibles are based primarily upon the principles of descent in the male line and agnatic kinship. Turkomans live in extended families composed of parents, all unmarried children and families of the married sons. The rule of residence on marriage is patrilocality. Family authority is vested in the father and is patriarchal.

The traditional Turkoman social structures, larger than the extended family, were the kin village, composed of families related in the male line; lineages and clans, likewise based upon agnatic kinship; and confederations. the largest of the units of traditional organization. There were five chief divisions of the Turkomans. The most senior of these was a division composed of the Salor-Sarik-Teke-Yomud-Emrili lines; the most senior of this division was the Salor line. The pastoral and nomadic Turkomans reckoned seniority on the basis of primogeniture. and order of birth of the ancestors. Their descendants were ranked in their descent lines. The second of the great divisions, like the first. held itself to be the direct descendants of the Oguz Turks. The other three divisions held a subordinate position. These were the old non-Oguz Turkomans (Kokhurli. Ananli and others), the recent non-Oguz Turkomans (Ali-eli, Khizr and others', and Turkomanized Arabs (Ata. Khodja. Said and others).

Although most of the Central Asian Turks, such as the Kazakhs and Uzbeks, were divided into a noble stratum and a common stratum, the Turkomans had no such division. On the other hand, the Turkomans have a division according to economic function. The Yomud Turkomans. of the senior division, were divided into an agricultural group whom they called *Chomur,* and a pastoral group. whom they called *Clzorva.* The *Clzorva* were the prestige group, just as herding was, and is, the prestige occupation. *Chomurs* aspired to become pastoral *Clzorva;* and conversely *Chorvas,* becoming impoverished, became *Chomurs.* The cleavage between the two groups was functional and could be crossed. At the head of each division was a khan. This mode of organization exists no longer in the Soviet Union, but continues elsewhere.

The Turkomans are Moslem, of the Sunni sect, but, like most Turkic nomads, are not as deeply influenced by Islam as are the sedentary Turks. The majority live in the Soviet Union! where they numbered 1,004,000 in 1959. The number of Turkomans in the world is roughly estimated to be about 1,500,000.

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TURKS AND CAICOS ISLANDS, a group in the West Indies, are geographically a part of the Bahamas but politically a British colony. The area is 169 sq.mi. Pop. (mostly Negro) (1943) 6,138; (1960) 5,716.

The Turks Islands, so named from a local cactus resembling a Turkish fez, are eight in number, but only two, Grand Turk (9.4 sq.mi.; pop. 2,346) and Salt cay (4 sq.mi.; pop. 441) are regularly inhabited. These two and Cockburn harbour on South Caicos are ports of entry. The Caicos group, northwest of the Turks, includes six principal islands. South Caicos and North Caicos being the most important. The mean temperature is 82° F., but because of the prevailing trades the climate is not oppressive. Rainfall averages only $29\frac{3}{4}$ in. annually and drinking water is scarce, being rationed at times. Hurricanes are not infrequent. An unusually violent one in 1945 caused great damage.

Salt raking is the staple industry. with an average annual export of 43,000 tons, about half from South Caicos. Conchs and crayfish are also exported. Grand Turk, the seat of government, is an important cable junction. with cables to Jamaica. Bermuda and Barbados. There is frequent shipping and air service to Kingston, Jamaica. The islands were discovered by Juan Ponce de Leon in 1512 but were uninhabited until 1678, nhen Bermudians arrived and began the salt-raking industry. They were expelled by the Spanish in 1710 but soon returned, remaining despite Spanish and French attacks. In 1799 the islands were given representation in the Bahamas assembly, but in 1848, on petition from the inhabitants, they were placed under Jamaica as a separate colony. In 1873 they were annexed by Jamaica. In 1960 the group became a separate colony of Great Britain. A small U.S. air base was maintained on South Caicos from 1944 to 1947 and a guided missile base on Grand Turk after 1952. (L. W. BE.)

TURKS OR TURKIC PEOPLES. The terms Turkic peoples and Turks have no clearly defined racial significance. They can be properly applied, however, to those communities historically and linguistically connected with the 'Iu-Kiu, the name given by the Chinese to the nomad people who in the 6th century A.D. founded an empire stretching from Mongolia and the northern frontier of China to the Black sea. Some authorities consider that the name Hiungnu, which appears in Chinese sources as far back as 2000 B.C., also referred to the Turks; but it was probably a generic term applied to Turkic, Mongol and perhaps Tungus peoples.

With some individual exceptions. notably in the European part of Turkey and the Volga region, the peoples corresponding to the foregoing definition are confined to Asia. They may be divided into two main groups, the western and the eastern. The former includes the Turkic peoples of Europe and those of western Asia inhabiting the Asiatic part of Turkey and the northwest of Iran (Persia). The eastern group comprises the peoples of the Soviet republics of Kazakstan (Kazakhstan). Turkmenistan, Uzbekistan and Kirghizia (*qq.v.*), the Altai region, the Yakuts and other scattered elements of eastern Siberia and of the Chinese province of Sinkiang. Linguistically the Turkmens are connected with the western group.

HISTORY

Nothing definite is yet known about the origin of the Turks and much of their history even up to the Mongol conquests is shrouded in obscurity. In its Chinese form of Tu-Kiu the word "Turk" first appeared in history in the 6th century as applied to the founders of the empire referred to above. This empire consisted of two parts founded by two brothers and known to the Chinese as the northern and western Turks. It submitted to the nominal suzerainty of the Chinese T'ang dynasty in the 7th century, but the northern Turks regained their independence in 682 and retained it until 744. It is to this empire that the Orkhon inscriptions, the oldest-known Turkic records, relate. These inscriptions refer to the Oguz which was apparently the name of a confederation of Turkic tribes, to the Uigur as inhabitants of the basin of the Selenga river in Mongolia and to the Kirghiz as living on the Yenisei river. In 745 the Uigur established themselves as the rulers of Mongolia. Driven out of Mongolia by the Kirghiz in 840, they founded two kingdoms, one in Kansu and the other in Bishbalik and Karakhoja (in what is now eastern Sinkiang), the latter persisting until the Mongol period. The Kirghiz were the last Turkic-rulers of Mongolia. They were driven out in 924 and established themselves first in the Upper Yenisei and later in the region now called Kirghizia.

In 699 the western Turks passed under the domination of the northern Turks but later freed themselves. At the end of the 7th century they became involved in the Arab conquest of Transoxiana, which during the next three centuries became part of the realm of the Persian Abbasid and Samanid dynasties. In 999 Bukhara and Samarkand, and the country stretching as far as the Amu Darya, again came under Turkic rule.

At the beginning of the 11th century there were two great Turkish migrations which were profoundly to affect the later history of the Turkic peoples. Before these migrations two Turkic peoples. who appear to have early separated from the bulk of the Turks, were active south and east of the Urals. The first were the Khazars who in the 7th century established an empire which stretched to the Caucasus and later to the Crimea. They were finally destroyed by the Kievan Rus (*see* RUSSIA) at the beginning of the 10th century. The second were the Pechenegs whose earliest-known habitat was in the Ural-Volga area. Toward the end of the 9th century they controlled the region embracing Bessarabia and Moldavia to the eastern Carpathians. They were overrun by the Oguz or Guzz in 1065 and had been virtually extinguished by the Byzantines by the beginning of the 12th century. The first great migration was of the Oguz from north of the Syr Darya. One branch, the Khalji, advanced into Afghanistan and were the forerunners of the Ghilzai tribe which ultimately founded a dynasty in India. Another branch was that of the Seljuks who by the end of the 11th century controlled an empire stretching from the Amu Darya to the Persian gulf and from the Indus to the Mediterranean. This empire began to disintegrate about 1100 and was finally destroyed by the Mongols in the 13th century.

The second migration was of the Kipchaks who appeared from the Irtysh river and advanced to the southwest as far as the Syr Darya where they established themselves in the territory formerly occupied by the Oguz. They also advanced into eastern Europe, conquering the region between the Danube delta and the Carpathians, the Crimea and the lower reaches of the Volga. They were known to the Byzantines as Kumans (Cumans; *q.v.*) and to the Russians as Polovtsy and disappeared from history on their destruction by the Mongols in 1239.

The Mongol conquests, which began at the beginning of the 13th century, spread eventually over almost all the areas held or inhabited by Turkic peoples. The Kipchak empire was overrun and extinguished, and the last remnants of the Seljuk empire, the sultanate of Konya and the realm of the shahs of Khorezm, were subjugated. But following the distribution of Jenghiz Khan's empire, which took place after his death, a process of Islamization and Turkification ensued which resulted in the virtual absorption by the Turks of the Mongols outside Mongolian territory. The influence of the khans diminished, particularly in what is now known as central Asia, and the real power passed to the Turkish governors. One of these, Timur, seized power in Transoxiana in 1369 and eventually extended his territory over the whole of the Golden Horde, over most of Persia, and as far south as Baghdad; he captured Delhi, Aleppo and Damascus; he also defeated in 1402 the Ottoman sultan Bayezid I near Ankara, the Ottoman empire having been founded at the end of the 13th century by Osman, the first sultan of the Osmanli dynasty. (*See* TURKEY.)

While Timur's empire remained, that is, until about the middle of the 15th century, and for a considerable time afterward, a large proportion of the Turkic peoples in Asia were ruled by men of Turkic stock. At the end of the 15th century and during the beginning of the 16th, the Uzbeks, who were a returning wave of Turkic peoples from the Kipchak region, rose to power in central Asia and in 1500 their ruler Mohammed esh-Shaibani deposed Baber, the last of Timur's successors. Shaibani was, however, defeated by the Persian Safavid shah Ismail in 1510, and the territory as far north as Merv (Mary) was nominally included in the Persian empire until the end of the 17th century. Persian rule as far as the Amu Darya was re-established for a short time by Nadir Shah in 1740. The Azeris of Transcaucasia were also included in the Persian empire until 1813, when Azerbaijan was partitioned between Russia and Persia. (*See* AZERBAIJAN.) Elsewhere in Asia the Turks were ruled by their own people until the rise of Imperial Russia, except during the Kalmuck domination of large areas of central Asia between 1603 and 1758 when the Kalmuck empire was destroyed by the Chinese.

In Europe, after the collapse of Mongol domination in 1480, rule over the Turkic peoples was divided between the Russian and Ottoman empires, except for Crimea, which remained nominally independent until 1783 when it was annexed by Russia.

After the defeat of the Uzbeks by Persia, Uzbek territory was confined to the lands north of the Amu Darya and Kopet Dagh and eventually became the emirate of Bukhara. At the same time the Uzbek khanate of Khorezm or Khiva was formed. Abdullah esh-Shaibani, the emir of Bukhara, succeeded in uniting these two states before his death in 1597; but they did not remain under one rule for long. In 1740 both states were invaded and temporarily occupied by Nadir Shah of Persia. After a period of disorder, the last Bukharan dynasty, the Manghyt emirs, came to power in 1753 and retained nominal independence until the Soviet occupation in 1gzo. (*See* UZBEKISTAN.)

The Turkmens remained in their present habitat during the Oguz migration of the 11th century and were one of the few Turkic peoples who were not merged in the hlongol empire. In the 15th century the Turkmen tribes of Kara Koyunlu (Black Sheep) and Ak Koyunlu (White Sheep) wielded considerable power, but although the Turkmens kept themselves independent from the neighbouring states they never formed a regular state of their own. They finally lost their independence to Russia in 1881. (*See* TURKMENISTAN.)

The khanate of the Mogul was the name given to the last Turkish kingdom to arise out of the Mongol empire in the middle of the 14th century. In spite of their name, these Moguls spoke a Turkic language, and part of them, the Sarig Uigur (Yellow Uigur) retained the Uigur script until the 18th century. This kingdom, which stretched from Kashgar to the then Chinese frontier, was destroyed by the Kalmucks in 1682.

The Mongol domination of Russia came to an end in 1480. It is from this date that the domination of Russia over most of the Turkic peoples in Asia began. The first expansion of the Russians into Asia was due east along the line of least resistance. To the south, however, they advanced into the Caucasus and by 1689 had occupied the eastern portion. At this time the Turkic peoples under Russian rule included the Turks of the northeastern Caucasus, the Volga region and Bashkiria, as well as the outlying Yakuts in eastern Siberia. By 1800 this rule had been extended to include the Crimea, and by 1878 the whole of the rest of the Caucasus had passed from Turkish and Persian into Russian hands. The Russian advance into what is now Kazakstan (*q.v.*) did not begin until 1801. By 1900 the whole of central Asia to the Chinese, Afghan and Persian frontiers had passed under Russian rule or suzerainty.

DISTRIBUTION

The position of the Turkic peoples as regards habitat and political dependence may be briefly summarized as follows:

Turkey. — The vast majority of the population of the Turkish republic, that is, about 20,000,000 (1954 est.), may be described as Turks. They are Turkish-speaking, but with the passage of time, the pure Turkic stock has become diluted with other elements.

Iran. — The whole of the Iranian province of Azerbaijan is inhabited by Azeris or Turkish-speaking Turks. There are other scattered Turkic elements, notably the Turkmen in Khurasan. In the south, the tribes of Kashkai, Ainalu and Baharlu are of Turkic origin and Turkish-speaking. In the absence of an official census, it is impossible to estimate precisely the number of Turks living in Iran. but it is probably not less than 2,000,000.

Afghanistan. — There are a few thousand Uzbeks and a smaller number of Turkmens living in northern Afghanistan.

China. — According to Soviet estimates, there are about 4,500,000 Turkic peoples in the Chinese province of Sinkiang (about 4,000,000 Uigurs, 350,000 Kazaks and 150,000 Kirghiz).

U.S.S.R.—The total number of the Turkic peoples living in the U.S.S.R. was not less than 19,000,000 (1939 est.). A detailed ethnic survey was published with the census of 1926. Subsequent population figures, including those of the census of 1939, did not always distinguish clearly between the indigenous and settled populations. The total population of Kazakstan (1939 census) was 6,145,937, of whom 80% were made up of Kazaks and Russians. (*See* Table.)

The 1939 census showed the total Turkic population of Kazakstan, Uzbekistan, Turkmenistan. Kirghizia and of Tajikistan (excluding Tajiks) to be about 10,000,000, that is, an over-all increase of only about 3% over the 1926 census figures. the Kazaks having apparently decreased by 869.525. The over-all increase in the Turkic population of the whole U.S.S.R. between 1926 and 1939 was approximately 12%.

After 1939 there were a number of changes of which details were still not available by the mid-1950s. There has evidently been some growth of population, but there has also been some dispersal of the Turkic peoples. For instance, as a result of their alleged collaboration with the Germans during World War II the Crimean Tatar, the Karachai and Balkar peoples were uprooted and their existence as ethnic units is no longer recognized. The Crimean A.S.S.R. (Autonomous Soviet Socialist Republic) and the Karachai A.O. (Autonomous province) have thus ceased to exist. and the name of the former Kabardino-Balkar A.S.S.R. changed to Kabardinian A.S.S.R.

Distribution of the Turkic Peoples in the U.S.S.R.

Area	Census of 1926	Census of 1939
A. Volga Region		
Tatars	3,308,116	4,300,336
Chuvash	1,117,419	1,367,930
Bashkirs, etc.	741,080	842,925
	5,166,615	6,511,191
B. Caucasus		
Azeris	1,706,605	2,274,805
Kumyk	94,549	113,500*
Karachay	55,123	75,737
Balkar	33,307	42,666
Karapapakh	6,316	7,500*
	1,895,900	2,514,208
C. Central Asia		
Kazaks	3,968,289	3,098,764
Uzbeks and Kurama	3,954,701	4,844,021
Kara-Kalpaks	146,317	183,[illegible]
Turkmen	763,940	811,769
Kirghiz	762,736	884.306
Others	169,877	203,900*
	9,765,860	10,028,535
D. East Siberia and Altai Region		
Yakuts	241,365	260,000*
Others	124,001	140,000*
	365,366	400.000
Total (A + B + C + D)	17,193,741	19,453,934

*Groups included in the 1926 but excluded from the 1939 census. An increase of 20% over 1926 has been estimated.

Source: F. Lorimer, *The Population of the Soviet Union* (New Tork, 1946). Comparison between the figures shown in the 1926 and 1939 censuses is complicated by the fact that many of the smaller ethnic groups mentioned in the 1926 census were not included in data of the 1939 census so far available.

As already indicated the main ties binding the Turkic peoples together are historical and linguistic rather than cultural. It is indeed difficult to speak of Turkish culture with any degree of precision. Insofar as there are any cultural links other than those of history and language which are strong and persistent, it is that of Islam. for—with the exception of the Turks of eastern Siberia (Yakuts) and the Altai region—all the Turks are Moslem. The Chuvash are Orthodox Christians. Little remains to indicate what the pre-Islamic culture of the Turks was. and it is hard to detect any common characteristics. The so-called "golden period" of literature, art and refined culture which flourished for about a century under Timur and his successors was Persian rather than Turkish. The same can be said of the culture of the Seljuk empire. Under the Turkish republican government efforts were made to revive the ancient culture of the Turks and to isolate it from Islam. Similar eiforts. although with a different purpose, were made by the Soviet government. The Turks of Iran, while retaining their language. had been considerably affected by Iranian culture, and no Turkic language was used as a medium of education in the schools.

Of the literature written in Turkic languages by far the most considerable is that of Turkey. In the U.S.S.R. the official tendency has been to discountenance much of the traditional oral literature as reactionary and to develop a new literature on Soviet and, to a large extent. Russian lines. A large number of translations and a smaller number of original works have been published in Turkic languages. In Iran and Afghanistan no translations or original works in Turkic languages had been published by mid-20th century.

Although the bulk of the Turkic peoples profess. Islam, they have been much affected by the appearance of laicism in the countries on which the great majority of them are politically dependent. In Turkey religious instruction had been discontinued in state schools but from 1947 the ban on religious instruction was relaxed. In the U.S.S.R. religious teaching forms no part of state education but is permitted in theological institutions.

See TURKIC LANGUAGES; *see* also Index references under "Turks or Turkic Peoples" in the Index volume.

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TURKU (Swedish ABO). a seaport of Finland on the Gulf of Bothnia. Pop. (1950) 101.824. It is the second largest town in Finland, and has a shipbuilding and repairing industry. An icebreaker keeps the port open throughout the winter.

There are four entrances to the harbour. with lighthouses for each, and there are four patent slips capable of taking vessels up to 1,200 tons. The chief imports are salt. salt fish, pig iron. oils. coal. cotton, machinery and colonial goods, and the exports timber, grain, butter, bar iron. pork. beef and game. There is a considerable coasting trade. After the diet of Borga in 1809, Turku became capital of the Russian grand duchy of Finland. but in 1819 the government was moved to Helsinki. It was founded in 1229 and has been a centre of Swedish culture, having a Swedish as well as a Finnish college.

TURKU-PORI (ABO-BJORNEBORG), a department. in the southwest of the republic of Finland. Area (in English square miles) 8.886. Pop. (1950) 631.049. It is a lowland region containing much boulder-clay soil and a consequent imperfect drainage. The department, together with most of Finland. has not yet recovered from the effects of severe glaciation. Finnish and Swedish are spoken. The chief towns are Turku (Abo), pop. (1950) 101,824; and Pori (Bjornehorgj. 43,213.

TURMERIC, the tuberous rhizomes (underground stems) of *Curcuma longa*, an herbaceous perennial plant belonging to the family Zingiberaceae (*q.v.*). It is a native of southern Asia, cultivated on a large scale both on the mainland and in the islands of the Indian ocean. Turmeric has been used from a remote period both as a condiment and as a dyestuff, and was once employed to a more limited extent as a medicine. In Europe it is employed chiefly as a dye, also as an ingredient in curry powder and as a chemical test for alkalies. The rhizome is prepared by cleaning it and drying it in an oven. There are several varieties (Madras, Bengal, Gopalpur, Java, China and Cochin turmeric), differing chiefly in size and colour of the tubers and to a slight degree in flavour. All are hard and tough, but break with a short resinous or waxy fracture; the exposed surface varies in tint from an orange brown to a deep reddish-brown. The colour is due to curcumin, of which the drug contains about 0.3%. When pure it forms yellow crystals having a vanilla odour and exhibiting a fine blue colour in reflected light. On oxidation with potassium permanganate it gives vanillin, the flavouring and odorous material of vanilla (*q.v.*). It is soluble in alcohol, in chloroform, but only sparingly in water. Paper tinged with a tincture of turmeric exhibits on the addition of an alkali a reddish-brown tint that becomes violet on drying, thus providing a test for alkalinity discovered by H. A. Vogel in 1815.

TURNEBUS, ADRIANUS [ADRIEN TURNEBE] (1512–1565), French classical scholar, was born at Les Andelys in Normandy, and at the age of 12 was sent to Paris to study. After having held the post of professor of belles-lettres in the Cniversity of Toulouse, in 1547 he returned to Paris as professor (or royal reader) of Greek at the Collège Royal. In 1552 he was entrusted with the printing of the Greek books at the royal press, in which he was assisted by his friend, Guillaume Morel (*q.v.*). He died of consumption on June 12. 1565. His works chiefly consist of philological dissertations, commentaries (on Aeschylus, Sophocles, Theophrastus, Philo and portions of Ciceroj, and translations of Greek authors into Latin and French. His son. Etienne, published his complete works. in three volumes (Strasbourg, 1600), and his son Adrien his *Adversaria*, containing explanations and emendations of numerous passages in classical authors.

See *Oratio funebris* by Léger du Chesne (Leodegarius a Quercu) prefixed to the Strasbourg edition; L. Clément, *De Adriani Turnebi praefationibus et poematis* (1899); J. E. Sandys, *History of Classical Scholarship*, iii (1908).

TURNER, FREDERICK JACKSON (1861–1932), noted historian of the C.S. frontier, mas born in Portage, Wis., Nov. 14, 1861. He attended local schools, was graduated from the University of Wisconsin in 1884, and returned. after a short interval as a reporter, to prepare for college teaching. Turner concentrated on history. working under the guidance of William Francis Allen. an effective teacher who stimulated students to analyze and criticize source materials and interrelationships in history. Studying at the State Historical society during this time, Turner probed the Lyman C. Draper collection of western Americana, with its wide spectrum of manuscript materials on the pioneer days of Wisconsin. After winning his master's degree in 1888, Turner went to Johns Hopkins university to continue graduate work in the famed seminar of Herbert Baxter Adams. There he met a number of first-rate scholars, including Woodrow Wilson, who became a lifelong friend. In 1889 he married Caroline Mae Sherwood of Chicago and returned to Wisconsin as an assistant professor: completing his doctoral dissertation the next year. Personable and handsome. with a quiet sense of humor, Turner was a teacher of unusual ability who encouraged independent thought on the part of his students. In 1892 he was made professor of American history, a position in which he brought distinction to his alma mater for 18 productive years. He moved to Harvard in 1910, following his election to the presidency of the American Historical association. After retirement in 1924, he was welcomed at the Henry E. Huntington library as a research associate, spending his final years studying and writing until his death Mar. 14, 1932.

Turner's doctoral dissertation on "The Character and Influence of the Indian Trade in Wisconsin" (1891) portrayed the trading post as a frontier institution that had evolved from antiquity, thereby disclosing the influence of Herbert Baxter Adams' emphasis on the evolution of institutions throughout history. Turner partly rejected, but never wholly abandoned, the concept that American institutions were products of European "germs," often called the germ theory.

"The Significance of the Frontier in American History," an essay that Turner read before a group of historians at the World's Columbian exposition in Chicago. Ill., on July 12, 1893, introduced a new hypothesis that promised to revise older interpretations of U.S. history. Teaching. developing a course on the history of the west, and further research preceded the publication of his first book of essays, *The Frontier in American History* (1920). A dozen additional essays appeared in his *Significance of Sections in American History* (1932), which was awarded the Pulitzer prize in 1933. Earlier Turner had written *The Rise of the New West, 1819–1829* (1906) for the American Nation series. An incomplete manuscript was published posthumously as *The United States, 1830–1850: the Nation and Its Sections* (1935).

Turner's eminence rests on the enormous influence his ideas had on subsequent interpretation of U.S. history. Whereas religious liberty. slavery. English tyranny, nationalism and the rise of democracy had occupied his predecessors, Turner emphasized the impact of a wilderness environment on a transplanted civilization. He wrote that frontier individualism had from the very beginning of American history promoted democracy. Free land on the frontier, drawing men away from European influences! helped build a new Americanism. Frontier traits of self-reliance, individualism, restless energy, and "that buoyancy and exuberance that conies with freedom," left their imprint on society. With Jefferson. Jackson and Lincoln as leaders, Turner viewed western democracy as an effective force in American life.

"The significance of the frontier" is a phrase with fundamental implications that has, at times, been used in connection with the expanding frontiers of Australia. and many nations of the western hemisphere. Within the United States the phrase gave meaning to the history of every town. county and state, lifting local history from the confines of antiquarianism. Turner's disciples were captivated by the phrase, and some of them saw the frontier philosophy as the whole key to America's past. At Harvard, away from his Wisconsin homeland. Turner had tempered some of his earlier generalizations, thus giving evidence of flexibility of mind and integrity as a historical thinker.

It is difficult to pin point the essence of Turner's thinking on the subject of the frontier in United States history because there are modifications of the frontier hypothesis throughout his writings. He did stress the significance of free land, the importance of environmental influences, and the persistence of older customs as the frontier moved westward and pioneer sections went through a process of social evolution. Primitive at first, the frontier areas were eventually supplanted by a modern civilization with sectional variations, caused in large part by physiographic factors. The new civilization that emerged after about three centuries was distinctly different from the old; and this difference could be largely traced to the influence of the passing frontier.

Despite its early general acceptance by historians, the frontier hypothesis, especially the famous essay of 1893, made Turner the centre of a bitter historical controversy. Scholars nevertheless have generally accepted Turner's frontier hypothesis as a suggested interpretation, rather than as a theory, and thus have abandoned needless bickering.

Detailed examination of Turner's writings, correspondence and lecture notes taken in his classes, reveals the concept of multiple hypothesis as one of his main contributions. He had borrowed this idea from the distinguished geologist and president of the University of Wisconsin. Thomas C. Chamberlin. It was appropriate that Turner would think in terms of multiple causation in history. for his researches ranged beyond the social sciences into the natural sciences. Turner's provocative essays on sectionalism, predicated on this concept, completely revised the old view of uncomplicated rivalries between the north, south, and west in U.S. history. His penetrating analysis revealed intricate economic, social and geographical forces that divided the nation into a number of distinct sections or regions, and demonstrated that a federation of sections nourished a complex American spirit. Sectional rivalries for control of pioneer areas, Turner pointed out, gave clues to the development of America's political party history. Although western American history was Turner's field of specialization, he was willing to consider any interpretation of United States history, few of which he failed to suggest in his lectures or published works.

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TURNER, HERBERT HALL (1861–1930), English astronomer who pioneered some of the procedures universally used in measuring astronomical photographs, was born at Leeds on Aug. 13, 1861. A student, and later a fellow, at Trinity college, Cambridge, Turner in 1884 was appointed chief assistant at the Royal observatory. Greenwich, where he remained until 1893, when he was appointed Savilian professor of astronomy and director of the University observatory at Oxford. He published more than 200 papers and essays on astronomical and seismological subjects and is best remembered for his enthusiasm in pushing to completion the Oxford. and other, zones of the astrographic catalogue; his introduction of standard co-ordinates in the reduction of astronomical photographs and a series of notes, light in vein, contributed monthly to the periodical, *Obseraatory,* under the heading "From an Oxford Notebook." He died in Stockholm, Swed., on Aug. 20. 1930. (O. J. E.)

TURNER, JOSEPH MALLORD WILLIAM (1775–1851), English romantic landscape painter and pioneer in the study of light, colour and atmosphere, was born on April 23, 177.5. in London, the son of a barber, William Turner: who was a native of Devonshire, and Nary Marshall. Both families were traders; nothing is known about Turner's mother except that she died insane in 1804.

Life and Training.— At the age of ten Turner mas sent to live with an uncle at Brentford, Middlesex. where he attended school. Several drawings in the Turner bequest are dated 1787, when he was 12, and these are sufficiently professional to corroborate the tradition that his father used to sell the boy's work to his customers. After some instruction under Thomas Malton, Turner entered the Royal Academy schools in 1789 and exhibited a water colour the following year n-hen he was only 15. He used to spend the summer holidays touring the country in search of subjects, and visited Oxford in 1783, Bristol in 1791 and Wales in 1792. His sketchbooks, filled with drawings to be worked up later into finished water colours for commissions or for exhibition, are preserved in the British museum. His early work is topographical in character, imitating the best masters of the day—Thomas Malton, Edward Dayes and Paul Sandby. In 1794 he began working for engravers, supplying designs for *The Copperplate Magazine* and *The Pocket Magazine.* Engraved views of picturesque ruins of castles and abbeys were much in demand at the time. In the winters he attended the evening sessions at the house of Thomas Monro, the doctor and connoisseur, who had treated John Robert Cozens during his last illness and owned a number of his drawings. Turner, Thomas Girtin and other young artists were employed at making copies or elaborations of his unfinished drawings. The influence of Cozens and of Richard Wilson helped to broaden Turner's outlook and revealed to him a more poetic and imaginative approach to landscape, which he pursued to the end of his career with ever-increasing brilliance.

From 1796 Turner began to exhibit oil paintings as well as water colours at the Royal academy. The first one. "Fishermen at Sea" (on loan to the Tate gallery, London), is a moonlight scene and was acclaimed by a contemporary critic as the work "of an original mind." In 1799, at the age of 24. Turner was elected an associate of the Royal academy and in 1802 he became an academician, a dignity he was to enjoy for nearly half a century. He took his duties seriously, attended academic functions regularly, was helpful and encouraging to other artists and left £20,000 to the academy in his will, but when he was appointed professor of perspective in 1808, his lectures are said to have been difficult to follow, and in 1838 he resigned from this office.

His travels in 1797 took him to Yorkshire and the Lake district. in 1798 to Wales again, and in 1801 to Scotland, places he nas to revisit frequently in later years. He was now overwhelmed with commissions and the success of his career was assured By 1800 he had taken a studio at 64 Harley street. London, and later his father came to live with him and devoted the rest of his life to serving as a studio assistant and general agent. in fact giving his son every possible domestic and business help In 1804 Turner opened his private gallery. where he continued to show his latest work for many seasons. though toward the end of his life admission was difficult to obtain. As he never married, had no expensive habits and devoted his time entirely to his art. he was able to amass a considerable fortune. In order to be able to paint undisturbed he became secretive about his residence In 1812 he moved to Hammersmith and later built himself a house at Twickenham, Sandycombe lodge, uhich still stands. His father's death in 1829 broke up his domestic arrangement. At the end of his life he lived in Chelsea under the assumed name of Booth and was looked after by his old Margate landlady.

Development of his Painting.— -In 1802 Turner made his first journey to the continent. The crossing to Calais was rough and he has left a vivid record of his experience on arrival in his picture "Calais Pier" (National gallery, London), a composition in which he tried to rival the Dutch marine painters. In Paris he made detailed notes in the Louvre, where all the paintings brought from Italy by Napoleon were then displayed. He filled a sketchbook with copies and criticism of the paintings, showing that his taste was for the great Venetians and for Poussin, but not for Rubens, whose landscapes struck him as "one continual glare of colour."

From Paris he proceeded to Lyons, Grenoble. Geneva, around Mont Blanc to Courmayeur and Aosta, over the St. Bernard pass to Vevey, then to Interlaken, the St. Gothard pass. Zurich, Schaffhausen and back to Paris through Strasbourg and Nancy. He made over 400 drawings during the tour and continued for many years after to paint pictures of scenes that had impressed him, the most important being. three pictures of Bonneville. Savoy (1803 and 1812); "The Festival at Mâcon" (1803, Sheffield); water colours of the "Devil's Bridge" and the "Falls of Reichenbach" (Bedford); "The Fall of the Rhine at Schaffhausen" (1806, Boston. Mass.) and "Snowstorm: Hannibal Crossing the Alps" (1812, Tate gallery). His figure compositions. "Venus and Adonis' (*c.* 1803. Sir Raymond Quilter) and "The Holy Family" (1803 Tate gallery), show that he tried his hand in the Venetian manner.

The methodic endeavour to master every style he admired and the ease with which he accomplished this are seen in many of his early sea pieces in which he surpasses the Dutch marine painters, and in the exercises in the style of Claude Lorrain culminating in '(Dido Building Carthage" (1815), which he bequeathed to the National gallery together with "Sun Rising Through Vapour" (1807) on condition they were hung beside his two favourite Claudes. Other instances of similar rivalry are "Aeneas and the Sybil—Lake Avernus" (*c.* 1803) recalling Wilson, "The Garden of the Hesperides" (1806) recalling Poussin, a series of genre subjects such as "The Blacksmith's Shop" (1807) in the style of David Teniers and Sir David Wilkie (all at the Tate gallery) and "Dordrecht" (1818) in the style of Albert Cuyp (Farnley hall, Yorkshire).

In 1805 Turner exhibited "The Shipwreck" (Tate gallery), which was purchased by Sir John Leicester and was the first of many works to be engraved by Charles Turner. A list of subscribers to the plate is preserved in one of the "Shipwreck" sketchbooks and shows that by this time Turner had a wide public among the nobility and collectors as well as among fellow artists. This was the year of the battle of Trafalgar, and when the "Victory" returned with the body of Nelson on board, Turner went down the Thames to sketch the flagship and collect material for the picture of "The Battle of Trafalgar"—usually known as "The Death of Nelson"—(1806–08, Tate gallery). In 1824 he completed a larger picture of the same subject for King George IV, now in the National Maritime museum. Greenwich.

Engraved Work.——In 1807 Turner first began his great enterprise of publishing a series of plates known as the *Liber studiorum.* This may have been suggested by the success of the publication in 1777 of R. Earlom's engravings of Claude's *Liber veritatis,* but the purpose was quite different. Claude's book of drawings was kept as a record of pictures he had sold. Turner's aim was to perpetuate the great variety and range of his work; some of the subjects were taken from existing paintings and water colours. others were specially designed for the *Liber.* The publication was issued in parts consisting of five plates each, covering all the styles of landscape composition, such as historical, architectural, mountainous, pastoral and marine. The first part appeared in June 1807 and the last in 1819, when Turner evidently lost interest in the project and abandoned it. He had employed several engravers. including F. C. Lewis. Charles Turner and William Say, had supervised the work personally at every stage, etched some of the plates himself and made innumerable preparatory drawings. Though originally planned to consist of 100 plates, only 71 were in fact published. The technique was a combination of etching and mezzotint. In 1823 steel engraving superseded the copper plate and Turner embarked on a new project, *The Rivers of England,* for which he designed 16 plates. Other publications to which he contributed were W. B. Cooke's *Southern* Coast (1814–26), *England and Wales* (1829–38), Sir Walter Scott's *Provincial Antiquities* (1826) and *Works* (1833–34), Samuel Rogers' *Italy* (1830) and *Poems* (1834) and *The Rivers of France* (1833–35). At the height of his career Turner was regarded as the most desirable illustrator, his journeys were usually paid by the puhlishers and he received from 10–25 guineas for each subject. These include some of his most intricate and delicate water colours.

Paintings of the Middle Period, 1810–1835.—During the second decade Turner was much in demand as a painter of castles and country seats for their owners. Two examples are "Linlithgow Palace" (1810, Liverpool) and "Somerhill" (1811, Edinburgh). He continued to excel in marine painting, the two most ambitious works being "Spithead" (1808–09) and "The Wreck of a Transport Ship" (1810). The earl of Egremont had bought a sea piece in 1802 and became a regular patron and close friend. In later years Turner was often invited to stay at Petworth, Sussex. He probably paid his first visit to his other great friend and patron, Walter Fawkes, at Farnley hall, Yorkshire, in 1810, and used to spend some weeks staying there nearly every summer till the death of Fawkes in 1825.

In 1811 Turner made an extensive tour of Devonshire, Cornwall and Somerset and in 1813 he returned to Devon. In 1815 and 1816 he toured Yorkshire again for the purpose of supplying 20 water colours to illustrate T. D. Whitaker's *History of Richmondshire.* The following year he went to the continent, primarily to visit the field of Waterloo, of which he afterward painted a dark and romantic picture, then up the Rhine, as far as Mainz, returning through Holland. In 1818, 1822 and 1831 he went to Scotland.

His painting during these years was becoming increasingly luminous and atmospheric in quality. Even when painting actual places, as in the views of "Greenwich," "Windsor" (both 1809), "St. Mawes" (1812), "Abingdon" (1809) and "Oxford" (1811), the hard facts of topography are diffused behind pearly films of colour; pictures like "Frosty Morning" (1813) and "Bligh Sands" (1815) are entirely based on effects of light.

Turner had begun the series of fanciful Carthaginian subjects in 1815 with "Dido Building Carthage" and was to continue producing variations on that theme to the end of his life. By appending long poetic quotations either from James Thomson's *Seasons,* Byron, Milton. Shakespeare, Pope or from his own composition, *Fallacies of Hope,* he showed that he regarded the poetic interpretation as of paramount importance. Among the most ethereal dreams of this period are "The Lake of Geneva" (1810, Los Angeles County museum), "Crossing the Brook" (1815) and "-England; Richmond Hill, on the Prince Regent's Birthday" (1819, Tate gallery), one of his largest and most ambitious pictures. As if he felt that he had done all he could with the beauty of his native country, he set out in the summer of 1819 on his first visit to Italy. He spent three months in Rome, visited Naples Florence and Venice and returned home in midwinter. During his journey he made about 1,500 drawings and in the next few years he painted a series of pictures inspired by what he had seen. They show a great advance in Turner's style, particularly in the matter of colour, which becomes purer, more prismatic, with a general heightening of key. A comparison of "The Bay of Baiae" (1823) with any of the earlier pictures reveals a far more iridescent treatment resembling the transparency of a water colour. The shadows are as colourful as the lights and he achieves contrasts by setting off cold and warm colours instead of dark and light tones.

During the 1820s tours of the continent alternated with visits to various parts of England and Scotland. In 1821 he painted a series of delicate water colours of the Seine on blue paper; in 1825 he revisited Holland and Belgium, and the following year the Meuse, Moselle and the Loire. Notable among the pictures of this period are the views of "Cologne," "Dieppe" and "Mortlake Terrace" in the Frick collection, New York. In 1828 he went to Italy again and held an exhibition of some of his pictures in Rome. The previous year he had stayed with John Nash, the architect, at Cowes and painted the brilliant sketches of the regatta now at the Tate gallery. One of the finished pictures is at the Victoria and Albert museum. London. The splendid sketches of Petuorth probably belong to the early 1830s.

Late Works. — In the last 15 years of his life, Turner revisited Venice, Switzerland, Germany and France. Observers have recorded the untiring energy with which he sketched while abroad, and the drawings numbering nearly 19,000 in the Turner bequest bear witness to this labour. While his earlier paintings and drawings show the most accurate observation of architectural and natural detail, in his later work this is sacrificed to general effects of colour and light with the barest indication of mass. His composition tends to become more fluid, suggesting movement and space; some of his paintings are mere colour notations, barely tinted on a white ground, like "Norham Castle" and "Boat Between Headlands." It is reported that Turner used to send canvases in this state to the academy and add the detail, required by public taste. on varnishing day. This may account for the large number of slightly brushed-in canvases found in his studio at the time of his death. Or he may have realized that additional elaboration could only ruin the beautiful effect he had achieved. These colourful abstractions are far more appreciated now than the romantic subjects he exhibited.

Apart from fanciful reconstructions of ancient Rome and the scintillating Venetian subjects, which found ready purchasers in his day, the outstanding examples of his late work are: "Ulysses Deriding Polyphemus" (1829); "Hero and Leander" (1837), a daring composition of sunset and moonlight with visions of spirits rising from the waters; "The Fighting Téméraire Towed to Her Last Berth" (1839), a tribute to the passing age of sail; and "Rain, Steam and Speed" (1844)—all in the national collections. Actually the first picture to be hung in the National gallery was the opalescent "Venice From the Steps of the Europa" (1842), bequeathed by Robert Vernon in 1847 while Turner was still alive. Turner's preoccupation with the elements of fire and water appears in two pictures of the "Burning of the Houses of Parliament" (now in Cleveland and Philadelphia), in the large sketch "Fire at Sea" (National gallery) and in "Rockets and Blue Lights" (1840, Clark Art institute, Williamstown, Mass.). The "Snowstorm" (1842, National gallery) was painted from observations made when Turner crossed from Harwich in such a wild storm that he had to be lashed to the mast for four hours and did not expect to survive. The last pictures he exhibited in 1850 show some falling off of his powers, though the colour is still radiant.

Turner died in London on Dec. 19, 1851, and was buried in St. Paul's cathedral. By his will he intended to leave his fortune of £140,000 to found a charity for "decayed artists," and his pictures to the nation, on condition that a gallery was built to exhibit them. As a result of protracted litigation with his rather distant relatives, the money reverted to them, while the pictures and drawings became national property. The first selection shown to the public included only 34 paintings. Since then many more have ,been put on view, but it was not until 1908 that a special gallery was built by Sir Joseph Duveen to house them at the Tate gallery. All the drawings and water colours were transferred to the British museum for safety after the Thames flood of 1928, when the storerooms at the Tate gallery were inundated. At the time of his death. Turner's gallery was in such a state of neglect that many of his paintings were said to be mere shadows of what they had been originally. Fortunately the sketches. which were not then considered worthy of exhibition, have escaped the hands of unskilled restorers and have retained their original freshness and spontaneity.

The immense reputation that Turner enjoyed at the end of his life and for over half a century after was partly due to the enthusiastic championship of Ruskin, who published *Modern Painters* to prove Turner's superiority to all previous landscape painters and to extol his accurate rendering of natural appearance. The present attitude toward Turner is somewhat different. In his pursuit of light and pure colour Turner had anticipated the achievements of the French Impressionists, and when Monet and Pissarro saw his work in London in 1870 they were greatly interested, although few of his truly impressionist sketches were shown at that time. In the 1920s, when the Postimpressionist cult was at its height through the writings of Roger Fry, Turner's reputation suffered a temporary eclipse, but prices remained high in the market. In 1948. a representative collection of his work was shown at the Venice Biennale and afterward in the principal capitals of Europe, and abstract painters began to find a common purpose with their own in some of his late colour compositions. Thus each generation has been able to discover new sources of inspiration in his work. The important exhibition "Turner in America" held in Indianapolis in 1955 further strengthened his prestige, and the prices at the Lennox library sale in New York in 1956, when "Staffa: Fingal's Cave" (1832) reached $47,000 and "Fort Vimieux" (1831) $56,000, caused a sensation. The record price remains 29,000 guineas, paid in 1927 for "Venice: Dogana and Salute" (1843) at the Ross sale, while the highest price for a water colour was 11,000 guineas paid for "The Lake of Lucerne" at Christie's in 1959. *See* also PAINTING: *Great Britain;* WATER-COLOUR PAINTING; LANDSCAPE PAINTING.

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TURNER, NAT (1800–1831), Negro leader of a slave insurrection in Virginia. known as the "Southampton insurrection," was born in Southampton county. Va., in 1800. From his childhood he claimed to see visions and hear voices, and he became a Baptist preacher of great influence among Negroes. In 1828 he confided to a few companions that a voice from heaven had announced that "the last shall be first," which was interpreted to mean that the slaves should control.

On the night of Aug. 21, 1831, with seven companions, he entered the home of his master, Joseph Travis, and murdered the inmates. After securing guns, horses and liquor they visited other houses, sparing no one. Recruits were added, in some cases by compulsion, until the band numbered about 60. About noon on Aug. 22 they were scattered by a small force of whites, hastily gathered. Troops were hurried to the scene, and the Negroes were hunted down. In all 13 men. 18 women and 24 children had been butchered. Turner was captured on Oct. 30 and was tried and hanged, having made, meanwhile, a full confession. Nineteen of his associates were hanged and 12 were sent out of the state. The insurrection led to the enactment of stricter slave codes.

TURNHOUT, town in the province of Antmerp, Belg., 26 mi. N.E. of that city. Pop. (1955 est.) 34.061. It carries on an active industry in cloth, playing cards and other manufactures. There is a leech breeding establishment.. The town hall was formerly a palace of the dukes of Brabant. Two miles west of Turnhout is the curious penal or reformatory colony of Merxplas. The system of this establishment is to allow certain approved prisoners to follow their usual occupations within a defined area.

TURNIP (*Brassica rapa*), a hardy biennial, of the family Cruciferae. which has been cultivated from a remote period for its fleshy roots. The tender growing tops are also used widely as a green vegetable. The so-called "root" is formed by the thickening of the primary root of the seedling together with the base of the young stem (hypocotyl) immediately above it. The great mass of the "root" consists of soft "wood" developed internally by the cambium layer and composed mainly of thin-walled, unlignified, wood-parenchyma.

The stem remains short during the first year, the leaves forming a rosettelike hunch at the top of the root; they are grass green and bear rough hairs. In the second season the bud in the centre of the rosette forms a strong erect branched stem bearing somewhat glaucous smooth leaves. The stem and branches end in corymbose racemes of small, bright yellow flowers, which are succeeded by smooth, elongated, short-beaked pods.

The turnip probably originated in middle and eastern Asia and by cultivation has spread throughout the temperate zone.

The varieties of turnip are classified according to their shape as (1) long varieties, with a root three or more times as long as broad; (2) tankard or spindle-shaped varieties. with a root about twice as long as broad; (3) round or globe varieties with an almost spherical root; (4) flat varieties with a root broader than long; there are also many intermediate forms. Turnips are also grouped according to the colour of the upper part of the root, which comes above ground, and according to the colour of the flesh, which is white or yellow.

The yellow-fleshed varieties, which are not hybrids between the turnip and Swedish turnip, are more robust, of slower growth and superior feeding value to the white-fleshed turnips and are less injured by frost. The foliage turnip produces no enlarged root but only a profusion of leaves which are used as a potherb. A variety of this form called Seven-Top is widely grown in the southern United States.

The Swedish turnip (*Brassica napobuassica)* or rutabaga differs from the turnip proper in having the first foliage leaves glaucous, not grass green, in colour and the later leaves smooth and glaucous; the root bears a distinct neck with well-marked leaf scars. the flesh is firmer and more nutritious. and the roots keep much better during winter. The white-fleshed forms have a rough, green skin, firm white flesh and are of irregular form. The flowers are of a bright canary colour. The yellow-fleshed Swedish turnips have a firm yellow flesh, a smooth skin of a green. purple or bronze colour. The flowers are buff yellow or pale orange. The Swedish turnip has 38 chromosomes, the true turnip 20.

Cultivation and Trade.—Both the turnip and rutabaga are cool-season crops. The rutabaga grows less rapidly, requiring a longer season. In the lower latitudes turnips are sown either in early spring or in late summer, developing rapidly enough to make a crop before extremes of summer or late fall weather occur. Rutabagas, however, are sown only as a main or late crop and are more hardy to cold. Rutabagas are little grown in the United States except in the northernmost states. but are grown extensively in Canada, Great Britain and northern Europe. Both species are grown as livestock feed in northern climates but in the U.S. are grown almost entirely as a vegetable.

Extensive culture of turnips as a forage crop for sheep and cattle began in Great Britain about 1724 and increased rapidly because it fitted so well into the system of crop rotation and stock feeding that was developing in the 18th century. Turnips afforded large quantities of winter feed, thus increasing the conversion of straw into barnyard manure for the improvement of the lighter soils. They are generally grown in rotation with grain crops and are well adapted to clean row culture designed to free the land of weeds that interfere with grain production. Animal manures are generally applied, although chemical fertilizers alone may be used.

White turnips are often sown broadcast, in both Europe and America, and neither cultivated nor thinned. Rutabagas and yellow turnips are usually sown in rows about 2 ft. apart. When large stock-feeding varieties are grown, they are thinned to about 10 in. apart in the row; but when rutabagas or turnips are grown for human food they are thinned to only 3-6 in. apart in the rows.

Although considerable quantities of these species are grown in home and market gardens: and are even shipped long distances in the United States, the total volume of trade in them remains comparatively small. (V. R. B.)

TURNSTONE (*Arenaria interpres*), a shore bird found on the coasts of every part of the world, but breeding only in the high arctic. About nine inches long, it is allied to the plovers (*q.v.*). The turnstone has short legs and a heavy build. The white face. striped with black, the black gorget and white band on the wings are characteristic features. The sexes are alike in appearance. The bird feeds on small crustacea, worms, etc., which it seeks under stones. The nest contains four olive-green eggs, closely blotched with brown. Both male and female incubate.

TURNU SEVERIN, a town of Rumania. in the region of Craiova, on the main Walachian railway, and on the left bank of the Danube river! below the Iron Gates cataracts. Pop. (1956) 31,559. It is a modern commercial town, having a school of arts and crafts, several churches, and large government yards for the building of river steamers, lighters and tugboats. There is a considerable trade in livestock, preserved meat, petroleum and cereals. The town! which was originally called Drobetae by the Romans, took its later name of Turris Severi, or the "Tower of Severus," from a tower built to commemorate a victory over the Quadi and Marcomanni by the Roman emperor Severus (A.D. 222–235). Near Turnu Severin are the remains of the celebrated Trajan's bridge. the largest in the Roman empire, built in A.D. 103 by Apollodorus of Damascus.

TURNVEREIN, an institution founded as a German unifying force by Friedrich Ludwig Jahn (*q.v.*), who set up the first public outdoor gymnasium in Berlin in 1811. In the German revolution of 1848, the turners sided with the political factions which revolted against monarchistic rule. Many turners came to the United States where *Turnverein* took root. The Cincinnati Turngemeinde, established in 1848, is the oldest in the U.S. The U.S. turners have sponsored an educational program combining physical and mental development to strengthen deniocracy and citizenship and to improve cultural opportunities. (J. E. Br.)

TURPENTINE, the oleoresins which exude from some conifers — such as *Pinus* sylvestris — and from the terebinth tree, Pistacia terebinthus. It was to the product of the latter, now known as Chian turpentine, that the term was first applied. The tree is a native of the islands and shores of the Mediterranean, passing eastward into central Asia; but the resinous exudation found in commerce is collected in the island of Chios. Chian turpentine is a tenacious semifluid transparent body, yellow to dull brown in colour, with an agreeable resinous odour and little taste. On exposure to air it becomes dry, hard and brittle. Turpentines are semifluid bodies, consisting of resins dissolved in turpentine oil, the chief constituent of which is pinene. They are largely used in the arts, being separated by distillation into rosin or colophony (see ROSIN) and oil or spirit of turpentine.

Crude or common turpentine is the commercial name for the oleoresin yielded by several coniferous trees. both European and American. The principal European product (Bordeaux turpentine) is obtained from the cluster pine, *Pinus* pinaster, in the Landes *département* of France. Crude turpentine is further yielded by the Scotch fir, P. *sylvestris,* and by the Corsican pine, P. laricio. In the United States the turpentine-yielding pines are the long-leaf pine, P. palustris, and slash pine, P. caribaea, both inhabiting North and South Carolina, Georgia, Florida, and Alabama. Venice turpentine is yielded by the larch, Larix *europaea;* Strassburg turpentine is obtained from the bark of the silver fir. Less known turpentines are obtained from the mountain pine, P. *pumilio,* the stone pine, *P.* Cembra, the Aleppo pine, P. *halepensis,* etc. The so-called Canada balsam, from Abies balsamea, is also a true turpentine.

Turps. — Oil of Turpentine, or Turps, as a commercial product is obtained from all or any of these oleoresins, but on a large scale only from crude turpentine. The essential oil is rectified by redistillation with water and alkaline carbonates, and the water which the oil carries over with it is removed by a further distillation over calcium chloride. Oil of turpentine is a colourless, oily liquid, with a strong odour and a hot disagreeable taste. It begins to boil at about 155° C., and its specific gravity is between 0.860 and 0.880. It rotates the plane of polarized light either to right or left in varying degrees according to the species of tree, the American product from P. palustris being dextrorotatory and P. caribaea levorotatory and the French levorotatory. It is almost insoluble in water, is miscible with absolute alcohol and ether, and dissolves sulfur, phosphorus, resins and caoutchouc. On exposure to the air it dries to a solid resin, and absorbing oxygen gives off ozone. Agitated with successive quantities of sulfuric acid and distilled in a current of steam, it yields terebene, a mixture of dipentene and terpinene mainly, which is used in medicine. Chemically, oil of turpentine is a mixture of terpenes (*q.v.*). It is largely used in the preparation of varnishes and as a medium by painters in their flat colours.

Pharmacology and Therapeutics. — Oil of turpentine (*Oleum* terebinthinae) is used internally as an anthelmintic to kill tapeworm. Externally it acts as a rubefacient, an irritant and a counterirritant. It is an antiseptic and, in small quantities, a feeble anesthetic. It is absorbed by the unbroken skin. It is largely employed as a counterirritant, the pharmacopoeia1 liniments being useful in myalgia, bronchitis, "chronic fheumatism" and pleurisy. In large doses oil of turpentine causes purging and may induce hemorrhage from the bowel or kidneys. It is absorbed unchanged and has a marked contractile action upon the blood vessels. It is a nervous depressant leading even to coma and total abolition of reflex action. The drug is excreted partly by the bronchi and partly in the urine. Glycuronic acid also appears in the urine. It may give rise to an erythematous rash. It must not be given to the subjects of Bright's disease, Its chief uses are as constituents of fomentations and enemata and as a local disinfectant in bronchiectasis (*q.v.*). Old turpentine and French oil of turpentine are antidotes to phosphorus, forming turpentine-phosphoric acid, which is inert. (A. D. J.)

TURPIN, archbishop of Reims. long regarded as the author of the legendary *Turpini Historia* Karoli *Magni* et Rotholandi, and one of the 12 peers in the entourage of Charlemagne in some chansons de geste (*q.v.*), is undoubtedly to be identified with the historical Tilpin, monk of Saint-Denis and archbishop of Reims (c. 751–794 or 800), successor to Milo, who had been intruded into the see by Charles Martel. Sources for his career are his third successor. Hincmar, and Flodoard, 10th-century monk of Reims.

The *Historia* Karoli *Magni* et Rotholandi was composed toward the middle of the 12th century by an ecclesiastic to assist the church's battle to Christianize society. to stimulate national pride by glorifying Charlemagne and to entertain and edify. To win acceptance of his work, the author fraudulently invested it with the authority of Pope Calixtus II (d. 1124). The *Historia* became part of the Codex *Calixtinus* (or Liber Sancti Jacobi), itself compiled to propagandize St James's shrine at Santiago de Compostela. Manuscripts that preserve it in Latin, Old French and Provencal number in the hundreds. Within the first 20, perhaps the first 10, years of the 13th century, six distinct translations of it into Old French appeared. It became a source for some historians writing on Charlemagne (but was rejected by others) and for epics and romances. See also CHARLEMAGNE LEGENDS; ROLAND. LEGEND OF.

See A. Hämel's review of C. Meredith-Jones's 1936 edition in *Speculum,* 13:248–252 (1938); *R.* N. Walpole, ***Philip*** *Mouskés and the Pseudo-Tuupin Chronicle* (1947). (J. N. G.)

TURPIN, RICHARD (DICK) (1706–1739), English robber, was born in 1706 at Hempstead, near Saffron Walden. Essex, where his father kept an alehouse. He was apprenticed to a butcher, but, having been detected at cattle stealing, joined a notorious gang of deerstealers and smugglers in Essex. When the gang was broken up Turpin went into partnership with Tom King, a well-known highwayman. To avoid arrest he finally left Essex for Lincolnshire and Yorkshire, where he set up under an assumed name as a horse dealer. He was convicted at York assizes of horse stealing and hanged on April 7, 1739. Harrison Ainsworth, in his romance Rookwood, gives a spirited account of a wonderful ride by Dick Turpin on his mare, Black Bess, from London to York. But as far as Turpin is concerned the incident is pure fiction. A somewhat similar story was told about a certain John Nevison, known as Nicks, a well-known highwayman in the time of Charles II, who to establish an alibi rode from Gad's Hill to York (some 190 mi.) in about 15 hours.

TURQUOISE, a mineral extensively used as a gem and ornamental stone for more than 80 centuries. As early as 3400 B.C. it was obtained from the Sinai peninsula, Egypt, in what probably was the world's first important hard-rock mining operation. Material of excellent colour later was mined in Persia and brought into Europe through Turkey; this probably accounts for the mineral name (turquoise means Turkish).

Turquoise is a complex phosphate of aluminum and copper with the general formula $CuAl_6(PO_4)_4(OH)_8.4H_2O$. Iron commonly substitutes for a little of the aluminum, and an excess of water is present in some varieties. The mineral ordinarily occurs as dense, cryptocrystalline to finely granular nodules, seams and encrustations. Its hardness is 5 to 6, its specific gravity 2.6 to 2.8.

The colour of turquoise ranges from blue through various shades of green to greenish- and yellowish-gray. A delicate sky-blue, which provides an attractive contrast with precious metals, is most valued for gem purposes. The mineral is opaque except in the thinnest splinters, takes a fair to good polish, and has a feeble, faintly waxy lustre. The lustre tends to become greasy and the colour more greenish and grayish in the presence of perspiration and various acids, also with long-term exposure to sunlight, heat or dry air. Such deterioration is most pronounced in porous varieties.

A secondary mineral deposited from circulating waters, turquoise is found chiefly in arid regions, generally in fractured volcanic and sedimentary rocks. Most of the world production has come from Iran? Egypt, Turkestan, Abyssinia, Australia, Siberia, Germany, France, Mexico and the United States. Iran has yielded material of finest quality, principally from the Ali-Mirsai-Kuh mountains near Nishapur, in the province of Khurasan. Numerous deposits in Arizona, California, Colorado, Nevada, New

Mexico and Utah were opened centuries ago by the American Indians, and some are still being worked. Best known are mines in the Cerrillos hills, near Santa Fe. N.M.

For most gem uses. turquoise is cut *en cabochon,* with a low convex upper surface. Irregular pieces also are set in mosaics. with or without jasper, malachite, obsidian. pyrite and other gem materials. "Turquoise matrix." any natural aggregate of turquoise with limonite or other substances. also is extensively used.

A little turquoise occurs as a replacement of bones and other fossil matter. However, most "bone turquoise." also known as odontolite and "fossil turquoise." is merely hone, teeth or ivory stained by vivianite (iron phosphate) or copper compounds. *See* also GEM. *(R.*H. J.)

TURRETINI (TURRETIN), the name of three Swiss Reformed churchmen and theologians.

BENOIT TURRETINI (1588–1631), was born at Zürich Nov. 9, 1588, was ordained a pastor in Geneva in 1612 and became a professor of theology in 1618. In 1620 he represented the Genevan church at the national synod of Alais. when the decrees of the synod of Dort were introduced into France; in 1621 he was sent on a successful mission to the states-general of Holland and to the authorities of the Hanseatic towns, with reference to the defense of Geneva against threatened attacks of the duke of Savoy. Be published in 1618–20 a two-volume defense of the Genevan translation of the Bible, *Eine Verteidigung der genfer Bibelübersetzung.* He died March 4. 1631.

FRANÇOIS TURRETINI (1623–1687), son of the preceding. was born at Geneva Oct. 17, 1623. He became pastor of the Italian congregation in Geneva in 1647; aiter a brief pastorate at Lyons he again returned to Geneva as professor of theology in 1653. He was one of the most influential supporters of the *Formula Consensus Helvetica* and of the particular type of Calvinistic theology which that symbol embodied. His *Institutio theologicae elencticae,* 3 vol. (1680–83) passed through frequent editions. He died Sept. 28. 1687.

JEAN ALPHONSE TURRETINI (1671–1737). son of the preceding, was born at Geneva Xug. 13, 1671. After travel in Holland, England and France he was received into the Vénérable Compagnie des Fasteurs of Geneva in 1693. Here he became pastor of the Italian congregation, and in 1697 professor of church history and later (1705) of theology. During the next 40 years he advocated a more liberal theoiogy. and it was largely through him that the rule obliging ministers to subscribe to the *Formula Consensus Helvetica* was abolished. He died Slay 1. 1737.

TURRIFF, a small burgh of Aberdeenshire, Scot.. 34 mi. N.N.W. of Aberdeen by road. I'op. (1951) 2.994. The old town dates from the 6th century. The Wars of the Covenanters began with the skirmish known as the Trot of Turriff (1639). A prosperous market town and a centre of the Aberdeen-Angus cattle trade. Turriff has extensive agricultural engineering works.

TURTLE, common name for members of an ancient order of reptiles chiefly characterized by a shell that encloses the vital organs of the body and more or less protects the head and limbs. Although there has been much confusion over the scientific as well as the common name of the group, most scientists now accept the earlier term Chelonia rather than the later ones Testudines and Testudinata. Two common names are in wide use, tortoise and turtle. "Tortoise" is applied in the British isles to all members of the group except the few marine species. all of which have paddle-shaped limbs. '"Turtle" has long been much more broadly applied in the United States. with the addition of "terrapin" for some edible species. Usage both in the British isles and in the United States left the group without a general name comparable to "bird" or "mammal." However. the American Society of Ichthyologists and Herpetologists standardized the common nnnies of the reptiles of the United States. assigning "turtle" to all of those with a shell. "tortoise" being reserved as a secondary name for the slow-moving terrestrial species, such as those of the genera *Testudo* and *Gopherus.*

Origin and **Evolution.**—The evolution of the turtle is one of the most remarkable in the history of all vertebrates. Unfortunately, the origin of this highly successful order is obscured; by the middle of the Triassic period (about 175,000,000 years ago) its members were already numerous and in possession of the basic turtle characteristics. The links between turtles and the cotylosaurs (the most primitive reptiles) from which turtles probably sprang are almost entirely lacking. The most likely missing link is a small. toothed reptile (*Eunotosaurus*) of the Permian period of southern .Africa.

While some reptiles flourished and vanished (as the dinosaurs), others persisted. some as once successful groups, and a few as initiators of expanding groups (snakes and lizards). The turtles, however. have plodded a stolid and steady course through evolutionary time, changing very little in basic structure.

Structure. — The protective shell, to which the evolutionary success of turtles is largely attributed, is a case of bone covered by horny shields. Plates of bone are fused with vertebrae, ribs and elements of shoulder and hip girdles. There are many shell modifications from family to family?some of them extreme.

At its highest development, the shell is not only surprisingly strong but also completely protective. For example. a box turtle (*Terrapene*) of North America can readily support a weight 200 times greater than its own; a man with proportionate supporting power could bear up two large African elephants. In a closed position the lower shell (plastron) can fit so snugly against the upper (carapace) that a knife blade cannot be inserted between them.

This protection was acquired by the development of structural peculiarities. two of which are especially worthy of mention. As a rule. the limb girdles of vertebrates lie outside the rib box; in turtles, however, they are partly within it. This is accomplished by a fusion of the developing ribs with the growing shell, which carries the ribs to a position partially within the rib box.

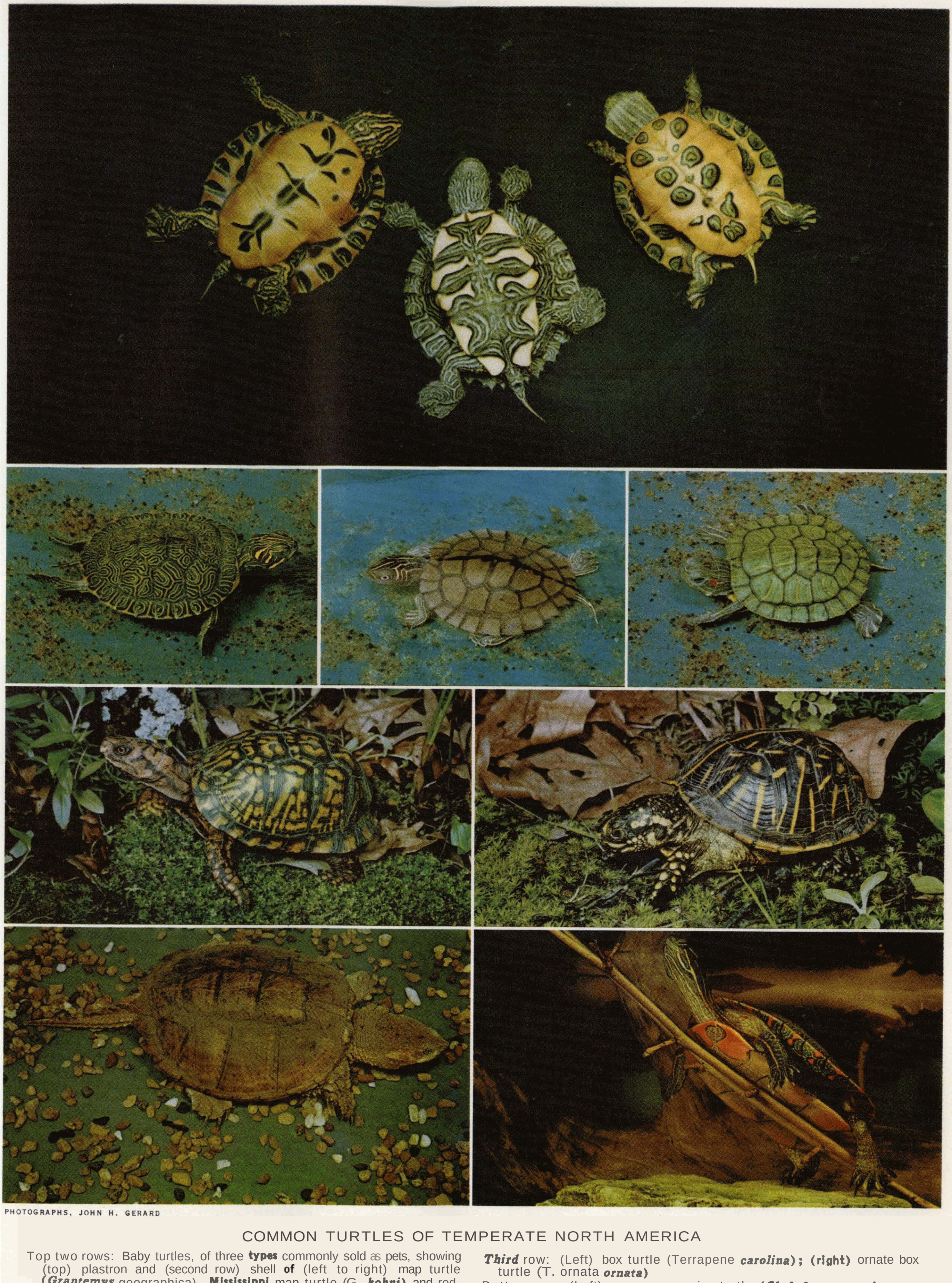
In man the ribs play an important part in the chest expansion that enables him to breathe. The turtle's ribs are immovable. and so the task of chest expansion has been transferred to abdominal muscles; two muscles enlarge the chest cavity for inspiration, and the others press the organs against the lungs to force the air out. Some aquatic species have additional methods of breathing: the vascularized mucous membrane of the cloacal region or of the throat can function like the gill of a fish. Such accessories to ordinary respiration enable turtles to lie quietly submerged for hours or even days.

The vertebral column, with very little to support, underwent drastic modification. The trend in turtles. in contrast to that in most other reptiles, has been to reduce the number of vertebrae. The ability to retract the head into the shell is related to the retention of eight specialized vertebrae. The result is that the neck has almost as many vertebrae as does the central part of the column (between neck and tail). The manner in which the neck bends is of importance in classification.

Natural History. — Turtles have been toothless for more than 150,000,000 years; the teeth of even the Triassic turtles were oddly placed, having been as far as is known, confined to the palate. In some modern types the moderately sharp and jagged edges of the horny jaws function as teeth. Food is chewed, the claws of the forelimbs often assisting in manipulation, until it is reduced to fragments that can be swallowed.

Most turtles prefer a varied diet. Fibrous parts of plants are avoided because the jaws are not sharp enough to cut well and are entirely incapable of grinding. Small invertebrates such as worms, snails, slugs. insects, thin-shelled bivalves and crayfishes and other crustaceans make up the bulk of the animal food. Large aquatic turtles are able to catch fishes and occasionally a few birds and small mammals.

Turtles, like other reptiles. can survive long fasts, being able to live on weekly or even monthly feedings; however, when food is readily available, they may eat frequently and grow very fat. The rate of digestion varies with the temperature. In the wild, they probably maintain a relatively constant temperature by retiring to suitable surroundings; this may require constant activity. Turtles drink readily, and some store water in cloacal bladders. an ability that allows them to survive long periods of drought.



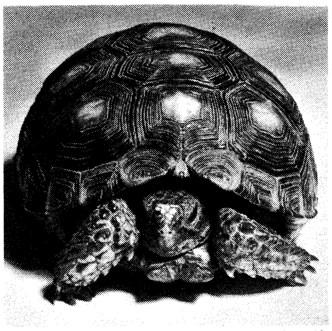
PHOTOGRAPHS, JOHN H. GERARD

COMMON TURTLES OF TEMPERATE NORTH AMERICA

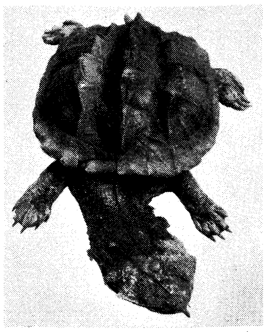
Top two rows: Baby turtles, of three **types** commonly sold as pets, showing (top) plastron and (second row) shell **of** (left to right) map turtle (***Graptemys*** geographica), **Mississippi** map turtle (G. ***kohni***) and red-eared turtle (***Pseudemys scripta elegans***)

Third row: (Left) box turtle (Terrapene ***carolina***); **(right)** ornate box turtle (T. ornata ***ornata***)

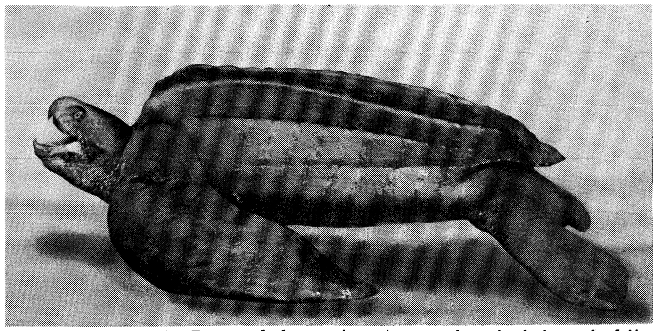
Bottom row: (Left) common snapping turtle (***Chelydra serpentina serpentina***); (right) painted turtle (***Chrysemys*** picta)



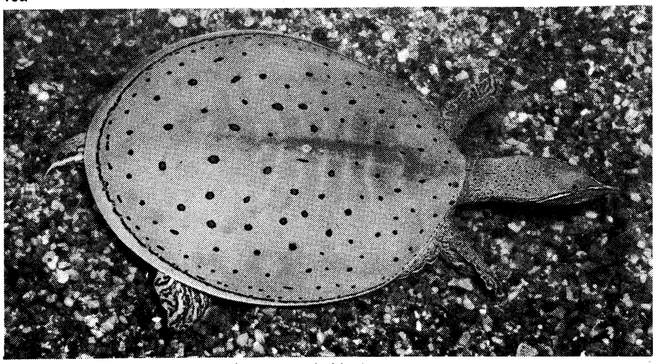
Texas tortoise (*Gopherus berlandieri*), a gopher tortoise of North America



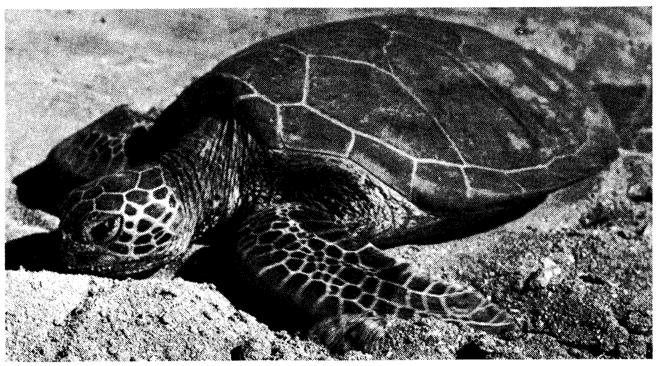
Matamata (*Chelys fimbriata*), a South American fresh-water turtle



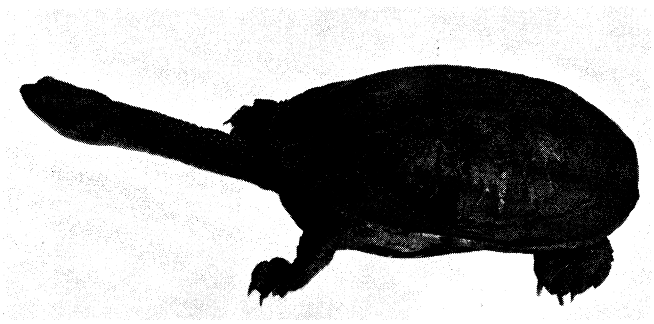
Atlantic leatherback (*Dermochelys coriacea*), **a marine giant, largest of the** living turtles



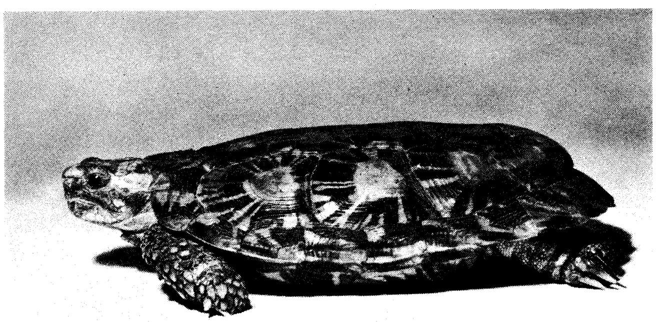
Spiny softshell turtle (*Trionyx spinifer*), widely distributed in U.S. and adjacent parts of Mexico



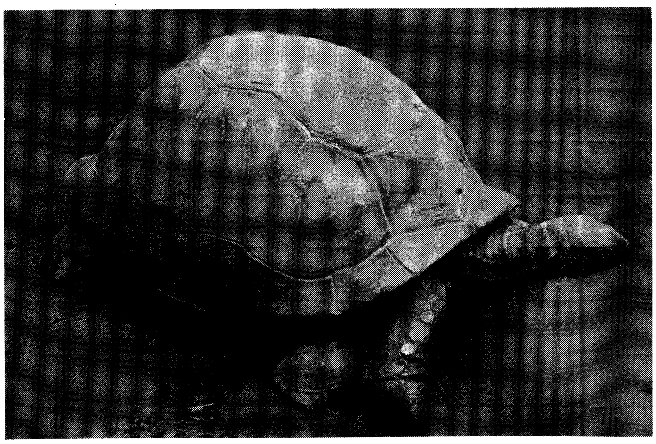
Green turtle (*Chelonia mydas*), large marine turtle of both the Atlantic and Pacific oceans



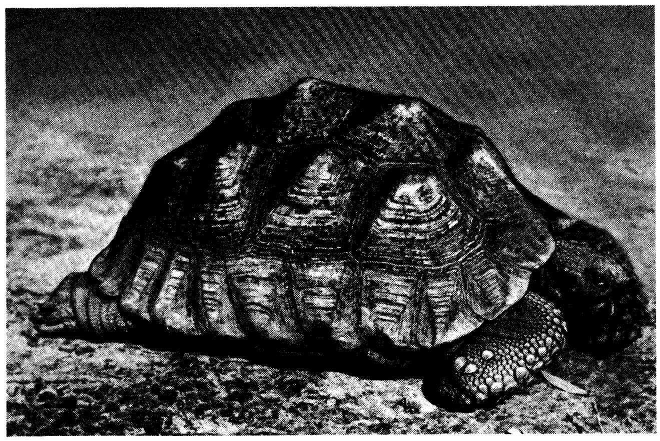
Australian snake-necked turtle, *Chelodina longicollis*



Pancake, or Tornier's, tortoise (*Malacochersus tornieri*) of central Africa, remarkable among land tortoises for the plasticity of its shell



Elephant tortoise (Testudo gigantea), a giant land turtle of the Seychelles and Aldabra Islands



Leopard tortoise (Testudo *pardalis*), one of the two largest mainland tortoises of Africa

MARINE, FRESH-WATER AND TERRESTRIAL TURTLES

BY COURTESY OF (TOP CENTRE. THIRD ROW LEFT, BOTTOM LEFT) RAYMOND L. DITMARS AND THE AMERICAN MUSEUM OF NATURAL HISTORY, (TOP RIGHT) THE AMERICAN MUSEUM OF NATURAL HISTORY. PHOTOGRAPHS. (TOP LEFT THIRD ROW RIGHT) ISABELLE HUNT CONANT, (SECOND ROW LEFT, SECOND ROW RIGHT) JOHN H. GERARD, (BOTTOM RIGHT) ROGER CONANT

Copulation is usually preceded by an elaborate courtship highly characteristic for a species or related group of species. The male's courtship performance may include such antics as lunging at the female while roaring. or. in some aquatic kinds, gracefully swimming backward in front of her while stroking her lores (cheeks) with the excessively long nails of his forelimbs. The penis, paired in snakes and lizards, is single in turtles. The most unusual aspect of turtle reproduction is the ability of females to lay fertile eggs for years after a single mating.

Both terrestrial and aquatic turtles lay their eggs on land. For the nest the female usually selects a sunny place; she then digs a hole, about as deep as her hindlimbs are long, into which she deposits round or elliptical whitish eggs (they are never pigmented like birds' eggs), the shells of which may be either flexible or brittle. Several clutches may be laid in a season, though this is by no means the rule. A clutch may have more than 200 eggs (as in some sea turtlesj or as few as one. The sea turtles and the largest tortoises lay eggs about two inches in diameter. whereas nearly all of the other turtles lay much smaller ones.

Most nests are carefully constructed and hidden; a fen- are crudely made. The period of incubation depends to an appreciable extent on the temperature. After the nest is completed: the mother appears to take no further interest in it. or, for that matter, in the hatchlings. As a result, the nest is often robbed of eggs, and freshly hatched turtlets, whose shells are still soft, are frequently preyed upon by large birds and small mammals.

These shelled reptiles outlive all other vertebrates. including man, the longest-lived mammal. An eastern box turtle (*Terrapene carolina*) survived 138 years in the wild. There is good evidence of a turtle of another species having lived more than a century and a half. In spite of widespread belief, turtles do not grow unusually slowly; maturity is reached in less than ten years. and gronth in a large species may be more rapid than that in man himself.

Age estimates are sometimes made for some cpecies by counting the growth rings on the horny shields of the shells: this method is of little practical value. however. because the rings become indistinct with maturity. Size is equally untrustworthy as an indication of age.

Turtles run the gamut in size. The .Atlantic lestherhack (*Dermochelys coriacea*). largest of living kinds, may weigh more than $\frac{3}{4}$ ton and measure 12 ft. from the tip of one flipper to that of the other. An extinct marine giant. *Archelon,* of North America was probably noticeably larger. and an extinct tortoise of Asia (*Colossochelys* atlas) had a shell 7 ft. long. The largest living tortoises may weigh more than 500 lb.

At the opposite extreme the adults of some species weigh less than a pound and have a shell less than five inches long. The length of the shell of most adult turtles would fall between 5 and 15 in.

Although scientific evidence is lacking, turtles appear to depend heavily on their sense of smell. Their sight is reasonably good and they are able to distinguish colours: they are especially responsive to reds. colours that most often figure in the adornment of the turtles themselves. Turtles do not hear in the ordinary sense of the word; they are indifferent to sounds carried by the air hut are sensitive to vibrations transmitted through solids. Turtles seldom emit sounds: except when courting and mating; even then they do little more than grunt or bark. Exceptions are a few sea turtles that can give a loud cry of anger or a "plea for mercy."

Experiments on the intelligence of turtles indicate that they learn readily: in some ways they are comparable to the laboratory rat. Persons who have had extensive experience n-ith pets sometimes elicit from turtles a degree of intelligence usually credited only to mammals. To the casual observer. however. a turtle oiten appears to be very stupid, especially when it repeatedly climbs over an obstacle it could easily go around.

The turtle is proverbially one of the slon-est animals. and there is some justification for this reputation. at least for some land forms. It is an odd fact that aquatic species in general move faster, even on land. The tortoises of the genus *Gopherus* have been clocked at rates of 0.13 to 0.30 m.p.h., whereas the rate on land of a normally aquatic cooter (*Pseudemys floridana*) has been recorded at 1.07 m.p.h. in spite of the fact that it was out of its element.

A green turtle (*Chelonia mydas*) has been known to swim 300 mi. in 10 days; it must have traveled at an appreciable rate, since it scarcely could have swum steadily ahead without taking time to eat. sleep or rest. Softshell turtles (Trionychidae) are able to move their limbs at a rate comparable to that in birds and mammals.

The sense of location is well developed; turtles released in an enclosure will usually pick out a resting place and spend much time in it. Some species have a "home area" to which they will return if they are taken a short distance away. The sea turtles are probably exceptions to the general rule of living in a restricted area. There is some evidence to indicate that sea turtles are able to make long migratory journeys and that mass migrations from breeding beach to feeding ground and back take place annually.

Economic **Value.**—Man has always relished turtles, and it is likely that almost every species has at one time or another satisfied the broad human appetite. The green turtle! with its distribution extencling around the world. no doubt has supplemented the diet of peoples of more cultures than has any other wild vertebrate. Tortoise populations of many oceanic islands have been decimated; it has been estimated that 10,000,000 land giants were taken from the Galápagos Islands as food supply for the early whaling ships. Turtle eggs are also prized as food. These are deposited in such abundance on certain beaches that harvesting them has become a national industry in one country.

Just as turtle meat has long satisfied our appetite, so has "tortoise shell" gratified our sense of beauty. In recent years, plastics have come to the rescue of the hawksbill turtle (*Eretmochelys*), chief source of the horny shields from which tortoise-shell ornaments are made.

Care in Captivity. — Turtles are among the most popular reptile pets. The vast majority of those kept in captivity are baby turtles: these demanding charges are unfortunately often given over to children who are too young to properly care for them. Countless numbers of tiny cooters (*Pseudemys*) and their relatives are shipped from the southern U.S. where they are adapted to a warm climate. Cooters. aquatic and normally capable of attaining a large size. when placed in the home aquarium. nearly always suffer from malnutrition and slowly die. Their lamentable condition may persist for months without being noticed, Imperceptible growth, failure of the shell to harden and sore eyes are danger signs. Turtles suffering these disorders can seldom be restored to health.

The diet must include raw fish or lean raw beef finely chopped and mixed with generous amounts of bonemeal and cod liver oil. This mixture should be given daily until the shell is several inches long (often attained in two or three years:), when two feedings a week will suffice. As few owners want such big pets the older turtles are discarded for the more popular turtlets.

However. adult turtles of many species make good pets. and they do not suffer readily from malnutrition. It is only necessary to identify the species and learn about its particular habits from a good handbook. Hatchling cooters will of course thrive on a diet of the animals which they normally eat in nature. but the collecting of such food requires special knowledge and techniques. The adults can live on artificial foods. but they fare better when their diet is supplemented by natural foods such as aquatic greens. lettuce. carrot tops, worms, insects. fish. etc. Vegetarian species usually present fen-er problems than do the carnivorous ones; however. most turtles are omnivorous, preferring a varied diet (see *Natural History,* above).

Classification and Distribution. — The hackboned animals (subphylum Vertebrata) are divided into eight classes: bony fishes and their relatives (four classesi. Amphibia, Reptilia. Aves and Mammalia. The turtles (Chelonia) constitute one of the 15 or 16 orders of living and extinct reptiles. Together with the cotylosaurs the turtles are known as anapsid reptiles (subclass Anapsida), characterized by a skull with a solid roof.

Turtles fall into three suborders: Amphichelydia, extinct primitive turtles; Pleurodira, side-necked turtles; and Cryptodira. all remaining kinds. The last two suborders, which evolved from the first during the late Mesozoic, are thriving today. The pleurodires are now restricted to South America, Africa, Madagascar, Australia and New Guinea and adiacent islands. The cryptodires. in contrast. are found on all the continents except Australia and include about $\frac{4}{5}$ of all living species. When reckoned by families. about half of the 21 or 22 families known to science are now extinct.

The living species of turtles number approximately 225 and new species are continually being discovered. The two suborders and the important families may be characterized as follows (the English names of these families are not well fixed):

Suborder Cryptodira (Vertical-necked *Turtles*).—Among these turtles the neck is drawn into the shell by vertical flexure, an ability that calls for highly specialized cervical vertebrae. The largest family, the common fresh-water turtles, Emydidae, includes a third of all living species and has a geographical range about as extensive as that of the entire suborder. The species, many of which occur in the eastern half of the U.S., are predominantly occupants of aquatic and semi-aquatic habitats. Next in number of kinds are the true tortoises, family Testudinidae, with a little more than half as many species as are found in Emydidae.

The slow, plodding tortoises of fable belong to this widely distributed terrestrial group, the gigantic species of which are confined to oceanic islands.

There are only two other groups of cryptodires having an appreciable number of species. One of these, family Kinosternidae. the musk turtles and mud turtles, is confined to the new world and includes only about twenty species, several of which are found in the United States, many in Mexico. The group is sometimes divided into two families.

Members of the remaining large lot of cryptodires, family Trionycidae, are readily recognized by their skin-covered flexible shells. These are the softshells, aquatic creatures that have been described as animated pancakes. Their range, wide on both sides of the world, excludes, however, both Australia and South America.

The six species of marine turtles live in warm seas; they are divided into two groups: Dermochelyidae, comprising only one form, the leatherback, largest of living turtles; and Cheloniidae, the sea turtles. All marine turtles are large and can be easily recognized by their paddlelike limbs.

Chelydridae, the snapping turtle family, though it has only two species, is, nevertheless, well known in North America because its members, large and bad-tempered, have a disputed economic status. One species ranges into northwestern South America. Three other famílies of cryptodires, each consisting of a single species, are less well-known groups having narrow geographical distribution.

Suborder *Pleurodira* (Side-necked Turtles). — This suborder, once world-wide in distribution and now restricted to the southern continents, includes about 20% of living turtles. The habit of bending the neck sideways to retract the head makes recognition of these primarily aquatic reptiles sure and easy. The neck of some species is responsible for one common name of the larger of the two families, Chelidae, the 28 species of snake-necked turtles.

The queerest of all turtles, the matamata (Chelus *fimbriata*) of South America, belongs here. The other family, Pelomedusidae, with only half as many species, comprises the side-necked turtles from which the common name of the suborder is derived.

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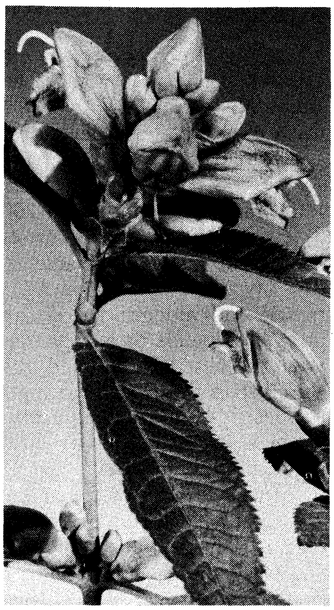
(C. H. Po.)



ROCHE

TURYLEHEAD (CHELONE GLABRA)

TURTLEHEAD (Chelone). a small genus of North American herbs of the figwort family (Scrophulariaceae; *q.v.*), all smooth perennials that bear clusters of showy flowers. the corolla resembling a turtle's head. The common turtlehead (C. *glabra*), with ahite flowers, occurs from Newfoundland to Manitoba and southward.

Other species, having yellowish, pink and purple flowers, are found in damp, woodsy soil in the southeastern and central states.

TUSCALOOSA, a city of western Alabama, U.S., on the Warrior river 58 mi. S.W. of Birmingham; the seat of Tuscaloosa county. The city lies at the edge of the great coal and mineral deposits of Alabama in a rich agricultural region. In the county are many important industries, including chemicals, kraft paper, lumber, cottonseed products, fertilizer and auto and truck tires and tubes.

There are many old residences and gardens, dating from the time Tuscaloosa was the capital of the state (1826–46). The streets are wide and lined with magnificent oaks, planted in the early days of settlement. In the city are the Bryce hospital and Partlow state school (major units of the Alabama state hospitals) ; a Gnited States veterans' hospital; Hale Memorial Tuberculosis hospital; Stillman college (Presbyterian, founded 1876) ; and the University of Alabama (see ALABAMA : Education).

The town was named for the Choctaw chief Tuskalusa, who is commemorated by a granite monolith on the courthouse lawn. The first white settlers arrived in 1816. The county of Tuscaloosa was created in 1818; the town was incorporated Dec. 13, 1819, one day before the state of Alabama was admitted to the union. The population in 1960 was 63,370 in the city and 109,047 in the standard metropolitan statistical area (Tuscaloosa county). (B. CR.)

TUSCANIA, a town of the province of Viterbo, Italy, 15 mi. N.E. of Corneto by road, 545 ft. above sea level. Pop. (1951) 5,987. The ancient town lay on the Via Clodia; its Etruscan tombs have yielded valuable antiquities, and remains of a large thermal establishment of the Roman period have also been found. The medieval walls with their towers are still preserved. On the ancient citadel hill is the Romanesque church of S. Pietro, belonging to four different periods — 739, 1093 (the date of the reconstruction of the crypt), the middle of the 12th and the end of the 12th century. It has the shape of a Roman basilica, with a nave and two aisles and one apse. The elaborate façade with its rose window also belongs to the 12th century. Sta. Maria in the valley below dates from 1050 to 1206, and has a similar façade and a massive square campanile. In the town are two other Romanesque churches.

The town was called Toscanella until 1912, when it resumed the name which it bore in ancient Latin times.

TUSCANY (Italian TOSCANA), a region of central Italy, consists of the provinces of Arezzo, Grosseto, Florence (Firenze), Leghorn (Livorno), Lucca, Massa-Carrara, Pisa, Pistoia and Siena (*qq.v.*), with a total area of 22,989 sq.km. (8.876 sq.mi.) and a population (1951) of 3,158,811. In the north and northeast the region is bounded by the Tuscan-Emilian Apennines (Appennino Tosco-Emiliano), these being separated by a series of long valleys (Mugello. Casentino) from the sub-Apennine uplands of Monte Albano, Pratomagno and others. Quite separate from the Apennine and sub-Apennine systems are the so-called anti-Apennines of Tuscany, consisting of low mountains (*e.g.,* the Apuane alps and the Colline Metallifera) and plateaus extending as far south as the volcanic uplands of the Lazio region. Farthest west are several isolated massifs along or near the coast (Monte Argentario, Monte Amiata). The lowlands of Tuscany are either interior valleys (*e.g.,* Val di Chiana and Valdarno) or littoral plains, the most important coastal plain being the Maremma. Watered chiefly by the Arno (*q.v.*) and the Ombrone, Tuscany has few rivers capable of supporting major hydroelectric projects, but the borax deposits at Larderello produce enough underground steam to power a major generating station. Among the mineral resources, easily worked iron ore from Elba (*q.v.*) is nearing exhaustion but lead, zinc, antimony, mercury, copper and iron pyrites are still produced in the region. Lignite is mined around San Giovanni Valdarno and the marble of Carrara is world famous. Steel and iron are manufactured at Piombino (*q.v.*), chemicals at Leghorn and near Pisa, ships at Leghorn and textiles and ceramics in many cities. Besides larger manufacturing establishments Tuscany is famous for its artisan industries, especially in Florence (leather, lace, silver).

Agriculture in Tuscany is among the most prosperous in Italy, characterized by specific forms of land ownership and a variety of crops. The classic form of land ownership and utilization is share growing, the *mezzadria* system, with the landlord (who provides capital and current expenses) sharing the harvest with the tenant, who supplies the labour. (See MÉTAYAGE SYSTEM.) Shares are fixed by law, and many tenancy contracts have been carried on for generations between landowner and tenants. Besides cereals. Tuscan agriculture is noted for wines (the wines of the Chianti district, near Siena, are the best known and most widely exported of all Italian wines), olives and olive oil (around Lucca), vegetables and fruit. Cattle, horses, pigs and poultry are raised in large numbers. The railway system is characterized by two trunk lines, the coast line, running from Rome through Grosseto, Leghorn and Pisa to Genoa; and the interior line, from Rome through Arezzo to Florence, Bologna and Milan. There are numerous secondary railways and a good network of highways and of bus services. Florence is the largest city and Leghorn the leading port; Florence, Pisa and Siena are important tourist resorts. (G. KH.)

HISTORY

The name Tuscany is derived from that of the Tusci, Tuscans or Etruscans (*q.v.*). Their country, Etruria (*q.v.*), which was finally annexed by the Romans in 351 B.C., comprised not only Tuscany but also the northern part of what is now Lazio. In the 8th century A.D., however, after Charlemagne occupied the Lombard kingdom in northern Italy, the name of Tuscia or Toscana became restricted to the area north of Viterbo and Eolsena. Tuscany then became a march or frontier district of the Frankish dominions, the principal authority in the march being, from 774, in the hands of the counts of Lucca (*q.v.*). Boniface I, the first known count of Lucca, died in 823 and was succeeded by his son Boniface II, whose victories over the Arabs in the Mediterranean served to bring both Corsica and Sardinia into the Tuscan sphere of influence. With the decline of the Carolingian power in Italy the counts began to assume occasionally the style of duke or margrave of Tuscany. The 10th century, however, saw the rise of the house of the Attoni of Canossa (*q.v.*), and a member of this house, Boniface, *c.* 1027 was invested with the margraviate of Tuscany by the emperor Conrad II. On the assassination of Boniface (1052). his widow Beatrice governed till 1076, when her daughter, the great Matilda (*q.v.*) of Tuscany, took her place.

The quarrel about investiture between the empire and the papacy coincided with the rise of the communes in northern Italy (see ITALY: History), whereby a number of the more prosperous towns asserted their independence of their overlords. In Tuscany the first communes to emerge were Pisa, Lucca and Pistoia, which, having obtained concessions from the emperor Henry IV, joined the Ghibelline faction. Subsequently Siena, Florence and Arezzo also established communes. Florence, influenced to some extent by Matilda's benevolent attitude toward its commune, inclined, as she did, to the Guelph or papal side. As Matilda bequeathed all her extensive possessions to the church, her death (1115) was followed by a struggle over her inheritance between the popes and the emperors. This enabled the Tuscan cities gradually to confirm their independence till the old unity of the march was lost altogether. Widespread inundations in the Arno valley and in the Lucca area led to destitution which helped to bring about the politico-economic upheaval.

Pisan supremacy in the 12th and 13th centuries was contested by Florence and by Lucca (which eventually left the Ghibelline camp), and Pisa. though supported by Siena and Pistoia, had also Genoa for an enemy. After the defeat of the Pisan navy by the Genoese in the battle of Meloria (1284), Florence grew to be the leading city of Tuscany. The Tuscan dialect as spoken in Florence and written by Dante (q v.) came to be a standard iorm for Italian.

The Medici Grand Duchy.—The later medieval history of Tuscany is chiefly that of the consolidation of Florentine supremacy (see FLORENCE) and of the establishment in Florence of the dynasty of the Medici (*q.v.*). Twice between 1430 and 1530 (1495–1512 and 1527–30) the Medici were expelled, but after the surrender of Florence to the emperor Charles V's forces in Aug. 1530 they were restored, and Alessandro de' Medici became gonfaloniere for life, a dignity that was made hereditary in the family. As he held the title of duke of Città di Penna, he is generally called duke of Florence. Under his successor Cosimo de' Medici. Siena, the one remaining outpost of republicanism in Tuscany, was annexed (1559), and Cosimo mas created grand duke of Tuscany (Cosimo I) by Pope Pius V in 1567. His son Francesco I was recognized as grand duke by the emperor Maximilian II in 1576. Under his descendants, Ferdinand I, Cosimo II, Ferdinand II, Cosimo III and Gian (Giovanni) Gastone, Tuscany played but a small part in European history.

The House of Habsburg-Lorraine.—Gian Gastone being childless, it was agreed in the preliminaries (1715) of the treaty of Vienna during the War of the Polish Succession that Francis of Lorraine, future husband of the Austrian archduchess Maria Theresa of Habsburg, should succeed eventually to Tuscany in compensation for Lorraine, of which he was dispossessed. In 1737 Gian Gastone died, and Tuscany was governed for Francis, who resided in Austria, by a series of foreign regents.

Francis, who had been elected emperor in 1745, died in 1765 and was succeeded on the throne of the grand duchy by his younger son, Leopold I (see LEOPOLD II, Holy Roman emperor). Leopold resided in Tuscany and proved one of the most capable and remarkable of the reforming princes of the 18th century. He substituted Tuscans for foreigners in government offices. introduced a system of free trade in foodstuffs (at the suggestion of the Sienese Sallustio Bandini) and promoted agriculture. He reorganized taxation on a basis of equality for all citizens. reformed the administration of justice and local government and suppressed torture and capital punishment. He also curbed the power of the clergy, suppressed some religious houses, reduced the mortmain and rejected papal interference With the aid of Scipione de' Ricci. bishop of Pistoia, he even attempted to reform church discipline, but Ricci's action was condemned by Rome and he was forced to resign. At the death of his brother Joseph II in 1790, Leopold became emperor and moved to Vienna. After a brief regency he appointed his second son, Ferdinand III (q *v.*), grand duke.

The French Occupation.—During the French Revolutionary Wars a French force entered Florence in 1799 and mas welcomed by a small number of republicans. The grand duke nas forced to flee. and a provisional government on French lines was established. But the mass of the people were horrified at the irreligious character of the nen regime, and a counterrevolution broke out at Arezzo. Bands of armed peasants expelled the French from the countryside, with many atrocities. With Austrian help Florence was occupied and a government established in Ferdinand's name, but after Bonaparte's victory at Marengo the French returned in force, dispersed the bands and re-entered Florence (Oct. 1800). They too committed atrocities, but they were more warmly welcomed than before by the people, after the experience of Austro-Aretine rule. Joachim Murat set up a provisional government.

By the treaty of Lunéville (1801), Tuscany was renounced by the Austrians. It was then erected into the kingdom of Etruria for the Bourbon prince Louis, son of Ferdinand, duke of Parma. When Louis died (1803), his widow, the Spanish infanta Maria Luisa, ruled as regent for her son Charles Louis until 1807. Then the emperor Napoleon obliged her father, Charles IV of Spain. to agree to the cession of Tuscany-Etruria to France, compensating Charles Louis with a Portuguese principality.

From 1808 to 1809 Tuscany was a French *département*. Then in 1809 the grand duchy was revived for Napoleon's sister Elisa Bonaparte and her husband Felix Baciocchi. French progressive ideas gained some adherents, but to most Tuscans the new institutions were distasteful as subversive of cherished traditions. The heavy taxes and conscription were especially resented.

The **Habsburg** Restoration.—After Napoleon's defeats in 1814, Ferdinand III returned to Tuscany, where he was received with some enthusiasm. The congress of Vienna added some further territory to the grand duchy and guaranteed, moreover, that Lucca should in due course revert to it (as it did in 1847). The restoration in Tuscany was unaccompanied by the excesses which characterized it elsewhere: and much of the French legislation was retained. Ferdinand was succeeded in 1824 by his son Leopold II (*q.v.*), who continued his iather's policy of benevolent but enervating despotism. When the political excitement consequent on the election of Pius IX spread to Tuscany, Leopold, in Feb. 1848, granted a constitution. For some months Gino Capponi (*q.v.*) was prime minister. A Tuscan contingent took part in the Sardinian (Piedmontese) campaign against Austria, but the increase of revolutionary agitation in Tuscany, culminating in the proclamation of the republic (Feb. 9, 1849), led to Leopold's departure for Gaeta. Under the republican triumvirate of F. D. Guerrazzi, Giuseppe Mazzini and G. Montanelli disorders continued, and Leopold was invited to return and did so, but forfeited his popularity by according the protection of an Austrian army (July 1849). In 1852 he formally abrogated the constitution, and three years later the Austrians departed. When in 1859 a second war between Sardinia and Austria became imminent, revolutionary agitation broke out once more. There mas a division of opinion between the moderates, who favoured a constitutional Tuscany under Leopold as part of an Italian federation, and the popular party, led by Ferdinando Bartolommei, who aimed at the unity of Italy under Victor Emmanuel. At last a compromise was reached and the grand duke was requested to grant a constitution and to take part in the war against Austria. Leopold having rejected these demands, the Florentines rose and expelled him (April 27, 1859).

Union With the Italian Kingdom.—A provisional government, led by Ubaldino Peruzzi and afterward by Bettino Ricasoli (*q.v.*), was established. It declared war against Austria and then handed over its authority to a Sardinian royal commissioner (May 9). A few weeks later a French force under Prince Napoleon ("Plon-Plon"; see BONAPARTE) landed in Tuscany to threaten Austria's flank, but meanwhile the emperor Napoleon III made peace with Austria and agreed to the restoration of Leopold and other Italian princes. Victor Emmanuel was obliged to recall the royal commissioners, but together with Cavour he secretly encouraged the provisional governments, and the constituent assembly of Tuscany voted for annexation to Sardinia. The king accepted the annexation (March 22, 1860). On Feb. 18, 1861, the kingdom of Italy, comprising Tuscany, was proclaimed. See ITALY: History. See also Index references under "Tuscany" in the Index volume.

(L. V.; X.j

TUSCARORA, an Indian tribe of Iroquoian family. originally numbering 5,000, in North Carolina. Encroachments by the whites, including kidnapping of their children as slaves, led to a war with the settlers (1711–13), at the end of which the Tuscarora fled or drifted northward and were admitted into the League of the Iroquois as a sixth nation. About 700 survive in Canada and New York.

TUSCULUM, an ancient city of Latium, in a commanding position on the north edge of the outer crater ring of the Xlban volcano, $1\frac{1}{2}$ mi. N.E. of the modern Frascati. The highest point is 2,198 ft. above sea level. It has a very extensive view of the Campagna. with Rome lying 1j mi. distant to the northwest: Rome was approached by the Via Latina (from which a branch road ascended to Tusculum. while the main road passed through the valley to the south of it), or by the Via Tusculana.

According to tradition, the city was founded by Telegonus, the son of Ulysses and Circe. When Tarquinius Superbus mas expelled from Rome his cause was espoused by the chief of Tusculum, Octavius Mamilius. who took a leading part in the formation of the Latin league. composed of the 30 principal cities of Latium, banded together against Rome. Mamilius commanded the Latin army at the battle of Lake Regillus (497 B.C.). but was killed, and the predominance of Rome among the Latin cities was practically established. In 381 B.C. the people of Tusculum received the Roman franchise. Several of the chief Roman families were of Tusculan origin; *e.g.*, the gentes Mamilia. Fulvia. Fonteia, Juventia and Porcia (to which the Catos belonged). By the end of the republic, and still more during the imperial period, the territory of Tusculum was one of the favourite places of residence of the wealthy Romans. The number and extent of the remains is very great. Even in the time of Cicero we hear of 18 owners of villas there. Much of the territory (including Cicero's villa). but not the town itself, which lies far too high, was supplied with water by the Aqua Crabra. On the hill of Tusculum itself are remains of a small theatre (excavated in 1839), with a reservoir behind it, and an amphitheatre. Both belong probably to the imperial period. while a temple (the substructures of which are preserved), often called the villa of Cicero, or of Tiberius, near the latter, is probably earlier. Between the amphitheatre and the theatre lay the forum. The citadel—which stood on the highest point, an abrupt rock—was approached only on the side, toward the city. Upon it remains of the medieval castle, which stood there until 1191, are visible.

It was there that Cicero composed his Tusculun Disputations and other philosophical works. His villa must have been at or near Grotta Ferrata and what is now known as Poggio Tulliano a little to the east (where remains of a villa exist) may well have been its site. After the transference of the seat of empire to Constantinople, Tusculum became an important stronghold, and in the 10th–12th centuries its counts occupied a leading position in Rome. During the 12th century there were constant struggles with Rome. but in *1191* the Romans destroyed the city. (T. A.)

TUSI, NASIR AL-DIN (1201–1274), an outstanding Persian philosopher, scientist and mathematician. Born at Tus, Feb. 18, 1201, he became astrologer to the Isma'ili governor Nasir al-Din 'Abd al-Rahim. His attempts to join the caliph's court at Baghdad led to his being detained in the fortress of Alamut, headquarters of the Isma'ili terrorist sect, the Assassins. In 1256 he betrayed the defenses of the fortress to the invading Mongols whose army he joined; Hulagu Khan took him as a confidential adviser when he attacked and destroyed Baghdad in 1258. Tusi profited by his office as head of the ministry of religious bequests to build a fine observatory at Maragha. A man of exceptionally wide erudition, he wrote many books in Arabic and Persian. He improved upon earlier Arabic translations of Euclid, Ptolemy, Autolycus, Theodosius, Apollonius and others, and made original contributions to mathematics and astronomy; his *Zij-i Ilkhani* is a splendidly accurate table of planetary movements. His *Tajrid* al-'aqa'id is a highly esteemed treatise on Shi'ite dogmatics; in philosophy he defended Avicenna (*q.v.*) against the attacks of Fakhr al-Din al-Razi. His most famous and popular work is the *Akhlaq-i Nasiri,* a treatise on ethics in the Greek tradition resting upon the Tuhdhib al-akhlaq of Ibn Miskawayh (d. 1030) which he drafted while a prisoner of the Assassins and later revised ior his Mongol master. Tusi is credited with a number of distinctively Isma'ili dissertations, notably the *Tasavvurat.* A "quisling" in politics, he made important contributions to many branches of Islamic learning and wrote an excellent philosophical prose. He died at Baghdad. June 26, 1274

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TUSKEGEE, the seat of Macon county. Ala., U.S., 42 mi. E. of Montgomery. The city is best known as the site of Tuskegee institute, incorporated as a state coeducational and normal school for Segroes on Feb. 10. 1881. Booker T. Washington was principal of the school from its founding until his death in 1915. Tuskegee subsequently became an accredited. degree-granting institute offering professional, technological and teacher training and graduate work in some areas. On the campus is the laboratory used by George Washington Carver for his agricultural research. The library of the institute includes most of the known books relating to the southern Negro.

The town of Tuskegee was founded in 1533: the name is a variation of an Indian place name. Ft. Decatur, 8 mi. S.W. on the Tallapoosa river, founded as a military post in 1315. was the headquarters for John Sevier. the Indian boundary line commissioner appointed under the treaty of Fort Jackson. General Sevier died and was buried there but his remains were moved to Knoxville. Tenn.. in 1888.

Tuskegee has cottonseed oil. planing and gristmills and a fertilizer factory. There is also a large veterans hospital in the city. (P. A. B.)

TUSSAUD, MARIE (1760–1850), founder of "Madame Tussaud's exhibition" of wax figures in London, was born in Berne. Switz., on Dec. 1, 1760. After being taken to Paris she began to model in wax to assist her uncle. Philippe Curtius. During the Revolution Marie modeled the heads of many of the prominent leaders and victims.

On Oct. 20. 1795, she married François Tussaud, and together they ran Tussaud's museum. exhibiting Madame Tussaud's figures. In 1802 she took part of her collection to England and. after showing it successfully at the Lyceum theatre in London, traveled around the country exhibiting the collection. It was not established in permanent quarters. in Baker street. London, until 1833.

Madame Tussaud died there on April 16, 1850. The exhibition was moved in 1884 to a large building in Marylebone road.

Madame Tussaud's is one of the most continuously successful shows of London. The collection, which is of enormous value, still includes a number of molds cast by Madame Tussaud herself, including those taken from life of Benjamin Franklin. Sir Walter Scott and Voltaire, and a number of death masks, including that of Louis XVI. from the time of the Revolution. The most popular section of the exhibition, the chamber of horrors, includes models of many notorious murderers.

PICKOW FROM THREE LIONS

AMERICAN PRESIDENTS TABLEAU AT MARIE TUSSAUD'S WAXWORKS EXHIBITION, LONDON

Front row (left to right): Harry S. Truman, Dwight D. Eisenhower and Herbert Hoover (seated); back row (left to right): Woodrow Wilson, William Howard Taft, Franklin D. Roosevelt (seated), George Washington, William McKinley, Theodore Roosevelt, Grover Cleveland and Andrew Johnson

See J. T. Tussaud, *The Romance of Madanze Tussaud's* (1920); L. Cottrell, *Madame Tussaud* (1951).

TUSSER, THOMAS (c. 1524–1580), English poet. son of William and Isabella Tusser. was born at Rivenhall. Essex, about 1524. He was a chorister at Wallingford castle and then at St. Paul's cathedral, and from there went to Eton college. He was elected to King's college. Cambridge, in 1543, moved to Trinity hall, and on leaving Cambridge went to court in the service of William, 1st Baron Paget of Beaudesart. as a musician. After ten years of life at court, he married and settled as a farmer at Cattiwade, Suffolk, where he wrote his *Hundreth Good Pointes of Husbandrie* (1557, 1561, 1562, etc.). For his wife's health he moved to Ipswich. After her death he married again and farmed at West Dereham. After farming at Fairsted. Essex. be moved to London. Thomas Fuller says he "spread his bread with all sorts of butter, yet none would stick thereon." He died on May 3. 1580.

The *Hundreth Good Pointes* was enlarged to *A Hundrath Good Pointes of Husbandry, Lately Maried Unto a Hundreth Good Poyntes of Huswifery . . . ,* the first extant edition of which, "newly corrected and amplified," is dated 1570. In 1573 appeared *Five Hundreth Pointes of Good Husbandry . . .* (reprinted 1577, 1580, 1585, 1586, 1590, etc.). The numerous editions of this book, which contained a metrical autobiography, prove that the homely and practical wisdom of Tusser's verse was appreciated. The later editions include *A Dialogue of wyvynge and Thryvynge* (1562). Modern editions are by William Mavor (1812), by H. M. W. (1848) and by W. Payne and Sidney J. Herrtage for the English Dialect Society (1878).

TUTENKHAMON (sometimes spelled TUTANKHAMUN, or TUT-ANKH-AMEN), son-in-law of the Pharaoh, Ikhnaton (*q.v.*), and himself Pharaoh for not less than six years in the middle of the 14th century B.C. The fame of this politically unimportant sovereign is due to the discovery of his tomb still containing the larger part of its magnificent equipment. Even in Egypt the survival of royal burial equipment is unique, for the plundering of royal tombs began at a remote date. A pyramid is a gigantic husk of masonry to protect the body of the Egyptian sovereign; but not a single pyramid escaped plundering by the ancient tomb robbers. The Egyptian rulers, therefore, abandoned the pyramid and excavated the kings' tombs in the face of the Nile cliffs. For 400 years the excavation of these royal cliff tombs continued; by 1150 B.C. there were over 500. After the fall of the empire about 1150 B.C. not a single known royal tomb was left intact.

The preservation of the burial of Tutenkhamon was due to accident, to its small size and to the unimportance of its occupant. The demoralization of the government at the death of Tutenkhamon, about 1350 B.C., was such that the cemetery ghouls found no difficulty in robbing his cliff tomb. Fortunately they were caught in the act, and much of their plunder was returned; although the heavy golden vessels and much other magnificent work was evidently too great a temptation for the officials. The tomb was never molested again. and 200 years later, when the empire was tottering. the architects of Rameses VI. excavating the tomb of this Pharaoh just above that of Tutenkhamon, ordered the workmen to throw their waste limestone chips down the slope below it, thus completely covering up the tomb of Tutenkhamon.

The expedition which discovered the tomb was maintained by Lord Carnarvon (*q.v.*), but the actual discovery was due to Howard Carter (*q.v.*), who on Nov. 4, 1922, uncovered the steps leading down to the entrance gallery. For eight seasons (October to April) following. Carter salvaged this magnificent treasure, nearly all of which was placed in the national museum in Cairo. The body of the youthful Pharaoh still lies in his beautiful stone sarcophagus in the burial chamber of his tomb. The stone lid has not been replaced, and the gorgeous outer coffin, richly wrought in gold, is a unique and impressive sight.

The mortuary furniture of Tutenkhamon will continue to make his name a household word, notwithstanding his lack of political significance. He succeeded to the throne by his marriage with

Ikhnaton's third daughter. and he must have been hardly 12 years old when he was crowned. A puppet in the hands of the priestly party which was vindictively striving to exterminate his father-in-law's memory, the boy king had little chance to survive. The examination of his mummy showed that he was about 18 years old at his death. after a reign of probably not more than six years. The body showed no discernible traces of foul play.

See Howard Carter and A. C. Mace, ***The Tonzb of Tut-ankh-amen,*** 3 vol. (London, Toronto. 1923–33). (J. H. Br.)

TUTICORIN, a seaport of India in the Tirunelveli district of Madras. Pop. (1961) 124.273. It is the southern terminus of the South Indian railway, 443 mi. S.W. of Madras city. Tuticorin is an old town, and was long in possession of the Dutch, who developed pearl fisheries there. Salt is manufactured, cotton woven, and there are cotton ginning and pressing factories.

TUTTLINGEN, a town of Germany. in Baden-Württemberg, on the left bank of the Danube, 37 mi. N.E. of Schaffhausen by rail and at the junction of lines to Stuttgart and Ulm. Pop. (1950) 21.271. The chief manufactures of Tuttlingen are shoes, cutlery, surgical instruments and woolen goods.

TUVA, an Autonomous Soviet Socialist Republic of the Russian Soviet Federated Socialist Republic of the U.S.S.R., bounded west by the Altai kray, northwest and north by the Krasnoyarsk kray, east by the Buryat X.S.S.R. and southeast and south by Mongolia. Area: 65.830 sq.mi. Pop.: (1925) 63,800; (1959) 171,928 (with a Turkic majority). Capital: Kyzyl, pop. (1959) 34,000.

The region comprises two valleys. Tuva and Todzin, separated by the Tumat-Taiga range which reaches 8.950 ft. The Sayan range, rising to 9.377 ft.. forms the greater part of the Tuvinian northern boundary. while its southern boundary is formed by the ranges of Tannu-Ola (10.043 ft.) and Sangilen (10,741 ft.). The Shapshal range, reaching 11.857 ft., forms its western boundary.

Tux-a has considerable timber resources and some mineral wealth (gold, coal, asbestos and salt). Under the Soviet regime the primitive nomadic hunters of Turkic race have been settled as agriculturists and livestock breeders. In 1941 the total number of livestock was 1,462,000 head. of which three-fourths were sheep and goats. In 1954 there were 128 primary and 22 secondary schools with 30,900 pupils. There are no railways, but good motor roads link Kyzyl with Abnkan (Khakassia), on the South Siberian railway, and Teli in western Tuva.

Tuva, known as Urianghni. was part of the Chinese empire until 1911, when tsarist Russia fomented a separatist movement and in 1914 took the country under its protection. It founded its capital. Byelotsarsk, renamed Kyzyl ("Red") in 1917, on the left bank of the upper Yenisei (Ulug-Khem), near the point where the Small Yenisei (Ka-Khem) joins the Great Yenisei (Biy-Khem). In Aug. 1921 the Tannu Tuva people's republic's independence was proclaimed. In 1924 Soviet diplomacy settled the Tuvinian-Mongolian territorial dispute and two years later Tannu Tuva and Mongolia recognized each other's independence. On Oct. 13, 1944, the supreme soviet of the R.S.F.S.R. decreed Tuva to be, an autonomous region of Russian federation. (K. Sm.)

TUY, a city of northwestern Spain, in the province of Pontevedra, on the right hank of the Miño river, opposite Valença do Minho in Portuguese territory. Population (1950) 13,738 (mun.).

During part of the 17th century Tuy was the I'isigothic capital. Túy is the southern terminus of the railways to Santiago de Compostela and Corunna: Valença do Minho is the northern terminus of the Portuguese railway to Oporto. To the east of Thy is the Louro river; and beyond the Louro, on the railway to Corunna. are the hot mineral springs of San Martín de Caldelas. The cathedral is of a fortresslike architecture.

TUZLA, a town of Bosnia and Hercegovina. Yugos., 50 mi. N. of Sarajevo; from 1949 the capital of Tuzla oblast. Pop. (1961) 37.673.

Tuzla is the seat of an Eastern Orthodox bishop, with several churches and many mosques. Petroleum fields and lignite mines are in the area and there are also salt deposits. Agricultural products include plums.

TVA, the abbreviation for Tennessee Valley Authority. *See* Electric Power; Tennessee River.

TVER (now Kalinin), an *oblast* in the Russian Soviet Federated Socialist Republic. U.S.S.R..surrounded by those of Smolensk. Leningrad. Vologda, Yaroslavl and Moscow, and not coinciding with the pre-1917 province of that name. Area 32.545 sq.mi. Pop. (1959) 1,806.787, mainly Great Russians. with Karelians in the north. The climate is continental, with severe winter frosts of five months' duration and an average July temperature of 67" F. Average rainfall is 18–20 in. per year. Coniferous forests. especially firs. cover 32.2% of the region, and 12% is marshland. In the remaining area meadow and grassland prevail, plowed land occupying only 25%. There was a marked diminution of grain production and a tremendous increase in the cultivation of long-fibred flax with the use of mechanized equipment on collective farms.

Industries developed there include fur preparation. wooden wares, sawmilling, flour milling, leather goods. textiles. bricks. glass. machinery, oil pressing and brewing. The principal cities are Kalinin (Tver), pop. (1959) 261.000; Rzhey. (1956 est.) 42,-200: Vyshni-Volochok, (1959) 66.000.

The region is well drained by the upper Volga and its tributaries. especially the Tvertsa and Mologa; 17% of the rivers are available for steam navigation, and boats and rafts can be floated on many of the others. The Vyshni-Volochok system of canals connects the Volga with the Baltic and the Tikhvin system connects the Mologa with Lake Ladoga. Railways are comparatively good and the region is thus well situated for trade.

TVER (now Kalinin), chief town of the Tver (Kalinin) *oblast,* U.S.S.R..on the Volga, at its confluence n-ith the Tvertsa in 56" 52′ N., 35° 48′ E. The low right bank is protected from inundations by a dam.

The town grew rapidly in the 20th century; pop. (1900) 45,-644; (1959) 261.000. Its situation on the Moscow-Leningrad railway and on the navigable Volga gave it great trading importance as a centre for a productive region. Its chief manufactures are machinery, textiles and leather goods.

A fort was erected in 1180 at the mouth of the Tvertsa to protect the Suzdal principality against Novgorod. In the 13th century it became the capital of an independent principality. and remained so until the end of the 15th century. It long remained an open question whether Moscow or Tver would ultimately gain the supremacy in Great Russia. In 1486. when the city was almost entirely burned down by the Muscovites, the son of Ivan III became prince of Tver; the final annexation to Moscow followed four years later.

In 1570 Tver had to endure, for some reason now difficult to understand, the vengeance of Ivan the Terrible, who ordered the massacre of 90,000 inhabitants of the principality. The town and region were renamed in honour of M. I. Kalinin, president of the supreme council of the C.S.S.R., 1938–46.

TWACHTMAN, JOHN HENRY (1853–1902), U.S. Impressionist landscape painter, was born in Cincinnati, O., on Xug. 4. 18j3, of German descent. He went to Munich in 187j for advanced study of painting and later studied at the Académie Julian in Paris. Before returning to the United States in 1884 he changed his style from broad brushwork with rich darks to a feathery touch in broken colour approximating to Impressionism. Unfortunately he sent his accumulated work ahead in a ship that was lost. Unsuccessful at first, he supported himself after 1889 by teaching at the Art Students' league, New York city. From that year, also, his lyrical interpretation of landscape attained its distinguished maturity; the delicacy of his high-keyed atmospheric treatment was only a veil for the underlying strength of form construction. He was prominent among the Ten American painters, a group exhibiting independently of the National Academy of Design from 1895 onward. A few honours were awarded Twachtman in his later years, but the importance of his work was not generally recognized until after his death, which occurred at Gloucester. Mass.. on Aug. 8, 1902.

See A. Tucker, ***John H. Twachtman*** (1931); ***E.*** Clark, ***John Twachtman*** (1924). (Vl. B.)

TWAIN, MARK, was the pen name of Samuel Langhorne Clemens (1835–1910), the United States most famous humorist and the author of popular and outstanding autobiographical works, travel books and novels. The first 36 years of Clemens' life gave him experiences—as a boy in a little town in Missouri, as a steamboat pilot. as a reporter on the far western frontier and as a traveler abroad—which he thereafter used as materials for his best and his most successful writings.

He was born Nov. 30, 1835, the third son and fifth child of John Marshall and Sarah (Lampton) Clemens, both descendants of Virginians. His birthplace was Florida. Mo., a village to which the family had moved the previous June. The boy's father, a storekeeper and at times a lawyer, had little talent for money-making and failed there as he had elsewhere. The Clemenses therefore moved in the fall of 1839 to Hannibal. Mo.

Hannibal was the town of Sam Clemens' boyhood. destined to figure importantly in several of his finest books. Almost in the geographical centre of the United States, it had the wide Mississippi river rolling past it on the east. and on the other sides were forests, farm lands and prairie. The river was the route from and to the rest of the nation, bringing as it did all sorts of exciting visitors—river men, revivalists, circus troupes, minstrel show companies. migrants to points as far westward as California. The steamboats which Sam and his gang of boyhood friends watched wheeling past or docking at the wharf were endlessly fascinating. So, too, were the steamboat men and the townspeople, many of whom were prototypes of characters in Twain's books. The river, an island nearby and the woods around the town mere wonderful places for boys to play. In the summer Sam ordinarily paid a vacation visit to the farm of his uncle John Quarles. near Florida. Some of his happiest and most vivid memories were to be of his play around Hannibal and of his visits to the farm.

Clemens had relatively little schooling. He attended for a time "a dame school" then two "common schools" operated by schoolmasters. His father's death in 1847 having left the family in straitened circumstances, he was apprenticed to a printer, and he probably ended his schooling about 1848. In 1851 when his elder brother. Orion, became a newspaper publisher in Hannibal, he worked for him. At his printer's case: Sam set up not only news stories but also some of the literary and humorous selections culled from other newspapers in various parts of the country for reprinting. The late 1840s and the 1850s were periods during which localized humour of a superior sort flourished in both New England and what then was the southwest, and the humorous writings introduced him to techniques which were to figure prominently in some of Twain's best writings. He contributed some amateurish bits of humour to Orion's *Journal* and quite possibly was the "S.L.C." of Hannibal whose sketch, "The Dandy Frightening the Squatter," was printed in a Boston humorous paper, *The Carpet-Bag,* May 1, 1852. This was an anecdote similar to a number then going the rounds, contrasting the strength and forthrightness of a frontiersman with the weakness and foolishness of an eastern dandy.

Since Orion was as poor a businessman as his father had been, the *Journal* did not do well. and young Clemens became restless. In 1853 he set out as an itinerant printer and worked his way eastward on newspapers in St. Louis, New York city and Philadelphia. In the summer of 1854 he rejoined Orion. who had now moved to Iowa. Except for a brief period as a printer in St. Louis, he worked at his trade for Orion in Keokuk. Ia., until the fall of 1856. One letter which he wrote at the time to a girl friend. Annie Taylor, stands out among his apprentice writings as the best and is closest in form and quality to his later work. When in 1856 he began another period of wandering, he had a commission to write some comic travel letters for the *Keokuk Saturday Post.* These, signed nith the pseudonym Thomas Jefferson Snodgrass, were characterized by the misspelling, the atrocious grammar and the weirdly constructed sentences then becoming fashionable among rising humorists.

In 1856 Clemens started down the Mississippi on a trip which he planned to South America; but a boyhood ambition revived, and he arranged to become an apprentice to Horace Bixby, the pilot of the boat. Having learned the mysteries of navigating up and down the tortuous river channels, he was licensed as a pilot after about 18 months of training. He plied his trade until the spring of 1861, when the Civil War disrupted river traffic. Clemens found his life during this boom period of the steamboat age both instructive and exciting. Later he was to say, "In that brief, sharp schooling, I got personally and familiarly acquainted with about ail the different types of human nature. . . . When I find a well-drawn character in fiction or biography I generally take a warm personal interest in him, for the reason that I have known him before—met him on the river."

After an inglorious few weeks during the spring of 1861 in the militia on the Confederate side, Clemens joined his brother in a trip to Nevada territory. Orion had been appointed territorial secretary. The west was still an exciting new frontier and there were rumours abroad about fortunes to be made in the mining districts of Nevada and California. The two reached Carson City. Nev., Aug. 14, 1861. Clemens at first tried his luck with a timber claim. then with mining speculations: he was unsuccessful with both. Confined in his cabin during a spell of bad weather in the spring of 1862, he wrote and sent off some humorous contributions, signed "Josh," to the *Virginia City* (Nev.) *Territorial Enterprise.* When, at a particularly unprosperous moment, he was offered a post as a feature writer on the *Enterprise,* he accepted. Clemens' travels about the territory and his work in a picturesque and rugged mining town gave him a fund of experiences. Day-to-day assignments developed his abilities as a writer; he became well known in the west; and he had a few sketches published in the east. Assigned to report the Nevada constitutional convention, he began to sign his stories with the nom de plume, Mark Twain, which he used thereafter. (It was derived from a phrase, meaning "two fathoms deep," which had been used to report river soundings during his steamboat days.)

From Virginia City, in the spring of 1864, he went to San Francisco. There he served as a local reporter for the *Call* and as a correspondent for the *Enterprise,* and wrote articles and sketches for two local periodicals, *The Golden Era* and *The Californian.* Bret Harte, on the verge of national fame, was a contributor to the former of these magazines and the editor of the latter. Though Twain and Harte later disagreed, at the time Harte's tutelage was valuable. During a vacation spent with Jim Gillis, the brother of a friend, in Calaveras county, Calif., Clemens heard a number of fireside tales. One of these he adapted with great skill in "The Celebrated Jumping Frog of Calaveras County." Published in a New York periodical, *The Saturday Press,* Nov. 18, 1865, this was an immediate hit when it was reprinted in newspapers far and wide. Written much in the manner of the southwestern humour of the period of Clemens' youth, this fine tall tale not only gave him his first national fame, it also won for the first time approval of his work by several discerning critics. In 1866 when he was sent to the Sandwich Islands by the *Sacramento Union,* he developed the art of writing travel reports which a few years later was to be utilized in his first sensationally successful book. And an article on a marine disaster, the survivors of which he interviewed in Honolulu, Hawaii, was published in *Harper's Magazine.* Lectures about his travels delivered in the west proved successful and launched him on a remunerative career as a humorous lecturer which was to last until late in the century.

Clemens left San Francisco Dec. 15, 1866, as a traveling correspondent of the *San Francisco Alta California,* "not stinted," so the newspaper announced, "as to time, place, or direction—writing his weekly letters on such subjects and from such places as will best suit him." He traveled by way of the isthmus to New York, sending back letters which recounted the journey. Later he contributed other letters about his exploration of New York city and about visits to St. Louis, Hannibal, Quincy, Ill., and Keokuk. He gave successful lectures in New York, Brooklyn and several midwestern cities. He found a publisher for his first book, a collection of sketches, *The Celebrated Jumping Frog of Calaveras County, and other Sketches,* in 1867. Then, the same year, between June 8 and Nov. 19, he took an excursion to France, Italy, Greece, Turkey and the Holy Land.

Letters reporting this trip and his reactions along the way, most of them published in the *Alta California,* a few in the *New*

York Tribune, were drawn upon for the substance of *Innocents Abroad* (1869). Despite high prices for the time—it sold for amounts ranging between $3.50 and $5—this book found 150,000 purchasers by 1874 and continued to sell at a lively rate long after that date. There were several reasons for its wide appeal: The excursion which it told of had been much publicized. It was distributed—as most of Twain's books were—by book agents, at the time more effective than bookstores in making sales. Before and after the book appeared, Twain plugged it widely in writings, interviews and lectures. As literature, it had appeals to readers of many sorts. Twain's purpose, as he said in his preface, was "to suggest to the reader how *he* would be likely to see Europe and the East if he looked at them with his own eyes instead of the eyes of those who traveled in those countries before him." Contemptuous of tourists who learned what they should see and feel by carefully conning guidebooks, the author sharply satirized them. He assumed the role of a keen-eyed, shrewd westerner who was refreshingly honest and vivid in describing foreign scenes and his reactions to them. It is probable that Americans liked the implication that a common man could judge the old world as well as the next man. But the chief attraction of the book was its humour, which readers of the time found delightful.

Some of the shrewder reviewers noticed that the setting of the humour gave it much of its impact and made the long book highly readable. The book showed that Mark Twain had found a method of writing about travel which, though seemingly artless, artfully employed change of pace. Serious passages—history, statistics, description, explanation, argumentation—alternated with laughable ones. What is more, the humour itself was varied, sometimes being in the vein of the southwestern yarn spinners whom he had encountered when a printer's devil, sometimes in that of contemporaneous "phunny phellows" such as Artemus Ward and Josh Billings. who chiefly used burlesque and parody, anticlimactic sentences, puns, malapropisms and other verbal devices to win laughter. Thereafter he was to use the formula successfully in a number of books combining factual materials with humour.

During the trip Clemens had been shown a miniature painting of Olivia Langdon by her brother, a fellow passenger. In 1867 he met her and began to visit her at the Langdon home in Elmira, N.Y. Rough though his background had been, Clemens had a typically Victorian chivalrous attitude toward womanhood. "I wouldn't have a girl that I was worthy of," he wrote a friend. "*She* wouldn't do." Olivia, a delicate semi-invalid and a cultured easterner, seemed to him to meet the test. His love letters were as rhapsodic as almost any in literature, and he was all but overwhelmed when she accepted him, when her well-to-do family gave consent and when, in 1870, she married him. Though in later years he wrote patently jocose letters to intimate friends about her tyranny (which some solemn biographers have been humourless enough to take seriously), his life with her was evidently his idea of the perfect married state. William Dean Howells, Clemens' most intimate friend, testified that Mrs. Clemens "was in a way the loveliest person I have ever seen, the gentlest, the kindest" and that "she merited all the worship he could give her, all the devotion, all the implicit obedience, by her surpassing force and beauty of character."

Some students of Clemens have accused his wife of having cramped his style by exercising too much censorship over what he wrote and printed, but there is a great deal of evidence against their claims. Concerning religious matters (about which Twain was to write frequently) she and her family were extraordinarily liberal. Clemens himself tended to be as skittish about treating sex—in print—as some of the sternest Victorians, and in this field he probably would have exercised censorship himself if Olivia had not. Finally, it should be recalled that, subdued though he may seem—as a rule—to moderns, Twain managed to shock many of his contemporaries by his irreverence and by his unconventional attitudes concerning numerous cherished beliefs.

After their marriage the Clemenses lived in Buffalo, N.Y., where Twain had purchased a share of a newspaper. Soon, however, they moved to Hartford, Conn., where he was a free lance writer during his most productive years. (The family left Hartford in 1891 and thereafter lived in Europe, in Redding, Conn., and in New York.) This move marked a turning point in his career. "Up to the time of his anchorage in Hartford," as Dixon Wecter noticed, "the most important facts about Mark Twain are the things that happened to him, shaping his development as an artist and filling the granaries of memory. After that date the chief milestones are books he wrote out of that accumulation." (Dixon Wecter, *Literary History of the United States*, rev. ed., vol. 2. p. 925, The Macmillan Company, New York, 1953.) There were two outstanding works of reminiscence: *Roughing It* (1872) recounted his journey to the far west and his experiences there. Since it caught the life of a picturesque section of the country at an exciting moment, the book had value not only as literature but also as history. "Old Times on the Mississippi," written for the *Atlantic Monthly* and published serially in 1875, was the story of Clemens' career as an apprentice and pilot on the river. These chapters, evocative as they are of a scene, a way of life and an atmosphere, stand high among the best autobiographical passages he ever wrote. Journalistic travel books such as *A Tramp Abroad* (1880) and *Following the Equator* (1897)—accounts of specific journeys—though they follow the formula for books compounded of facts and humour which Twain had used in *Innocents*, are now as wholes much less appealing. The same may be said of the chapters about a revisiting of the Mississippi which, added to "Old Times," eked out *Life on the Mississippi* to book size—and its final form—in 1883. All these journalistic writings, however, contain interludes of great merit. "Jim Baker's Blue-Jay Yarn" in the first of them, for instance, based upon a story heard in the Gillis cabin back in California, is, in its combination of comedy and underlying pathos, one of the best of Twain's shorter efforts.

Robust humour and pathos or sympathy here and else here were expressions of two aspects of the author's personality. His frontier upbringing and his wandering career had acquainted Mark Twain with aspects of life which were not. to put it mildly, genteel. For a good many years his idea of a fine time was a stag party with plenty of drinks and outrageous pranks; he once was jailed overnight for drunkenness. He was a shaggy-headed masculine person with ebullient spirits, a passion for the wildly incongruous and a tendency to speak his mind in the most uncompromising terms when the spirit moved him. Yet he was a man of great sensitivity, "Among the half-dozen, or half-hundred, personalities that each of us becomes," wrote Howells, "I should say that Clemens's central and final personality was something exquisite. His casual acquaintances might know him, perhaps, for his fierce intensity. his wild pleasure in shocking people with his ribaldries and profanities, or from the mere need of loosing his rebellious spirit in that way, as anything but exquisite, and yet that was what in the last analysis he was. . . . One could not know him well without realizing him the most serious, the most humane, the most conscientious of men." (William Dean Howells, *My Mark Twain* [New York, 1910], p. 34. By permission of the heirs of William Dean Howells.)

This latter aspect of Twain's character showed itself in his tendencies toward romanticism, in surprisingly delicate expressions of feeling, in his deep compassion and understanding. Often in Twain's writings the two facets shone incongruously at the same time, as when he combined earthiness and soaring fancy in his best tall tales. Sometimes the two attitudes came together more harmoniously, as in his best fiction—a combination of the realistic and the poetic.

In 1873 Twain began to turn some of his memories into fictional works in a novel written in collaboration with a Hartford neighbor, Charles Dudley Warner—The *Gilded Age*. This was made up, unfortunately, of a number of fairly complicated and rather shopworn plots. But weak as it was as a whole, it foreshadowed what Twain was destined to do with backgrounds and characters. Some of the pictures of the midwest of his boyhood were vivid and authentic, and in Colonel Sellers and Senator Dilworthy he created two memorable characters. The portions of the book representing the contemporary scene. moreover, offered telling satire against the speculative spirit and the corruption of government in the 1870s. For the scenes set in Washington, D.C., Twain drew upon memories of life in that city when he had lived there in 1867 and 1868.

The Adventures of Tom Sawyer (1876) was one of Twain's best books, certainly his best for a juvenile audience. The setting was St. Petersburg, which was Hannibal made idyllic by the passage of time; the characters were the grownups and the children of the town in the 1830s, also for the most part viewed sympathetically. Twain once characterized the book as "simply a hymn, put into prose form to give it a worldly air." The nostalgic attitude was typical of the period when in every section of the country writers such as Edward Eggleston, Harriet Beecher Stowe and George Washington Cable were writing local colour stories wistfully recreating pre-Civil War life. The happenings were shaped by American humour which for some time had been making fun of the Sunday-school story—its prematurely moral children who were rewarded and its prematurely immoral children who came to grief. Tom, says the first chapter, "was not the Model Boy of the village. He knew the model boy very well though—and hated him." Tom was by contrast "the normal boy," the book implied, mischievous and irresponsible but goodhearted; and the subplots in which he figured showed him again and again winning triumphs. These happy endings endear the book to children; the lifelike picture of a boy and his friends is enjoyed by both young and old.

Shortly after finishing *Tom Sawyer,* Clemens began to write his masterpiece, *The Adventures of Huckleberry Finn.* His work on this novel, however, was sporadically interrupted by work on other projects. One mas the writing of *The Prince and the Pauper* (1880), a historical novel making use of the ancient device of transposed identities. Since the pauper replaced a prince, the book offered some telling arguments for democracy. Children have always found the book engrossing, and in 1880 it was much praised for proving that Twain was "more than a mere humorist," but its reputation has faded. Another project was the return to the river to supply chapters for *Life on the Mississippi.* The trip reawakened Mark's interest in Huck and suggested new possibilities for the continuation of the book about him. It was finished in a burst of activity and published in 1884.

Huckleberry Finn, by general agreement, is Twain's finest book and an outstanding American novel. Its narrator is Huck, a much better realized character than the one with the same name—or indeed any other character—in *Tom Sawyer.* Modern critics and authors have enthusiastically praised his style, one which initially gives the impression of carelessly recorded vernacular speech, but which is admirably adapted to detailed and poetic descriptions of scenes, vivid representations of characters, renditions of actions or emotions and exploitations of comedy both broad and subtly ironic. The style gives the book a certain unity; so does the character whom it expresses.

Huck, son of the village drunkard, is uneducated, superstitious, sometimes credulous; but his faults are outweighed by such virtues as a native shrewdness, a cheerfulness which is hard to put down, compassionate tolerance and an instinctive tendency to reach the right decisions about important matters. At the start, as Twain once put it, "He has run away from his persecuting father and from a persecuting good widow who wants to make a nice, truth-telling, respectable boy of him." His companion is a runaway slave, Jim, and the story is of their movement, interrupted by frequent stops, far down the Mississippi on a raft.

During the journey Huck meets and comes to know members of greatly varied groups, so that the book memorably portrays almost every class living on or along the river. Jim, whom in time, despite initial prejudices, Huck learns to respect and love, offers a fine full-length picture of a slave. A pair of rapscallions who join the two for a while stand for the riffraff preying on folk along the shore. Pappy, Boggs and the "river rats" encountered in a sleepy little town are the poor whites; the Wilkses are a middle-class family; the Grangerfords are what Huck calls "the quality." The pages arc dotted with idyllic descriptions of the great river and the surrounding forests, and Huck's exuberance and unconscious humour permeate the whole. But a thread which runs through adventure after adventure is the theme of man's inhumanity to man—of human cruelty. Children miss this theme, but adults who read with the care this classic deserves cannot fail to be impressed by an attitude mhich was to become a reiterated preachment of the author during his later years.

Twain turned next to historical fiction. *A Connecticut Yankee in King Arthur's Court* (1889) employed the fantasy characteristic of the tall tale in a book-length narrative. It transplants a common-sensible Hartford Yankee to Camelot and through his comments—for he is the narrator—satirizes both past and contemporaneous follies. In this novel as in its predecessor there are bitter passages about what Twain more and more came to think of as "the damned human race." The writer returned to the American scene in *Pudd'nhead Wilson* (1894), interesting for its regional portraiture and also for its study of miscegenation. It has not rated as one of his best efforts, but its stock tended to rise among some critics 50 or 60 years later.

About the time *Pudd'nhead Wilson* went to press, Clemens' financial affairs became desperate. This was the result in part of the disastrous panic of 1893 and in part of the writer's mistakes as a businessman. Some years before he had become a publisher, and although some books his firm published (including his own) sold well, he backed others which failed. For another thing, this son of the venturesome frontier was almost incapable of resisting any temptation to gamble on a wild enterprise. At this unpropitious moment a typesetting machine into which he had sunk hundreds of thousands of dollars proved to be worthless. Clemens had to go into bankruptcy.

He turned over management of his affairs to a friend, Henry H. Rogers of the Standard Oil company, and set out to earn enough to pay off his indebtedness at 100 cents on the dollar. The returns from a historical novel. *Personal Recollections of Joan of Arc* (1896), a lecture tour around the world and *Following the Equator* (1897), nhich told of it, did the trick, though neither of the books was up to his best standard.

Both books had gloomy touches, the former in its stern depiction of Joan's enemies, the latter in a number of pessimistic aphorisms used as chapter epigraphs and in passages about the mistreatments and miseries of mankind. Personal misfortunes coming in this period doubtless added to Clemens' unhappiness. In England during the lecture tour, Clemens received news of a daughter's death in Hartford. Within the next few years, Orion and a sister, Pamela, died; his daughter Jean and Mrs. Clemens became hopeless invalids; and Mrs. Clemens died. But these misfortunes did no more than accelerate a trend in Clemens' thinking which had started long before. He completed a book, *What is Man?* which he had begun in the 1880s: it emphasizes the idea of determinism and argues that selfishness motivates all human actions. "The Man That Corrupted Hadleyburg" (1899), one of his best-wrought short stories, indicates that Hadleyburg—or any town—is corruptible because of the greed of its citizenry. *The Mysterious Stranger,* a novelette published posthumously in 1916, poetic though it is in style, underlines the grimmer aspects of life and offers as its only solace the possibility that life "is all a dream—a grotesque and foolish dream." There are similarly dark passages in the *Autobiography,* which he worked at fitfully beginning in 1877, but nhich became a major enterprise after 1906; but there are also happier passages which hark back to the days about which he always did his best writing—the days of his boyhood in Missouri, his youth on the Mississippi and his young manhood in the far west. The rambling, uneven account was uncompleted when he died April 21, 1910.

Twain's uritings vary in excellence largely ,because he was a self-trained artist who at both his worst and his best worked intuitively. Too often his journalistic tendencies or his habit of improvising misled him. But he was a man of great charm and remarkable sensibility, and frequently even his inferior writings delight readers by affording intimate glimpses of his fascinating personality. Furthermore, he looked back over a significant span of American history in which he had intimately participated. When his genius as a writer enabled him to make the best of his incomparable materials, he wrote greatly enough to win a high place among American authors.

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TWAYBLADE (*Listeraj*, a genus of small plants of the orchid family (Orchidaceae). The greenish-yellow flowers, each with a down ardly directed, forked labellum, are borne in terminal racemes.

Four twayblades are native to North America—the heart-leaved (*L. cordata*), the broad-lipped (*L. convallarioides*), the southern (*L. australis*) and the western (L. *caurina*). The common twayblade (*L. ovata*) and the heart-leaved twayblade (*L. cordata*) are found in the British Isles. *Liparis lilifolia*, large or lily twayblade, is native to bogs, peaty meadows and damp thickets from Canada through the north central states to northern Alabama. *See* also ORCHIDS.

TWEED, WILLIAM MARCY, U.S. political boss and leader of the "Tweed ring," was born in New York city April 3, 1823. In 1852 he was elected an alderman of the New York city council. From 1854 to 1856 he served as U.S. representative in Washington, D.C. His real power in municipal politics began in 1857 with his election to the board of supervisors, which he came to dominate. By working the downfall of Fernando Wood, a notoriously corrupt mayor, Tweed came into power under a cloak of respectability.

He fortified himself through his political appointments. From 1858 to 1871, while holding successively the positions of school commissioner, deputy street commissioner, state senator and deputy commissioner of public works, Tweed, except for brief intervals, controlled the city administration. In 1868 he also controlled the state Democratic assembly at Albany, and in 1869, though he lost the assembly, he secured the election of his nominee as governor. The "Tweed ring" of history, composed of Tweed, Mayor A. Oakey Hall, Peter B. Sweeny and Richard B. Connolly, began its operations in Jan. 1869 and lasted until Tweed's downfall in 1871. Conservative estimates place the amount stolen directly from the city during that period at $45,000,000, though including taxes lost through arbitrary reductions by the "ring" for money or favour and the issuance of bonds at extravagant rates of interest some authorities have estimated as high as $200,000,000. Exposure came through a bookkeeper who placed evidence in the hands of the New *York Times*, where it was printed. Tweed was tried, found guilty and sentenced to 12 years in the penitentiary. In 1873 he escaped from the Ludlow street jail where he was confined. fled to Cuba and thence to Spain, where he was arrested by the Spanish government and returned to the United States. He was again imprisoned in Ludlow street jail where he died April 12, 1878.

See D. Lynch, *"Boss" Tweed* (New York, 1927).

TWEED, a river in the south of Scotland. It is 97 mi. long and drains an area of about 1,870 sq.mi. The last 2 mi. of its course, from just above Berwick. are in England and for the preceding 17 mi. it forms the boundary between the two countries. Its source is in Tweed's Well (1.500 ft.) near the foot of Hart Fell on the borders of Peebles and Dumfries. The Annan rises close by. For 16 mi. the Tweed flows northeastward to its junction with the Biggar water whose broad valley formerly brought in the waters of the upper Clyde. After receiving the Lyne on its left bank it turns eastward to Peebles where the Edelston water joins it, also from the left. From Peebles to Melrose the Tweed flows through a typical dale, deeply cut, narrow floored and wooded like those of the Ettrick, the Gala and the Leader which all join it in this section. Below Melrose the valley widens into the drumlin covered plain known as the Merse and the river course becomes tortuous. The sheep farming of the upper valleys, which gave rise to the wool and textile industry of Galashiels, Hawick and Selkirk, is now replaced by cultivation and stockfeeding. This richer farming extends up Teviotdale as far as Hawick. From Kelso the Tweed adopts the northeastward direction of the Teviot. It receives the Till from Northumberland and the Whiteadder from the Lammermuir hills before entering the North sea at Berwick. (T. HER.)

TWEED, a term of very general application in the woollen and worsted trades. It is employed as a trade description for a very large variety of woollen and worsted fabrics that embody the same general textural features, but which differ in the minor details of their manufacture, construction and finish. They are described as "Scottish," "Harris," "Cheviot," "Irish." "Yorkshire," "Saxony" and "West of England" tweeds, according to the particular locality of their origin, the yarn used in their construction, their character of structure, texture, finish and other details.

The description of this particular variety of worsted fabrics as "tweeds" is commonly, but erroneously, associated with the Scottish river of that name.

The origin of the word "tweed" has no reference to the Tweed river, but is said to be due to an error on the part of a London cierk who, in the year 1826, when writing out an invoice for these goods, inadvertently wrote the word "tweeds" instead of "tweels," the Scottish for "twills." Orders were placed for more "Scottish tweeds"—a novel description which immediately won the popular favour and became firmly established in the clothing trade as a brand of quality.

The chief characteristic feature of the true type of "tweed" fabrics in general is, as the name suggests, their construction on a twill weave basis, although they are not restricted entirely to the simple regular twill weave structures, as many tweed fabrics are based on the numerous modifications of those weaves. Tweed fabrics are produced from Scottish, Cheviot, Saxony and many other types of worsted and woollen yams of various counts and quality, and woven in solid colours, mingled "heather" tones, and coloured stripes and checks in endless variety of pattern and colour, and in every variety of texture suitable both for men's and women's clothing for outer wear, and for every season of the year.

"Herringbone" twills, "diamonds," "chevrons," "cross-twills" and "basket" weaves are popular styles for tweed designs, which are now more of a broken character than formerly, while more intricate patterns are introduced in textures of superior quality. A new vogue of recent origin consists of printed tweed effects with the pattern printed on both sides of the fabric to give the impression of woven designs. These printed tweeds are executed with such realistic effect that it is in some cases very difficult without close inspection to distinguish the printed imitation tweed effect from the genuine woven tweed patterns. (H. N.)

TWEEDDALE, JOHN HAY, 2ND EARL and 1ST MARQUESS OF (1626–1697), was son of John, 8th Lord Hay of Yester (*c.* 1599–1654), created earl of Tweeddale in 1646. Before succeeding to the peerage in 1654 the second earl fought for Charles I during the Civil War, but he was in the Scottish ranks at Marston Moor. Changing sides again, he was with the royalists at Preston; but he was a member of Cromwell's parliament in 1656, and was imprisoned just after the restoration of Charles II. He was soon, however, in the king's favour, and in 1663 was appointed president of the Scottish council, and in 1664 an extraordinary lord of session. In Scotland he sought to mitigate the harshness shown by the English government to the Covenanters, and for this attitude he was dismissed from his offices in 1674; but he regained an official position in 1680 and held it during the reign of James II. A supporter of William of Orange, he was made lord high chancellor of Scotland in 1692, and two years later was created marquess of Tweeddale and earl of Gifford.

He favoured the scheme for the expedition to Darien, and as lord high commissioner during William's absence he formally assented to the act establishing the trading company in 1695; for this action he was dismissed from office when the king returned to England in 1696.

He died on Aug. 11, 1697.

TWEED RIVER: see RICHMOND RIVER AND BASIN.

TWEEDSMUIR, JOHN BUCHAN, 1ST BARON (1875–1940), Scottish author and statesman, outstanding in his generation for achieving an equal reputation both as creative artist and as man of affairs. He was born in Perth, Aug. 26, 1875, brought up in Fife the Scottish Borders and Glasgow, educated at Glasgow university and Oxford, where he began to publish fiction and history, and was called to the bar in 1901. After working on Lord Milner's staff in South Africa (1901–03), he became a director of Nelsons, the publishers, for whom he wrote the best of his Stevensonian adventure stories, *Prester John* (1910), a vivid prophetic account of an African rising inspired by a pseudo religion. During World War I he held a staff appointment and in 1917 became director of information. His patriotism also found expression in *The Thirty-Nine Steps* (1915). the first of a successful series of secret-service thrillers. After the war he became assistant director of the British news agency, Reuters, and was member of parliament for the Scottish universities, 1927–35. His biographies, *Montrose* (1928) and *Sir Walter Scott* (1932), are illuminated by compassionate understanding of the tangled web of Scottish history and literature. In 1935 he was raised to the peerage and appointed governor general of Canada. His love of Canadian people and places and his foreknowledge of approaching death combined to produce the pity and terror of his fine novel, *Sick Heart River* (1941; *U.S.* title, *Mountain Meadow).* He died at Montreal, Feb. 11, 1940.

His autobiography, *Memory Hold-the-Door,* was published in 1940. (A. M. S.)

TWELVE TABLES, the tables of wood on which was engraved or painted the earliest codification of the Roman law. Originally ten in number, two supplementary tables were added, and the whole code was termed the *Lex XII tabularum* ("Law of the Twelve Tables"). *See* ROMAN LAW and ROME: *Ancient History: The Republic.*

TWELVE TRIBES OF ISRAEL. In the Old Testament Israel is presented as a community with a tribal structure from its emergence as a people until the absorption of the tribal structure in the monarchies of Israel and Judah (*qq.v.*). The 12 tribes. with some important exceptions, correspond to the 12 sons of the patriarch Jacob (Gen. xxix–xxx), whose mothers were:

1. *Leah:* Reuben, Simeon! Levi, Judah, Issachar, Zebulun.
2. *Rachel:* Joseph (or Ephraim and Manasseh), Benjamin.
3. *Bilhuh:* Dan. Naphtali.
4. *Zilpah:* Gad. Asher.

Only the enumeration of the blessing of Jacob (Gen. xlix) follows the list of the sons of Jacob. In the tribal lists of Num. i, ii, xxvi and Josh. xiii–xix, Levi is omitted and Joseph is replaced by Ephraim and Manasseh. In the blessing of Moses (Deut, xxxiii) Simeon is omitted and Joseph, while mentioned, has two places, one for each of his sons! Ephraim and Manasseh. These variations, together with other indications too numerous and scattered to be set forth here, lead most modern scholars to conclude that the tribal origins of Israel are too complex to be explained by descent from a single family. The 12-tribe structure appears as a constant; while it probably has reference to some family grouping, to some degree it rests also on reckoning by artificial genealogies through which tribal groups express their community. The structure admitted new members to replace tribes that departed from the group, merged with other tribes or perished, but the number remained at 12. Martin Noth, followed by many scholars, calls the 12-tribe federation of Israel an amphictyony (*q.v.*), the Greek name for a union of communities about a central shrine. In Israel the unity of the tribes rested upon their worship of the one God Yahweh, centred visibly upon the Ark of the Covenant, the symbol of the presence of Yahweh in Israel. Few scholars, however. accept Noth's view that the unity called Israel did not exist before the covenant assembly at Shechem related in Josh. xxiv where, in his view: the tribes accepted the worship and the covenant of Yahweh imposed by Joshua.

Israel is mentioned as a people dwelling in Palestine in the stele of Merneptah of Egypt (*c.* 1220 B.C.); many urge this as a difficulty against Noth's view. It is also employed as the name of a monarchy by Shalmaneser III of Assyria (859–824 B.C.) and in the Moabite stele of Mesha (c. 850–800 B.C.; *cf.* II Kings iii), both of which clearly designate the monarchy of northern Israel.

On the assumption that there is an artificial unification of the traditions which brings all the 12 tribes into the sojourn in Egypt, the Sinai episodes and the invasion and settlement of Canaan, scholars have proposed divergent theories of the prehistory of the various tribes. These theories are too numerous and complex to be set forth here, and it is possible to do no more than to point out certain features in the traditions and in tribal geography which suggest these conclusions.

Rachel Tribes.—The Rachel tribes (Ephraim, Manasseh, Benjamin) must, it seems, be identified with the sojourn in Egypt and the invasion and settlement. This conclusion rests upon the identification of Ephraim and Manasseh with "the house of Joseph" and the fact that Josh. i, 1—x, 28 deals almost entirely with Israelite victories in the territories of Ephraim and Benjamin. The Ark of the Covenant was located in the same territories until the destruction of Shiloh by the Philistines. Joshua himself was a man of Ephraim. Ephraim and Manasseh are possibly derived from Egyptian names. These tribes appear in Joshua and Judges as the largest and most powerful of the tribes, and Hosea uses Ephraim as a title of the kingdom of Israel.

Leah Tribes.—The Leah tribes (Reuben, Simeon, Levi, Judah, Issachar, Zebulun) present certain problems. Leah in the patriarchal tradition was the first wife of Jacob, and this implies some claim to pre-eminence on the part of the Leah tribes. The response of the Rachel tribes to this claim was the position of Rachel as the preferred, though second wife of Jacob. It is observed also that the first four sons of Leah, with the exception of Levi (Reuben, Simeon, Judahj, are located in the south on both sides of the Dead sea, removed from the other tribes by geographical barriers and Canaanite fortresses. The conquest of the territory of Judah is attributed to Joshua in Josh. x, 29 ff., but Judg. i, 1–20 reports a movement of Judah, Simeon and the Calebites into this territory. Most modern scholars believe that the account of Joshua is a later composition in which the separate movements of the tribes were telescoped into a single movement led by Joshua. Reuben and Simeon disappear early as distinct tribes; Reuben was probably merged into Moab and Gad. and Simeon into Judah. Levi is a landless tribe. Hence of the Leah group only Judah remains as a strong distinct tribe which later can be opposed to "Israel." Noth believes that the Leah tribes were the original 6-tribe amphictyony upon which the 12-tribe amphictyony was erected This view seems improbable to many scholars, but the distinct grouping of the Leah tribes is not easily denied, and perhaps the majority of scholars believes that the Leah tribes were not in Egypt and were in Canaan when the Rachel tribes arrived. The other two Leah tribes, Issachar and Zebulun. are located in Galilee; the tradition of their later birth (Gen. xxx) may represent their later union with the Leah tribes of the south.

The problem of the tribe of Levi remains without a satisfactory solution in this hypothesis, as it does in any hypothesis. In the traditions Moses was of this tribe. and hence the Sinai experience and the Israelite worship of Yahweh cannot be dissociated from Levi; yet Levi belongs not to the Rachel tribes but to the Leah tribes. The traditions reflect a time when the tribe of Levi was not a priestly tribe, and Gen. xxxiv is thought by many scholars to retain a recollection of an attempt by Simeon and Levi to take Shechem, later the central city of Ephraim and Manasseh. Levi's lack of land also appears to reflect some early disaster to the tribe. The complexity of the data has led Walther Eichrodt, followed by a few scholars. to suppose that two different but similar names are merged in Levi, which carries the traditions both of the priestly tribe and of the secular tribe that perished *(see* LEVITES).

Tribes East of Jordan.—The tribes east of the Jordan (Gad, Reuben, Manasseh) also present problems. Num. xxxii suggests that these tribes urged a claim to their territories that was older than the claims of the tribes of western Palestine, and-Josh. xxii narrates a dispute about the cult of Yahweh. This passage has possibly been softened in transmission and redaction; in its present form it is late but at its base there may lie a defection from the amphictyonic cult of Yahweh that was more profound than the text now reveals. The presence of two "half-tribes" of Manasseh, one on each side of the Jordan, is disturbing.

Bilhah and Zilpah Tribes.—The Bilhah tribes (Dan, Naphtali) and the Zilpah tribes (Gad, Asher) are reckoned as sons of slaves, and it may be suspected that this reflects an earlier subordinate position of these tribes. They do not, like the Leah and Rachel tribes. represent a geographical grouping, although Dan and Saphtali are found next to each other at the northernmost point of Israelite territory. Tradition, however, relates a movement of Dan from its territory adjacent to Philistia to the north because of Philistine pressure (Judg. xviii). Judg v, 17 suggests that Dan was seated in the north at the time of the battle of the Kishon, which is dated about 1125 B *c*.: the story of Samson (Judg. xiii–xvi), which can be dated only generally in the last three quarters of the 12th century B.C., supposes that the tribe was still dwelling in the south.

Asher in Galilee and Gad in eastern Palestine likewise are not geographically adjacent. Asher occupies an insignificant position in Israelite history, and many scholars believe it was the least "Israelite" of all the tribes; i e., most remotely akin, most geographically remote and most Canaanite in culture. The fact that the northern tribes (Zebulun, Issachar, Naphtali, Dan, Asher) are not grouped according to maternal descent suggests that there was no grouping of any kind antecedent to their entrance into the amphictyony.

Related Groups and Tribal Names.—The ultimate reason for the rigidity of the number 12 in the amphictyony is not altogether clear, but it seems that a number of other groups would rank easily as tribes if the number could have been enlarged. The Calebites in Judah seem as important as Simeon and appear later in the traditions (*see* CALEB). The same is true of the Renites (q *v.*). also connected with Judah. Two half-tribes of hlanasseh arouse suspicion; the eastern Manasseh is often designated as Machir. son of Manasseh. and it appears likely that the tribe of Machir entered the amphictyony only by merging with Manasseh A similar relationship with hlanasseh seems indicated for the clan of Jair of eastern Palestine.

Noth has made the suggestion that some tribal names are geographic names and that the original name of the tribe has been replaced by the name of the region in which it settled. Ephraim. hlanasseh. Judah and some of the Galilee tribes are alleged as examples. The relation of the tribal name Gad with the geographical name Gilead is obscure. The territory of Gilead is shared between Manasseh and Gad; yet Gilead is used in contexts which suggest its use as a tribal or clan name. and it is called the son of Machir, the son of hlanasseh (Suin. vi. 21). Soth's opinion is not widely accepted, but it shows another facet of the complexity of the question.

Intertribal Conflict.—Israel of the period of the judges exhibits the tribal structure. There is no central political authority. The Israelite victories related in Judges are victories of single tribes or small groups of tribes. and not even in the battle of the Kishon (Judg. iv–v). where the largest Israelite coalition was mustered, were all the tribes active. The intertribal war of Judg. xix–xxi is related in a form which was written much later than the events, and no accurate memory of the details is preserved; but the story itself illustrates the possibilities of conflict which were implicit in the tribal structure. Intertribal disputes are also attested in the stories of Gideon (Judg. viii. 1–7, 14–17) and Jephthah (Judg. xii, 1–6). Such unrestrained tribal freedom made Israel an easy victim for the more closely organized and disciplined Philistines. The Philistine danger moved the Israelites to elect Saul king. It is not clear, however, how many tribes acknowledged the monarchy of Saul, at least at the beginning of his reign. No doubt he gathered more tribes with his military successes, but it is not certain that "all Israel" in the sense of all the tribes accepted a single king before the reign of David.

This unity endured through the reigns of David and Solomon, but it was a unity in the person of the monarch rather than a true political unity. The administrative districts of Solomon (I Kings iv, 8–19) cut across tribal divisions and were probably intended to do so, but Solomon could not suppress the consciousness of the distinct realities of Israel and Judah which probably went back to the time when the Rachel tribes entered a land in which the Leah tribes were already present. The failure of Solomon's successor Rehoboam to give proper respect to the larger community of Israel led to the political breach that was never healed. The unity in the worship of Yahweh, however, survived the institution of separate Israelite shrines. and in the last phase of Israelite history. Judah was the sole survivor and heir of the faith of the 12-tribe amphictyony.

"Ten Lost Tribes."—Historians regularly find it necessary to explode the fable of "the Ten Lost Tribes" and their reappearance in some other part of the world. Some of the inhabitants of the kingdom of Israel were removed to other regions of the Assyrian empire after 721 B.C. Those who were removed and those who remained mere absorbed by other populations; they were neither lost nor did they survive as a distinct ethnic group. See also JEWS; JUDAISM.

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TWENTY-FOUR PARGANAS, THE, a district of West Bengal, Republic of India; area 5.288 sq.mi. Pop. (1961) 6,293,-758. It occupies part of the Gangetic delta east of the Hooghly, surrounding (but not including) the city of Calcutta. It also includes the greater part of the almost uninhabited Sundarbans (*q.v.*), so that within its confines are found virgin forest, settled tilth and the busy life of the suburb of a great city. The administrative headquarters are at Alipore, a southern suburb of Calcutta. The country consists for the most part of an alluvial plain with a population devoted to agriculture, but a chain of industrial towns stretches along the bank of the Hooghlp from Garden Reach northward. Rice is the staple crop, followed by jute, pulses and sugar cane.

Of the industrial towns Bhatpara has (1961) 147,725 and Baranagar 107,542 inhabitants.

Other industrial centres are Titagarh ([1951] 71.622). Budge-Budge. Naihati, Ramarhati, south Dum-Dum and Kanchrapara, in the last of which are the works of the broad gauge system of the Eastern railway. In other towns various manufactures are to be found, principally jute mills, jute presses and, at Dum-Dum, government factories for rifles.

TWICKENHAM, a municipal borough and parliamentary division of Middlesex, Eng., 10 mi. W.S.W. of St. Paul's cathedral by road. It has a frontage to the River Thames of about 9½ mi. Pop. (1961) 100,822. The borough includes Teddington, Hampton and Hampton Wick (all added in 1937), as well as Hampton Court (*q.v.*) palace, Bushy park and Home park (all three crown property). It is a residential area and a popular centre for Thames fishing and boating. It has a famous Rugby Union football ground. At Whitton, Kneller hall. originally built in 1709 by Sir Godfrey Kneller but much altered, is the home of the Royal Military School of Music.

The church of St. Mary has a Perpendicular tower. Among men of eminence buried there are Alexander Pope and Sir Godfrey Kneller.

There are many fine houses, some in beautiful grounds and having historical associations. Strawberry Hill, the residence of Horace Walpole, was built to his taste in a medley of Gothic styles. Marble Hill was erected by George II for the countess of Suffolk, and Alexander Pope, Jonathan Swift and John Gay took part in its equipment. Orleans house was the residence in 1800 of Louis Philippe. It was pulled down in 1927. York house (now the municipal offices) was given to Lord Clarendon by Charles II.

Twickenham at the Domesday survey was included in Isleworth. Anciently it was called Twittenham or Twicanham. The manor was early in the hands of the monks of Christ church, Canterbury. but in the reign of Henry VIII it came into the possession of the crown, and by Charles I was assigned to Henrietta Maria as part of her jointure.

In 1670 it was settled for life on Catherine of Braganza, queen of Charles II. The old manor house, now demolished, was Catherine's residence. It had been, according to tradition. the place of the retirement of Catherine of Aragon after her divorce from King Henry VIII.

Twickenham was incorporated in 1926 and contains more than 2,050 ac. of public open spaces, including the crown property.

TWILIGHT, the period after sunset when light continues to be received from the region of the overlying atmosphere that is still in sunlight. The corresponding early morning period of light before sunrise is popularly known as the dawn; but the technical practice in navigation and astronomy is to distinguish between the two periods by the terms evening twilight and morning twilight.

The phenomenon of twilight is caused by the atmosphere. If there were no atmosphere, complete darkness would set in sharply at sunset, as it does on the moon; but on earth the upper atmosphere remains illuminated until the sun is some distance below the horizon, because the air within the illuminated region reflects and scatters light into the shadow of the earth. Darkness comes on gradually after sunset as the sun sinks farther below the horizon and illuminates less of the air above.

It was determined in ancient times that twilight ended when the sun dropped about 18" below the horizon. Subsequent observations have not materially modified this figure, and it has been adopted as the point that separates complete darkness from sunset or sunrise; this interval is termed astronomical twilight. However, illumination is practically imperceptible when the sun is only slightly less than 18° below the horizon. Two intermediate levels of illumination also are recognized. Civil twilight covers the period when the sun is 6" or less below the horizon. In this period after sunset or before sunrise, natural illumination is sufficient for conducting ordinary outdoor activities. The second level, nautical twilight, marks the time when the sun is 12° below the horizon; illumination has deteriorated so that only the general outlines of objects are visible, the horizon is indistinct and all the brighter stars can be seen.

The duration of twilight is dependent on the season of the year and the latitude of the observer. Near the equator the sun rises and sets almost vertically, while at higher latitudes its path is slanted with respect to the horizon and a longer time is needed for the sun to travel a given number of degrees vertically from the horizon.

The durations and times of civil, nautical and astronomical twilight for any latitude. for all days of the year and for any year of the 20th century can be obtained from "Tables of Sunrise, Sunset and Twilight" published by the U.S. Naval Observatory as a supplement to the ***American Ephemeris*** for ***1946.***

The intensity of illumination at any level of twilight depends to a considerable extent on the amount of atmospheric cloud and dust and also upon reflective objects such as buildings, hills and trees in the environment of the observer. The duration of twilight decreases with increasing height of the observer above the surface of the earth and approaches zero at the upper limit of the atmosphere. (R. F. HA.)

Optical Phenomena. — During morning or evening twilight, a range of optical phenomena can be seen on both horizons if the skies are cloudless. In unusually clean air, as on a mountain top or from an airplane these phenomena can be of startling clarity, but in misty air (as in Great Britain) careful observation is required to follow them. w Since there is not a great difference between morning and evening twilights, both will be described in the time sequence of the evening twilight.

As the sun sets it is surrounded by a large luminous patch, and a yellow-red band forms along the horizon. Coloured bands that appear on the eastern horizon form what is known as the counter-twilight. The counter-twilight develops steadily, the colours rising as the sun sets, with the earth's shadow appearing beneath as dark night sky belo a reddish border. The coloured bands and the earth's shadow, as seen from low levels, are caused by the scattering of sunlight from low-lying dust, but the earth's shadow can be seen more clearly at high altitudes where there is little dust and the scattering comes from air molecules. Under average conditions counter-hilight ceases about 30 minutes after sunset when the sun is about 5° below the horizon. The earth's shadow then moves rapidly to the zenith.

In the west, the luminous patch around the sun sets until, when the sun is about 2° below the horizon a purple light appears on its upper border, about 25° above the horizon. The purple light is a highly variable phenomenon but usually it rapidly broadens and sinks and seems to intensify, so that on a clear evening it gives a purple hue to ground objects. It lasts about half an hour and, when the sun is about 6° below the horizon it has sunk into and brightened the horizontal bands, which have remained during the whole period. The only acceptable explanation of the purple light is in terms of scattering from a haze layer about 10 km. high, although there is no strong supporting evidence for such a layer from other sources.

After the purple light disappears, the twilight glow is visible in the west as a broad arch of light stretching up to 20° above the horizon. It gradually sinks into the horizon, lasting about 1½ hours until the sun is 18° below the horizon. The twilight glow is caused by scattering from the high atmosphere, partly from dust and partly from air molecules, the precise role of each being uncertain.

The spectrum of the twilight glow shows some bright lines when only the atmosphere above 60 km. is illuminated. The negative bands of ionized nitrogen ($N_2{}^+$) and the sodium D-lines are caused by resonant scattering. The red atomic oxygen lines are also enhanced above their nighttime values, but this is a more complex process.

Like most atmospheric phenomena, all these effects are very variable, particularly when the air contains unusually large quantities of dust. (R. M. Go.)

TWILIGHT SLEEP, a state characterized by analgesia and amnesia produced by the administration of scopolamine in conjunction with morphine, formerly widely used in obstetrics. ***See*** SCOPOLAMINE.

TWILL, a woven cloth in which the passage of the weft is arranged, not in regular succession as in plain weaving, but over one thread and under two or more according to the kind of twill. This gives a succession of diagonal lines to the cloth, and though in the normal type of twill this diagonal traverses from selvage to selvage at an angle of 45°, considerable variations may be made.

TWIN FALLS, a city in south central Idaho. U.S.. the seat of Twin Falls county. is the centre of a large reclamation and irrigation project. Located close to Twin falls (140 ft. high), Shoshone falls (212 ft.) and Auger falls (140 ft.) of the Snake river, the city is adjacent to a spectacular canyon which bisects the broad, arid Snake river plains.

An average annual rainfall of 9.8 in. retarded settlement of the region until the 20th century. Established in the desert in 1004, the town grew up almost overnight with the coming of irrigation and a branch railway. Until then there had been no major development in that region. but half a dozen more cities sprang up in the area during the next four years. A city of agricultural industry,. Twin Falls obtained a number of important plants, including sugar, cheese and farm implement factories) and a fruit dehydrating plant. The city has a council-manager form of government, in effect since 1950. For comparative population figures ***see*** table in IDAHO: *Population.* (M. D. B.)

TWINING, NATHAN FARRAGUT (1897–), U.S. air force officer, was born in Monroe, Wis., on Oct. 11, 1897, and graduated from the U.S. Military academy, West Point, N.Y., in 1918. He became a U.S. army pilot in 1924 and gained further experience thereafter as a combat unit commander and as a staff and engineering officer.

In World War II, as commander of the 13th air force in the South Pacific, Twining directed the air war against the Japanese on Guadalcanal and Bougainville. During 1944–45 he led the 15th air force in the strategic bombing campaign from Italy against Germany and the Balkans, returning to the Pacific in the closing months of the war to command the 20th air force B-29s that were assaulting Japan from the Marianas. One of the most widely experienced and best qualified of U.S. air commanders, Twining became chief of staff of the U.S. air force in 1953, contributing much toward making it an almost all-jet combat force with a very high atomic capability. In 1957 he was appointed chairman of the joint chiefs of staff. (A, GG.)

TWINS AND TWINNING. Human twins are of two kinds: one-egg and two-egg twins. One-egg twins are variously known as identical, uniovular or monozygotic; two-egg twins, as fraternal, biovular or dizygotic. Most mammals regularly bear several young to a litter, each young derived from a separate egg. Some of the larger mammals, however, habitually bear only one young at a time (as in the case of man, cattle, horses), but sometimes bear srnall litters of two. three or more. When such uniparous species bear plural young, the latter are known as plural-egg tuins, triplets, etc. Some mammals, however, such as the nine-banded armadillo (*Dasypus novemcinctus*) and related South American species, have been shown to give rise to multiple offspring in an entirely different manner. A single early embryo divides and subdivides into four parts, which severally develop into four distinct offspring—one-egg quadruplets. In addition to two-egg twins, the human race produces considerable numbers of one-egg twins, triplets, etc., in a manner probably similar to that knonn for the armadillos.

Supertwins.—Both one-egg and plural-egg twinning in man go beyond mere twinning proper to produce triplets, quadruplets, quintuplets and sextuplets (the highest number known to occur). Two, three, four or five offspring from a single egg are known (the Dionne quintuplets being surely monozygotic). Plural-egg triplets may come from two or three eggs; quadruplets from two, three or four eggs; and quintuplets from two, three, four or five eggs.

Frequencies of Twins, Triplets, **etc.**—In the United States, which has a mixed population of almost all races, one out of 44 babies born is a tuin. For every 86 single births there is one twin birth, making a percentage of twin births of 1.15. Tain frequencies differ greatly among different races and countries, being highest among north Europeans and lowest among various Mongoloid peoples. Among countries keeping reliable vital statistics, Belgium claims 1.79% of twin births; Finland, 1.65%; while Japan has only 0.69%, due largely to relatively few two-egg twins. One-egg twins seem to have about the same incidence the world over. Triplets are about 86 times as rare as twins, and quadruplets about 86 times as rare as triplets. If then we speak of the frequency of twin births to singles as one to 86, that of triplets is about one in 86^2 and that of quadruplets about one to 86^3, a curious but unexplained set of ratios.

Diagnosis of One-egg Twins.—Two methods of distinguishing one-egg from tuo-egg twins are used. the foetal membrane method and the similarity method. According to the membrane method, one-egg twins should always be enclosed in a common birth robe (chorion) and two-egg twins in separate chorions, but some one-egg twins have separate chorions. Hence the membrane method is somewhat unreliable. According to the similarity method, twins that are so similar as to be easily confused are classed as one-egg twins and those that differ markedly, as two-egg twins. The few doubtful cases are resolved by meticulous comparisons of such details as blood groups, eye colour and fingerprints. In the hands of experts, few mistakes are likely to be made.

Hazards of **Twinning.**—The human species is highly specialized for single-offspring births, and plural-offspring births are less viable. The prenatal and infantile mortality rate of twins probably averages about 50%, or about five times that of singles. Also, more than half of all twins are born prematurely and are thus more likely to be injured at birth. All of these hazards increase progressively for triplets, quadruplets and quintuplets.

Sex Distribution.— Twins are more frequently of like than of unlike sex. Extensive counts covering more than 700,000 cases show that twins are of unlike sex in only about three-eighths of them. From such counts an estimate can be made of the frequency of one-egg twins, for these are never of unlike sex, while of the two-egg twins half are expected to be so. Since, in fact, three-eighths are of unlike sex, it may be inferred that tnice this number, or three-fourths, must be two-egg twins, and hence one-fourth, or the remainder, must be one-egg twins.

Joined-together Twins.—Occasionally twins are joined at birth, as in the famous Siamese twins. In most cases they are joined symmetrically, like part with like. Superficial unions are easily severed at birth. More deeply united pairs seldom survive, though a few have lived to become natural curiosities. Most joined tnins exhibit abnormal disposition of blood vessels and viscera, knonn as *situs inversus,* in which the organs of one twin are more or less completely a mirror image of those of the other. A few cases of separate one-egg twins show the same peculiarity. Joined tuins are always same-sexed, and much evidence points to the conclusion that one-egg twins always result when the twinning division of the originally single embryo has been incomplete.

Heredity of **Twinning.**—The tendency to bear twins is regarded as slightly hereditary, though its exact mode and pattern of inheritance is far from clear. That relatives of twins have twins somewhat more frequently than the general population has been claimed by many writers, though satisfactory records are rare. According to some investigators, the production of two-egg twins seems to be influenced only by the mother and depends greatly upon her age, for the frequency of twins increases at least three-fold from the age of 18 to that of 38. It is generally agreed that the tendency to bear two-egg twins is somehow hereditary, but opinions vary widely as to one-egg twinning. Some writers hold that the frequency of one-egg twinning depends on the inheritance of the father as well as that of the mother, but is uninfluenced by age or environmental factors. Others regard one-egg twinning as probably nonhereditary and due to an early arrest of development that disturbs the unity of the embryo and favours the development of two or more growth centres (organizers), each of which grows into a separate individual.

Twins and Human Genetics— Twins have been extensively used in attempts to estimate the relative shares of hereditary and environmental factors in determining differences in physical, mental and temperamental traits. In character differences determined wholly by heredity, one-egg twins should be exactly alike, whereas two-egg twins should show degrees of resemblance no greater than brothers and sisters by different births. Most human differences, however, are determined partly by heredity and partly by environment. With respect to each trait we wish to know what relative shares hereditary and environmental factors have in determining differences. A comparison of large numbers of one-egg twin pairs reared together with an equal number of two-egg pairs reared together should give for each trait the percentage share of hereditary determination, for the two groups differ only with respect to heredity, the one-egg pairs being alike and the two-egg pairs different. A second comparison has been made between 50 pairs of one-egg twins reared together and 20 pairs of one-egg twins (all that could be found) reared apart under various degrees of environmental differences. This comparison should give us the effects of environmental differences, for the two groups are alike as far as heredity is concerned. From both comparisons it was evident that physical traits are least affected by environmental differences; that mental ability is affected more; educational achievement, still more; and personality or temperament, the most.

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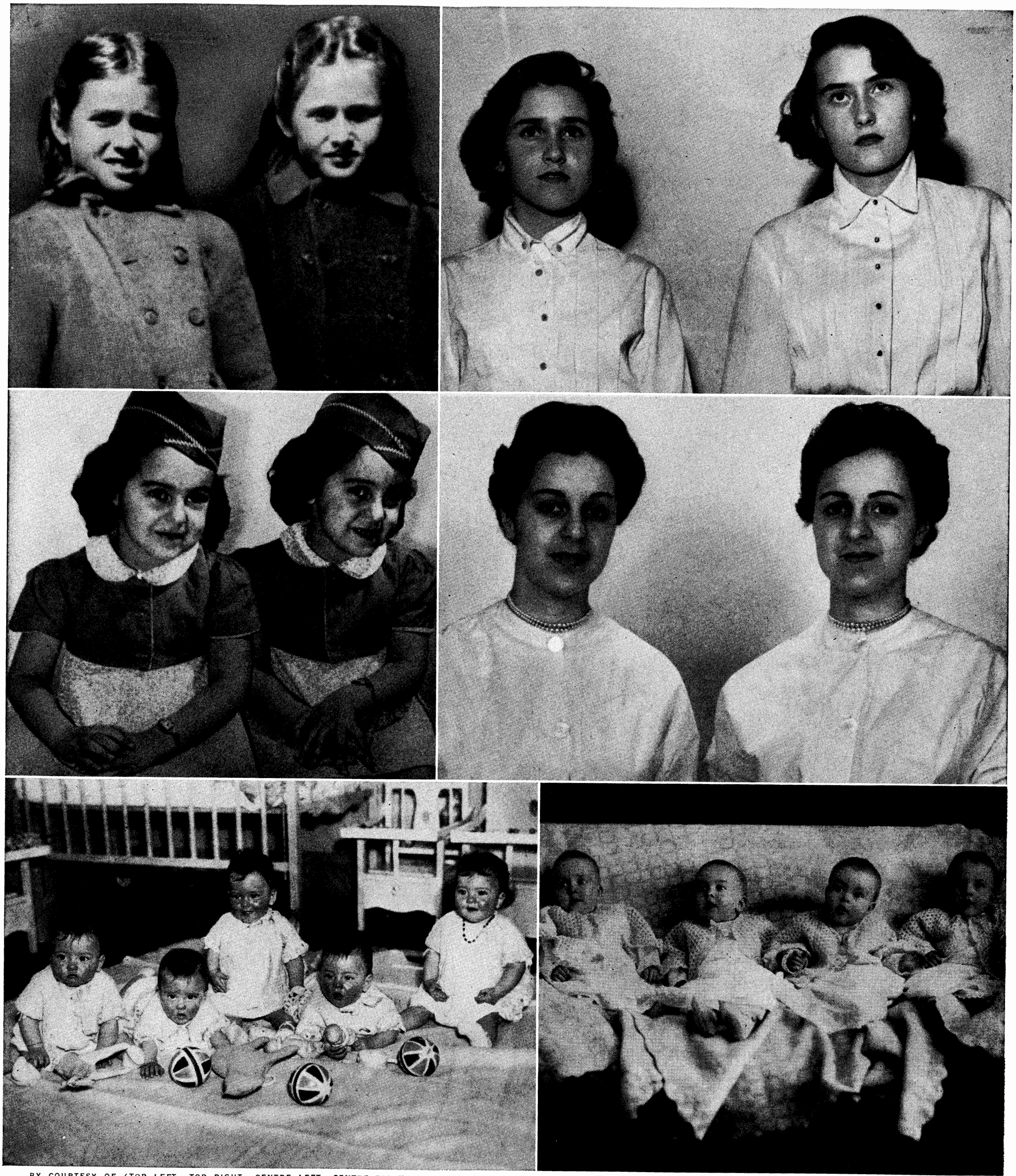
(H. H. N.)

TWISS, SIR TRAVERS (1809–1897), English jurist, was born in London on March 19, 1809, the eldest son of the Rev. Robert Twiss. He was educated at University college, Oxford, of which he was afterward successively bursar, dean and tutor. While at Oxford he published an epitome of Barthold Niebuhr's History *of Rome,* an annotated edition of Livy and other works. His studies, however, were mainly in political economy, international law and international politics. In 1840 he was called to the bar and became an advocate at Doctor's commons. During his connection with Oxford he was a public examiner in classics and mathematics. Drummond professor of political economy (1842) and Regius professor of civil law (1855). He enjoyed a large practice in the ecclesiastical courts and held many posts, such as commissary general of the city and diocese of Canterbury (1849),



BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE LEFT, CENTRE RIGHT) DR. F. J. KALLMANN, DEPARTMENT OF MEDICAL GENETICS, NEW YORK STATE PSYCHIATRIC INSTITUTE, (BOTTOM LEFT) NEA SERVICE, INC., (BOTTOM RIGHT) COPR. F. M. KEYES

TWINS, QUADRUPLETS AND QUINTUPLETS

Top left, top right: Two-ego twins at the ages of 9 and 15 years (dissimilar fingerprints and blood groups)

Centre left, centre right: One-egg twins at the ages of 4 and 16 years (no significant dissimilarity in fingerprints or blood groups)

Bottom left: The Dionne quintuplets, diagnosed as one-egg quintuplets, at the age of 13 months

Bottom right: Quadruplet daughters

vicar general to the archbishop (1852) and chancellor of the diocese of London (1858).

From 1852 to 1855 he was professor of international law at King's college, London. His successful career continued in the civil courts and, in addition to his practice, he was appointed in 1862 advocate general to the admiralty and in 1867 queen's advocate general. which officehe held until 1872, when, following his resignation. the position ceased to exist.

He was knighted in 1867. Twiss served during his legal career upon a great number of royal commissions, such as those dealing with marriage law, neutrality, naturalization and allegiance His reputation abroad led to his being invited by the king of the Belgians in 1884 to draw up the constitution of the Congo Free State. During the Berlin conference of 1884–85, he served as counsel extraordinary to the British embassy. Twiss lived in retirement after 1871 when he was involved in an unpleasant scandal concerning statements made about his wife's conduct before their marriage.

Twiss devoted himself to the study of international law and related subjects until his death on Jan. 14, 1897. Among his important publications of this period were *The Law of Nations in Peace* and *The Law of Nations in War*.

TWO RIVERS, a city of eastern Wisconsin, U.S.. in Manitowoc county, about 85 mi. N. of Milwaukee on Lake Michigan. Situated at the base of Door peninsula where the Neshoto and Mishicot rivers join to flow into the lake through a single channel (hence the name), Two Rivers and the surrounding region have developed into a popular resort area.

Manufactures include aluminum products, furniture, electrical toys and appliances, gasoline engines, iron and steel, castings, chemicals, yarn and knit goods, agricultural equipment and tile. The town is a marketing centre for the surrounding agricultural area which produces, among other crops, rye and barley. Dairying is also important.

Two Rivers was first settled by fishermen who began commercial fishing there in 1836. Until the 1870s the town was also a busy lake port. Lumbering was an important activity of the early settlers and shipbuilding was an important industry between 1850 and 1875. Two Rivers was incorporated in 1878 and in 1925 the city adopted a council-manager form of government.

For comparative population figures *see* table in WISCONSIN: *Population.*

TWO-STEP. A ballroom dance that stemmed from folk dancing in the early 1800s. The two-step consists of sliding steps taken to each side in 2/4 time. Though still prevalent in Europe, the dance is no longer much used in the U.S., except that it is sometimes substituted for the waltz and fox trot. *See* FOLK DANCE: *Continental Europe.* (A. Mu.)

TWYSDEN, SIR ROGER (1597–1672), English antiquary and royalist pamphleteer, was educated at St. Paul's school, London, and then at Emmanuel college, Cambridge. He entered Gray's Inn on Feb. 2, 1623. He succeeded to the baronetcy on his father's death in 1629. For some years he remained on his estate at Roydon, East Peckham, largely engaged in building and planting, but also in studying antiquities and the law of the constitution.

Twysden took the most prominent part in preparing the Kentish petition of March 1642 and in subsequent demonstrations on behalf of Charles. He incurred the wrath of the parliament and was arrested on April 1, 1642, but was soon let out on bail and on his promise to keep quiet. But his respect for legality would not let him rest, and he was repeatedly in trouble with the parliament until 1650, when he compounded and went home. He lived quietly there till the Restoration, when he resumed his position as magistrate. He died on June 27, 1672.

Twysden published *The Commons' Liberty* (1648), demonstrating that finings and imprisonings by parliament were illegal; *Historiae anglicanae scriptores decem* (1652), a work encouraged by Cromwell; and *Historical Vindication of the Church of England* (1657).

TYARD (THIARD), **PONTUS DE** (1521?–1605), French poet and member of the *Pléiade* (*see* DORAT, JEAN), was seigneur of Bissy in Burgundy. where he was born in or about 1521. He belonged to the Lyons group of poets and was a friend of Antoine Héroet (*q.v.*) and Maurice Scève.

His *Erreurs amoureuses,* originally published in 1549, was augmented with other poems in successive editions until 1573. He translated (1551) the *Dialoyhi d'amore* of Léon Hébreu, the breviary of philosophic lovers of that day. Two of his *Discours philosophiques* (1587) have a-hat may fairly be called parallel statements of the *De'fense et illustration de la langue française* of Du Bellay. Tyard was one of the first to write sonnets in French (the actual priority belongs to Mellin de St.-Gelais).

It is also said that he introduced the sestine into France, or rather reintroduced it, for it was originally a Provençal invention. In 1578 he became bishop of Châlon-sur-Saône. He resigned in 1594 and died Sept. 23, 1605.

TYBURN, a left-bank tributary of the Thames, England, now having its course entirely within London and below ground. The name, which also occurs as Aye-bourne, is of obscure derivation, though sometimes stated to signify Twy-burn; *i.e.* (the junction of) two burns or streams. The Tyburn rose on the southern slope of the Hampstead heights in two streams, the more westerly of which rose in the spring and was known as the Shepherd's well. It ran south, crossing Regent's park, its course being marked by Regent's park water, and farther south by the windings of Marylebone lane and the dip in Piccadilly near the junction of Half Moon street. It then crossed the Green park and entered the flood plain of the Thames near where Buckingham palace now stands. The exact point at which it entered the Thames is doubtful but its water is now drained off by sewer. After 1238 it supplied the city with water for a long time by means of nine conduits. The name is more famous in its application to the Middlesex gallows, also called Tyburn tree and Deadly Never green and also, at an early peribd, the Elms, through confusion with the place of execution of that name at Smithfield.

The Tyburn gallows stood not far from the modern Marble arch. Connaught squnre is said by several authorities to have been the exact site, but it appears that so long as the gallows was a permanent structure it stood at the junction of the present Edgware and Bayswater roads. The site, however, may have varied, for Tyburn was a place of execution as early as the end of the 12th century. In 1759, moreover, a movable gallows superseded the permanent erection. On some occasions its two uprights and crossbeam are said to have actually spanned Edgware road. Round the gibbet were erected open galleries, the seats in which were let at high prices. Among those executed there were Perkin Warbeck (1499), the Holy Maid of Kent and confederates (1535), Haughton, last prior to the Charterhouse (1535), John Felton, murderer of Villiers, duke of Buckingham (1628), Jack Sheppard (1724), Earl Ferrers (1760).

In 1661 the skeletons of Cromwell, Ireton and other regicides were hung upon the gallows. The last execution took place in 1783, the scene being thereafter transferred to Newgate. The Tyburn ticket was a certificate given to a prosecutor of a felon on conviction, the first assignee of which was exempted by a statute of William III from all parish and ward duties.

See A. Marks, *Tyburn Tree, its History and Annals* (1908).

TYDEUS, in Greek legend, son of Oeneus, king of Calydon, and Periboea. Having slain his uncle (or other relatives) he fled for refuge to Argos, where Adrastus purified him and married him to his daughter Deipyle, who became the mother of Diomedes (*q.v.*).

In the expedition of the Seven (cf. OEDIPUS), Tydeus, who had fought valiantly, was mortally wounded by Melanippus. Having killed Melanippus, he proceeded to devour his head; this so disgusted Athena, who had meant to make him immortal, that she left him to die.

See Roscher's *Lexikon,* art. "Tydeus."

TYLER, JOHN (1790–1862), 10th president of the United States, was born March 29, 1790, at Greenway, the ancestral home, in Charles City county, Va., and was reared in the aristocratic yet democratic republicanism of the Jeffersonian era. He attended a local school where, as the leader of those who opposed an unpopular schoolmaster, he gave evidence of the courage and independence that were to characterize his later life. At 12 years of age he entered the grammar school of the College of William and Mary and graduated from the college in 1807. He studied law in the office of his father) who was governor of Virginia (1808–11) and U.S. district judge (1812–13). Admitted to the bar in 1809 he developed a lucrative practice.

Tyler began his public career as a member of the state legislature in 1811. Elected for five consecutive terms. he resigned in 1816 when elected to the council of state, but returned to the legislature in 1823–25 and again in 1839. He supported President Madison's war measures and in 1813 served for a few months as captain of a company raised for the defense of Richmond. He early became a champion of state rights. favoured a strict interpretation of the federal constitution and was a bitter opponent of the idea of a national bank. He supported resolutions censuring Virginia's U.S. senators for voting to recharter the first Bank of the United States after having been instructed to vote against it.

In the U.S. house of representatives (1817–21), Tyler supported measures designed to repair the breaches of war but opposed the new nationalistic legislation brought forward by Henry Clay and John C. Calhoun—including protective tariffs, federal aid to internal improvements, establishment of the second Bank of the United States and recognition of the independence of Spain's South American colonies. He also opposed Andrew Jackson's exploits in Florida. Although Tyler recognized the evils of slavery and hoped the institution would gradually die out, he opposed the Missouri Compromise as an unconstitutional restriction on slavery in the territories and an infringement of the rights of slaveholders. Tyler declined re-election in 1821 because of ill health and business reasons but accepted election to the state legislature in 1823 and was elected governor of Virginia in 1825. The latter position was one of prestige but little power. Tyler urged upon the legislature, with little success, a program of public education and internal improvements. He resigned the governorship in 1827 when elected to the U.S. senate. He reluctantly accepted election to the Virginia constitutional convention of 1829–30 where he joined the conservative faction and opposed democratic reform of suffrage, representation and court procedure.

Tyler's senatorial career (1827–36) was marked by courageous independence of party and consistent support of state rights and strict construction of the constitution. Considering Jackson a mere military hero with little civilian standing. Tylcr supported William H. Crawford for the presidency in 1824. He refused to accept Jackson's cry of "corrupt bargain" when John Quincy Xdams. with the support of Clay, was elected president by the house of representatives and then appointed Clay as his secretary of state. He did not support either the Adams administration or the Jackson group. He was elected to the senate in 1827 by an anti-Jackson faction but in the presidential election the following year he threw his support to Jackson against. Xdams as the lesser of two evils. He opposed Jackson's appointment of newspaper editors to high federal office and his sending commissioners to Turkey without submitting their names to the senate for approval. On the other hand, he voted to confirm Jackson's appointment of Martin Van Buren as minister to England. Believing that protective tariffs were unconstitutional, he voted against the tariff acts of 1828 and 1832, but he condemned South Carolina's nullification of the two acts as unwise and inexpedient. He also condemned Jackson's proclamation, which denounced nullification, as subversive of constitutional principles. He declared that the Force hill, which authorized the president to use troops to enforce the law in South Carolina, tended toward "consolidated military despotism"; and he was the only senator to vote against it. Fearing dissolution of the union, Tyler approached Clay, urged him to sponsor a compromise and suggested that he consult Calhoun. Clay did so and the compromise tariff of 1833 was the result. Tyler's wisdom in adhering to state sovereignty may be questioned but not the courage, patriotism and sincerity he displayed in the nullification crisis.

Tyler heartily supported the stand Jackson took on federal aid to internal improvements in his veto of the Maysville road bill. He voted against the bill to recharter the Bank of the United States and also sustained Jackson's veto of the bill, but he refused to go along with Jackson on the removal of federal deposits from the bank. With the open support of the Clay faction, Tyler was re-elected to the senate in 1833 and in 1834 voted for the two resolutions censuring Jackson and his secretary of the treasury. Roger B. Taney, for the removal of deposits. Sen. Thomas Hart Benton immediately moved to expunge the resolutions of censure from the senate journal. The Virginia legislature, controlled by Jacksonians, in 1836 instructed the state's senators to vote for Benton's resolutions. Recognizing the legislature's right of instruction, but unwilling to vote as instructed, Tyler resigned from the senate on Feb. 29, 1536.

During his senatorial career Tyler served as chairman of the District of Columbia committee. In this position he sought to prohibit the slave trade in the district but opposed abolition of slavery in the district without the consent of Virginia and Maryland. Unlike Calhoun and other extreme proslavery men. Tyler believed that congress should receive abolition petitions and refer them to committee.

Having broken with the Democratic party, Tyler ran for vice-president on a ticket with Hugh Lawson White in 1836 and received 47 electoral votes. In 1838 he once more became a member of the Virginia legislature. The next year he conducted an unsuccessful campaign for the U.S. senate on the Whig ticket. The national Whig convention, meeting at Harrisburg, Pa.. in Dec. 1839, unanimously nominated Tyler for the vice-presidency on the ticket with William Henry Harrison, hero of the battle of Tippecanoe. Tyler's nomination came unsought in spite of his well-known opposition to the national bank, protective tariffs and distribution among the states of the money received from the sale of public lands. It came chiefly because, as a champion of state rights. it was thought he could win the southern states. With the slogan "Tippecanoe and Tyler Too," the Whig candidates won 234 of the 294 votes and were elected.

When Harrison died on April 4, 1841, one month after his inauguration, Tyler succeeded to the presidency. The opposition proposed to recognize him as acting president only but Tyler successfully claimed all rights and privileges of the office. Senator Clay, hoping to control the policies of the administration, publicly assumed leadership of the Whig party and in a special session of congress proposed four major measures: the repeal of the Independent Treasury act, distribution of the proceeds of public land sales. an increase in tariff duties and the establishment of a national bank. The contest was now joined between the nationalist senator and the state rights president. Tyler signed the act repealing the independent treasury and one levying new protective duties, but forced the dropping of distribution, and vetoed a national banking act. Clay declared that he would "drive the president before him" but Tyler vetoed a second bill providing for a "fiscal corporation." As a result, the entire cabinet, with the exception of Daniel Webster, promptly resigned. Tyler replaced them with men of state rights views. Webster remained in office long enough to complete negotiations with Lord Ashburton for the settlement of the northeastern boundary and then resigned. He was replaced first by Abel P. Upshur and then by Calhoun.

Tyler was now a president without a party; he had been repudiated by the Whigs but the Democrats refused to recognize him. Even so, Tyler's administration accomplished a great deal. It reorganized the U.S. navy, established a depot for nautical charts and instruments that later became the Naval observatory, tested and developed the system of magnetic telegraph, established the weather bureau, brought the Seminole War to an end, quieted the Dorr rehellion, negotiated a treaty with China, strengthened the Monroe Doctrine, and annexed Texas by a joint resolution of congress. The latter achievement gave Tyler some claim to the Democratic nomination for president in 1834 but he was passed over for James K. Polk. Tyler was nominated by an irregular convention but withdrew in favour of Polk and his expansionist platform.

'Tyler held no other public office until the eve of the American

Civil War but he took an active interest in public affairs; his opinions were often sought and he was in much demand as a public speaker. Returning to the Democratic party in 1844, he remained loyal to it until his death. He thought the Mexican War could and should have been avoided but he nevertheless advocated vigorous prosecution of the conflict. He voted for Lewis Cass in 1848, Franklin Pierce in 1852 and favoured Pierce over James Buchanan in 1856. He took a decided stand against the Wilmot proviso (1846) as a gross injustice to the south, and accepted Calhoun's doctrine that the constitution follows the flag; but he favoured the compromise of 1850 as a means of saving the union. He supported the Kansas-Nebraska act (1854) on the ground that the people of the territories had the right to decide the question of slavery for themselves. He had long held that congress had no right to restrict slavery in the territories and that Negroes were not citizens, hence he was pleased with the Dred Scott decision. He was much disturbed by John Brown's raid and commended the action of the Virginia governor in this matter.

Throughout the period of his retirement, Tyler was a strong champion of southern rights and southern interests but he held the view that the southern delegates acted unwisely in seceding from the 1860 Democratic convention in Charleston. He favoured John C. Breckinridge for the presidency but at the same time endorsed the Bell-Douglas fusion in New York and proposed that the Democrats pool their support for either Breckinridge or Douglas depending on which was the stronger. Tyler took a firm stand against secession and exerted himself on behalf of the' union although he believed that states had a constitutional right to secede. He served as a commissioner from Virginia to confer with President Buchanan and urged him to maintain the status quo at Ft. Sumter. He was largely responsible for, and presided over. the Washington peace convention of 1861. He hoped that it might "agree upon some suitable adjustment," but he did not believe the plan proposed constituted such an adjustment of differences and, after the plan had been rejected by the U.S. senate by a vote of 28 to 7, he gave up all hope of saving the union. He was elected to the Virginia secession convention and urged immediate secession. He was unanimously elected to membership in the provisional Confederate congress and to membership in the house of representatives under the permanent constitution. He died in Richmond on Jan. 18, 1862, before that body assembled.

Tyler was twice married, first in 1813 to Letitia Christian (1790–1842), and second in 1844 to Julia Gardiner (1820–1889). He made his home on plantations near his birthplace. In 1821 he bought the ancestral home, Greenway, where he resided until 1842 when he bought Sherwood Forest, a 1,200-ac. plantation only three miles distant. Tyler owned a labour force of more than 75 Negro slaves. He was a kind master but not a successful planter.

See also UNITED STATES OF AMERICA: *History*.

See Oliver Perry Chitwood, *John Tyler, Champion of the Old South* (1939); Lyon Gardiner Tyler, *Letters and Times of the Tylers*, 3 vol. (1884–96). (F. M. G.)

TYLER, MOSES COIT (1835–1900), U.S. historian who set high standards for subsequent intellectual and cultural histories by his pioneer research and writing. He mas born in Griswold, Conn., on Aug. 2, 1835, reared in rural Michigan. and educated in Detroit and at Yale university, where he graduated in 1857. After theological training in New Haven, Conn.. and Andover, Mass.. he was ordained as a minister and served Congregational pastorates at Owego and Poughkeepsie, N.Y. (1859–62). After several years in England as a lecturer and journalist Tyler became professor of rhetoric and English literature in 1867 at the University of Michigan. There he remained, except for 18 months in New York city as columnist on Henry Ward Beecher's *Chi-istian Union*, until called to Cornell university in 1881 to the first chair of U.S. history established in the United States.

Tyler considered literature the most sensitive register of dynamic ideas, and he searched the entire available written record at first hand. His interpretation of the spirit of national development broadened the scope of historical writing and challenged both anglophile and encyclopedic literary estimates. He was an energetic, volatile man whose enthusiasm for America's free republican progress was tempered by the canons of objectivity of scientific history. His most important published works were *A History of American Literature*, 1607–1765, 2 vol. (1878, rev. 1897); *The Literary History of the American Revolution*, 1763–1783, 2 vol. (1897); *Patrick Henry* (1887); and *Three Men of Letters* (1895). Tyler was a founder in 1884 of the American Historical association. He died in Ithaca. N.Y., on Dec. 28, 1900.

See Howard M. Jones, *The Life of Moses Coit Tyler* (1933). (L. W. C.)

TYLER, WAT (WALTER) (d. 1381), English rebel, was a native either of Kent or of Essex. Nothing definite is known of him previous to the outbreak of the peasant revolt in 1381, but Froissart says he had served as a soldier in the French War. The name Tyler. or Teghler, is a trade designation and not a surname. The discontent of the rural labourers and of the poorer class of craftsmen in the towns, caused by the economic distress that followed the Black Death and the enactment of the Statute of Labourers in 1351, was brought to a head by the imposition of a poll tax in 1379 and again in 1381. At the end of May in the latter year riots broke out at Brentwood in Essex; on June 4 similar violence occurred at Dartford; and on June 6 a mob several thousand strong seized the castle of Rochester and marched up the Medway to Maidstone. There they chose Wat Tyler to be their leader, and the rising spread over Kent. On the 10th Tyler seized Canterbury, sacked the palace of Archbishop Sudbury, the chancellor, and beheaded three citizens as "traitors." Next day he led his followers, strengthened by many Kentish recruits, on the road to London, being joined at Maidstone by John Ball (*q.v.*), whom the mob had liberated from the archbishop's prison. Reaching Blackheath on the 12th, the insurgents burned the prisons in Southwark and pillaged the archbishop's palace at Lambeth, while another body of rebels from Essex encamped at Mile End. King Richard II was at the tower, but neither the king's councilors nor the municipal authorities had taken any measures to cope with the uprising. The drawbridge of London bridge having been lowered by treachery, Tyler and his followers crossed the Thames; and being joined by thousands of London apprentices, artisans and criminals, they sacked and burned John of Gaunt's splendid palace of the Savoy, the official residence of the treasurer, Sir Robert Hales, and the prisons of Newgate and the Fleet. On the 14th Richard II, a boy of fourteen, rode out to confer with the rebels beyond the city wall. At Mile End the king met Wat Tyler; Tyler demanded the immediate abolition of serfdom and all feudal services, and the removal of all restrictions on freedom of labour and trade, as well as a general amnesty for the insurgents. Charters were immediately drawn up to give effect to these demands. Meanwhile, Tyler with a small band of followers returned to the tower, and dragged forth Archbishop Sudbury and Hales from the chapel and murdered them on Tower hill. During the following night and day London was given over to plunder and slaughter. Meantime the people of property began to organize themselves for the restoration of order. On June 15 Richard rode to Smithfield for a further conference with the rebels. Tyler formulated a number of fresh demands, including the confiscation of ecclesiastical estates and the institution of social equality. Richard replied that the popular desire should be satisfied "saving the regalities of the Crown." Tyler thereupon grew insolent, and in the altercation that ensued was killed by the mayor, Sir William Walworth (*q.v.*), and John Standwick, one of the king's squires. The enfranchisement of villeins granted by Richard at the Mile End conference was revoked by parliament in 1382, and no permanent results were obtained for the peasants by Wat Tyler's revolt.

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TYLER, a city of northeastern Texas, U.S., 100 mi. E.S.E. of Dallas; the seat of Smith county. The town was laid out in

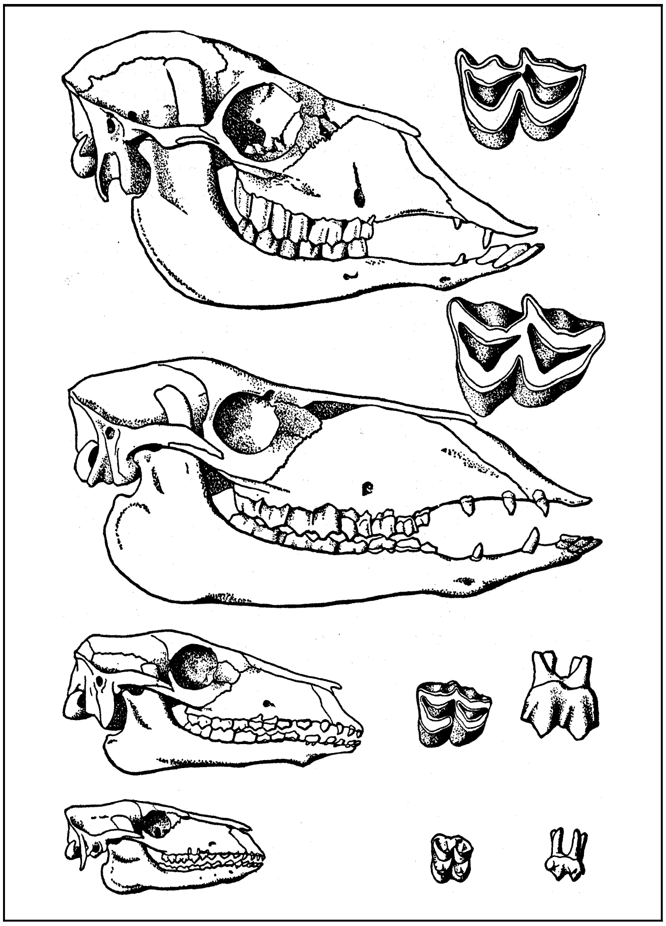
1846 and was named for Pres. John Tyler; its economy was based on trade and farming until 1930 when the East Texas oil field was discovered. Tyler subsequently became headquarters for many operators and oil companies and the population increased rapidly. In 1960 the population of the city was 51,230; that of the standard metropolitan statistical area (Smith county) was 86,350. (For comparative population figures see table in TEXAS: Population.) Tyler is also a distribution centre for densely populated east Texas, which produces cotton, corn, berries, pecans, oil and natural gas. Manufacturing includes oil refining, iron foundries, metal fabrication, prefabricated homes, air conditioners and ceramics. A majority of the nation's field-grown rose bushes are produced in nurseries in the area. Tyler was chartered as a city in 1907. It has a council-manager form of government, in effect since 1915. Educational facilities include Texas college, a private institution founded in 1894, and a public junior college organized in 1926. Tyler State park, a municipal rose garden, city parks and six nearby lakes provide excellent recreation. The Tyler Rose festival in October and the East Texas state fair in September attract thousands of tourists. (L. C. PI.)

TYLOPODA, a suborder of the paired-hoofed mammals (see ARTIODACTYLA) including the Xiphodontidae and Camelidae, of which the old world camels (see CAMEL) and the South American llamas and their allies (see LLAMA) are the only living representatives. The outstanding distinctions of the Tylopoda are: (1) the retention of the lateral incisors, canines and usually the first premolars as small recurved laniary tusks; (2) reduction of the remaining premolars and narrowness of the molars; (3) the peculiar form of tympanic bulla, folded in upon itself and filled with cancellous tissue; (4) elongate cervical vertebrae and peculiar course of the vertebral artery, perforating the inner side of the pedicle of the arch instead of the transverse process as in all other mammals (except *Macrauchenia, q.v.*); (5) carpal and tarsal bones remain separate, the trapezoid and magnum never co-ossified, nor the cuboid and navicular, while the trapezium is reduced to a small nodule in Miocene and disappears in later genera, only the ecto- and mesocuneiform are consolidated; (6) fore and hind feet completely didactyl, the lateral pair of digits absent except for small vestigial splints or nodules in the early forms, the median pair long, slender, appressed in early stages, consolidated into a cannon-bone in all later Tertiary and modem Tylopoda; (7) the distal ends of metapodials remain separate and slightly divergent, the keels of their distal facets confined to the palmar surface and not extending over the dorsal surface as in the pecora; (8) phalanges flattened and widened in varying degree and the hoof correspondingly reduced and limited to the upper surface of the terminal phalanx, conformant with the development of a heavy cutaneous pad on the palmar surface, and a digitigrade rather than unguligrade gait. No horns or antlers are developed. The femur and humerus are relatively elongate and the thigh and upper fore-limb are more free from the flank than in other ruminants. Many features of the soft anatomy are peculiar to the group; the absence of a distinct psalterium and presence of pockets in the stomach, the diffuse placenta and the oval blood corpuscles are the most remarkable.

The modern camels and llamas are the remnants of a group which played an important part among the Tertiary mammals of North America, and in the Pliocene and Pleistocene found its way to South America, Asia, eastern Europe and northern Africa. Fossil camels have been found in the Pleistocene of Alaska, in the Pliocene and Pleistocene of China, Siberia and Russia, the Pleistocene of Rumania and of Algeria, all of them related to the modern camels, but the Pliocene species from China and Russia are in a more primitive generic stage (Paracamelus). In South America the fossil Camelidae are related to the llama group, the older forms of late Pliocene and early Pleistocene more primitive in dentition (Palaeolama).

The ancestry of the camels is shown in North America by a very complete fossil record from Oligocene to Pleistocene, with more doubtful predecessors in the Eocene. The earliest stage is *Protylopus* of the Upper Eocene, about the size of a jack-rabbit. It has none of the characteristics of the Tylopoda well developed but is said to show them in a rudimentary stage. *Xiphodon* and other genera from the Upper Eocene of Europe have some claim to be associated with the Tylopoda.

Poebrotherium of the American Oligocene is the first of the undoubted ancestral line of the camels. It is about as large as a sheep and the long neck and limbs, peculiar course of the vertebral artery, the characteristic form of the tympanic bulla and the structure of teeth and feet are unmistakably camelid. The dentition is complete; the anterior teeth are all incisiform in some species, in others the canines are small, recurved, spaced tusks. The feet are two-toed, the lateral digits reduced to nodules, the median pair elongate and appressed but not co-ossified into a cannon-bone, the distal facets like those of modern Camelidae.



FROM SCOTT, "LAND MAMMALS OF THE WESTERN HEMISPHERE"
THE DEVELOPMENT OF THE SKULL AND MOLAR TEETH IN THE CAMEL

Oxydactylus of the Lower Miocene has the anterior teeth small recurved tusks, the vestiges of the lateral digits have disappeared or co-ossified, the median pair is more closely appressed and the size has increased to that of a llama or larger.

In Protolabis of the Middle Miocene the first and second upper incisors are reduced in size, the molar crowns are higher, and the metapodials are co-ossified to a varying degree in different species and at different ages. In Procamelus of the Upper Miocene the first and second upper incisors have disappeared, and the co-ossification of the metapodials is complete. Another side branch, *Alticamelus,* in the later Miocene and Pliocene differs from *Procamelus* in the long limbs and neck and relatively small head.

In the Pliocene follow a number of diverse genera incorrectly grouped under the name of Pliauchenia, and characterized by the loss of the second premolar in upper and lower jaw; but while they agree in this particular they differ widely in size, proportions, retention or loss of other teeth, height of molar crowns, etc. The best known is Megatylopus, probably identical with *Paracamelus* of the Chinese Pliocene, larger and more robust than the modern camel, with foot-pads less developed, but in most respects approximately ancestral. A group of smaller species, to which the name *Pliauchenia* may be found applicable, shows a similar approach to the llamas; a third group appears to be derived from *Alticamelus*, and a fourth parallels the Virginia deer in proportions (although not related).

In the Pleistocene the genus *Camelops* has lost the third lower premolar as well as p$\frac{2}{2}$, and p$\frac{3}{}$ is much reduced; p$\frac{1}{1}$ is present or absent in different species. It is of about the size and proportions of the modern camels, but lacks the broadly flattened toes and probably had not much padding on the foot. Another genus, akin to the llamas but with longer cannon-bones, relatively smaller head and sometimes retaining p$_{\overline{3}}$, occurs in the Pleistocene of the southern and south-western United States.

It has been generally believed that the camels became extinct in North America in the older Pleistocene, but recent evidence shows that some at least survived in Nevada until almost recent times, and probably elsewhere in the south and south-west until late Pleistocene. The splitting up of the family into the camels proper and the llama group is clearly foreshadowed in the geographical distribution of the Pliocene and Pleistocene species, many of the south-western species showing more affinities to the llamas, while those of the north-west are nearer to the camels. The Alaskan species and the Chinese *Paracamelus* make a still closer approach to the camel, and the Siwalik species is a typical *Camelus*. The Rumanian *"Camelus" alutensis* is, however, a side branch with low-cro ned molars, slender jaw and retaining p$_{\overline{3}}$, related to one of the North American Pliocene groups. In South America *Palaeolama* of the early Pleistocene, while retaining the second and third premolars like *Procamelus*, is quite llama-like in details of molar construction, in characters and proportions of skull and skeleton.

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(W. D. M.; X.)

TYLOR, SIR EDWARD BURNETT (1832–1917), English anthropologist, a dynamic figure in the history of anthropology. was one of the first to apply a systematic, comparative method to cross-cultural studies. Born at Camberwell, London,.on Oct. 2, 1832, of a well-to-do Quaker family, he was educated at Grove House. Tottenham, a denominational school. During 1855–56 he traveled in the United States and in the latter year visited Mexico with Henry Christy, the prehistorian. Tylor's observations were published as *Anahuac, or, Mexico and the Mexicans, Ancient and Modern* (1861). In 1865, his reputation was established by his *Researches Into the Early History of Mankind;* this was followed in 1871 by his most important work, *Primitive Culture* (new ed., 2 vol., 1958). He also published a popular text, *Anthropology* (1881). Tylor was keeper of the University museum (1883) and reader in anthropology (1884) at Oxford university. In 1888 he became lecturer at Aberdeen university and, in 1896, first professor of anthropology at Oxford. A fellow of the Royal society, he was knighted in 1912.

Like most of his contemporaries, Tylor was a cultural evolutionist. but in moderation. On the question of diffusion versus independent invention as an explanation of cultural similarities! he put fact before theory, carefully assessing the evidence in each case. His studies on mythology and magic and his famous derivation of religion from animism are both scholarly and provocative. He died on Jan. 2, 1917, in Wellington, Somerset.

See also ANIMISM; FOLKLORE; MAGIC; ANTHROPOLOGY.

See N. W. Thomas (ed.), *Anthropological Essays,* a volume dedicated to Tylor with a bibliography by B. Freire-Marreco and an appreciation by Andrew Lang (1907); and R. R. Marett, *Tylor,* "Modern Sociologists Series" (1936).

TYNDALE (or TINDALE), **WILLIAM** (*c.* 1492–1536), translator of the New Testament and Pentateuch (*see* BIBLE, TRANSLATIONS OF), was born on the Welsh border, probably in Gloucestershire. between 1490 and 1495. In Easter term 1510 he went to Oxford. where Foxe says he was entered at Magdalen Hall. He took his M.A. degree in 1515 and removed to Cambridge, where Erasmus had helped to establish a reputation for Greek and theology. Ordained to the priesthood, probably towards the close of 1521, he entered the household of Sir John Walsh, Old Sodbury, Gloucestershire, as chaplain and domestic tutor. Here he lived for two years, using his leisure in preaching in the villages and at Bristol, conduct which brought him into collision with the backward clergy of the district, and led to his being summoned before the chancellor of Worcester (William of Malvern) as a suspected heretic: but he was allowed to depart without receiving censure or being given any undertaking.

Translation of the Bible. — But the persecution of the clergy led him to seek an antidote for what he regarded as the corruption of the Church, and he resolved to translate the New Testament into the vernacular. In this he hoped to get help from Cuthbert Tunstall, bishop of London, and so "with the good will of his master" he left Gloucester in the summer of 1523. Tunstall disappointed him, so he got employment as a preacher at St. Dunstan's-in-the-West, and worked at his translation, living as chaplain in the house of Humphrey Monmouth, an alderman, and forming a firm friendship with John Frith; but finding publication impossible in England, he sailed for Hamburg in May 1524. After visiting Luther at Wittenberg, he settled with his amanuensis William Roy in Cologne, where he had made some progress in printing a 4to edition of his New Testament, when the work was discovered by John Cochläus, dean at Frankfurt, who not only got the senate of Cologne to interdict further printing, but warned Henry VIII. and Wolsey to watch the English ports. Tyndale and Roy escaped with their sheets to Worms, where the 8vo edition was completed in 1525. Copies were smuggled into England but were suppressed by the bishops, and William Warham, archbishop of Canterbury, even bought up copies on the Continent to destroy them. Attempts were made to seize Tyndale at Worms, but he found refuge at Marburg with Philip, landgrave of Hesse.

Other Works. — About this time he changed his views on the Eucharist and swung clean over from transubstantiation to the advanced Zwinglian position. His *Parable of the Wicked Mammon* (1528), *Obedience of a Christen Man* (1528), in which the two great principles of the English Reformation are set out, viz. the authority of Scripture in the Church and the supremacy of the king in the state, and *Practyse of Prelates* (1530), a strong indictment of the Roman Church and also of Henry VIII.'s divorce proceedings, were all printed at Marburg. In 1529 on his way to Hamburg he was wrecked on the Dutch coast, and lost his newly completed translation of Deuteronomy. Later in the year he went to Antwerp where he conducted his share of the classic controversy with Sir Thomas More.

After Henry VIII.'s change of attitude towards Rome, Stephen Vaughan, the English envoy to the Netherlands, suggested Tyndale's return, but the reformer feared ecclesiastical hostility and declined. Henry then demanded his surrender from the emperor as one who was spreading sedition in England, and Tyndale left Antwerp for two years, returning in 1533 and busying himself with revising his translations. In May 1535 he was betrayed by Henry 'Phillips, to whom he had shown much kindness, as a professing student of the new faith. The imperial officers imprisoned him at Vilvorde Castle, the state prison, 6 m. from Brussels, where in spite of the great efforts of the English merchants and the appeal of Thomas Cromwell to Archbishop Carandolet, president of the council, and to the governor of the castle, he was tried for heresy and condemned. On Oct. 6, 1536 he was strangled at the stake and his body afterwards burnt.

Though long an exile from his native land, Tyndale was one of the greatest forces of the English Reformation. His writings show sound scholarship and high literary power, while they helped to shape the thought of the Puritan party in England. His translation of the Bible was so sure and happy that it formed the basis of subsequent renderings, especially that of the authorized version of 1611. Besides the New Testament, the Pentateuch and Jonah, it is believed that he finished in prison the section of the Old Testament extending from Joshua to Chronicles.

Beside the works already named Tyndale wrote *A Prologue* on ***the***

Epistle to the Romans (1526), *An Exposition of the 1st Epistle of John* (1531), *An Exposition of Matthew v.–vii.* (1532), a treatise on the sacraments (1533), and possibly another (no longer extant) on matrimony (1529).

The works of Tyndale were first published along with those of John Frith (*q.v.*) and Robert Barnes by John Day, in 1573 (folio). A new edition of the works of Tyndale and Frith, by T. Russell, was published at London (1828–31). His *Doctrinal Treatises and Introductions to Different Portions of the Holy Scripture* were published by the Parker society in 1848. For biography, *see* Foxe's *Acts and Monuments;* R. Demaus, *William Tyndale* (1871); also the Introduction to Mombert's critical reprint of Tyndale's Pentateuch (1884), where a bibliography is given.

TYNDALL, JOHN (1820–1893), British natural philosopher best known for his researches on radiant heat, was born at Leighlin Bridge, County Carlow, Ire., on Aug. 2, 1820. After a brief career as a surveyor and engineer he entered the University of Marburg in 1848 and obtained his doctorate in 1850. He became known through some early magnetic observations and in 1852 was elected a fellow of the Royal society.

In 1853 he was chosen professor of natural philosophy at the Royal institution, where he became a colleague and friend of Michael Faraday. Tyndall became superintendent in 1867. He retired in 1887 and died at Hind Head, Surrey, Dec. 4, 1893.

Tyndall's investigations of the transparency and opacity of gases and vapours for radiant heat, which occupied him during many years (1859–71), are frequently considered his chief work. But his activities were many-sided. He definitely established the absorptive power of clear aqueous vapour—a point of much meteorological significance. He made brilliant experiments elucidating the blue of the sky and discovered the precipitation of organic vapours by means of light. He called attention to curious phenomena occurring in the track of a luminous beam. He examined the opacity of the air for sound in connection with lighthouse and siren work, and he finally verified what had already been substantially demonstrated, that germ-free air did not initiate putrefaction. However, his contributions to science are due more to his gift for making difficult things clear than to his original researches.

For the substantial publication of his researches, reference must be made to the publications of the Royal societv: but accounts of many of them were incorporated in his books,-which include the famous *Heat Considered as a Mode of Motion* (1863), the first popular exposition of the mechanical theory of heat.

TYNE, a river in England, flowing into the North sea. It is formed by the junction near Hexham (30 mi. from the sea) of the North Tyne, flowing from the southwestern end of the Cheviots, and the South Tyne, coming from the northern slopes of Cross Fell. Lesser tributaries include the Rede to the North Tyne, and the East and West Allen which combine to enter the South Tyne, all flowing through picturesque wooded valleys in sheep- and cattle-raising country. The Derwent, which enters the Tyne 2 mi. W. of Newcastle, forms part of the boundary between Northumberland and Durham. The Tyne continues the boundary for the last 15 mi. of its course as it crosses the Northumberland and Durham coal field where its banks are lined with factories, shipbuilding yards and wharves. Before 1900 the principal shipbuilding centre in Great Britain, it now ranks second to the Clyde. For more than 600 years it shipped coal but the export section of the trade declined. The main road and rail routes to Scotland cross the river between Gateshead and Newcastle, the lowest bridging point, 8 mi. from the sea. The river is navigable for large craft to Newcastle and a few miles farther for colliers. (T. HER.)

TYNEMOUTH, a municipal (1849) county (1904) and parliamentary borough of Northumberland, Eng., at the mouth of the Tyne, on its left bank, 9 mi. E.N.E. of Newcastle. The borough is bounded on the south by the Tyne for 3.5 mi. and on the east by approximately 2.4 mi. of coast line. It is divided into the wards of Chirton, Collingwood, Cullercoats, Dockwray, Linskill, Percy, Preston, Trinity and Tynemouth. Pop. (1961) 70,112. Tynemouth is a residential district and seaside resort; it is also partly industrial and contains a small mining area.

North Shields is an important seaport with a big fishing industry and a regular steamship service to Norway. The municipal buildings are situated there. It is connected by ferry with South Shields, on the opposite bank of the river. The borough's main industries, beside fishing, include ship repairing, the manufacture of furniture, textiles, confectionery, plastic board and light engineering. At Chirton a 200-ac. estate has been laid out for light industries. The central public library contains a splendid collection of engravings; open spaces include five public parks. On a rocky promontory at Tynemouth stands the castle, originally a fort once occupied by the earls of Northumberland but now used as barracks. Within the grounds are the ruins of the priory of St. Mary and St. Oswin, founded in 617–633 by Edwin, king of Northumbria. The church is a magnificent example of Early English work engrafted upon Norman. The priory was probably fortified in Saxon times and again by Robert de Mowbray. After the Dissolution the fortifications were repaired by Henry VIII. Charters were granted in 1203 and 1204 to the prior and convept. In 1292 there were disputes between the citizens of Newcastle and the prior, who had built a quay at North Shields but was obliged by act of parliament to destroy it. Tynemouth and North Shields did not become important until the 19th century. After the Napoleonic Wars the trade of North Shields rapidly increased, and fish quays were constructed. With Whitley Bay urban district Tynemouth returns one member to parliament.

TYPE, PRINTING: *see* PRINTING TYPE.

TYPE-CASTING MACHINES: see PRINTING TYPE; PRINTING.

TYPE METAL, an alloy of lead, antimony and tin used to make type characters for printing by the raised letter or letterpress method, or used as the master for making duplicate printing plates. (*See* ELECTROTYPING.) The same basic alloy has been used for over five centuries because of its low melting point and good castability and its minimum of contraction upon solidification, which provides clean, sharp type characters. Additional advantages are: ease of machinability, ease of solderability, availability of raw materials, re-usability of the alloy, and the ease with which the hardness of the alloy can be adjusted for various applications simply by varying the percentages of tin and antimony (*qq.v.*). The composition of type metals is not critical; in actual practice, however, the composition of the alloy is controlled carefully to provide optimum working properties for use in the type of casting equipment employed.

Type metal alloys are divided into classes according to the methods of casting to be used. Typical alloy compositions are given in the table:

Alloy Compositions

	Lead	Tin	Antimony	Brinell hardness number†	Melting point C.°
Foundry type*	62	13	25	34	325
Linotype metal	86	3	11	19	247
Monotype metal	78	7	15	24	262
Stereotype metal	80.5	6.5	13	22	252

*Sometimes as much as 2% of copper is added.
†250-kg. lead, 30 seconds (see HARDNESS TESTING).

Metal for foundry or re-usable type, being harder and having a higher melting point than the other type metals, is die cast. Individual type characters are set by hand and foundry type is used when the highest quality of printing is required.

Metal for Linotype, used extensively for printing newspapers, magazines and books, is cast on an automatic machine right in the composing room.

An entire line of indented brass type molds is assembled, and the complete line is cast with Linotype metal and cooled to a solid bar while the next line is being set. After use in printing, the type is melted for re-use. An alloy having a low, sharp melting point is required for this use.

In the Monotype, single type characters are die cast in the composing room in a casting machine developed by the Lanston Monotype Machine company.

Monotype is desirable where molding operations are involved, as in making electrotypes, stereotypes, plastic printing plates or molded-rubber printing plates.

In the stereotype method of making duplicate printing plates, molten type metal is poured against a paper mat, usually after the mat has been curved so that final plate can be used on a cylindrical press.

The paper mat is made by moistening a special paper board and pressing it against a flat array of type and halftone plates. This process is used by practically all large newspapers.

Because it is easily cast, type metal can be used for making statuettes, metallic candlesticks and various other decorative objects.

See also PRINTING TYPE. (R. W. J.)

TYPESETTING. Up to the end of the 19th century type was composed by hand, letter by letter, much as it had been in the 15th century. Keyboard-operated composing machines, which came into use about the beginning of the 20th century. introduced the radically new principle of "hot-metal" composition in which type is cast especially for each occasion from molten metal. This method revolutionized the setting of what the printer calls body matter or straight matter (*e.g.*, the text of a book or a newspaper). For more than a generation, however, hot-metal composition found no application in the other main field of typesetting, the setting of display matter (cards, letterheads, advertisements, etc.). Even in the 1960s hand composition was widely used in this class of work.

Meanwhile, a new and much more revolutionary change began to affect both of these main divisions of type composition. For display work, it was possible, beginning in the 1920s, to compose letters on sensitized film in the variety of designs and large sizes required by advertisers. The principle of filmsetting was extended to straight matter. and by the 1950s keyboard-operated filmsetting machines that entirely eliminated the use of type metal were in operation.

Filmsetting (also known as photosetting or photocomposition) has the same aim as did the hand methods of the 15th century—to secure a uniform printed page with identical likeness of like characters, a flatness of the composite image and a general rectangularity of page or column. The characters are composed on photographic film from which a plate can be made for letterpress. intaglio or lithographic printing. A page reproduced from type set on film is indistinguishable from one set in metal type, but by abandoning the whole idea of metal casting and by eliminating the third dimension (depth) of the matrix (see below), filmsetting initiated the most profound technological revolution in the history of type composition since the development of movable type.

The Form.—For centuries after the invention of printing, replica casting in metal was the only way of ensuring perfect likeness between any prints of the same letter. The letters had to be cast in female dies called matrices, which were struck to a standard shallow depth by relief-cut, steel model letters called punches. The face, or printing surface, of the type, the only part that touches the paper, thus precisely reproduced the flat face of the punch. But the cast letters had to be tall enough to provide a convenient grip for the compositor's finger and thumb, so the matrix was clamped on a mold in order to seal the bottom of its casting orifice. The mold, in which the body (or shank) of the type was cast, was of vital importance to the whole invention of printing with movable type for it was the means of assuring that when the cast types were assembled, their bodies would fit together so precisely that the types could then be securely fastened together (locked up) into one rigid composite master image—the form, or forme, from which a whole sheet was printed at a single impression. The form had to be exactly rectangular in shape and of uniform thickness (height-to-paper) so that its composite printing surface, formed by the relief-cast faces of the letters, would be perfectly flat. Until the introduction of filmsetting, all methods of type composition were concerned with the fitting together of solid metal objects about one inch high; these objects were either individual printing types, such as the single piece (or "stamp") of type, or line-long "slugs." Each of these was given a name and the hot-metal machine operators took over the old hand composition phraseology wherever possible. Filmsetting in its turn is using the same terminology to describe its analogous methods of producing those effects.

The Mold.—The cavity of the two-part mold used in casting types had to be adjustable "setwise" (from side to side) to allow for the different widths of the characters of the alphabet. But in the dimension that the printer calls body size, *i.e.*, from the top to the bottom of the printing surface of the character, it was, and remains, inalterable. Hence every type cast in a particular mold, whatever the character on its face, was of the same body size. Types of different faces (in the sense of typographical designs) could thus be cast from the same mold, so long as the sets of matrices were of appropriate size. When type of another body size was cast, another mold and another set of matrices had to be used. One striking advantage of photographic composition is that it can produce images of any desired size from one set of master letters by a simple adjustment of lenses.

Type Size.—The pioneer printers, who had to make their own type, possessed molds that they had made or commissioned for themselves; their type was in whatever sizes they happened to need for the work at hand. Sizes were therefore roughly graded, though not by any common unit of measurement. Their earliest names identified merely the type size that was thought suitable for a particular kind of book. A famous instance is the pica size (now 12 point), which is said to have derived its name from the conventional type size for the pocket breviaries that William Caxton called "pies." But in the 16th century punch cutting became an independent profession and the distinction between sizes became established as the letter engravers sold "strikes" (brass matrices) of their steel punches to more than one printer in more than one country. In time printers found it convenient to purchase their supplies of type ready-made from founders; the type was made up in fonts, or founts (complete castings from one set of related character matrices), of types of the same alignment and body size. This meant that each type-founding firm had to establish and maintain to a fine tolerance the sizes that are still called pica, brevier (now 8 point) or long primer (10 point). But the measurement of the metal type might vary, according to the manufacturer's standard, by several thousandths of an inch, so that types from different founders could not be used interchangeably. The type founders profited by this anomaly, for once a printer had chosen his supplier, he had to go on ordering from that firm the tons of type that were required for the hand composition of books and periodicals.

Standardized Measuring Systems.—In the 18th century Pierre Fournier proposed a standard unit of measurement, the point, for all type sizes. The later Didot point system, in which the point was 0.0148 in., was widely adopted in France and is now the one most used in continental countries. English and American type founders, however, continued to resist adopting the standard units until the later years of the 19th century, when the arrival of the hot-metal machines altered the whole situation and forced in the point system. The square or quadrat or quad of pica (■) had meanwhile become a familiar unit of measurement, setwise as well as bodywise, in the English-speaking countries; so the pica size was arbitrarily fixed and the Anglo-American point made one-twelfth of it, or about +$ of an inch (.013837 in.). The traditional names are still used in some newspaper offices and print shops to refer to the nearest point sizes. and a number of eminent Scottish book-printing firms are using the old system of measurement.

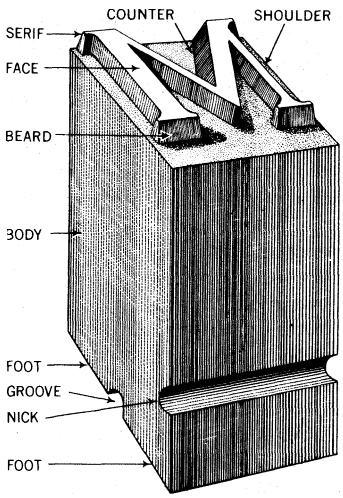


FIG. 1.—SINGLE PIECE OF TYPE USED IN HAND COMPOSITION

The other inalterable dimension of the mold, the depth of its cavity, had to be strictly standardized from the beginning for every mold that the typecaster used. Together with the depth of the intaglio matrix it determines the height-to-paper of the type from foot to face (see fig. 1). The Anglo-American printing world uses one standard height (.918 in.), but there is no uniformity of type height—or of point measurement—in other countries. When hot-metal casting was introduced, a great variety of molds had to be constructed for use in the other countries, where combinations of ten or more point systems, as well as regional varieties of type height, are to be found. The new filmsetting machines overcome such absences of uniformity.

Use of Film. — The whole idea of using photography instead of metal for typesetting was made to seem practicable and attractive to inventors by the steady increase in the amount of work printed by photolithography and, in display composition, by the mechanized process of serigraphy, or silk-screen printing. Both processes require photographic printing on a sensitized plate, and relief-cast type is used only in obtaining "repro proofs" (*i.e.,* proofs for photographic reproduction).

HAND COMPOSITION

The hand compositor, although he lives in an era of technological change and mechanization, remains an essential member of even the most completely mechanized printing house. In addition to assembling type by hand, he usually is also responsible for forwarding to the press, or to the platemaker. the machine-set type that emerges in long columns of lines. After (or before) corrections are made, the type has to be divided into pages or columns, which in turn have to be "imposed" in correct order upon the large flat table called the stone. In a book house this may mean placing 32 or more pages of composed type in such an order, head to foot, that when the whole large sheet is printed from the form (and "backed up" from a similar form) and then folded and trimmed, all the pages of the resulting "signature" will read consecutively. An elementary notion of the problems involved in imposition can be gained by folding any rectangular piece of paper twice across, numbering the resulting eight pages and then unfolding the sheet to see how the type pages would have to be arranged. In a ne spaper office the make-up man, or "stone hand," makes up the complex of headlines and text matter of each full page. No matter where he works, the compositor has the final duty of locking up the form in the chase, the iron frame in which it is taken to the next department.

All type for hand composition consists of individual letters or other characters. Hand type that is manufactured by specialist type founders from matrices of their own design is called foundry type; such type is made of metal that is harder than can be used in hot-metal composing machines. Type metal used in both foundry and hot-metal casting is a mixture of lead (the principal ingredient) and variable proportions of tin for toughness and antimony for sharpness of detail; foundry type also contains a small amount of copper to increase its durability. Single type can be cast in the print shop by the use of Monotype or other casting machines; such type is also cast for sale by trade houses that have such machines. Purchase of either foundry or Monotype type is by pound weight of font; that is, a sufficient quantity of one size and one design to serve for the kind of work that is to be done.

Each character (letter. figure or sign) is supplied in a number of "sorts" (identical examples), the quantity being proportioned to the expected frequency of appearance of that character in the language or in the class of work. A jobbing font of boldface type for occasional use in short lines might include 18 "a" (28 "e," 6 "f" and so on), 10 "A," 4 "&," proportionate quantities of figures 1 to 0, signs of punctuation, and such symbols as $. £, *, †, as well as ligatures, which are tied letters cast on one body, such as a?, ffl. It might also include accented sorts (à, ç, etc.). The strength of the font is reckoned by the number of sorts of some particular character, often the "a."

The scheme of the font is the indication of the particular characters that are included. A book font in a normal reading size would have a strength of 74 "a" (or more); a normal scheme (other than for mathematical, foreign language or other special purposes) would include not only roman a, A, etc., with related figures and signs, but also small capitals (A, B), the italic letters with their own figures and signs that must have the italic slant (cf. ; ;), leaders ( ) and perhaps the commoner fractions, although fractions and other mathematical signs are usually counted as "specials" that can be transferred from one font to another of the same body size.

Quads and spaces can also be transferred between fonts of similar size. These are the blank types that are cast less than type-high so as to leave white space in the print. Em, or "mutton," quads, as cast in foundry type. are the square (quadrat) of the point size and are mainly used for filling out short lines; *e.g.,* finishing out the last line in a paragraph. En, or "nut," quads are half as wide as the em; spacing widths most used for separating words grade down through thick, mid, and thin to the less-used "hair" space, which in careful display setting serves to equalize the visual differences in distance between letters.

A type case for hand type is a shallow tray subdivided into compartments for the respective characters and spaces. A jobbing case, *i.e.,* one for a font of large size and low strength, is made so as to contain the whole scheme of characters. Cases usually come in pairs, one for the capitals, small caps and certain less-used signs and spaces, and the other for the small letters that took their name of "lower case" from their position when the two cases are mounted in use—one above the other on a slanting frame on top of the storage cabinet or when the cases are partially pulled out of the cabinet. The cases form drawers in the cabinet and are labeled on the outside. There is a separate pair of cases for italic letters. The cabinets usually are ranged in rows that form aisles or corridors. Nearby is a circular power saw with which the compositor can trim, cut or mitre rules (long thin type-high strips, sometimes of brass, that are used as borders or column markers) or cut metal spacing material (long strips less than type-high used to provide white space between or around printed lines of type).

The compositor examines his copy and whatever specifications and layout (plan of arrangement) come with it. The layout represents a new event within the 20th century; whereas the 19th-century compositor was expected to be able to design as well as set his handbills, etc., his descendant must be able to interpret the directions of the customer or the typographic designer.

The compositor notes the measure (width of line) in which the job is to be set and accordingly adjusts his composing stick. What was originally a simple stick of wood hollowed out to receive a few lines of metal type has become a precision instrument of metal. It is often the personal property of the compositor and so in some sense is an emblem of his trade.

He slides out the pair of cases that he requires and fixes the copy within easy sight. Holding the stick in his left hand he reaches with first finger and thumb of his right hand for the first letter, positions it in his fingers by the feel of the "nick" or groove in the front of the type and places it at one end of the stick. The type is set upside-down so "The" is set "ꞱɥƐ." Between each word the compositor inserts a space. If the matter is to be set as text, *i.e.,* in a rectangular column or panel, at the end of the line he "justifies" the type by going back over the line and adding or removing equal amounts of spacing between words or letters until the line is filled to measure. Optically even spacing is the mark of a craftsman, whether at the case or at the keyboard.

The next line is set immediately above the preceding one, and so on until the stick is full; the type then is transferred to a galley, a long, shallow metal tray in which the composed lines are accumulated. If extra interlinear space is required, the compositor inserts between each line a thin, line-long strip of soft metal called a "lead" Leads are cast less than type-high in standard thicknesses usually from one point and up, in increments of half a point.

If the job is in display, the compositor takes all the lines that he has composed from different fonts and makes them up into the composite pattern of the whole area, inserting larger units of spacing material as required, together with any illustrative line or halftone engravings (blocks), etc. (When trade-marks. coats of arms, company names or other insignia are cast as metal type, they are called logotypes.) The whole composition is temporarily bound around its edges with cord. While still on the galley, it goes to the proofing press. The first proof goes to a proofreader and is marked for correction. "Literals" (*e.g.,* transposed letters) and any other departure from the copy may be corrected before the second, or author's, proof is sent out. After the form has been on the press, or printing plates have been made from it, it returns to the composing department. The surface is washed clean of ink and the form, while on the imposing stone, is unlocked. Type that was set by hand is retrieved for further use and "distributed," each letter being dropped back into its proper compartment in the case.

MECHANICAL COMPOSITION

Development of Hot-Metal Machines.—The earliest attempt at mechanical composition was patented by William Church in 1822. In 1842 J. H. Young and A. Delcambre in London used a machine for composing the *Family Herald.* For about the next 60 years inventors struggled with the problem of assembling and spacing out lines of cold (pre-cast) printing types by depressing keys that released each type as required from its channel in the magazine. Companion machines were invented for distributing the-types after use into their respective channels.

A key invention that helped make mechanical composition practicable was that of the pantographic punch-cutting machine, patented in 1884 by a U.S.type founder, Linn Boyd Benton of Milwaukee, Wis. Punches had previously been engraved by hand, and when a tiny steel letter broke in the course of striking a matrix, no hand engraver, however skilful, could reproduce it with absolute fidelity. Benton's machine made it possible to engrave any number of identical punches from a mechanical drawing; hence, for the first time, matrices could be manufactured in limitless quantity without the slightest variance.

In the same year (1884) Ottmar Mergenthaler (*q.v.*) of Baltimore, Md., a German-born U.S. citizen, patented the Linotype machine, the first and still the most famous of the hot-metal machines. It took over the general principle of the keyboard and resembled the earlier typesetting machines in that multiples of different characters were stored in a magazine. It was different in that it stored not type but a sufficient number of identical matrices to serve for the composition of one line of text. When the matrices for an entire line had been assembled, the line was cast as one solid slug and the matrices then returned to their respective channels in the magazine.

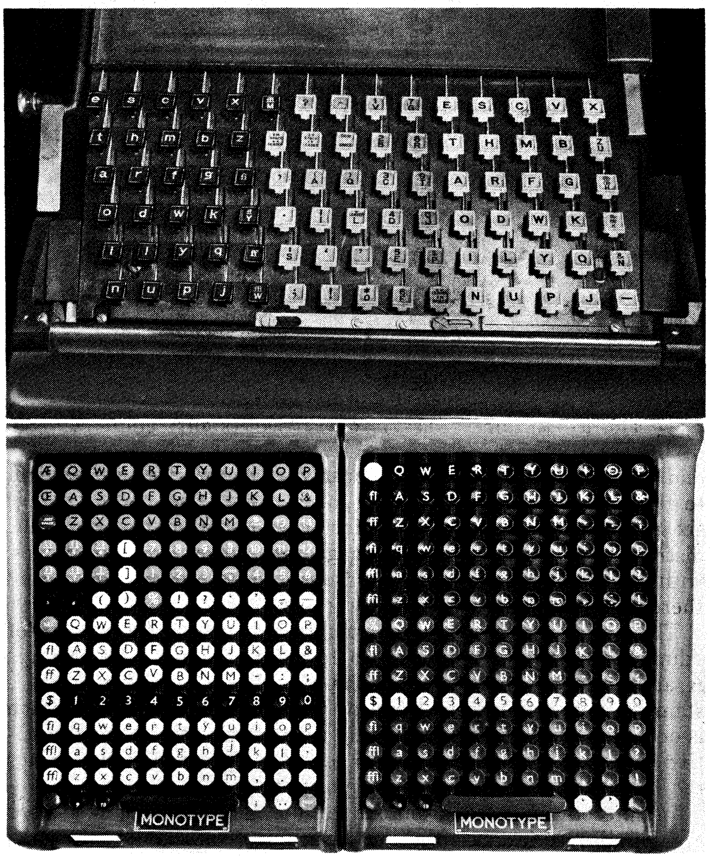
In the follo ing year (1885) Tolbert Lanston of Washington, D.C., took out the basic patent on his Monotype machine for hot-metal composition in single, or movable, type. This machine moved by means of a perforated ribbon encoded at a separate keyboard machine, a set of single matrices (one for each character in the font), from a traveling frame to the mold orifice where a single type was cast. This invention, which was developed after 1893, was equally dependent for its success upon the new means of making identical sets of matrices.

Immense capital resources were needed to manufacture in quantity any machine that had to work to the precise tolerance required in typecasting. The history of mechanical composition became that of a few powerful private enterprises formed to promote and defend patents and to develop an original mechanical concept by ancillary inventions. The Mergenthaler Linotype company of Brooklyn, N.Y., was first in the field. A Linotype machine was first used commercially in 1886 in the office of the New York *Tribune.* In a redesigned form it went into regular production in 1890 and was offered for sale on the world market in 1894. Since then, a succession of new and alternative models have improved and extended the machine's scope. When the basic Mergenthaler patents expired in 1914, a similar and competing machine was put on the market by the newly formed Intertype company of Brooklyn, N.Y. Lanston's more complex invention was developed during 13 years of engineering revision that exhausted the financial resources of the Lanston Monotype Machine company of Philadelphia. The $1,000,000 needed to put the machine into regular production was raised by selling the world rights outside the American continents to a specially formed English company, from 1931 called the Monotype Corporation Ltd.

Large-size display setting by hot-metal machines became possible when the Ludlow Typograph company of Chicago brought out in 1911 its Ludlow type-casting mechanism. With this machine, matrices, in sizes suitable for headlines and display work, are set and justified by hand and cast as slugs. Certain models of Linotype and Intertype machines also are equipped for casting large sizes of type. An attachment to Monotype casters extends the range of font casting to 36-point type. A Monotype Super Caster casts type fonts to 72-point size (one inch).

The words Linotype. Ludlow, Intertype and Monotype were registered as trade-marks by the respective manufacturing companies, and the latter three words are legally protected against misuse in a generic or descriptive sense. The word Linotype has been less successfully defended.

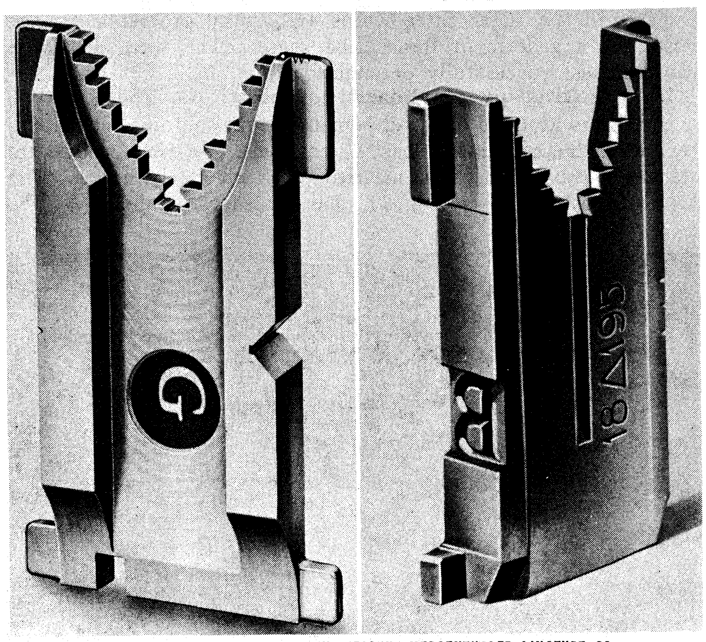
Line Casting by Keyboard Composition.—The Linotype machine has at least one and sometimes up to four magazines; each magazine contains at least 90 channels, in each of which are stacked up to 20 identical matrices of a given character. The keyboard has 90 keys (fig. 2), one for each channel. As the



BY COURTESY OF (TOP) KINGSPORT PRESS, INC., (BOTTOM) MONOTYPE CO

FIG. 2—KEYBOARD LAYOUTS: (TOP) LINOTYPE; (BOTTOM) MONOTYPE

operator touches a key, a pawl moves and releases the lowest matrix of the corresponding character. The matrix (fig. 3) slides down from the slanted magazine and is conveyed by a moving belt to the assembler (the "stick"). nhich has been adjusted to the required measure. After each nord is assembled, the operator presses a space key, which releases a steel spacehand (fig. 4) in the form of a sliding wedge. When the line contains as many matrices and spacebands as the measure will accommodate, the operator presses the elevator lever and the entire line is raised, securely gripped in steel fingers, and carried to the casting mechanism at the left of the machine. Here the line is automatically positioned between two vise jaws. There are four molds, all set in a revolving wheel. As the line of matrices and spacebands descends, the wheel makes a one-quarter turn and the mold to be used in casting that line comes into position. At this point a block presses upon the expandable spacebands and so drives out the line to the full measure by increasing the space between each word. The mold wheel moves forward and the mold seals the line under tight pressure. Molten type metal is pumped from the melting pot into the orifice and the line is cast. The slug, while still in the mold, is retracted from the matrices and a knife removes the rough jet of the casting. The slug is ejected and brought between two parallel trimming knives. Meanwhile, by successive automatic processes the line of matrices and spacebands is transferred to grooves, along which the teeth of the matrices slide. The spacebands fall out, since they have no teeth,



BY COURTESY OF (LEFT) INTERTYPE COMPANY, (RIGHT) MERGENTHALER LINOTYPE CO.

FIG. 3.— MATRICES: (LEFT) FOTOSETTER; (RIGHT) LINOTYPE

and are returned to their o n housing. The matrices are brought to the mouth of the distributing mechanism. The matrices have six pairs of teeth cut in particular combinations, and in the distributing mechanism they engage with corresponding grooves, with the result that each matrix drops into its proper channel and thereupon becomes available for re-use.

The number of available characters is increased by the use of "duplex" matrices, in which two forms of the same letter (*e.g.,* A and *A*, or b and **b**) are stamped. The alternative form is stamped below the normal casting position on the matrix, which is occupied by the more frequently used form. When the alternative sort is required, the operator presses a special key that brings the lower letter up into casting position.

In different machines from one to four additional side magazines are supplied to increase the operating range with additional fonts or sizes. The operating range also can be increased by exchanging magazines, which are interchangeable within certain type and mold size limits, and by hand insertion of special "sorts" into the assembled line before it is cast.

About 1950 a device called the Teletypesetter (developed in the early 1930s) came into wide use, especially on small daily newspapers in the United States, to set straight matter and special tabular material such as stock market quotations. The basic unit of this device was an attachment that fitted over the keyboard of a Linotype or Intertype machine; the attachment activated the keys as a perforated tape was passed through it. The tape, which was encoded with combinations of six holes, could be punched with a manually operated perforating unit in the same office or with a mechanical perforator operated by electrical impulses received over telephone wires from a transmitter many miles away.

Keyboard Composition in Single Type.—A separate and independent Monotype keyboard machine is first used to encode a paper ribbon by perforation. The ribbon is then transferred to an automatic Monotype composition caster. According to the nature of the work, from one to three casters, attended by one operator, may be fed by ribbon produced on one keyboard.

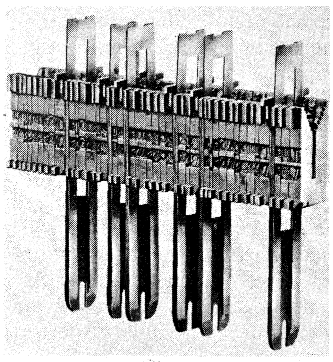
A Monotype keyboard has 276 or 304 keys arranged in two banks (fig. 2). As the operator presses a key, the paper ribbon at the top of the machine advances by $\frac{1}{8}$ in., unwinding from one spool to another, and is pierced by a combination of two punches, out of a row in line, that encode that particular letter by the relative positions of two holes. The width of each letter is registered on a moving scale. When the line is so nearly full as to accommodate only a few more letters, a revolving cylinder automatically calculates the amount of remaining space and indicates, from that point onward, which two justification keys,. out of a row of numbered red keys, should be pressed to complete the line. When the perforated ribbon of the text, or any part of it, is transferred to the caster, it passes in reverse direction over a row of air vents; thus the larger holes indicating justification, which control the width of each space to be cast between words, are the first to be presented to the caster. By releasing compressed air from corresponding vents, the justification holes set the spacing mechanism so that equal width will be cast between words so as to drive out the line to full measure.

The matrix case (fig. 5), which usually contains 255 different matrices arranged in rows according to the widths of the different characters, slides backward or forward in a frame at each revolution of the machine, and the frame itself moves laterally. According to the two perforations at that step of the ribbon, each movement is stopped by a pin blown up by compressed air. One perforation selects the required row, thereby controlling also the widening or narrowing of the mold cavity; the other determines the particular position (in the row) that contains the matrix. When the matrix is selected, it is clamped for a fraction of a second over the mold and the type is cast, trimmed and ejected.

In Monotype machine composition, the widths of letters and spaces are expressed in units—in effect, 18ths of the widest letter in the font. The basic unit is one-eighteenth of one point, or .0007687 in. The em is not necessarily square as in foundry type, for all space and letter widths are relative; *e.g.,* a condensed face in 10 point may be "$11\frac{1}{4}$ set,') the em being that much narrower (*i.e.,* $11\frac{1}{4}$ to 12) setwise than it is high pointwise.

Special single-type composing machines developed by the Lanston Monotype company increase the number of available matrices to 324. The separate keyboard has 120 keys and four shifts.

Filmsetting.—As early as 1895, a practicable invention for photographic composition was patented by William Friese-Greene, the English pioneer of cinematography, though it was abandoned for lack of financial support. The Dutch Hadego headline machine was in use before World War II; with it, display matrices of plastic are composed by hand and then photographed. In 1947 the Intertype company brought out its Fotosetter, the first keyboard-operated filmsetting machine to go into regular production. This adapts the general mechanical principles of the line-casting machines but uses toothed matrices that carry photographic negatives (fig. 3). The lines, composed on film as separately photographed characters, are justified in advance by a method that distributes excess space between letters as well' as between words.

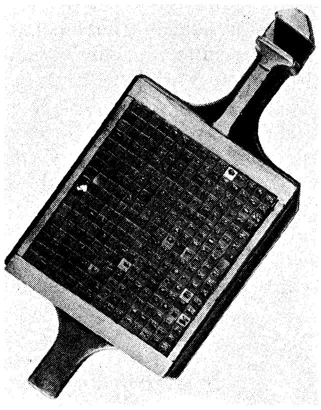


BY COURTESY OF MERGENTHALER LINOTYPE CO.

FIG. 4.— LINOTYPE MATRICES AND SPACEBANDS IN ASSEMBLED FORM

Another adaptation of an existing hot-metal machine is that produced by the Monotype Corporation Ltd. under the trade-mark Monophoto. The matrix case is again positioned by a ribbon perforated on a conventional Monotype keyboard; through the transparent plastic matrices a beam of light photographs each required letter in turn. When the line is completed, the strip of film is advanced on a revolving drum.

Several systems emerged along radically different lines. The Photon was developed under the sponsorship of the Graphic Arts Research foundation of Cambridge, Mass.; it was invented by Rene A. Higonnet and Louis Moyroud in France, where it is known as the Lumitype. The operator types the copy on a standard electric typewriter that is connected with a telephone relay system and a photographing unit. By electronic means involving a memory storage and computer system, justified lines can be set in combinations of 16 different fonts. The various characters are arranged in concentric circles in a revolving glass matrix disk. A stroboscopic lamp passes light through the selected character into an optical system. by means of which it is projected in any of 12 different point sizes onto the sensitized film. In the Mergenthaler Linotype company's Linofilm machine. a separate keyboard encodes the copy and justification electromechanically on a tape. The independent photographic unit is automatic and capable of storing 18 grids of 88 characters each for combination setting. Under the control of the tape. the desired font grid is presented from a turntable and each character in turn is selected and projected by shuttering a multilens system.



BY COURTESY OF MONOTYPE CO

FIG. 5.— MONOTYPE MATRIX CASE

The filmsetting methods that depart radically from any hot-metal principle gain very high projection speeds and a large range of characters but create special problems of servicing the machines and training operators. The filmsetting epoch was, in the early 1960s, in its infancy, since the influence of both the keyboard machines and the display machines, of which more than 50 competing makes had come on the market, was just beginning to be felt.

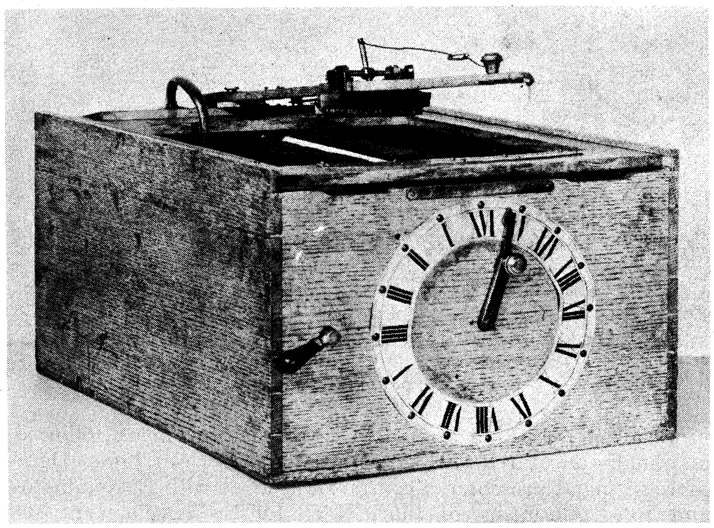
Rising labour costs and stoppages caused by labour disputes also encouraged the development of facsimile and other methods of reproduction from office typewriters, and several machines were invented that stood midway in development between the typewriter and the composing machine.

See also PRINTING; PRINTING TYPE; TYPOGRAPHY.

(B. L. WA.)

TYPEWRITER, a writing machine, enabling the operator to produce writing resembling printer's type at a speed far greater than that possible with the pen. It consists of a keyboard controlling the selection of characters for sequential impression from a group of type arranged on separate rods or on the periphery of a wheel. Formerly the term typewriter was also applied to the operator; later the operator became known as a typist.

History. — The first recorded attempt to invent a typewriter is found in the records of the British patent office. These show that on Jan. 7, 1714, a patent was granted by Queen Anne to Henry Mill, an English engineer, for "an Artificial Machine or Method for the Impressing or Transcribing of Letters Singly or Progressively one after another, as in Writing, whereby all Writing whatever may be Engrossed in Paper or Parchment so Neat and Exact as not to be distinguished from Print." No drawings of Mill's machine exist, and its construction is not known. Only one other attempt was recorded in the 18th century. This was a machine invented in France in 1784 for embossing characters for the blind. The first U.S. patent on a typewriter was granted in 1829 to William Austin Burt of Detroit. His machine (fig. 1), which he called a typographer, operated like modern toy typewriters, the type being mounted on a rotating semicircular frame which was positioned to bring the desired letter to the printing point and was then depressed against the paper by means of a lever. The only model of this machine was destroyed by fire at the Washington patent office in 1836. Various kinds of machines were attempted in the 19th century. Two models (one of which is illustrated in fig. 2) were developed by Charles Thurber of Worcester, Mass., in 1843–45; neither was successful, but they had such improvements as a cylinder or platen for holding the paper. Other machines of the time took various forms; most were large and cumbersome and several resembled pianos in size and general



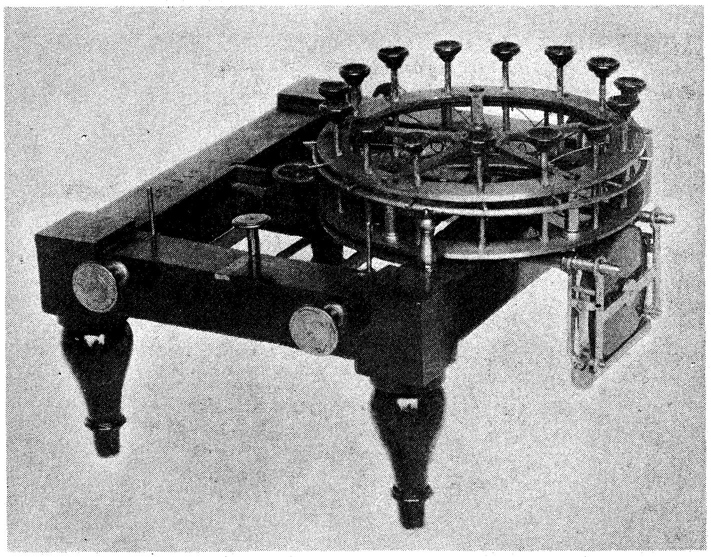
BY COURTESY OF ROYAL MCBEE CORP.

FIG. 1.— BURT'S TYPOGRAPHER. 1829

shape. The machines of the early 19th century accomplished reasonable printing quality but actually were much slower than handwriting. Many of the machines were intended for producing copy which the blind might read by touch.

Although Alfred Ely Beach of New York had invented a typewriter in the mid-1800s, his most significant contribution to typewriter technology was as editor of the *Scientific American,* in which he reprinted an article describing the invention of John Pratt, an American, which had appeared in a London magazine, *Engineering.* Pratt's machine, which was patented in England, utilized the type-wheel principle; it had 36 type slugs in three rows on the type wheel. On the same general principle a model by Thomas Hall of Brooklyn (1867), illustrated in fig. 3, used a moving stylus to select keys through a perforated dial plate. The reprinted article on Pratt's machine was read by Christopher Latham Sholes, who was inspired to construct the first practical typewriter in 1867.

First Practical Typewriter. — In the early days of the design Sholes, Carlos Glidden and Samuel W. Soulé worked together; Soulé soon retired from the undertaking, but Sholes, within five years, made nearly 30 experimental models. The first of these, showing the working principles only, was covered in patent of June 23, 1868. The second one, patent of July 14, 1868, was the first efficient typewriter model, in that it would write well at a speed far exceeding the pen. It was still, however, a very crude machine, lacking the now familiar keyboard layout, typewriter



BY COURTESY OF ROYAL MCBEE CORP.; SMITHSONIAN INSTITUTION

FIG. 2.—THURBER'S PRINTING MACHINE, 1843

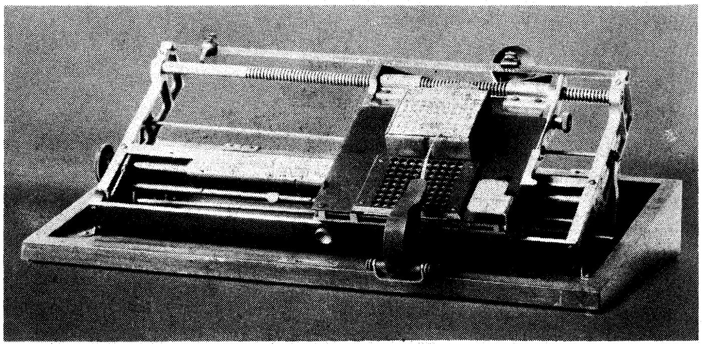


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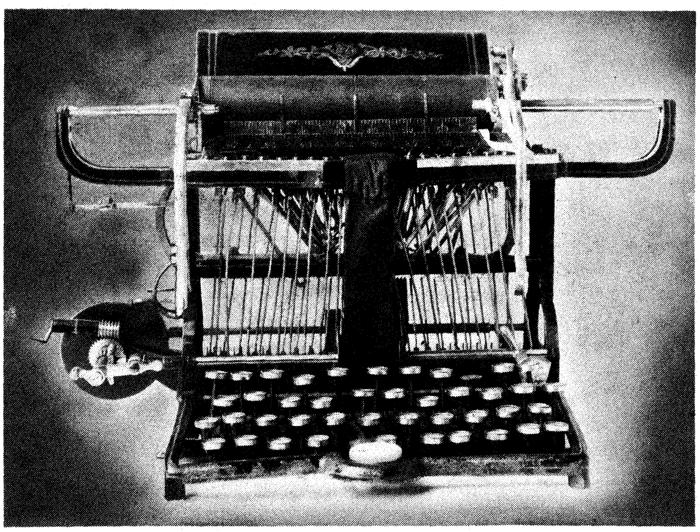
FIG. 3.— HALL'S TYPOGRAPHIC MACHINE, 1867

carriage and the cylinder or platen. Many improvements followed, and finally on March 1, 1873, with the assistance of James Densmore acting as promoter, a contract was made with E. Remington and Sons, gunsmiths, of Ilion, N.Y., for the development and manufacture of the Sholes machine. The first completed typewriters were placed on the market early in 1874, and the machine was soon renamed the Remington. Among its original features which were still standard in machines built in the second half of the 20th century were the cylinder with its line-spacing and carriage-return mechanism; the escapement which causes the letter spacing by carriage movement; the arrangement of the type bars so as to strike the paper at a common centre; the actuation of the type bars by means of key levers and connecting wires, printing through an inked ribbon; and the positions of the different characters on the keyboard, which conform almost exactly to the arrangement now known as universal. The Remington typewriter was not very successful; however, one *was* purchased by Mark Twain, who was the first author in history to submit a typewritten book manuscript.

Further Refinements.— The first typewriter had no shift-key mechanism—it wrote capital letters only. The problem of printing both capitals and small letters without increasing the number of keys was solved by placing two types, a capital and lower case of the same letter, on each bar, in combination with a cylinder-shifting mechanism. The first shift-key typewriter—the Remington model 2—appeared on the market in 1878. Soon there appeared another solution of the same problem in the so-called single-key or double-keyboard machines, which contained twice the number of keys—one for every character, whether capital or small letter. An example of this kind of machine is the Caligraph (fig. 4), designed by George Washington Yöst, Franz X. Wagner and H. L. Wagner in 1885. For many years the single-key and the shift-key machines competed for popular favour, but



BY COURTESY OF ROYAL MCBEE CORP.: SMITHSONIAN INSTITUTION

FIG. 4.—YÖST'S CALIGRAPH. 1885

the development of the touch method of typing, for which the compact keyboard of the shift-key machines was far better suited, decided this issue. Touch typing was slow in its early progress and before the 1890s was practised only by operators of exceptional skill. In the latter decade, however, it rapidly gained acceptance, and after 1900 it was virtually the universal method of instruction.

Another early issue in the field of the typewriter concerned the relative merits of the type-bar and the type-wheel principles. The latter construction traces its descent through the Burt machine of 1829 and the Pratt machine of 1866. In 1880, shortly after Sholes brought out his bar machine, James B. Hammond of New York patented a cylinder machine, shown in fig. 5; similar to the modern Vari-Typer, it had a hammer which hit the back of the paper, pressing it against the type cylinder. In 1881 Lucien S. Crandall of Groton, N.Y., developed a compact cylinder machine (fig. 6); depressing a key caused the cylinder to shift laterally and rotate, thus selecting the proper letter and pressing it against the paper.

In modern machines of this variety the type faces are mounted on a circle or segment, the operation of the keys brings each type to correct printing position, and the imprint of type on paper

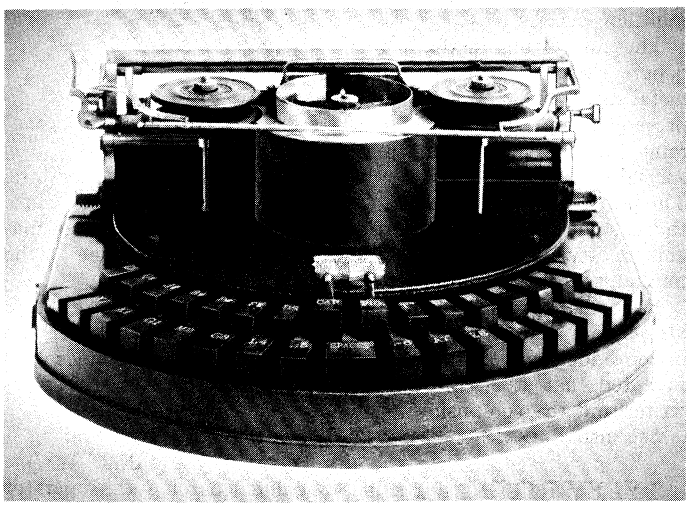


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FIG. 5.— HAMMOND'S MACHINE. 1880

is produced by a trigger action. The type-wheel machines offer an advantage in the ease with which the type segments may be changed, thus extending the range and versatility of the machine. However, machines of this construction have never been very serious competitors of the type-bar machines in the general commercial field.

Following the first shift-key typewriter of 1878, the next great advance was visible writing. On all the early type-bar machines the bars were arranged in a circular basket, located underneath the carriage, and the type printed at a common point on the underside of the cylinder. This construction compelled the operator to raise the carriage in order to see the writing line.

The first visible-writing machine appeared in 1883. The early machines employed the down-stroke principle, the type striking on top of the cylinder. Later the front-stroke machines took the lead in the general business field, the first machine of this type to attain prominence dating from 1890 as a result of the work of John N. Williams. In front-stroke machines the type bars are placed in a segment in front of the carriage, the type printing on the front of the cylinder. This solved the problem of visible writing, and all writing machines of the leading standard makes are of this type.

On nearly all typewriters the printing is done through an inked ribbon, nhich is fitted on spools, travels with the operation of the machine, and reverses automatically when one spool becomes completely unizound. On other machines an inking pad is used, the type contacting the pad prior to printing.

Noiseless **Typewriters.**—The noiseless linkage is a variation of the conventional type-bar linkage causing the type bar to strike the platen at a lower velocity but with the same momentum. Although it produces less noise than the conventional typewriter, the noiseless typewriter cannot produce as fine an impression or as many carbon copies. The noiseless typewriter has enjoyed only limited success.

Electric Typewriters. — A significant advance in the typewriter field was the development of the electrified typewriter; a modern model is shown in fig. 7. The electric typewriter is basically a mechanical typewriter, with the typing stroke powered by an electric motor drive. The typist initiates the key stroke, the carriage motion and other controls by touching the proper key. The actuation is performed by clutching the proper linkage to a constantly rotating drive shaft. Advantages of this system include lighter touch, faster and more uniform typing, more legible carbon copies and a greater number of them. and less operator fatigue. The electric typewriter made great progress as an office writing machine, having been adopted as standard equipment in many large offices. All major typewriter manufacturers produce electric typewriters.

Thomas A. Edison in 1872 produced the first electrically operated "typewriter," consisting of a printing wheel The machine later developed into the familiar ticker tape printer. The electric typewriter as an office writing machine was pioneered successfully by James Smathers, who produced a working model by 1920.

Portable Typewriters. — The early portables of the late 19th century were slow, awkward, type-wheel machines. In 1909 the first successful portables, invented by Frank S. Rose, appeared on the market By the 1950s practically every typewriter manufacturer produced a portable typewriter, all of which were type-bar machines similar in operation to the office machines. Designed with lighter parts than those of standard models. portables are more compact but less sturdy. Electrical operation of portable typewriters was introduced in 1956.

Modern Developments. — The inherent versatility of the typewriter, particularly the electric typewriter, led to its application to many tasks once considered beyond its scope. One example is the accounting machine, which evolved from the typewriter and the adding machine. This office machine is capable of tabulating in vertical columns, performing arithmetic functions concurrently, as well as typing horizontal rows, thus performing complete bookkeeping functions. The development of this equipment served as a natural bridge for the entry of the typewriter industry into the data-processing or computer field.

Special-purpose typewriting machines have been developed for use as composing machines. Although typewriters cannot compare in quality, style and versatility with special composing machines, which produce type directly on slugs of metal, the high cost of

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FIG. 6.— CRANDALL'S PRINTING CYLINDER MACHINE. 1881

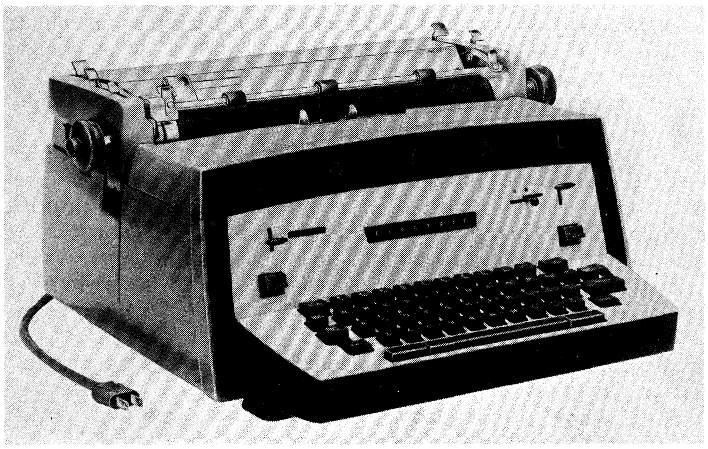

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FIG. 7.— MODERN ELECTRIC TYPEWRITER

skilled typesetting labour provided the impetus for the development of composing typewriters. use of which requires far less training. The fundamental requirement of a typewriter for this usage is the ability to supply different type font styles and sizes. For this purpose the type-wheel machine is far more suitable than the type bar. The Vari-Typer machine, especially developed for this service, operates on the principle of the Pratt machine of 1866. Other major requirements of a typing machine whose output must resemble print are the proportional spacing of characters in a word and justification, or alignment, of the right-hand margin. An electric type-bar machine was developed which provided proportional spacing — the assignment of space for each character in proportion to its width. The other requirement, margin justification, proved more difficult to attain. Most of these machines provided for preliminary typing of a line, determining the necessary compensation for the line length and retyping to the exact length. A more complicated machine was introduced which would automatically justify a line of type with one keyboarding. This was accomplished by a system on which the operator typed manually into a storage unit, from which a computer first automatically compensated for line length and then operated a second typing mechanism. By mid-20th century the typewriter already was in considerable use as a composing machine in spite of its limitations, and it promised to be even more widely used after the development of more efficient methods for justification.

One of the most important advances in the field of typewriters and office machines was the development of automatic controls that allow typing from remote electrical signals rather than from manual control. This technique provided the basis for a new concept in typewriter application. Office machine manufacturers developed an integrated system of business communication utilizing remote control typewriters and computer techniques. With this system, machines handling all the different office machine functions, such as the typewriter, calculating machine and printing telegraph, together with mass data processing computers and electronic storage systems, are tied together by the use of a "common language" coded electrical signals. Thus any component machine produced by any manufacturer could be connected to any other without the use of special code converters. Other automatic typewriter devices were available including a vacuum-operated system that controls and operates a standard typewriter from a perforated roll of paper tape in a manner much like that of the player piano.

The need for high-speed printing machines to convert the output of computers to readable form prompted the introduction of a specialized high-speed form of "typewriter" by 1953. In this class of machines, the paper is fed between a continuously rotating type wheel and a bank of solenoid-actuated printing hammers. At the instant when the proper character on the face of the type wheel is opposite the proper hammer, the hammer strikes the paper and prints the character, while the type wheel continues to rotate. By this means, speeds up to 100,000 characters per minute have been attained, as compared with about 1.000 characters per minute attainable with conventional type-bar mechanisms. A number of different models operating on this principle were developed, all of which required elaborate electronic controls to solve the complex synchronization problem.

Many other high-speed output devices for computers were developed. However, most of these utilize techniques that are remote from the typewriter field. in some cases using printing mediums other than paper. Speeds of up to 10,000 characters per second were attained by certain nonmechanical systems, which, although not actually typewriters, competed with typewriters as computer-output devices.

Effects of the **Invention.**—The typewriter was one of the great transforming factors of modern business. One problem which confronted the writing machine in its early days was the lack of competent operators. Out of that need arose the modern commercial school, which became a prominent feature in the educational system of every country. Socially the changes wrought by the typewriter have been even more noteworthy. The majority of stenographers and typists are women, and in all western countries it was the typewriter that first opened to women the doors of business life.

See COMPUTING MACHINES, ELECTRONIC; TABULATING MACHINES; OFFICE MACHINES AND APPLIANCES.

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TYPHOID AND PARATYPHOID FEVERS. Typhoid fever is an acute infectious disease of man caused by a bacterium, Salmonella typhosa (*Bacillus typhosus,* Eberthella typhi).

Paratyphoid fever is a disease closely resembling typhoid, though usually milder, caused by *Salmonella* organisms of other species.

Typhoid **Fever.**—*History.*—This disease is ancient. It can be recognized with reasonable certainty in clinical descriptions by medical writers dating back to the time of Hippocrates. However, it was not until the first half of the 19th century (P. Bretonneau, 1820) that typhoid fever (enteric fever) was clearly distinguished from other continued fevers and termed *fièvre typhoide* (P. C. A. Louis, 1829) by the French and *typhus abdominalis* (J. L. Schoenlein, 1839) by the German writers.

Before the advent of bacteriology the infective and contagious nature of the disease was recognized by William Budd in 1856, and the presence of the infective agent in the feces of ill and convalescent patients and its spread through contaminated water and milk was postulated. The recognition of the typhoid bacillus by C. J. Eberth in 1880 and its isolation in pure culture by G. Gaffky in 1884 laid the foundation for the development of knowledge leading to accurate means of diagnosis, critically differentiating this disease from all others and making possible studies to determine the means of spread and methods of prevention

Nature of the Disease.—The organism usually enters the body through the mouth, in contaminated food or water. penetrates the intestinal wall and multiplies in the lymph follicles (Peyer's patches and solitary lymph glands) near the lower end of the small intestine (ileum), particularly in the region of the ileocaecal valve, and possibly in other locations in the body; later it enters the blood stream. causing septicemia and systemic infection. The incubation period averages 10–14 days but may be shorter or longer. There are few or no symptoms during this period.

Early symptoms are headache, lassitude and generalized aching, feverish sensations and restlessness that may interfere with sleep. There may be loss of appetite, nose bleeds, cough, diarrhea or constipation. Persistent fever develops and gradually rises, usually in a stepwise fashion, reaching a high of 103° or 104° F. after 7–10 days and continuing with only slight morning remissions for another 10–14 days. In favourable cases, about the beginning of the fourth week the fever commences to decline, daily fluctuations in temperature readings become greater and there is a gradual return to normal.

In the first few days of the disease the patient may remain ambulatory, but before the end of the first week he is seriously ill and confined to bed. He is restless, hot and uncomfortable, and the cheeks are flushed, particularly in the latter part of the day. The pulse is slow, the abdomen is slightly distended and may be tender to pressure, especially over the right lower part, the region overlying that portion of the intestines where a specific ulceration is in progress. Diarrhea is a common but by no means constant symptom. When present, it may be slight or extremely profuse; the stools are light yellow in colour, resembling pea soup.

At the beginning of or during the second week of fever, at the height of the septicemia when typhoid bacilli are present in great numbers in the blood stream. a skin rash usually appears. It consists of isolated round or oval spots of a pale pink or rose colour measuring from two to four millimetres in diameter. These "rose spots" are usually few in number and are found chiefly on the abdomen. chest and back. They appear in crops, last four or five days and then fade away, leaving a brownish stain at the site. Occasionally they may be very numerous and may continue to appear until near the end of the fever.

Also during the second week of the fever specific changes occur in the intestine. The lymph follicles previously mentioned as the site of multiplication of the typhoid organisms during the incubation period have become swollen and enlarged, and portions have undergone necrosis (death of tissue). These areas of necrotic tissue extend through the mucous membrane to the lumen of the bowel. Necrotic fragments or entire glands slough off, leaving ulcers in the wall which may be few or numerous, have thin ragged edges and are usually oval, extending in the direction of the long axis of the bowel. They may in their progress erode blood vessels, causing minor or massive hemorrhage into the bowel, or perforate the bowel wall. allowing the contents to enter the peritoneal cavity. Ulceration exists from this time onward during the remainder of the fever and into the period of convalescence. The ulcers heal by formation of scar tissue without contraction of the calibre of the bowel. They do not all appear at once, so that ulcers in all stages of development and healing may be simultaneously present.

With the continued high fever the symptoms usually increase in intensity. Mental confusion and delirium appear; there may be tremors and jerking of the muscles and occasionally generalized convulsions. By the end of the third week the patient presents the so-called "typhoidal state"; he appears prostrated and emaciated, the tongue is dry and brown. abdominal symptoms are marked and mental disturbance is prominent.

With cessation of fever. convalescence proceeds slowly. Relapses are common but usually of short duration.

Typhoid fever is a disease of complications. By eroding blood vessels, the intestinal ulcers may cause massive and even fatal hemorrhage; hemorrhage occurs in from 5% to 10% of the cases. Perforation of the bowel (1% to 5%) results in peritonitis, which prior to the advent of the sulfonamides and antibiotics was highly fatal. The patient experiences a sudden intense abdominal pain, vomits and shows signs of collapse. This development demands immediate surgical intervention for repair of the defect and the start of intensive antibiotic therapy. Osteomyelitis, chiefly of the long bones, may occur even some time after cessation of the fever. Localization and abscess formation may occur in any organ. Other complications include acute inflammation of the gall bladder, heart failure. pneumonia, encephalitis and meningitis.

Death may result from toxemia and general debilitation or from one of the complications. The mortality rate varies widely and is influenced by the quality of nursing and medical care.

Diagnosis.—The clinical picture should suggest the diagnosis. Lowered white blood cell count is characteristic and eliminates many other diseases from consideration. Final proof of the diagnosis depends on isolation and identification of the organism in culture from the blood, urine or feces.

As with many infectious diseases, specific antibodies arise in the blood of the patient which will agglutinate (clump) suspensions of known typhoid organisms. This test, first applied in typhoid fever by F. Widal in 1896 and named after him, is of presumptive value in diagnosis after the first week of the disease.

Epidemiology.—Every case of typhoid fever is due to ingestion of typhoid bacilli originating from a case of the disease or from a carrier. The common means of communication are through water, milk, food, flies and direct contact. The organisms are excreted in the urine and feces, and these excreta and the patient's bedding and environs are a source of exposure to attendants and others in contact with him. Water contaminated by infective sewage provides a major means of spread.

Most major epidemics have been due to such pollution of public water supplies. Milk may be contaminated through a carrier (or a case) employed in the handling and processing, through flies or from polluted water used for cleaning purposes. Food similarly becomes contaminated from the fingers of persons harbouring the organism, or through water or flies. Flies having access to infective feces carry the organism to food. Fresh vegetables grown on soil fertilized or contaminated by untreated sewage, and shellfish, particularly oysters, grown in polluted water, are dangerous. Milk and other foods offer opportunity for the organism to multiply before ingestion, increasing the hazard.

Prevention and Treatment.—Prevention depends mainly on proper treatment of sewage, purification of water supplies by filtration and chlorination and the exclusion of carriers from employment in food industries. In the early part of the 20th century prophylactic vaccination using killed typhoid organisms was introduced, mainly in military forces and institutions, and contributed to lowering of the incidence of the disease.

The disease, a scourge of armies, was formerly extremely prevalent and continues to be so in the less sanitized areas of the world. Where modern methods of sewage disposal and water purification are practised, however, the incidence is very low. In the United States in 1900, the annual death rate was more than 30 per 100,000 population. In 1955 the total number of deaths from typhoid in the U.S. was only 50; in the United Kingdom in the same year the total for both typhoid and paratyphoid was 19.

Treatment formerly was entirely symptomatic and supportive. After 1948 specific treatment with chloramphenicol (chloromycetin) proved to be of value. Cortisone is sometimes given as an adjunct to chloramphenicol.

Bacteriology.—Salmonella typhosa is an actively motile, short, rod-shaped, nonspore-forming Gram-negative bacillus. It grows readily on common culture media. Special complex differential media were developed for isolation from stools. It can be distinguished from other organisms of the Salmonella group by its biochemical reactions, particularly sugar fermentations, and by serological reactions. The organism is destroyed by heat, drying or exposure to sunlight; under natural conditions, as in water, soil or feces, it may remain alive for weeks or months. It is not destroyed by freezing.

In typhoid fever during the first week of the disease, the organism is almost invariably present in the blood stream and can be cultured from the blood with ease. From the second week onward the numbers in the blood progressively diminish. Although positive stool cultures may be obtained early in the disease, the organism becomes present in large numbers in the feces only during the second week. It also usually appears in the urine at this time. With convalescence the urine and feces gradually become free of the organism.

Approximately 30% of cases become transient carriers, excreting the organism in the stool or urine for several weeks or months. About 5% remain long-term carriers, harbouring the organism and shedding it for several to many years. In these carriers, who show no apparent ill effects, it is found mainly in the gall bladder and biliary passages. It may be excreted continuously or intermittently. One of the most famous instances of carrier-borne disease in medical history was the case of "Typhoid Mary" (see CARRIER).

Paratyphoid Fever.—A group of organisms are responsible for paratyphoid fever, the commonest being Salmonella *paratyphi* (paratyphoid A), *S. schottmülleri* (paratyphoid B) and the paratyphoid C group, of which there are three varieties.

Paratyphoid fever due to paratyphoid A or B is similar to typhoid, usually milder, though occasionally simulating it in all respects. The means of infection, spread, clinical course, pathology, diagnosis, prevention, treatment and prophylaxis are similar to those for typhoid.

Whereas typhoid and paratyphoid A are diseases of man only, the paratyphoid B organism has been found in other animals and fowl, and accordingly these provide for additional means of contamination of food and water. The variety of paratyphoid C caused by S. hirschfeldii is mainly limited to man.

There are more than 200 recognized species of the *Salmonella* (named after D. E. Salmon) group of organisms, which are widely distributed over the world. In the main they are harboured by or cause diseases of animals, though many may infect man.

Aside from the typhoid bacillus and paratyphoid A, B and S. hirschfeldii, they usually cause in man a sharp, brief gastroenteritis (food infection) with fever, nausea, vomiting and diarrhea of several days' duration. In addition, a number of them may cause prolonged febrile illness similar to typhoid with all the complications.

Since Salmonella organisms may be found in practically all species of animals, food products derived from animals often contain them, particularly eggs, egg products and meat. Many species are harboured by rodents and fowl. Food exposed to infected animals (mice, etc.) frequently becomes contaminated. The incidence of paratyphoid, like that of typhoid, is closely related to sanitation or its lack. Paratyphoid, however, is much commoner than typhoid.

Mild *Salmonella* infections generally need only symptomatic treatment. Severe infections require treatment with chloramphenicol or one of the tetracyclines.

The general prophylactic measures mentioned under typhoid apply to the entire group of Salmonella diseases. Prophylactic immunization is available for paratyphoid A, B and C. Protection of food from contamination and adequate heat treatment of foods liable to contain the organism should be practised.

See also FOOD POISONING, BACTERIOLOGICAL.

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(N. B. M.; X.)

TYPHON, in Greek mythology, youngest son of Ge and Tartarus; or of Hera without father. He is described as a grisly monster, with 100 dragons' heads, who was conquered and cast into Tartarus by Zeus.

In other accounts he was confined in the land of the Arimi in Cilicia, or under Etna, or in other volcanic regions, where he was the cause of eruptions. He was probably a personification of volcanic forces. Among his offspring by Echidna were Cerberus, the Lernaean hydra, and the Chimera. He was also the father of dangerous winds, and by later writers is identified with the Egyptian Set.

TYPHOON. Regional name of tropical storms in the tropical part of the western North Pacific ocean. The term is of uncertain origin but is probably connected with the Chinese t'ai *fung*, "great wind," or the Arabic and Hindustani *tufan*, "a tempest." William Dampier entered in his logbook under July 4, 1687, the earliest-known European description of a typhoon (tuffoon).

Typhoons are distinguished from tropical storms in other parts of the world by their large number (average 20 per year), by the occasional development of very large storms and by the fact that they have occurred in all months of the year. The peak season is in August, September and October; in these months typhoons are most likely to move out of the tropics on paths ranging from northwest to northeast and strike China or Japan, occasionally even Korea and southeastern Siberia. In the other months they are more apt to cross the Philippines on a westerly track toward southern China or Indochina. While generally rare in winter, series of as many as five typhoons have crossed the Philippines in December, with a quiet spell of only a few days between storms.

Typhoons occasionally grow to extreme size; their area of influence may then become as large as the eastern United States. Nevertheless, though the area suffering damage is widespread and the atmospheric pressure in the centre may drop below 26.5 in. of mercury, the peak violence is no greater than in many storms only one-tenth as big. Military planes have carried out regular reconnaissance flights to the central parts.

Because of the high frequency, damage is widespread in all countries bordering the western Pacific. Even so, the arrival of a typhoon may also bring needed relief from drought. Parts of Japan, for instance, depend on typhoons for a considerable fraction of their annual precipitation.

See also TROPICAL STORM. (H. RL.)

TYPHUS FEVER, a disease characterized by sudden onset with headache, chills, fever and general pains, an eruption appearing on the third to fifth day, toxemia, and terminating in about two to three weeks. Originally considered a single clinical entity, it is now regarded as a group of closely related diseases caused by different species of rickettsia transmitted by arthropod vectors, under the following general classifications: epidemic (louse-borne) typhus; murine (endemic; flea-borne) typhus; scrub (mite-borne) typhus or tsutsugamushi disease; tick-borne typhus (this is described under ROCKY MOUNTAIN SPOTTED FEVER AND OTHER SPOTTED FEVERS).

EPIDEMIC (LOUSE-BORNE) TYPHUS

History and Distribution.— This is the classic disease, well known in medical history and described under many names which usage gradually narrowed to typhus fever. Up to the middle ages its existence was obscured in the undifferentiated pestilences, but it can be recognized with certainty in the writings of Spanish physicians toward the end of the 15th century and called el *tabardillo* from its spotted character. According to Joaquim de Villalba, the first reference to an epidemic was one that began during the civil wars of Granada in 1489–90. During the 16th century it spread over the Spanish peninsula, causing great mortality. It is possible that the infection was transported to the new world about this time by Hernán Cortés and his followers, although there is some evidence that the disease was known to the Aztecs and to certain Indian tribes in Mexico in pre-Columbian days. During the 17th, 18th and 19th centuries typhus prevailed intermittently in devastating epidemics throughout Europe and the British Isles. Its epidemiological characteristics became as well known as its clinical manifestations. It was associated with human misery—with people crowded together in filth, cold, poverty and hunger, with wars and famine, with refugees, prisons and jails and with ships. Beginning about 1846, and associated with the failure of the potato crop, an epidemic of unprecedented magnitude and severity centred in Ireland. The disease was disseminated in the subsequent flood of emigration from that country. It was repeatedly introduced into Canada and the United States by the arrivals of immigrant ships. For example, of 75,540 Irish persons emigrating to Canada in 1847, there were 30,265 who sickened with typhus; 5,293 died at sea, 8,012 at Quebec and 7,000 at Montreal, a total of 20,305 deaths. In spite of repeated introductions from Europe and from Mexico, this form of typhus failed to establish a permanent foothold in either Canada or the United States. The American Civil War of 1861–65 was one of the few wars of any magnitude in which typhus was not epidemic among military camps, prisons and refugee populations.

Clearly differentiated from typhoid fever and "relapsing fever," during the latter part of the 19th century and the first part of the 20th century typhus fever decreased and practically disappeared from the British Isles and western Europe with improvement in the hygiene of living conditions. It remained intermittently epidemic in Poland, the U.S.S.R., the Balkans, the highlands of Turkey, Iran, Iraq, north Africa and some parts of central and south Africa.

At the close of World War I the disease was prevalent in Poland, Russia and Rumania, where the estimates of cases and deaths between 1919 and 1923 ran into millions. In World War II from these areas it again spread into western Europe and caused devastating epidemics among refugees and displaced persons, particularly in the German concentration camps. For the first time military populations learned how to protect themselves.

In Asia, the disease was still well known in the second half of the 20th century in China, Korea, Afghanistan and northern India; outbreaks were reported among Communist troops in the Korean war. In the western world epidemics still occurred from time to time among the inhabitants of the mountainous sections of Mexico and Central and South America.

Epidemiology.- he epidemiological distributions of typhus are explained by its mode of transmission. It is conveyed from person to person by the louse (Pediculus humanus). Lice are infected by feeding upon a person sick with the disease. The causative agent is a rickettsia (Rickettsia *prowazekii*). The microorganisms grow in the epithelial cells lining the gut wall and are excreted in the feces of the louse. The infection kills the louse in from 12 to 18 days. There is no transovarial transmission of these rickettsiae from generation to generation in the developmental cycle of the louse. It is probable that man is commonly infected from deposits of louse feces on the skin through abrasions resulting from scratching. Rickettsiae may remain viable and retain their virulence for many days in dried louse feces. There is evidence that inhalation or the deposition on mucous membranes of air-borne infected material of this kind may be responsible for some human cases. Biological survival requires that a continuous chain of contacts be maintained. The human host harbours the rickettsiae in the peripheral circulation for only a short time. 10 to 14 days, during the early part of the illness. In order to maintain propagation of the disease in a population the supply of infected lice must be continuously replenished by feeding upon such sources and reach new and susceptible human beings before they perish.

Clinical and Pathological Features.— The incubation period is about 8 to 12 days. but varies between 5 and 15 days. Onset is commonly abrupt, with headache, loss of appetite and malaise. The fever rises rapidly with chills or chilly sensations. Prostration becomes marked. The patient is nauseated. The temperature reaches a maximum range by the end of the first week and is sustained until about the 12th day, when, if the outcome is favourable, it falls rather rapidly, reaching normal in an uncomplicated course about the 14th to 16th day.

In cases proceeding to a fatal issue prostration is progressive and delirium and coma supervene. Cardiac failure may be the terminal event. In recovery, depression and weakness may be protracted, with slow convalescence.

The most characteristic symptom of the disease is the eruption which appears about the fourth to sixth day after onset. It consists of dark reddish discrete spots two to five millimetres in diameter, some of which become slightly elevated, scattered over the body and limbs. It may be accompanied by a general mottling. These lesions at first are red and disappear on pressure, but they rapidly become darker in colour and leave a brownish stain in the skin if the area is blanched. In the more severe and fatal cases the rash becomes almost confluent, involving the whole body surface, and subcutaneous hemorrhages occur. With recovery the rash fades slowly. The case fatality varies somewhat in diiferent epidemics, ranging from about 5% to 25%. The prognpsis becomes more and more grave with advancing age. While the proportion of deaths among children may be less than 5%, it may be ten times as great among the aged.

The course and characteristics of the illness in man are manifestations of the underlying pathology. The rickettsiae localize and multiply in the endothelial cells lining the blood vascular system. The essential lesion is a focal injury to the capillary and precapillary vessel walls characterized by swelling and necrosis of the cells, infiltration of lymphocytes, plasma cells and monocytes, thrombosis and rupture with extravasation of red blood cells. Such lesions are significantly common in the skin, giving rise to the eruption; in the cerebral cortex they cause headache, irritability, confusion and delirium; in the heart muscle, weakness and sometimes circulatory failure; in the alveolar walls of the lung, an interstitial pneumonia; and they are widely scattered but less important in other organs and tissues.

It has been demonstrated that suspensions of rickettsiae have an acute toxic effect when injected intravenously into mice. To this toxic substance, which is neutralized by immune serums, may in part be attributed the host cell damage and interference with normal function.

Diagnosis and Treatment.— The characteristics of the rash usually lead to the clinical diagnosis. Laboratory confirmation is afforded by the Weil-Felix agglutination reaction. A more specific and delicate test is afforded by complement fixation using a suspension of the specific causative rickettsia as an antigen. The causative agent can be recovered and identified by inoculating guinea pigs intraperitoneally with blood obtained from the patient in the early stages of the disease.

The treatment of typhus is symptomatic and supportive. It is largely a matter of good nursing care, maintenance of nutrition and fluid balance. Parenteral administration of 5% glucose in normal saline is necessary when the patient shows signs of dehydration. Analgesics and sedatives may be required to relieve pain and restlessness. Aureomycin appears to have a definite effect on the course of the disease. It usually is given for two to three days and is effective at any stage in the course of the disease.

Prevention.—Delousing.—The prevention of typhus depends upon protection from lice. Doctors, nurses and orderlies should be provided with louseproof clothing. The patient, his immediate environment and his contacts should be subjected to a thorough delousing procedure. Clothing may be disinfested by several methods using heat or pediculicide powders. The louse-infested patient should be bathed and the hair of the head and body clipped. Disinfestation can be accomplished most expeditiously and effectively by dusting with a 10% DDT louse powder. It is blown from a hand-operated dust "gun" and can be applied without removal of the clothing. It does not kill nits but remains active and kills lice as they hatch for a considerable period. About one pound of powder is required for every 15 persons.

Vaccination.—Specific vaccines are produced by cultivation of rickettsiae in the yolk sacs of developing eggs or in the lungs of mice; the resulting suspension is then inactivated. The vaccine is given in a series of three injections at approximately weekly intervals. The protection afforded is not complete, but if infection occurs in a recently vaccinated person, the disease usually runs an abortive course with little or no eruption, and the risk of death is reduced.

A stimulating dose of one cubic centimetre of the vaccine should be administered every four to six months as long as danger of infection exists.

With proper public health organization, adequate resources and the discriminating use of methods available for vaccination and for delousing, epidemics of typhus fever need not be feared. With a reasonable expenditure and effort they can be brought under control in a short period of time. It is still an ever-present threat, however, to impoverished and destitute peoples in many parts of the world.

MURINE (ENDEMIC; FLEA-BORNE) TYPHUS

History and Distribution.—Following the elucidation (1909–18) of the role of the common louse in the epidemiology of the classic typhus of the old world, it soon became apparent that in some parts of the world a disease was endemic which was clinically indistinguishable from it except for a relatively milder course and a lower fatality rate, and which was not associated with lousiness. It was described under such names as Brill's disease,[1] endemic typhus, mild typhus and tropical typhus. Studies conducted between 1922 and 1928 revealed widespread distribution of this form in the southeastern United States, in southern California and in Mexico.

It was later found to exist in certain areas of Central and South America, the Mediterranean littoral, the Balkans, China, India, Malaya, Indonesia and Australia, and probably has a much wider distribution, overlapping to some extent the areas in which epidemics of louse-borne typhus occur.

Epidemiology.— The Norway rat is the principal reservoir of infection. Occasionally, the common house mouse and other species of small rodents have been found to be infected. While several species of fleas and mites found upon rats can be infected experimentally, there is reason to believe that the tropical rat flea *Xenopsylla cheopis* is the principal vector. Transmission to man probably occurs through the medium of infected flea feces. Inasmuch as this is an accident, the frequency of occurrence of human cases is determined by the character of man's association with his domestic rodents. Passage from man to man by the flea is extremely unlikely, but it has been demonstrated that lice can be experimentally infected by feeding upon humans sick with the murine form of the disease. It is possible, thus, that the endemic flea-borne form may occasionally give rise to the epidemic louse-borne form where conditions are favourable.

Clinical Course, Diagnosis and Treatment.— The course of the illness is essentially the same as for iouse-borne typhus except with regard to severity. It is relatively milder, complications are less frequent and the over-all fatality rate is less than 5%. The underlying pathology is similar. The Weil-Felix reaction becomes positive during the second week. Complement fixation with properly prepared antigens affords a differentiation between the flea-borne and louse-borne forms. These forms can also be distinguished by the reaction of guinea pigs to experimental infection. With a murine strain the male guinea pig develops redness and swelling of the scrotum (Neill-Mooser reaction) which is absent or inconsistently present in animals inoculated with an epidemic strain. Treatment of the patient follows the lines indicated for louse-borne typhus.

Prevention.— Prevention of murine typhus is dependent upon control of the rodent flea reservoir of infection. The number of rats, and consequently of rat fleas, must be reduced below the threshold of sanitary significance. In an area of high prevalence the flea population may be rapidly but temporarily reduced by applying a residual spray of DDT along rat runs.

A vaccine made from a murine strain of typhus rickettsia should afford some degree of protection to persons especially exposed through occupation or living in buildings heavily infested with rats in an endemic focus.

SCRUB (MITE-BORNE) TYPHUS (TSUTSUGAMUSHI DISEASE)

History and Distribution.— A typhuslike fever ascribed to the bite of a minute insect was known to the inhabitants of certain river valleys in Honshu, Jap., in the mid-19th century. K. Tanaka in 1899 presented a careful description of its clinical and epidemiological features and identified the vector as a mite found in large numbers in the affected valleys during the summer months, when most of the cases occurred. From 1906 to 1932, tsutsugamushi disease was the subject of intensive investigation by Japanese scientists.

In the meantime, typhuslike fevers had been described under many names as endemic in localities scattered through southeastern Asia and the adjacent island archipelagoes. As a result of the studies of Japanese, British. French, Dutch and Australian investigators, and of the U.S. Typhus commission during World War II, it became clear that these belong in two categories: (1) flea-borne murine typhus and (2) mite-borne typhus fever, scrub typhus, indistinguishable from tsutsugamushi disease. The latter was recognized as occurring in Formosa, the Pescadores Islands, the Philippines, Indochina, Malaya, Burma, India, Ceylon, Sumatra, Java, New Guinea and adjacent islands and northern Queensland, Austr. During World War II this form of typhus was far more important as a cause of morbidity and mortality to military forces operating in the southwest Pacific area and in the China-Burma-India theatre than was louse-borne typhus to the forces operating in the Mediterranean and European theatres.

[1] In 1910 Nathan Brill called attention to a disease in New York city which resembled typhus but differed from it in its relatively mild course and epidemiological features. It occurred sporadically among Jewish immigrants and showed no tendency to spread. In 1934 Hans Zinsser reviewed the distribution of this typhuslike disease in New York city and Boston, Mass. On the basis of his observations, he advanced the hypothesis that these cases represented recrudescences of infections originally acquired many years previously, when the individual had been living in a European country where louse-borne typhus was epidemic. This hypothesis received support from later laboratory studies, which demonstrated conclusively that cases of Brill's disease were infected with thypus of the louse-borne type and not the murine type.

Epidemiology. — The causative agent, R. tsutsugamushi, is primarily a parasite of trombiculid mites of which two closely related species were identified as vectors—*Trombicula akamushi* and T. *deliensis*. During the larval stage these mites attach themselves to and feed upon various species of wild rodents, and are occasionally found upon other animals such as shrews and marsupials and upon birds. Rodents were found to be infected in nature with R. tsutsugamushi.

Infection contracted by the larvae while feeding is passed by stage to stage transfer through the lymph, free-living adult and egg to the next generation. Since the larvae feed but once upon a mammalian host, transmission from rat to rat and from rat to man requires this transovarial passage of the infection with R. *tsutsugamushi* in successive cycles of trombiculid with development. It follows that the distribution of the human disease is determined by the ecology of the affected localities, with regard to the number of rodents, numbers of the vector species of mites and the opportunities for the larval mites to make effective contact with human beings.

The larvae live in the upper layers of the soil and the organic detritus which covers it and crawl short distances up on blades of grass and other vegetation. Accordingly, the disease shows an occupational selection for agricultural labourers, persons foraging in new or overgrown fields and abandoned plantations, explorers and prospectors, soldiers, etc.

Clinical and Pathological Features, Diagnosis and Treatment. — The distinguishing characteristic of this form of typhus is the occurrence of a primary lesion or eschar, usually single but sometimes multiple, at the site of the infective mite bite or bites. While not always present, an eschar can usually be found by careful examination somewhere on the patient. The eruption is redder, spottier and more evanescent than that of louse-borne typhus or flea-borne typhus. While the course of the fever may be terminated in two weeks, it is not unusual for it to last three or even four weeks. A more or less extensive pneumonitis is common, and lesions in the myocardium may give rise to impairment of heart function and sometimes to circulatory failure. The case-fatality rate varies in different geographic areas from about 2% to 20%. The prognosis becomes increasingly grave with advancing age.

Diagnosis is usually made on the presence of fever, the primary eschar and characteristic eruption. Laboratory confirmation is afforded by the Weil-Felix reaction, which becomes positive during the second week of the disease. About the same time, complement fixation becomes positive with an antigen made from a suspension of R. tsutsugamushi. The causative agent can be easily recovered and demonstrated by intraperitoneal inoculation of white mice with a minute amount of clotted blood obtained from the patient early in the course of the disease. As with other typhuslike fevers, treatment is symptomatic and supportive. J. E. Smadel and his colleagues showed that the clinical reaction can be completely suppressed by the administration of chloramphenicol (chloromycetin). In an adult, this requires that the drug be given at intervals of four to seven days for four weeks or longer.

Prevention. — Prevention depends upon protection from mite bites in the endemic area. Camp sites should be cleared and the brush and grass burned before occupation. Persons may be protected by wearing clothing that has been treated with miticide chemicals. During World War II methods were developed for treating uniforms with terminal laundry rinse and impregnation with a soap solution containing dimethyl phthalate or dibutyl phthalate and benzyl benzoate.

A satisfactory vaccine for this form of typhus had not been developed by mid-20th century. Attempts to protect man against scrub typhus by immunization with inactive vaccines gave uniformly discouraging results under the conditions of field exposure. It was possible to provide immunity by inducing a subclinical infection with an attenuated strain of R. tsutsugamushi and suppressing the overt disease by chemoprophylaxis. This method, however, was cumbersome. *See* also RICKETTSIAE.

See N. H. **Topping** *et al., Studies* of *Typhus Fever,* National Institute of Health bulletin no. 183 (1945). (K. F. M.)

TYPOGRAPHER is a derivation of the word typography and means "a printer." The term has recently been revived and is used by those engaged in designing books of an exclusive character, such as those printed at private presses, where a specially designed type may be employed for some specific work. It is also sometimes adopted by "layout hands" employed in advertising departments where booklets and other advertisement matter is prepared and sent to the printer to produce.

TYPOGRAPHY is the art of printing. (See also the articles PRINTING, PRINTING TYPE and CALLIGRAPHY.) It has as its first object not ornament, but utility. The printer must never distract, even with beauty, the reader from his text. In the printing of books there is less room for individuality of style than in the typography of propaganda. The laws of typography in books intended for general circulation are based upon (a) the essential nature of alphabetical writing; (b) the force of tradition. But strict as the conventions are, there is not, and can never be, a rigid character of typography applicable to all books produced in a given geographic or ethnic area; or a universal formula acceptable to all books printed in Roman types. The strength of tradition expresses itself in the details of book arrangement and these vary widely. Certain laws of linear composition are, however, obeyed by all printers who use the Roman letter.

A fount of Roman type consists of (1) Roman: CAPITALS, SMALL CAPITALS, lower case, : . " ; 1 2 3 4 5 etc (); and (2) Italic: CAPITALS, lower case. In addition to these, as necessary adjuncts, the printer possesses (3) spaces; (4) leads-, (5) straight lines of metal known as rules, and (6) a collection of mobile ornaments, head- and tail-pieces, flowers, decorated initial letters, vignettes and flourishes, wood blocks of borders, etc. Another decorative medium at his command lies in his use of (7) colour (red being the most widely used). For emphasis he possesses (8) special types of notably heavy face, and may use colour for the same purpose. (9) Space is another valuable element, margins, blanks, etc. being filled in with what are known as "quotations." Finally (10) there is the nature (colour, weight and texture) of the paper.

Composition is the selection and arrangement of all these elements; Imposition is the due placing of the composition upon the sheet; Printing comprises the press-work, securing a perfection of register (backing up), the quality and crispness of inking. Typography, therefore, controls composition, imposition and paper. The paper (*q.v.*) must be of a character capable of expressing the value of the composition. The margins must be proportionate to the area of the text, allowing convenient space for thumbs and fingers at the side and bottom of the page. The mediaeval margins as adopted by the Kelmscott Press, are handsome and agreeable in certain books, but, are neither agreeable nor convenient in other books, *e.g.,* where the page dimension is necessarily small or narrow, and the book is to be carried in the pocket. For this and other books, the type may well be centered on the measure of the page, and slightly raised above ocular centre.

Composition. — The fundamental principles of page-composition are deducible from the ocular facts of alphabetical printing in the Roman letter. The eye cannot, with ease, read pages of words composed of letters designed with sharply contrasting thicks and thins. Nor can the eye agreeably read a mass of words composed even in a rightly constructed letter, unless the line is kept to a certain maximum length; that is to say, the reader's eye cannot comfortably seize more than a certain number of words in any given size except in a proportionate length of line. Nor can a reader comfortably seize a letter, a word or a line, unless the printer's setting is related to the reader's normal habit of vision when holding a book for reading. The typographer's respect for these principles will generally protect the reader from the risk of "doubling" (that is, reading the same line twice), or from being given a book in a large and "staring" type.

The average number of words which the reader's eye can conveniently seize is between 10 and 12 (some 48 characters). The typographer, while exerting himself to the utmost to respect this ocular limitation, may often be confronted with certain conditions which make it impossible for him to secure a type of the right related size. He is often forced to the use of a small type, and in order to obviate the risk of "doubling," he inserts leads between the lines of type and thus increases the space between them.

The practice of leading, denounced in certain quarters, is an essential necessity. The typographer, therefore, in making the best use of his material, must make legitimate use of leads. It may be added, too, that in certain compositions, leads produce a happy effect; and in not a few cases, their absence may ruin a composition set even in a relatively large type.

The typographer should know how to extract the utmost from the use of a type which is narrow in relation to its height—leading and spacing play a decisive part here. A round, open, wide letter may, for certain purposes, be set "loose"; *i.e.,* the space between the letters will be greater (or appear greater by reason of the curves of the c, o, e, g, in the lower case), than in a relatively condensed letter. Consistency will here insert a satisfactory lead between the lines.

The space between words composed in a condensed letter is less than that between words in a round, wide form. A lead should always precede and follow quoted matter. Where there is no leading between the lines, and the composition is necessarily tight, it may be an advantage to set leads between the paragraphs.

Indention is a most important detail. The opening sentence of every work should automatically manifest itself as such. This may be contrived by using a large initial letter, by printing the first word in CAPITALS, or SMALL CAPITALS, or CAPITALS and SMALL CAPITALS. The first word may be set into the margin; but it should not be indented. Indention marks paragraphs—the subsequent sections of the text: Where for any reason it may be necessary to avoid indention in paragraphs, a lead is plainly desirable. Absence of indention and of lead means the virtual extinction of the paragraph.

The depth of the page will be related to the length of line. The measure must be symmetrical, displaying a form pleasing to the eye. A rectangle is more pleasing than a square.

A rectangular page composed of lines of 10–11–12 words long will generally be satisfactory. It remains to add the running page-heading, and the folio. The page-heading may either range to the left and right in the opening (fixing the two pages as a unity); or range to the right and left; or it may be centred. The folio may be centred at the foot, or range either way at the top or bottom; but it cannot be centred at the top without abolishing the running page headline. This may be done, but it is an undesirable practice. The running headlines may be set in capitals of the text, in upper- and lower-case of the text, or in any combination of capitals. The use of full-sized capitals renders over-conspicuous a repetitive feature inserted for extrinsic convenience—that is, the identification of loose leaves. By reason of its position, the headline looks ragged if set in upper- and lower-case. It seems best, therefore, to employ small capitals; all capitals are best separated by hair spaces as their rectangular structure and preponderance of perpendiculars tend to solidify the composition.

Full-sized capitals may well be used for chapter headings, the number of the chapter being kept in small capitals, and both indications being hair spaced. The practice of dropping the chapter opening is justified by the fact that the eye, in travelling from the generally occasional blank at the end of a chapter to the beginning of the next, finds a companion blank an agreeable consistency. It has also the psychological advantage of saving the reader from feeling overpowered by the text. The rectangle of type is so imposed upon the edge as to allow centre, head, fore-edge and tail margins of a dimension proportionate, first, to the length of line and, secondly, to the disposition of space at points where the text is cut into chapters, and where the body joins the prefatory and other pages known as "preliminaries." These last, less strictly governed by convention than the text pages, offer the maximum opportunity of design to be found in the volume.

The history of printing is in large measure the history of the title-page. The title when fully developed occupied a recto page, either partially or wholly; and the title-phrase, or a catchword of it, has generally been set in a conspicuous size of type. Sixteenth century Italian printers generally used large capitals, copied from inscriptions, or more exceptionally, from caroline manuscripts; while English use followed the French in employing a leading line of large upper- and lower-case, followed by a few lines of pica capitals. Next came the printer's device, and at the foot of the page, his name and address. The large sizes of upper- and lower-case, being an inheritance from printers who were accustomed to black-letter (never set in solid capitals), have gone. The device also has vanished, except from the University Presses.

The contemporary title-page is a bleak affair; in nine out of ten cases the blank between the title and the imprint of the printer-publisher tends to be the most outstanding feature. When the device was first abandoned, the author, printer or publisher took advantage of the leisure of the reader and the blank at their disposal to draft a tediously long title, sub-title and indications of the author's qualifications, designed to fill the entire page. The present day publisher goes to the other extreme, reducing the title to as few short words as possible, followed with "by" and the author's name. A professional writer may insert, *e.g.,* "Author of *The* Deluge" under his name, but three and sometimes four inches of space separate this from the first line of the imprint. Consequently unless the title be deliberately set in a size of type out of all relation to that of the remainder of the book, this space is over-conspicuous. It is clear that a volume in 12-point does not require a 48-point title unless it be a 900-page folio in double-column.

Care for the typography of a book means care for its unity. There is no reason for a title-page to bear any line in a type larger than twice the size of the text-letter. If the book be set in 12-point, the title need be no larger than 24-point—or even slightly smaller. It should be set in spaced capitals as a rule. The author's name, like all displayed proper names, should also be in capitals. The headings to the preface, table of contents, introduction, etc., should be in the same size and fount as the chapter heads; and should be dropped if they are dropped. The order of these pages remains unsettled, except that all begin on a recto page. The logical order of the preliminary pages is half-title, title, dedication, contents, introduction, preface. This rule is applicable to most categories of books. Novels need neither table of contents nor list of chapters, though one or the other is generally printed. If it is decided to retain either, it would be reasonable to print it on the back of the half-title and facing the title page, so that the entire nature of the book will be indicated to the reader at a single opening. Where the volume is made up of a few short stories, their titles can be listed in the blank centre of the title-page.

Book Sizes.—In addition to fiction, belles-lettres and educational books are habitually published in portable, if not in pocketable formats, crown octavo $7\frac{1}{2}'' \times 5''$ (in America known as 12 mo) being an invariable rule for English novels published as such. The novel in the form of biography will be published as a biography, $6'' \times 8\frac{1}{2}''$, the size also for history, archaeology, science, art and almost everything but fiction. Novels are only promoted to this format when they have become "standard." Size, therefore, is the most manifest difference between books.

Another obvious difference is bulk, calculated in accordance with the publisher's notion, first, of the general sense of trade expectation, and, secondly, of the purchasing psychology of a public habituated to certain selling prices vaguely related to number of pages and thickness of the proffered volume. Inconsistently enough, weight does not enter into these expectations. These habits of mind affect the choice of fount and size of type, and may necessitate the adoption of devices for "driving out," *i.e.,* making the setting take up as much room as possible. By putting the running headline between rules or rows of ornaments; introducing unnecessary blanks between chapters; contracting the measure; exaggerating the spaces between the words and the lines; excessively indenting paragraphs; isolating quoted matter with picas of white space; inserting wholly unnecessary sectional titles in the text and surrounding them with space; contriving to drive a chapter ending to the top of a recto page so that the rest of it and its verso may be blank; using thick but not heavy paper; increasing the depth of chapter beginnings and inserting very large capitals thereto; the volume can be inflated to an extra 16 pages —a feat which the able typographer accomplishes without showing his hand to the reader.

Limited editions of standard authors, or of authors who desire to rank as such, are commonly given a rubricated title. Under no circumstances, however, should red appear anywhere else in the work. Hand-made paper is generally used for editions-de-luxe, and none but the brave among typographers will disregard the superstitious love of the book-buying classes for its untrimmed, ugly and dirt-gathering rough edges. There is another category of limited edition produced by typographers working freely, without the handicap of trade conditions. These books are rapidly increasing in number, and use a wide variety of format, of type, of illustration and of binding.

Because, rather than in spite of, mechanical methods and standardization, printing is more various to-day than ever before. Whereas English books of whatever category of 20 years ago were printed in only three designs of type, no fewer than eight founts are employed to-day. It has been necessary that most of these are reproductions of classic old-faces, but it may well be that the near future will witness a real renaissance of type design based upon a sensitiveness to rightly-controlled type forms, and not animated by an uninformed curiosity for the original and the bizarre. (S. Mo.)

See bibliographies of PRINTING and PRINTING TYPE: also E. G. Gress, ***American Handbook of Printing*** (N.Y. 1907); H. Fournier, ***Traité de la Typographie*** (new ed., 1919); C. T. Jacobi, ***Printing*** (6th ed., 1919) F. Thibaudeau, ***La Lettre d'imprimerie*** (2 vols., 1921), and ***Manuel français de typographie moderne*** (1924); G. Milchsack, ***Gesammelte Aufsätze über Buchkunst und Buchdruck*** (Wolfenbiittel, 1922); A. W. Unger, ***Die Herstellung von Büchern*** (Halle, 1923); L. E. Brossard, ***Le Correcteur typographe*** (Tours, 1924); S. Morison, ***The Art of the Printer*** (1925); F. C. Collins, ***Authors' and Printers' Dict.*** (6th ed., 1928); J. C. Oswald, ***Hist. of Printing*** (1928).

TYPOLOGY. Typology results from a study of the various kinds of objects fashioned by man and the sorting of them into categories. The objects in each category can be often further classified, a geographical, chronological or evolutionary basis being taken. For example, in the case of artefacts made by primitive man in the Fiji islands the typologist might begin by sorting out all the paddles. These would then be further classified according to their locality and age. On studying such a group of objects it is often possible to make out an evolutionary series in a tool family, a certain type being clearly derived from an earlier one and itself the parent of some further development.

In prehistory, a typological study of the artefacts made by man is one of the four methods which yield information before written documents existed; the other three being stratigraphy (*q.v.*), a study of the state of preservation of the artefacts found, and of the objects associated with them. The two latter methods are useful as checks on the information obtained from stratigraphy and typology.

Although as shown above typology sometimes enables us to determine a chronological sequence, this is primarily obtained by the stratigraphical method; typology enables us to study systematically the industries belonging to the various cultures. By noting the peculiarities of the various tools which make up the industries we obtain type standards for each culture with which new finds, otherwise undatable, can be compared. Thus, it is found by experience that a particular implement, viz., the beaked burin, is almost exclusively confined to industries which on stratigraphical and other grounds, can be assigned to a Middle Aurignacian culture. If then a new industry is discovered otherwise undatable, but including a large number of beaked burins, we can assume, with some probability, that the age is Middle Aurignacian. Again, a certain type of celt, showing a rectangular cross-section and elaborate trimming, can at once be recognized not only as being of Scandinavian origin, but also as belonging to a definite period of late Neolithic date.

Typology can be applied to styles and techniques of painting. Thus, for example, in Southern Rhodesia palimpsests of Bushman paintings occur. The typologist can observe several different styles which are always found occurring in the same stratigraphical sequence, painted one over the other. In this way a succession of art styles has been determined. (M. C. B.)

TÝR was the Norse god of war and, perhaps, of justice as well. There is rich evidence, from inscriptions and in the works of classical authors, that Týr was worshiped in Germany, and he was also known in England, although his cult was not widespread in Scandinavia itself. Icelandic mythology has interesting stories of Tjrr. According to one of them, he placed his hand as a pledge between the jaws of the monstrous wolf Fenrir while the gods bound him, and the wolf bit it off. Tjrr was therefore known as the "one-handed god." He was identified with the Roman Mars, and hence Dies *Martii* was rendered "Tuesday" (O.E. *Tiwesdaeg,* O.N. *Týsdagr*). The name Tjrr is generally said to be of the same origin as the Sanskrit word devah and the Latin deus (god).

See J. de Vries, ***Altgermanische Religionsgeschichte,*** 2nd ed., vol. 2, pp 10–26 (1957). (G. T.-P.)

TYRANNOSAURUS: see DINOSAUR.

TYRANT, a term applied in modern times to a ruler of a cruel and oppressive character. This use is based on a misapprehension of the Greek word, which implied nothing more than unconstitutional sovereignty. Such rulers are not confined to a single period, the so-called "Age of the Tyrants" (see GREECE: History), but appear sporadically at all times. The use of the term in the bad sense is due largely to the ultraconstitutionalists of the 4th century in Athens, to whom the democracy of Pericles was the ideal of government. Thus the government which Lysander set up at the close of the Peloponnesian War is called that of the "Thirty Tyrants" (see CRITIAS).

TYRAS, a colony of Miletus, founded about 600 B.C., about 10 mi. from the mouth of the Tyras (Dniester). The types of its coins suggest trade in wheat, wine and fish. During the 2nd century B.C. it fell under the dominion of native kings. Destroyed by the Getae about 50 B.C., in A.D. 56 it seems to have been restored by the Romans and henceforth formed part of the province of Lower Moesia. Its coins display heads of emperors from Domitian to Alexander Severus. Soon after the latter's reign it was destroyed by the Goths. It was governed by five archons, a senate, a popular assembly and a registrar. Its site is covered by the medieval fortress of Monocastro or Akkerman (see BELGOROD-DNESTROVSKI).

TYRCONNEL, RICHARD TALBOT, EARL (TITULAR DUKE) OF (1630–1691), Irish Jacobite, son of Sir William Talbot (d. 1633), a Roman Catholic lawyer and politician, a royalist in the Great Rebellion, was at the storming of Drogheda by Cromwell (Sept. 3, 1647), later escaping to Spain. Arrested in London in Nov. 1655 for acting as agent in plots to upset the Commonwealth, he escaped once more. After the Restoration he was employed in the household of the duke of York, even after intriguing to ruin the character of Anne Hyde, the duke's wife. In 1678 he was arrested in connection with the "popish" plot agitation, and went into exile for a time. During the reign of James he was appointed commander in chief in Ireland and created earl of Tyrconnel (1685); in Feb. 1687 he was appointed lord deputy. Tyrconnel, who foresaw the revolution in England, intrigued for handing over Ireland to France, in the interests of the Roman Catholics, and in 1690, when James fled to France after the battle of the Boyne, Tyrconnel carried on the struggle against William III. When he raised the siege of Limerick Tyrconnel fled to France for help. Returning to Ireland, in Jan. 1691, he was of little use, and had to retire to Limerick, where he died on Aug. 14, 1691. In 1689 James created him duke of Tyrconnel, but the title was only recognized by the Jacobites.

TYRCONNELL (Tir-Conaill), an ancient kingdom of Ireland. Conall Gulban, a son of Niall of the Nine Hostages, king of Ireland, acquired the wild territory in the north-west of Ulster (the modern Co. Donegal, etc.), and founded the kingdom about the middle of the 5th century. Of the several branches of his family, the O'Connells, O'Cannanans and O'Dohertys may be mentioned.

The kings of Tyrconnell reigned until 1071.

TYRE, a seaport of Phoenicia, now Lebanon; pop. (1956 est.) 12,000. Tyre is built on a peninsula, once an island, has narrow streets and evident traces of antiquity in the material of its buildings. Of the two harbours which it formerly possessed, the northern, or Sidonian, still survives; the southern, or Egyptian, has disappeared. Once the great mart of the Mediterranean world, it has now an insignificant export trade in cotton and tobacco.

History.—The name Usu (Ushu), the designation of the mainland town, appears in the Tell el Amarna letters (14th century B.C.), and in Papyrus Anastasi I. (13th century). As it is not found in the list of Syrian cities tributary to Thutmoise III. (15th century B.C.), it is reasonable to conclude that it was founded before the beginning of the 14th century, but not before the beginning of the 15th. The earliest settlement, a colony of Sidon (*q.v.*), was in all probability divided between the mainland and the island. The building of a causeway connecting the island with the shore is attributed to Hiram, well known as the king of Tyre, who had commercial dealings with Solomon and supplied skilled labour and material for the erection of the temple at Jerusalem. Jezebel was a daughter of Ethbaal, a Tyrian king.

From her island fortress, Tyre, the mistress of the seas, could defy her enemies and for the most part Assyrian and Babylonian might spent itself against her defences in vain. Shalmaneser IV., after an unsuccessful attack by sea, maintained a blockade on the land side for five years until his death intervened. Ashurbanipal stormed the city in 664 B.C. In the 6th century B.C. it endured a 13 years siege from Nebuchadrezzar.

However, Tyre, with the marvellous vitality of those early times, recovered in a comparatively short time. The city passed under the sway of the Seleucids (198 B.C.) and the Romans (68 B.C.). Herod the Great endowed it with a temple. St. Paul spent a week there while the ship "unloaded her burden" on his journey from Ephesus to Jerusalem. By the 2nd century it had become the see of a bishop. With the rest of Syria it passed into the hands of the Muslims in the 7th century. The crusaders captured it (1124), and made it one of the chief cities of their kingdom of Jerusalem. After the fall of Acre, the Muslims destroyed it.

In Roman times Tyre, "seething with commerce" (*ebulliens negotiis*) was famous for the manufacture of silk and silken garments, as well as the famous Tyrian purple from the murex shell. Lucan (*Phars.* x. 41) tells how Cleopatra appeared at a banquet arrayed in thin-spun and clinging silk garments, made by the skilful Tyrians and then a new luxury.

A French archaeological expedition visited Tyre in 1921 and explored the neighbourhood. See PHOENICIA.

See Mme. D. le Lasseur, "Mission archéologique à Tyr" (1921): *Syria* 3 (1922); R. Dussand, *Topographie Historique de la Syrie Antique et Médiévale* (1927), 19 *seq.* (bibl.). (E. Ro.)

The most important references to Tyre in the Bible are 1 Kings v., vii., ix.; Is. xxiii.; Am. i. 9 *seq.;* Ezek. xxvi.–xxviii.; 2 Macc. iv. 18 sqq.; Mark iii. 8, vii. 24 *sqq.*; Matt. xi. 21 *seq.* *(and* parallels); Acts xii. 20. *Cf.* also Joshua xix. 29; 2 Sam. xxiv. 7; Ezra iii. 7; Neh. xiii. 16; Ps. xlv. 12, lxxxiii. 7, lxxxvii. 4.

Siege of, by Alexander the Great **(332 B.C.).**—After the battle of Issus, Alexander, as he marched southwards towards Egypt, called upon the Phoenician cities to open their gates, as it was part of his general plan to deny their use to the Persian fleet. The citizens of Tyre, who owed allegiance to the king of Persia, refused to do so, whereupon he laid siege to the city. New Tyre was built on a small island, about half a mile from the main land upon which the old city stood. Possessing no fleet Alexander demolished old Tyre, and with the *débris* built a mole 200ft. in breadth across the straits, and erected towers and war engines at its further end. Thereupon the Tyrians destroyed the towers by fire ships and damaged the mole. Many curious devices were made use of to defeat the Greeks, such as pots of burning naphtha and sulphur, and red-hot sand hurled from catapults. Alexander next widened the mole and rebuilt the towers, but he saw that without assistance of a fleet success could not be assured since the Tyrians had free access to the sea. From Sidon he obtained 80 Phoenician ships, and 24 from Rhodes, Malius, Soli, Lycia and Macedonia. Then the king of Cyprus, hearing of the defeat of Darius at Issus, joined Alexander with 220 warships. The reduction of Tyre was now but a matter of time, for if the assault from the mole proved unsuccessful, starvation must accomplish its work. Alexander was, however, impatient to complete the siege before Darius could raise another army, so he constructed floating batteries upon which rams were mounted, and forced his way into the Egyptian and Sidonian harbours, and scaled the city walls. Thus after a siege of seven months the city was taken, 8,000 of the citizens were slaughtered, 2,000 later on executed, and 30,000 sold into slavery.

See Arrian, *Anabasis of Alexander;* Diodorus Siculus; G. Grote, *History of Greece* (1906); *The Cambridge Ancient History,* vol. vi. (1927). (J. F. C. F.)

TYRE: see TIRE.

TYROL: see TIROL.

TYRONE, EARLS OF: *see* O'NEILL (Irish Family).

TYRONE, a county of Northern Ireland, bounded north by Londonderry, west by the frontier of the Republic of Ireland, south by parts of Fermanagh and Armagh and another portion of the frontier, and east by Lough Neagh. The area is 1,261 sq.mi. Pop. (1951) 132,082.

The largest county in Northern Ireland, Tyrone is mountainous in the north and hilly in the centre, but the land falls away in the south to the Clogher valley district and the river Blackwater, in the east to Lough Neagh and in the west to the valleys of the Mourne, Strule and Derg. It is almost altogether an agricultural county with much grazing. It has great historic interest as the ancient seat of the O'Neills and the centre of the Tyrone war in the reign of Elizabeth I.

Running along the northeastern boundary with Londonderry are the schist ridges of the Sperrin mountains, the highest peaks being Sawel (2,240 ft.) and Mullaghcloga (2,088 ft.). Most of the south of the county is occupied by sandstone formations. From Coalisland to Dungannon in the southeast there are coal measures, but efforts to work them have not been very successful or profitable because of difficulties of access.

Tyrone became a principality of one of the sons of Niall of the Nine Hostages in the 5th century, and from his name—Eoghan—was called Tir Eoghan, or the land of Eoghan, gradually altered to Tyrone.

From Eoghan were descended the O'Neills and their various branches. Tyrone was the central territory of the O'Neills for many centuries, and the adjacent Tirconaill or Donegal was the territory of their rivals the O'Donnells. The chief seat of the O'Neills was Dungannon, and at Tullahogue in the east of the county was the place where the chief O'Neill was inaugurated with traditional ceremony. The isolated position of Tyrone and the difficulty of penetrating into it in mediaeval times left the O'Neills for the most part unmolested there, while the eastern part of Ulster was invaded by adventurers of the type of John de Courcy. There was constant friction down the centuries between O'Neills and O'Donnells.

In the reign of Henry VIII, Conn O'Neill was persuaded to come to terms with the king and received from him the title of earl of Tyrone. It was agreed that Conn was to be succeeded by his putative illegitimate son, Matthew, who was meanwhile given the title of baron of Dungannon. But on Conn's death in 1559 another son, Shane, was proclaimed chief of the O'Neills, Matthew having already been killed and the claims of his son Brian being set aside. Although vigorously attacked, Shane held his ground and later went in person to interview Elizabeth I. He made the error, however, of being merely an O'Neill dynast and carried on war not only with the English but with the O'Donnells and with the MacDonnells of Antrim. In this warfare he finally perished. He was succeeded by his cousin Turlough. The English government raised up young Hugh O'Neill, second son of Matthew, as a rival to Turlough. Hugh had been educated in England.

Feeling his way carefully, Hugh came to terms with Turlough. Later he established good relations with the O'Donnells and with other neighbours. From the early 1590s he became leader of a general movement among Ulster chiefs to assert their independence. Several government expeditions against him were defeated, his biggest victory being at the Yellow ford on the river Callan, an affluent of the Blackwater, in 1598. Further disasters came upon the English forces, and Hugh sallied out from Ulster to rally the Irish in Munster and Leinster. Disappointed by his Spanish allies, he was finally defeated and hemmed into his own territory and surrendered in 1603.

The Tyrone war, which lasted nine years, was enormously costly to the English government and helped to lay the foundation of those financial difficulties between king and parliament which troubled the Stuarts.

Hugh was restored to his dignities and territory, but he found his situation too difficult and went to the continent in 1607. Tyrone was then soon confiscated and colonized under the scheme for the plantation of Ulster.

The county saw further fighting after the rising of 1641, a Scottish army sent to protect the colonists being defeated by the insurgent Irish under Owen Roe O'Neill at Benburb in 1646. In 1689 the county was for several months partly occupied by the forces of James II.

Tyrone today is a county of small farms. In the hilly country there is much hill pasture and rough grazing. At Omagh, the county town (pop. [1951] 6,757), shirts and milk products are manufactured. At Dungannon there is linen and rayon weaving and the manufacture of clothing and fabrics. Clothing and felt goods are made at Cookstown, and bricks, fire clay and rough pottery at Coalisland.

The county returns five members to the parliament of Northern Ireland, and it forms a portion of each of two constituencies—Mid-Ulster, and Fermanagh and South Tyrone—each of which returns one member to the United Kingdom parliament. (Hu. S.)

TYRRELL, GEORGE (1861–1909), Roman Catholic priest who was prominent during the Modernist controversy, was born in Dublin on Feb. 6, 1861. In 1879 after a year at Trinity college he became a Roman Catholic, joining the Jesuits in 1880. Ordained in 1891, he taught philosophy at Stonyhurst (1894–96). Always devoted to St. Thomas Aquinas, he disliked the Jesuit writers, especially Francisco Suárez, and ultimately declared that the Society of Jesus had become "dust and ashes" in his mouth and that he was no more bound in conscience to it. Casting about for an interpretation of dogma that would enable it to coexist with modern knowledge, he was much attracted by Maurice Blondel's system of the role of will in belief, and, briefly, by Newman's theory of the development of doctrine. Official opposition to such experiments ended by convincing him that organized Christianity was a dismal failure.

The first and most humane of his books was *Nova et Vetera* (1897), informal meditations, which appeared after his move to Farm street, London. *Hard Sayings* (1898) and *External Religion* (1899), conferences given to Catholic Oxford undergraduates, aimed more frankly at bringing to life beliefs academically and heedlessly held. In Dec. 1899 a heavily censored article on hell embittered his relations with the Jesuits, but, like his *Lex Orandi* (1903) and *Lex Credendi* (1906), it was so pervaded with irony that his full meaning could only be guessed. He was also publishing work under pseudonyms, notably *Religzon as a Factor in Life* (1902) by "Dr. E. Engels" and *The Church and the Future* (1903) by "H. Bourdon," which cut at the root of religious authority. In 1906 the publication in Italian of extracts from *Letter to a Professor of Anthropology*, which appeared in England as *A Much.Abused Letter*, finally occasioned his dismissal from the Jesuits. In 1907 Tyrrell was refused the sacraments after criticizing the encyclical *Pascendi*. Further writings, *Through Scylla and Charybdis* (1907), *Medievalism* (1908) and *Christianity at the Cross Roads* (1909), only reiterated his distinction between the "prison of theology" and the "liberty of faith." In 1907 he settled at Storrington (where he died on July 15, 1909) determined that he was a Catholic, but refusing to retract what he had written. He was despondent, seeing that both his efforts and his theories had failed to win general acceptance, and unaware of the remarkable progress of Catholic scholarship. Tyrrell's intelligence was very acute, but he suffered from lack of historical, scriptural or linguistic training, and could not really judge the scriptural criticism to which Baron F. von Hiigel introduced him nor could he understand the position obtained by his other and more vivacious friend, H. Bremond.

See M. D. Petre, ***Autobiography** and Life of G. Tyrrell*, 2 vol. (1912). (Cy. C. M.)

TYRRELL, SIR JAMES (d. 1502), the supposed murderer of the English king Edward V, and of his brother Richard, duke of York, was a son of William Tyrrell and a grandson of Sir John Tyrrell (d. *c.* 1437), who was treasurer of the royal household and was on three occasions speaker of the house of commons.

The family is said to descend from Walter Tirel, the murderer of William Rufus. During the Wars of the Roses James Tyrrell fought for the Yorkists; in 1471 he was knighted and in 1477 he was member of parliament for Cornwall. With regard to his share in the murder of the princes in 1483, he appears to have been selected by Richard III and sent to the Tower of London, where he supervised the crime which was carried out by his subordinates.

Afterward Tyrrell received several appointments from Richard and was sent to Flanders. He was also employed by Henry VII and was made governor of Guisnes, but he seems to have incurred the king's displeasure through his friendship with Edmund de la Pole, earl of Suffolk. Having been treacherously seized he was conveyed to England and was executed on May 6, 1502. Just before his death he made a confession about the murder of the princes.

TYRTAEUS, Greek elegiac poet, lived at Sparta about the middle of the 7th century B.C. According to the older tradition he was a native of the Attic deme of Aphidnae and was invited to Sparta at the suggestion of the Delphic oracle to assist the Spartans in the second Messenian war.

Later accounts reject his Athenian origin, but it is admitted that Tyrtaeus flourished during the second Messenian war (*c.* 650 B.C.)—a period of musical and poetical activity at Sparta, when poets like Terpander and Thaletas were welcomed—that he not only wrote poetry but served in the field and that he endeavoured to compose the internal dissensions of Sparta (Aristotle, *Politics*, v, 6).

About 12 fragments (three of them complete poems) are preserved. They are mainly elegiac and in the Ionic dialect, written partly in praise of the Spartan constitution and King Theopompus and partly to stimulate the Spartan soldiers to deeds of heroism in the field. The interest of the fragments preserved is mainly historical, and connected with the first Messenian war. The inspirational poems were very popular in the army (Athen. xiv, 630 F.). Of the marching songs, written in the anapaestic measure and the Doric dialect, only scanty fragments remain.

Verrall (*Classical Review*, July 1896, May 1897) definitely places the lifetime of Tyrtaeus in the middle of the 5th century B.c., while Schwartz (*Hermes*, 1889, xxxiv) disputes the existence of the poet altogether; *see* also Macan in *Classical Review* (Feb. 1897); H. Weil, *Études sur l'antiquité grecque* (1900), and C. Giarratani, *Tirteo e i suoi carmi* (1905). There are English verse translations by R. Polwhele (1792) and imitations by H. J. Pye, poet laureate (1795), and an Italian version by F. Cavallotti, with text introduction and notes (1898). The fragment beginning *Tetknamenai gar calon* has been translated by Thomas Campbell, the poet, as "The Young Hero."

TYRWHITT, THOMAS (1730–1786), English scholar, especially notable for his work on Chaucer, was born in London, March 27, 1730. He was educated at Eton and Queen's college, Oxford, becoming a fellow of Merton in 1755. He was called to the bar but never practised. He became deputy secretary at war (1756) and then clerk of the house of commons (1762), retiring in 1768. He died in London, Aug. 15, 1786.

In classical and English scholarship alike Tyrwhitt showed the same qualities of balance, wide knowledge and critical acumen. He was the one man who was able (1777) to reject on linguistic grounds the authenticity of the Romley-Chatterton poems. Of his several classical editions, the most important was of Aristotle's *Poetics* (1794). His fame, however, rests chiefly on his edition of Chaucer's *Canterbury Tales* (5 vol., 1775–78). Chaucer's reputation had long suffered because the principles of his verse were no longer understood. It was Tyrwhitt who pointed out that *-e's* now mute, should be pronounced as separate syllables and that the accent was often placed in the French manner; *e.g.*, virtúe, not virtue. Of his work on Chaucer, T. R. Lounsbury said, "The sanest of English poets had the good fortune to meet with the sanest of editors." Advances in knowledge have made Tyrwhitt's work obsolete but have not diminished the respect in which he is held.

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TYUMEN, a town in the Tyumen oblast of the Russian Soviet Federated Socialist Republic, U.S.S.R., in 57" 15' N., 65° 18' E., on the Tura, which is difficult for navigation because of its shallowness, though dredging has somewhat improved it; it is usually ice free from May 8 to Nov. 15. Pop. (1959) 150,000. The highway across the Urals passes through the town, and the railway links it with Sverdlovsk and Omsk. In 1580 Yermak wintered on the site and in the following year captured Isker or Sibir, the fort from which Siberia took its name; the fort of Tyumen was established in 1585. Later it became the centre for the colonization of the Tura, Tavda, Tobol and Ob rivers, but was superseded by Chelyabinsk (1959) 688,000, which had a railway link earlier than Tyumen. In 1893 the first dairy farm was begun near Tyumen by the English wife of a Russian, and this led to the rapid development of that industry in western Siberia. It has the largest tanning and leather industry in Siberia, and has smelting works, sawmills, match factories and steamer and boatbuilding yards. Wool is dressed, and there are potteries. The peasant industries include cooperage, the making of carts, furniture, sledges, horse collars and wooden household utensils. Tyumen carpets, with bright floral and animal designs, are famous; the former Samoyede vegetable dyes are being replaced by aniline. The plows of the Kamen volost are also noted.

TZETZES, JOHN, Byzantine poet and grammarian, flourished at Constantinople during the 12th century A.D. Tzetzes has been described as a perfect specimen of the Byzantine pedant. Excessively vain, he resented any attempt at rivalry, and violently attacked his fellow grammarians. O ing to want of books, he was obliged to trust to his memory; hence he is to be used with caution. But he was a learned man, and deserves gratitude for his efforts to keep up the study of ancient Greek literature. Of his numerous works the most important is the Book of Histories, usually called Chiliades ("thousands") from the arbitrary division by its first editor (N. Gerbel, 1546) into books each containing 1,000 lines (it actually consists of 12,674 lines in "political" verse). It is a collection of literary, historical, theological and antiquarian miscellanies, subsequently re-edited by the author with marginal notes. The Chiliades is based upon a collection of letters (107 in number) which are addressed partly to fictitious personages, and partly to the great men and women of the writer's time. They contain a considerable amount of biographical details. He is the author of the Iliaca, an abridgment of and supplement to the Iliad in 1676 hexameters, and the Homeric Allegories, dedicated to the empress Irene, two didactic poems in which Homer and the Homeric theology are explained on euphemistic principles. Tzetzes also wrote commentaries on Greek authors, for instance, on the Cassandra or Alexandra of Lycophron (ed. C. G. Miiller, 1811), in which his brother Isaac probably helped him. He is our earliest authority (Chil. 3, 88, 339–48) for the story of the beggary of Belisarius. Mention may also be made of a dramatic sketch in iambic verse in which he describes the wretched lot of the learned.

Editions:—Chiliades: *Corp.* Poet. Graec. (Lyons, 1612); ed. Kiessling (1826). Iliaca: ed. Lehrs & Diibner (Paris, 1868). Allegories in Matranga, Anecdota Graeca, vol. i. (1850); Scholia to Lycophron, ed. Miiller (1811).

For the other works of Tzetzes see J. A. Fabricius, *Bibliotheca* graeca (ed. Harles), xi. 228, and C. Krumbacher, Geschichte der *byz.* Lit. (2nd ed., 1897); monograph by G. Hart, "De Tzetzarum nomine, vitis, scriptis," in Jahn's Jahrbucher *für* classische Philologie. Supplementband xii. (Leipzig, 1881).

TZ'U-HSI (1835–1908), the empress HSIAO-CH'IN, who is best known in western literature as "Old Buddha" or the "Empress Dowager," was born on Nov. 29, 1835. She was a consort of the emperor Wen-tsung (reign title Hsien-feng, 1851–61), the mother of the emperor Mu-tsung (reign title T'ung-chih, 1862–75) and the adoptive mother of the emperor Te-tsung (reign title Kuang-hsii, 1875–1908). For almost half a century she ruled the Manchu imperial house and the Chinese empire with an iron will. After the end of the T'ai P'ing rebellion in 1864, there followed a period relatively free of disruptive foreign wars and internal unrest when China might have regenerated and adapted itself to the modern world, but Tz'u-hsi, despite her shrewdness and strength, lacked the vision of a statesman. Her greed gave rise to increasing corruption in the officialdom; her diversion of funds from naval construction in order to build an imperial pleasure garden was a factor in the defeat of China by Japan in 1895. Afterward she personally thwarted the reform movement of 1898 and connived in the disastrous antiforeign Boxer uprising of 1900.

One of the most powerful women in Chinese history, Tz'u-hsi died on Nov. 15, 1908, having contributed nothing to the ultimate welfare either of China or of the Manchu dynasty. (L. T. F.)

U IN the Semitic alphabet the letter Y (*vau,* "hook") was sixth in order and represented a labial semi-vowel (equivalent to English *w*). The Greeks used the letter to represent a vowel and placed it last in their alphabet following T (*tau*). In the place occupied by Y (*vau*) in the Semitic alphabet the western Greek alphabets had the letter digamma F, which they used to represent the bilabial semivowel (modern English *w*), a sound that had fallen out of use in some dialects (*see* F). Greek forms of the letter were Y, Y or V and the last of these passed from the Chalcidic alphabet into Latin. The form Y was identical in both the Etruscan and Lydian alphabets.

The Latins, who first used the combination FH to express the unvoiced labial spirant (English *f*), came under Etruscan influence to represent this sound by F alone. Thus, this letter, which in Greek had represented the bilabial semivowel (English *w*), was no longer available, and *v* had to do duty for both the vowel (English *u*) and the bilabial semivowel (English *w*). In later Latin before the separation of the Romance languages the bilabial passed into the voiced spirant equivalent to English *v*. Meanwhile, while the majuscule letter retained its form V, the minuscule and uncial had a rounded form, e.g., u (uncial), u (cursive of the 6th century) and, later, Carolingian u. Thus the letter passed into the mediaeval hands having the majuscule pointed form V and the minuscule rounded form *u* and representing two sounds, the vowel (*u*) and the spirant (*v*). In the later middle ages a differentiation took place similar to that between the letters *i* and *j*. The majuscule form, being generally used initially, came to represent the consonant, which usually occurred initially, in all positions; while the rounded form was used exclusively for the vowel. As a result a minuscule *v* and a majuscule *U* were adapted for use when required. The differentiation was wise and useful, and reversed the process by which in the Latin alphabet the single symbol had done duty for both consonant and vowel.

NAME OF FORM	APPROXIMATE DATE	FORM OF LETTER
PHOENICIAN	B.C. 1.200	?
CRETAN	1.100-900	V
THERAEAN	700-600	V
ARCHAIC LATIN	700-500	V
ATTIC	600	V
CORINTHIAN	600	Y V
CHALCIDIAN	600	Y
IONIC	403	V Y
ROMAN COLONIAL	PRE-CLASSICAL AND CLASSICAL TIMES	V
URBAN ROMAN		V V
FALISCAN		V
OSCAN		Y V
UMBRIAN		V
CLASSICAL LATIN AND ONWARDS		U

THE DEVELOPMENT OF THE LETTER "U" FROM THE EARLIEST TIMES TO THE PRESENT DAY

In Attic Greek the sound represented by the letter was a high front rounded vowel (similar to French *u,* German *ü*). In Latin the vowel was a middle high rounded one (similar to the sound of *oo* in "*shoot*"). In modern English the short *ŭ* has become in most positions a low middle vowel closely resembling the original sound of short *ă* (*e.g.,* in the words "*but,*" "*dumb*"). There are certain exceptions, however (cf. "*bull,*" "*bush,*" "*put*"). The long vowel has within the last 200 years developed a palatal semivowel (the sound of *y*) before it, except when it follows a liquid (*r* or *l*). Contrast the sound of the pure vowel in the word "*brute*" with that in the words "*huge,*" "*rebuke.*" This change is sufficiently recent for such words as begin with long *ū* (e.g., "*university*") to be preceded, when the indefinite article is required, by the form *an,* not *a,* showing that the sound was a pure vowel sound. It is still so pronounced in certain cases in the United States. It is an interesting fact that this change was exactly paralleled in the Boeotian dialect of Greek. (B. F. C. A.; J. W. P.)

UAKARI, the name of certain tropical American monkeys, distinguished by their short tails. They constitute an aberrant group of the genus *Pithecia* confined to the forests of Amazonia, and frequently distinguished as the genus *Cacajao.* (*See* PRIMATES.)

UBANGI, a river of equatorial Africa (extreme length 1,400 mi.), the chief northern affluent of the Congo (*q.v.*). The Ubangi (otherwise Mubangi or Mobangi) enters the Congo by various mouths between 0° 22′ and 0° 37′ S. and 17° 40′ and 17° 50′ E. The Ubangi is formed by the junction of the Bomu and the Uele (Welle), the latter rising a few miles from the western edge of the western rift-valley, north of Lake Albert and after a course of 745 mi. it joins the Bomu at Yakoma. Both streams, which have hitherto received numerous affluents, flow westward as a wide river. A short distance below the junction of the Bomu and Uele, the Kota, coming from the borders of Darfur and forming the most northerly extension of the Congo basin, enters the united stream (right). The remaining tributaries, mostly on the right bank, are smaller. Below the confluence with the Kouma, which river offers water communication to within easy reach of the Shari basin, the Ubangi makes a great bend south and immediately it flows between hills and passes the Zongo or Grenfell rapids, which are a barrier to navigation save for small boats in flood season. Above Zongo rapids the river is navigable up to the confluence of the Uele and Bomu, and the former is navigable at high flood up to the Bomokandi confluence in 26° 8′. The Ubangi and the Bomu form the frontier between Belgian Congo and former French Equatorial Africa.

UBE, mining and industrial city, is located on the Inland sea in Yamaguchi prefecture, Japan. Between 1940 and 1958 its area increased from 15 sq.mi. to about 86½ sq.mi., and its population increased from 100,700 to an estimated 160,020. About 3,000,000 tons of coal, mostly bituminous but some anthracite, are produced annually. The Tertiary coal beds extending out under the sea are near the harbour, convenient for export to other parts of Japan. Coal is the basis of Ube's chemical industry and cement production rates next to coal.

(C. A. MR.)

ÜBERWEG, FRIEDRICH (1826–1871), German historian of philosophy, was born on Jan. 22, 1826 at Leichlingen, in the Prussian Rheinprovinz, where his father was Lutheran pastor. Educated at Göttingen and Berlin, he qualified himself at Bonn as *Privat dozent* in philosophy (1852). In 1862 he was called to

Konigsberg as extraordinary professor, and in 1868 he was advanced to the ordinary grade. He died on June 9, 1871.

Überweg's compendious, accurate and impartial *Grundriss der Geschichte der Philosophie* (1863–66) is his most lasting monument.

UCCELLO, PAOLO (PAOLO DI DONO) (1397–1475), Florentine painter, an artist of great distinction and individuality, whose works embody, more fully than those of his contemporaries, the ideals of early Renaissance art. The son of Dono di Paolo, a barber-surgeon from Pratovecchio in the Casentino. he was born in Florence. His only signed works are inscribed Pavli Vccelli or Vcieli Opvs. and the name Uccello also appears in documents; the reason for this appellation is not known. Uccello is mentioned as a member of the studio of Lorenzo Ghiberti in 1407 and 1412, and became a member of the Compagnia di San Luca in 1414. In 1425 he left Florence for Venice, where he is mentioned once more in 1427 and seems to have remained till 1430 employed as master mosaicist at St. Mark's.

The works Uccello executed there are lost, but a summary reproduction of a mosaic of St. Peter by Uccello is found in Gentile Bellini's "Procession of the Reliquary of the Cross" (Accademia, Venice).

A mistaken attempt has been made to connect Uccello's name with the mosaics in the Cappella Mascoli in St. Mark's. When in Venice Uccello must have come into close contact with International Gothic painting in north Italy, and this had a considerable influence on his later work.

In 1432 he was once more resident in Florence, and after this time he executed two frescoes in the Chiostro Verde of Sta. Maria Novella. These represent "The Creation of the Animals and the Creation of Adam" and "The Creation of Eve and the Fall"; they are ascribed to the artist by early sources but are not documented. In 1436 he was engaged to paint the effigy of Sir John Hawkwood in Florence cathedral. The new discipline of linear perspective plays an important part in this scheme, and is further developed in the somewhat later "Scenes From Monastic Legends" on the east wall of the cloister at S. Miniato al Monte. This group of works culminates in the decoration of the clock face of Florence cathedral (1443), where linear perspective is used to create an illusory architectural scheme. On the strength of these and later works Uccello has been credited with the invention of perspective, but their novelty resides less in the representational technique than in the decorative function which it serves. In 1443–44 Uccello prepared four cartoons for the circular windows of the cathedral cupola.

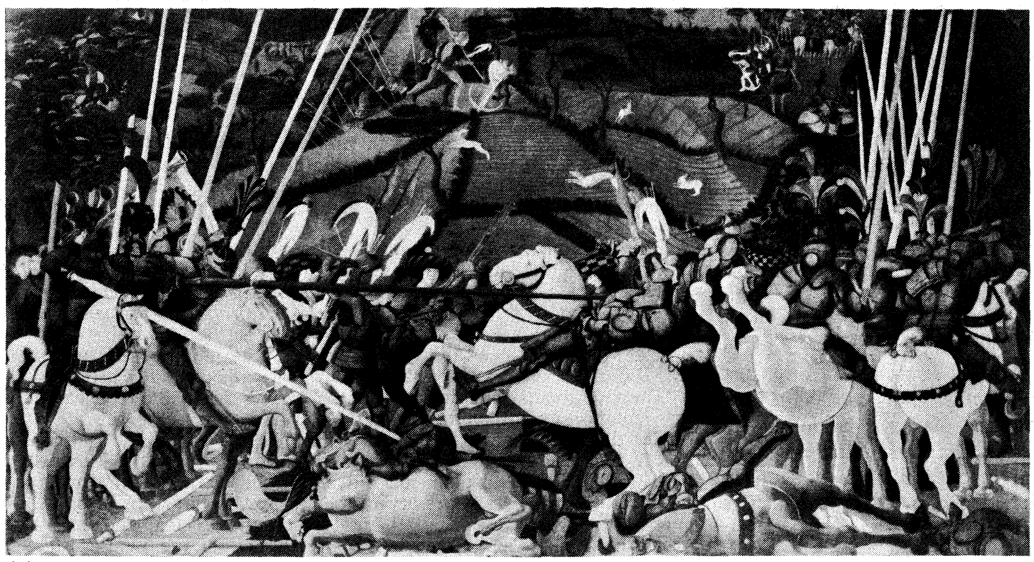
After this time he is said to have been in Padua, where he executed monochrome frescoes of giants in the Casa Vitaliani (now lost); these were much admired by Andrea Mantegna. Returning to Florence, he completed, probably about 1447, two further frescoes in the Chiostro Verde representing "The Drunkenness of Noah" and "The Flood." Though much damaged, these are Uccello's masterpieces, and are strongly influenced by the theory of L. B. Alberti and by the realism of Donatello. Their elaborate perspective schemes assume a yet more complex form in a later fresco of "The Nativity" in the cloister of S. Martino alla Scala, Florence. Three large battle pieces of "The Rout of San Romano," apparently painted on the commission of Cosimo de' Medici, date from about 1456 (National gallery, London; Uffizi, Florence; Louvre, Paris). The pronouncedly decorative character of these panels has made them the artist's best-known works. In 1465 Uccello was at Urbino engaged on an altarpiece of "The Institution of the Eucharist" for the Confraternity of Corpus Domini, of which the predella, with "The Profanation of the Host." survives in the Galleria Nazionale at Crbino. In 1468 Uccello returned to Florence, and after this time he executed the "Hunting Scene" now in the Ashmolean museum, Oxford. A reputed self-portrait of Uccello occurs, along with heads of Giotto, Donatello, Filippo Brunelleschi and Giannozzo Manetti, on a panel in the Louvre; the identification of this head and the authorship of the panel are both doubtful. Uccello died on Dec. 10, 1475. Many stories were told by Giorgio Vasari to illustrate Uccello's addiction to the study of perspective. His contribution to the development of perspective representation has been exaggerated.

See Giorgio Vasari, *Vite,* ed. by Milanesi; J. Pope-Hennessy, *The Complete Work of Paolo Uccello* (1950). (J. W. P.-H.)

UDAD (AOUDAD or AUDAD), the Barbary sheep. *Ammotragus lervia,* the only wild sheep found in Africa, where it inhabits all the mountain ranges of the north, descending eastward far into the Sudan.

It is distinguished by the abundant hair on the throat and forequarters of the rams. the length of the tail, the absence of face glands and the goatlike structure of the horns.

UDAIPUR or MEWAR, a town, district and division in the state of Rajasthan, India. The picturesque town is 2,469 ft. above sea level. Pop. (1951) 89.621. It is situated amid wooded hills on the bank of a large lake (Pichola), with palaces built of granite and marble. The maharana's palace, which crowns the ridge on which the city stands, dates from about 1570, but additions have made it a conglomeration of architectural styles. In Lake Pichola are two islands, on which are palaces dating respectively from the mid-17th and mid-18th centuries. In the neighbourhood are Eklingji (with a magnificent temple of the 15th century) and Nagda, the seat of the ancestors of the chiefs of Udaipur.



ALINARI

"THE ROUT OF SAN ROMANO," ONE OF THREE BATTLE PANELS BY PAOLO UCCELLO FOR THE PALAZZO MEDICI. NOW IN THE UFFIZI, FLORENCE.

The DISTRICT OF UDAIPUR (pop. [1951] 1,191,232) is one of five comprising the DIVISION OF UDAIPUR (pop. [1951] 3,171,114). The greater part of the country is hilly; in the south black cotton soil predominates. A section of the Aravalli hills runs from northeast to southwest and is rich in mica, lead zinc, steatite and asbestos. A great variety of building stones, such as sandstone, limestone and marble, is also to be found. The general inclination of the division is from southwest to northeast, the Banas and its numerous feeders flowing from the base of the Aravalli range. There are many lakes and tanks, the finest of which is the Dhebar or Jai Samand, with an area of 23 sq.mi.

Before 1948 Udaipur was a state ruled by the head of the Sisodia clan of Rajputs. He claimed to be the direct representative of Rama, the mythical king of Ajodhya, and was universally recognized as the highest in rank of all the Rajput princes. The dynasty offered a heroic resistance to the Mohammedans, and boasted that they never gave a daughter to a Mogul emperor. They are said to have come from Gujarat and settled at Chitor in the 8th century. After the capture of Chitor by Akbar in 1568, Maharana Udai Singh moved the capital to Udaipur. In the 18th century the state suffered greatly from internal dissension and from Maratha inroads. It came under British protection in 1817. In April 1948 it merged with Rajasthan and the maharana became maharajpramukh of that union.

The name Mewar is derived from the Meos, or Minas, a tribe of mixed Rajput origin.

There is another UDAIPUR, a former state now a district of Madhya Pradesh. (S. GL.)

UDALL, NICHOLAS (*c.* 1505–1556), English playwright and translator, was born in Hampshire, probably of the family of Uvedale who in the 14th century had become lords of Wykeham. He was educated at Winchester college and Corpus Christi college, Oxford, where he fell into some disgrace for suspected Lutheranism. When he left Oxford Udall took up schoolmastering. In June 1534 he was appointed headmaster of Eton, and in 1537 he became vicar of Braintree, although he did not take up residence there, but, according to a custom of the time, paid a curate to do the work of the living; which, however, he resigned in 1544. His rule at Eton was short. He was brought up before the privy council on March 14, 1541, for various offenses, was dismissed and for a time was sent to prison. He tried, but failed, to get restored to Eton. He maintained himself apparently by literary work and translations, which found favour with Catherine Parr, and he was made tutor to Edward Courtenay, the young earl of Devon who had been in the Tower since he was 12 years old. In 1551 he obtained a prebend at Windsor and two years later a living at Calborne, Isle of Wight. In spite of his Protestant tendencies, under Mary he became tutor in the household of Stephen Gardiner, bishop of Winchester, and in Dec. 1555 was appointed headmaster of Westminster, which post he held until his death, in Dec. 1556.

'Throughout his career Udall was an indefatigable writer. In 1533 he produced with John Leland "ditties and interludes" for Anne Boleyn's coronation. A year later he published *Flowers for Latin speaking selected and gathered out of Terence and the same translated into English*, a second edition of which he later published for the benefit of his Eton boys. Among his other translations were Erasmus' *Apothegms* (1542), *Paraphrases of the Gospels* (1552) and other works. Only the first three of the *Paraphrases* were translated by Udall himself; that on St. John was being translated by the princess Mary until she fell ill and handed her work over to Francis Mallett. The work was done at the suggestion and expense of Catherine Parr.

Udall is, however, better known as a playwright. John Bale credits him with *plures comediae*, and his pupils would have provided him with actors; but the only surviving play that can without doubt be assigned to him is *Ralph Roister Doister*. *Ralph Roister Doister* is famous as the first English comedy under classical influence. It has sometimes been described as a mere adaptation of Plautus' *Miles Gloriosus*. The central idea of the play — that of a braggart soldier (with an impecunious parasite to flatter him) who thinks every woman he sees falls in love with him and is finally shown to be an arrant coward — is undoubtedly taken from Plautus, but the plot and incidents, and above all the dialogue, are adapted to English conditions. The play was entered in the Stationers' Register and printed in 1566 (only one copy, presented to Eton in 1818, survives). It must, however, have been written earlier, for a quotation from the play was added to the third edition of Thomas Wilson's *Rule of Reason* in Jan. 1554. Since the reference does not appear in the previous editions of 1551 and 1552, the likelihood is that the play appeared in 1552 or 1553, and was therefore written neither for the Eton nor for the Westminster boys as has sometimes been asserted.

Other plays possibly by Udall are *The History of Jacob and Esau*, with divisions similar to *Ralph Roister Doister* into acts and scenes; *Jack Juggler*, which borrows from Plautus; and *Thersites*, with its farcical braggart figure. Another play, certainly by him, has unfortunately not survived. This was *Ezechias* ("Hezekiah"), acted before Elizabeth in King's college chapel on Aug. 8, 1564, during her visit to Cambridge. From the accounts of the performance it included Hezekiah's destruction of the idols of the grove, probably symbolizing Henry VIII's reforming measures.

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UDINE, a town and archiepiscopal see of Veneto, Italy, capital of the province of Udine, situated between the Gulf of Venice and the Alps, 84 mi. by rail northeast of Venice, 450 ft. above sea level. Population (1951) 65,199. The interesting Porta Aquileia (14th century) is almost all that is left of the old city walls. Some of the streets are arcaded and there are some fine palaces. The old castle on a hillock in the centre of the town, at one time the residence of the patriarchs of Aquileia, and now used as a museum and picture gallery, was erected by Giovanni Fontana in 1517 in place of the older one destroyed by an earthquake in 1511. The Romanesque cathedral contains some interesting examples of native art by Giovanni Martini da Udine (a pupil of Raphael) and others. The church of S. Maria della Purità has frescoes by Giovanni Battista and Domenico Tiepolo. In the picturesque principal square stands the town hall, built in 1448–1456 in the Venetian-Gothic style, and skillfully restored after a fire in 1876; opposite is a clock tower resembling that of the Piazza di San Marco at Venice with the elegant loggia of S. Giovanni leading to the church of the same name (1533). In the square is a statue of Peace, erected in commemoration of the peace of Campo Formio (1796), which lies j mi. to the west southwest, and two columns, one with the tier of S. Mark, the other with a statue of Justice. The archiepiscopal palace contains frescoes by G. B. Tiepolo. The leading industry of Udine is silk-spinning, but it also possesses manufactures of linen, cotton, hats and paper, tanneties and sugar refineries, and has a considerable trade in flax, hemp, etc. Branch railways lead to Cividale del Friuli and S. Giorgio di Nogaro.

Udine lay on the line of the Via Julia Augusta, and there is proof of its existence in Roman times. In 983 it was given by the emperor Otto II to the patriarch of Aquileia, to whom it may have belonged even earlier. In 1222 or 1238 the patriarch Berthold made it the capital of Friuli, and in 1420 it became Venetian. In 1752 it became an archbishopric. It was the seat of the Italian Commando Supremo (G.H.Q.) during World War I from 1915 to 1917.

UDMURTSK (till 1932 VOTYAK) **AUTONOMOUS SOVIET SOCIALIST REPUBLIC,** within the Russian Soviet Federated Socialist Republic, U.S.S.R., originally part of Vyatka province. Area 16,178 sq.mi. Pop. (1956 est.) 1,285,000 (urban 502,000). It is surrounded by the Tatar A.S.S.R., and by the *oblasts* of Sverdlovsk and Kirov, and lies between 56° and 58° 30′ N. and 51° 30′ and 54° 15′ E. Geographically it includes a part of the Ural foothills forming the watershed between the Vyatka and Kama and the tributaries of the Chepsa. The soils, mainly sands and clays and gray forest soils, are not very productive, and 43% of the area is forest covered; there are vast swamps and marshes. The prevailing trees are fir (76%) and pine (12%); birch, ash, elm, maple and oak occur in small areas in the south.

Agriculture is the chief occupation. Rye and oats are the chief crops, and flax and potatoes are also grown.

There is an abundance of good quality timber. The rivers are unfavourable for navigation, but on many streams it is possible to float timber after the spring thaws; in summer they become very shallow. Mineral wealth includes the iron of the northeast region, slate, copper, quartz sand, chalk and red clay. Peat is abundant. The Varziachinsk district, a health resort from 1888, became noted for its mud and sulfur springs.

Factory industry was developed at Izhevsk (*q.v.*), the administrative centre, where there are steelworks and ammunition factories and where other metal goods are produced. In the northeast there is much iron smelting, and glass, pottery and vegetable oils are produced in the province. There are sawmills and rosin turpentine manufacture.

The Molotov-Kirov railway goes through the north of the area and the Kazan-Sverdlovsk through the south. Roads generally are poor.

The region was inhabited by Finnish tribes when Slav penetration and colonization began in the 12th century. For some time it was under the overlordship of Novgorod, but in the 15th century passed under that of Moscow. Though colonization went on continuously, the forest, marsh and poor soil did not prove attractive to Russians, and the Finnish tribes preserved their language and customs. The Votyaks (Otyaks), who call themselves Ot, Ut or Ud, and who are called Ar by the Tatars, may be akin to the Ars of the Yenisei. They are of middle stature, with light-coloured eyes and fair, often red, hair, and Finnish skull and facial characters. Their dialect is akin to that of the Permyaks. They are mainly agricultural, factory and town populations (43.3% of the total) being Russian.

UFA, the capital town of the Bashkir Autonomous Soviet Socialist Republic of the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on the high right bank of the Belaya river, just below its confluence with the Ufa river. Its site in a loop formed by the two rivers led to its foundation as a fortress in 1586 to protect the trade route across the Urals from Kazan to Tyumen. From its position on this major trade route the town derived its early importance, but with the industrialization of the Urals in the 20th century. it became a manufacturing centre. The great development of the petroleum industry of Second Baku after World War II gave an additional impetus to the growth of Ufa, the 1959 population of 546,000 being more than double the 1939 figure. After 1956 the satellite town of Chernikovsk, a few miles to the northeast, was united administratively with Ufa. The major industry is engineering, in particular the manufacture of power machinery, mining equipment, electrical apparatus (including telephones) and typewriters. Petroleum processing is carried on in Chernikovsk, as are a range of timber industries—sawmilling, veneer and match manufacture, papermaking and tannin extraction. The town remains an important centre of communications with railways west to the Volga at Kuibyshev and Ulyanovsk, east to Chelyabinsk and south to Sterlitamak and the Ishimbay oilfields. The Belaya is navigable below Ufa to the Kama river, thus linking the town to the Volga system of waterways. Ufa is the seat of Bashkir State university and has a teachers' training college and institutes of petroleum, aviation, agriculture and medicine. (R. A. F.)

UGANDA, a British protectorate in eastern equatorial Africa, bounded on the north by the Sudan, on the east by Kenya, on the south by Tanganyika and Ruanda-Urundi and on the west by the Republic of The Congo. The name is a derivation of Buganda, the African kingdom that forms one of its four provinces.

PHYSICAL FEATURES

The protectorate comprises 93,981 sq.mi., of which 13.689 sq.mi. are open water, 2,500 sq.mi. swamps, 6,200 sq.mi. forest reserves and 3,000 sq.mi. game parks and national reserves. It consists of a series of plateaus, broken up by wide, steep-sided valleys. Lake Victoria, about half of which is in the protectorate, is the size of Ireland and is the source of the Nile. This mighty river passes through the Owen Falls dam near Jinja and descends about 700 ft. in 50 mi. to Lake Kyoga. From there it is navigable for about 50 mi., after which it is unnavigable as far as the Murchison falls. Navigation can then be resumed into Lake Albert. After leaving this lake, the Victoria Nile becomes the Albert Nile and is navigable as far north as Nimule (3° 40' N.). Lakes Albert, George and Edward lie in the western branch of the Great Rift valley. Between these lakes extend the snow-capped peaks and glaciers of the Ruwenzori range, the highest point being Margherita peak (16,763 ft.); Ruwenzori forms part of the western boundary with the Republic of The Congo. The eastern boundary passes through Mt. Elgon (14,178 ft.).

The climate is tropical, though the temperature (60°–85° F.) is ameliorated by the relatively high altitude. The protectorate may be divided broadly into the long grass zone within the range of influence of Lake Victoria and enjoying well-distributed rainfall, and the short grass zone with about three months of hot, dry weather, the rain falling in two marked seasons.

Geology.—Pre-Cambrian rocks cover large areas of the protectorate. They include quartzites, gneisses and schists of the Basement complex in West Nile and Karamoja, and the Toro system of Toro, Ankole and much of Buganda, consisting of similar rocks with mudstones, grits and shales; this system forms the mass of Ruwenzori. The Karagwe-Ankole system is somewhat younger and includes quartzites, sandstones and conglomerates with phyllites and mica-schists near the margins of intrusive granites (granites underlie at least half the protectorate and are associated with economically important minerals). The Bunyoro series has tillites at the base, while the Singo series of Buganda consists of flat-bedded sandstones, conglomerates and siltstones. Fossiliferous shales of Karroo (Permocarboniferous) age occur near Entebbe. Plutonic ring complexes near Tororo are covered with laterite and are associated with phosphates and iron ore. Volcanic rocks of different types are found round Mt. Elgon and Ruwenzori. The Kisegi lacustrine beds of the Toro-Semliki part of the Albertine rift are of Lower Miocene age. The Kaiso sandstones and clays around Lake Albert contain early Pleistocene fossil mammal remains. In high terraces above the Kagera, Kafu and Muzizi rivers abundant stone implements testify to man's presence in Uganda from Lower Pleistocene times.

Vegetation. — Most of the protectorate lies within the floral province of the eastern and southern African steppes, but the forests of western Uganda are west African in character. In the region of lakes and mountains, elephant grass more than 10 ft. high dominates the landscape. Tropical rain forests of this zone have tall, evergreen and semideciduous trees, with shrubs and lianes beneath. The forests of the south, bordering Lake Victoria, are characterized by huge yellow wood trees (Podocarpus) and are intersected by swamps. Swampy ground everywhere has a thick growth of papyrus and other rushes and reeds, as well as wild date palms. Forests on higher ground farther north contain rubber trees and umbrella trees, while Podocarpus dies out. Parallel with this belt, 100 mi. farther west, are patches of forest of west African character. North of Lake George, ironwood trees predominate. The forests of Bunyoro, containing mahogany, are the most valuable in Uganda. Another economically important tree is the African teak, growing mostly in Busoga. The drier country of Northern province is characterized by figs, acacias and euphorbias. Above the forested lower slopes of the higher mountains such as Elgon and Ruwenzori, beginning at about 7,000 ft., is a zone of bamboo. This is followed by a zone where St. John's wort and tree heaths predominate; between 9,000 ft. and 14,000 ft. grow giant groundsels and lobelias up to 20 ft. in height.

Fauna. — The fauna of Uganda generally is of Ethiopian character, typical of eastern and southern Africa and of the Sudan. In the west, the fauna merges with the west African type. Along the eastern shores of Lake Edward, the western and northern shores of Lake George and beside Kazinga channel connecting the two lakes is the Queen Elizabeth National park which is 700 sq.mi. in extent and includes the forested volcanic foothills of the Ruwenzori range, the home of chimpanzees, colobus monkeys and giant forest hogs. The more open country is inhabited by elephants, buffaloes, lions, leopards and many kinds of antelope, while hippopotamuses abound in Lake George. The Murchison Falls National park farther north is 1,200 sq.mi. in extent and was once the paradise of ivory poachers. It contains certain forms which are not to be found in the Queen Elizabeth park, such as the black rhinoceros, giraffe, hartebeest and oribi. The square-lipped white rhinoceros is found in the West Nile. Notable among the birds are the splendidly coloured touraco. the gray parrot, whale-headed stork, ostrich and the crested crane which is the symbol of the protectorate. Hippopotamuses and crocodiles are common in the lakes and in the Nile, while tiger fish and the great Nile perch (running up to 300 lb.) afford great sport for anglers. (S. M. C.)

HISTORY

For perhaps a thousand years the territory now known as Uganda has been subjected to a series of immigrations of Hamitic, Nilotic and Nilo-Hamitic peoples from the north. The invaders dominated the original inhabitants of northern Uganda, imposing upon them their languages and attempting to introduce their social and political systems. The result of this pressure upon societies possessing only the most primitive forms of organization was to produce, by the mid-19th century, an agglomeration of small village and clan communities engaged in almost continual warfare with each other. To the south and west the invaders became, by the mid-16th century, a governing aristocracy in an area occupied mainly by Bantu-speaking peoples. A number of kingdoms were established, among them Bunyoro, Buganda and Ankole, each with a highly centralized and frequently despotic form of government. The distinction between the rulers and their subjects was most evident in Ankole, while in the other kingdoms it tended in time to disappear as the result of intermarriage. For nearly two centuries Bunyoro was the most powerful of these states but in the 19th century able rulers raised Buganda to the leading position.

Contact with the Outer World. — The first trade goods from the outside world reached Uganda in the late 18th century via the neighbouring state of Karagwe to the southwest. The first Arab trader to enter the country, Ahmed bin Ibrahim, arrived from Zanzibar by the same route in 1844 in search of ivory and slaves. Mainly for geographical reasons but also through fear of the Masai the road to Uganda passing through what is now Tanganyika was from the beginning preferred to the more direct route through Kenya. During the next ten years Ahmed was followed by several other Arab merchants whose penetration to Uganda was mainly due to the decline in the supply of slaves in Tanganyika. Firearms and cheap cotton cloth proved a great attraction in the kingdoms north of Lake Victoria as they had among the tribes to the south. The traders were welcomed in Buganda by Kabaka (king) Suna. Meanwhile, slave raiders from the Sudan had begun to prey upon the less well organized peoples to the north.

European explorers reached Uganda from north and south almost simultaneously. After travelling round the western shore of Lake Victoria J. H. Speke and J. A. Grant arrived at the Buganda capital in 1862 to find that Suna had been succeeded six years earlier by his more famous son, Mutesa. The latter was already worried by the news of slavers from the Sudan and in his anxiety to prevent a link-up between the foreigners from north and south tried to discourage Speke and Grant from continuing their journey. They persisted and, after discovering the source of the Nile near Jinja in July 1862, followed the river downstream through the Sudan and Egypt. At Gondokoro they met the explorer Samuel Baker and his wife, and these two, acting on information given by Speke, discovered Lake Albert in 1864.

In 1869 the vacant throne of Bunyoro was occupied by the warlike Kabarega, largely as a result of the assistance given him by Sudanese slavers. But almost immediately the threat to Uganda from the north took on a more serious shape in consequence of the expansionist policy of the khedive Ismail of Egypt. First Samuel Baker and later Col. Charles George Gordon carried the Egyptian flag into Uganda in the 1870s and only Mutesa's diplomacy checked Gordon's plan to attack the slave trade by planting a chain of military posts across Uganda and down to the coast at Mombasa. The Mahdist rising put an end to Egypt's designs upon the territory to the south but already, two years earlier, Gordon had ordered Eduard Schnitzer, better known as Emin Pasha, the new governor of Egypt's Equatorial province, to withdraw his garrisons from northern Uganda.

The Missionary Period. — In 1875 the explorer and journalist, Henry Stanley (*q.v.*), reached Uganda. Impressed by Mutesa's intelligence and apparent interest in religious discussions, he appealed to English missionary societies to send representatives to Buganda. The first party, sent by the (Anglican) Church Missionary society, arrived at Mutesa's capital after crossing Lake Victoria from the south in June 1877. They were joined in Feb. 1879, by further reinforcements which had come by the northern route up the Nile. A week later members of the Roman Catholic White Fathers mission also reached Buganda from the south. But Stanley had mistaken the reason for Mutesa's interest in Christianity: the kabaka had shown a similar enthusiasm for Islam when the Arab traders from the coast had offered the best means of support against the threat from Egypt. When the Christian missionaries showed no intention of supplying him with firearms, Mutesa's early friendship waned, and he became suspicious of complicity between England and Egypt when he found missionaries using the northern route to his kingdom. In the face of his growing opposition the White Fathers withdrew from Buganda in 1882.

In Oct. 1884 Mutesa died. He was succeeded by his son, Mwanga, a man of weak character and uncertain temper. Mwanga recognized that Islam and Christianity had introduced rival loyalties into his kingdom where hitherto loyalty had centred upon the kabaka. To counter the influence of the Anglicans he encouraged the White Fathers to return to the country but quickly showed his hostility to missionary activities by having three Anglican youths executed in Jan. 1885. On his orders James Hannington, first Anglican bishop of Eastern Equatorial Africa, was murdered in Busoga on his way to Buganda in October of the same year. In June 1886, 45 young African supporters of both Christian missions were put to death. Roman Catholics, Anglicans and Moslems united against Mwanga in 1888 when they discovered that the kabaka and his pagan followers had planned to massacre all supporters of the new religions. Mwanga fled from the country and was replaced briefly by his brother, Kiwewa, who was soon overthrown in an attempt by the Baganda Moslems to seize power with the aid of the Arab traders. Another brother, Kalema, was installed as kabaka. In Dec. 1888 an apparently chastened Mwanga presented himself to the White Fathers at the south end of Lake Victoria. After some initial reluctance he was accepted by them and by another large group of Christian exiles in Ankole as the leader whose return to the throne of Buganda held out the greatest hope of peace. At the head of a joint Anglican and Roman Catholic army Mwanga finally drove Kalema from power in Feb. 1890.

The Imperial British East African Company. — On his return to Buganda Mwanga was visited almost at once by the German adventurer Karl Peters, who, to promote Germany's colonial policy, negotiated a loose agreement with the kabaka. But Peters' work was undone by the Anglo-German agreement of July 1, 1890, which declared Uganda to be within the British sphere of influence. On Dec. 18, 1890, Capt. F. D. Lugard arrived in Buganda, representing the Imperial British East Africa company, which had been granted a charter authorizing it to develop the British sphere of influence in east Africa on behalf of the British government. On Dec. 26, Lugard induced Mwanga to sign a treaty under which the company undertook to keep order in Buganda. Recognizing the weakness of his position, Lugard planned to add to his military strength by enlisting the support of a force of Sudanese soldiers left by Emin Pasha in western Uganda in 1889. Lugard's plan involved the dangerous decision to leave Capt. W. H. Williams at Kampala, the company's fort in Buganda, with only a handful of troops, at a time when rivalry between Roman Catholic and Anglican factions was rapidly becoming acute. On Lugard's return in Dec. 1891 the situation at Mwanga's capital was tense. A slight incident led to fighting and Lugard, who hitherto had attempted to show favour neither to Anglicans nor Roman Catholics, gave his support to the former party. After the so-called battle of Mengo in Jan. 1892 the Roman Catholics, together with Mwanga who had favoured their cause, fled to Bulingugwe Island on Lake Victoria. The island was attacked by Captain Williams and Mwanga escaped to German East Africa. He was induced to return by Lugard who made a fresh treaty with him on the basis of allocating the Sese Islands and the southern county of Buddu to the Roman Catholics and the rest of Buganda to the Anglicans.

Uganda Protectorate. — Financial stringency forced the Imperial British East Africa company to review its commitments in Uganda in 1891. Lord Rosebery sent Sir Gerald Portal to report on the situation in Uganda and to make recommendations for the future. Portal arrived at Kampala in March 1893 and proclaimed a provisional protectorate on behalf of the British government on April 1. He also negotiated a new distribution of territory between the rival Roman Catholic, Anglican and Moslem factions. Various considerations, including Great Britain's obligation to suppress the slave trade within its sphere of influence, the insecurity of the missionaries in Uganda and the strategic necessity for checking French and Belgian expansion from the west, had induced the Conservative government in England to authorize the survey of a rail route to Uganda by Capt. J. R. L. Macdonald in 1891. Rosebery too, even before he received Portal's report, was disposed to proclaim a protectorate, a step which Lugard had strongly urged on his return to England in 1892. Portal's provisional treaty was therefore confirmed by the formal assumption of a British protectorate over Buganda on June 18, 1894. Its extension to other parts of Uganda was mainly due to military necessity. After completing the railway survey Macdonald had been ordered to report on the events culminating in the fighting of 1892. In 1893 he found himself temporarily in control of British interests in Buganda when the Imperial British East Africa company's responsibility had been cancelled by Portal's treaty. and Portal himself had left the country Almost immediately he had to deal with a Moslem rebellion against the terms of Portal's land settlement. Swift military action restored order, but there remained a threat to the security of the country in the presence of Kabarega of Bunyoro on its western border. Macdonald therefore planned an invasion of Bunyoro which was set in hand on Dec. 31. 1893, by Col. H. E. Colvile, commissioner in Buganda, who had arrived in the country in November. Kabarega's capital was quickly occupied but the king himself escaped to carry on guerrilla warfare until captured in 1839. The British protectorate was extended to Bunyoro on June 30, 1896. Fears of Belgian expansion from the Congo had already been modified by the Anglo-Belgian agreement of May 12, 1894, which fixed the 30th meridian of east longitude and the Nile-Congo watershed as the boundary between the rival spheres of interest.

Mwanga in 1897 gave his support to a revolt planned by some of his chiefs. When the plot was prematurely uncovered he fled to Buddu where he was defeated in battle by a protectorate military force. From Buddu he escaped to German East Africa and gave himself up to the German authorities. On Aug. 14 his infant son, Daudi Chwa, was proclaimed kabaka and a regency of three chiefs was set up. Almost immediately a section of the protectorate Sudanese troops mutinied as the result of arrears of pay and of the great demands placed upon them. The main action took place at Luba's fort, near Jinja, where the mutineers were besieged by a force led by Lieut. Col. J. R. L. Macdonald. The mutineers escaped northward but were defeated and scattered in a battle at Kabagambe, in Buruli, in Feb. 1898. Meanwhile Mwanga had escaped from the Germans and. after being defeated in Buddu by a force sent by Macdonald to deal with him, joined Kabarega. The two were finally taken in 1899 and exiled to the Seychelles.

Establishment of Civil Administration. — Under criticism for the expenses incurred in almost continuous military campaigns, the British government sent Sir Harry Johnston as special commissioner to Uganda to establish civil administration. Johnston arrived in Kampala in Dec. 1899 and on March 10, 1900, concluded an agreement with the regents and chiefs of Buganda. The agreement, referred to rather confusingly as the Uganda agreement, stated that Buganda should be a province of the Uganda protectorate and that the laws of the protectorate should be enforced in Buganda unless otherwise specified in the agreement. The kabaka was to continue to rule over his people as long as he remained loyal to the protectorate government. Of great importance was the section which won the support of the leading chiefs for the rest of the agreement by granting them, in freehold, land amounting in all to almost half the area of Buganda. Hitherto they had held it only as tenant officials of the kabaka. Similar though less complicated agreements were made with the rulers of Toro and Ankole in 1900 and 1901. The rest of the protectorate was divided into administrative districts. On April 1, 1902, the Eastern province, stretching as far as the Kedong river, was transferred to Kenya to provide that protectorate with a profitable hinterland; and during the next ten years the frontiers bordering on the Congo and German East Africa were settled by boundary commissions. In 1914 Gondokoro and Nimule districts were transferred to the Sudan and in 1926 Rudolph province was handed over to Kenya to. simplify administrative problems. The Uganda order in council of 1902 provided for a high court and subordinate courts.

Lugard and Johnston had both stressed the possibility of developing the country's economy on the basis of plantation-grown crops among which coffee, rubber and cacoa would be the most important. The idea of encouraging the immigration of European planters lingered on for about 30 years but their arrival was hindered by poor communications within the protectorate, by the slow progress of the survey of *mailo* (freehold) land allotted to the Buganda chiefs by the 1900 agreement and by the greater temptations offered to settlers in Kenya. Furthermore, Hesketh Bell, commissioner in 1905–07 and governor in 1907–09, encouraged by the promise shown by good-quality peasant-grown cotton introduced jointly in 1904 by K. E. Borup of the Church Missionary society and by the Uganda government, laid down the policy of developing the protectorate primarily as an African country. The trade of the protectorate, however, was developed and thereafter largely carried on by a number of European companies and numerous Asian traders. In the agreement districts the British mere able to exercise considerable control while retaining the outward forms of the traditional governments. Elsewhere effective administration was gradually extended by means of district officers working at first with the assistance of Baganda agents and later through a civil service of "chiefs" created by the protectorate authorities. On April 1. 1905, the responsibility for Cganda was transferred from the foreign office to the colonial office. Largely through the efforts of Hesketh Bell the construction of a network of all-weather roads was quickly undertaken. The railway from the coast had reached Kisumu at the end of 1901 and the rest of the journey to Uganda depended upon the marine service on Lake Victoria. By 1913 the Busoga railway had opened up the cotton-growing territory of the Eastern province, thereby creating a challenge to the previously overwhelming predominance of Buganda in the affairs of the protectorate. From 1915, largely as a result of the great output of cotton, Uganda was able to dispense with a grant in aid from the imperial government. This progress continued in spite of a serious sleeping sickness epidemic between 1901 and 1907.

From World War I to World War 11.—After a few skirmishes on the German border to the southwest World War I affected Uganda chiefly by the demands it made upon its manpower and the limitations it imposed on its trade. But the virility of the peasant-grown cotton industry revived the protectorate's economy in the mid-1920s. A lesson had been learned, however, and the agricultural department, set up as an independent body in 1910, encouraged peasants to grow other economic crops, particularly coffee. Coffee had also become the main crop of the European planters. Cacoa had failed in Uganda, and the decline in the world price of rubber had discouraged its planting on a large scale. A temporary ban, which in practice became permanent. was placed on the sale of land to Europeans in 1916 and made it clear that Uganda offered little future to large numbers of foreign planters although there was a boom in tea planting by Europeans in Toro district in 1926–27. In 1924, also, the first sugar refinery in Uganda was opened by an Asian businessman. The discovery of tin in Ankole in the 1920s raised hopes of a new field for European investment.

Progress was also made in other spheres. In 1920 an order in council empowered the creation of executive and legislative councils. In the same year a new currency was introduced based on the East African florin which replaced the rupee as the standard coin of the three East African territories and was itself replaced in the following year by the East African shilling. In 1925 an education department was created, primarily to assist the missions in a field which they had pioneered and in which they were still doing excellent work. The question of creating a federation of the east and central African territories gave rise to considerable opposition throughout the 1920s, especially in Buganda where fears were felt for the security of the 1900 agreement. In 1929 a railay linked the two Eastern province centres of Tororo and Soroti and the opening of the Nile bridge at Jinja in 1931 completed the important rail link between Kampala and the coast. In 1933 an agreement was made between the protectorate government and the ruler of Bunyoro along the lines of those made with certain other districts at the beginning of the century.

World War II and the Postwar Years. — During World War II the demand for food for export compelled Uganda to abandon its original idea of concentrating simply on being self-supporting so far as food was concerned. Large stocks of timber were also contributed to the war effort, and once again heavy demands were made on the protectorate's manpower. By the end of the war an interest had awakened in politics among some of the Africans, and largely as a result of the activities of political agitators riots took place in Buganda in 1945 and 1949. The first three African members were appointed to the legislative council in 1945, and the number was increased to eight in 1950. The first unofficial member of the executive council was appointed in 1946. Equally important steps were taken toward the development of responsible local government as a result of the African Local Governments ordinance of 1949 and the District Administrations ordinance of 1955. A source of mistrust, however, was the constitution of the East Africa high commission in 1947. It was suspected by some as a move toward political federation.

After the mar, at the invitation of the governor, Sir John Hall (1944–51), E. B. Worthington drafted a ten-year development plan for the protectorate. Investigations had shown great promise for the development of copper mining. and an extension of the railway was authorized from Kampala westward to the mining area. Work was also begun on the construction of a hydroelectric plant at the Owen falls on the Nile at Jinja. The scheme was inaugurated by Queen Elizabeth II during a visit in 1954. The high world price of cotton and coffee was bringing great profits to Uganda. A feature of the postwar period was the successful encouragement by the protectorate authorities of African co-operative marketing of produce. Sir Andrew Cohen appointed a committee to make recommendations on African education. Further constitutional reforms increased the unofficial representation in the legislative council in 1954. But these changes were overshadowed by a clash between the protectorate government and Kabaka Mutesa II of Buganda over the latter's constitutional position. This led to the withdrawal of recognition from the kabaka by the British government in Nov. 1953. During 1954 a committee elected by the Buganda Zukiko (parliament) sat at Namirembe, near Kampala, under the chairmanship of Sir Keith Hancock, to make recommendations regarding the future constitutional position of the kabaka. The committee proposed amendments to the 1900 agreement which would make the kabaka a constitutional ruler. The governor proposed the further enlargement of the legislative council from 56 to 60 members of whom 30 should be Africans. He also recommended the introduction of a ministerial system for the protectorate to include five unofficials as ministers of whom three should be Africans, He stated that there would then be no further change in the constitution for six years. The governor announced that if the Zukiko accepted the recommendations as a whole, they would be free to elect a new kabaka or to request the return of the exiled kabaka. (K. I.)

THE PEOPLE

At the 1948 census Africans in the protectorate numbered 4,917,555, Asians 36,696, Europeans 3,448. In 1954 it was estimated that the African population had increased to 5,350,000, Asians to 50,300 and Europeans to 7,000. The density of population in Uganda is 62 per square mile, the highest being in Kigezi (201) and the lowest in Karamoja (11).

The administrative capital of the protectorate is Entebbe (pop. 7,942), lying on a peninsula projecting into Lake Victoria in 0° 4′ N.. 32° 27′ E. About 20 mi. N.N.W. of Entebbe is Kampala, the capital of Buganda and an important commercial centre. Before World War II, its population was 8,000; after 1945, its growth was phenomenal, the population being 24,200 at the 1948 census and in 1953 estimated at 40,000. The town is built on seven steep hills. The town residence of the kabaka and the buildings of the lukiko are on Mengo hill. Port Bell, 7 mi. distant, is Kampala's lake port. The next most important town is Jinja (pop. 19,200), a cotton and transport centre which expanded greatly in the 1950s with the development of the Owen Falls hydroelectric scheme.

Ethnology. — The indigenous population may be divided into the Bantu-speaking negroids, the Nilotic negroes, and the Nilo-Hamites. In addition, there are people of Hamitic origin, the Bahima, who differ physically from the Bantu speakers among whom they live, but who have adopted their language. The "Bantu line" runs through the centre of the protectorate; south of this imaginary line, the people are almost entirely Bantu-speaking. Among them are the primitive tribes of the Ruwenzori and Lake Albert region (Baamba and Bakonjo), who have a strong infusion of pygmy strain and resemble the forest negroes of the Congo, and another aboriginal tribe (Bagishu) living on the slopes of Mt. Elgon. The most numerous group are the Baganda (17% of the African population of the protectorate), followed by the Basoga, who resemble them closely and speak a dialect of the Luganda language. The Banyankole speak Lunyoro and include both the Bahima pastoralist aristocracy of Hamitic origin, and the Bairu peasant or serf class. Other tribes speaking Lunyoro are the Banyoro and Batoro. Uganda north of the Victoria Nile is inhabited by Nilotic negroes or Nilo-Hamitic tribes; among the Nilotes or Luo are the Acoli. Alur, Lango and Jopadhola, while the Nilo-Hamitic peoples include the Iteso and the Karamoja group. such as the Karamojong. The languages spoken may be classified broadly as Bantu. Luo, Bari and Madi. Of the former, Luganda is the most important and is the lingua franca of the protectorate (though Kiswahili, the language of the east African coast, is widely understood and a knowledge of English is common, especially in Buganda). Lunyoro is spoken over a wide area, from the junction of the Victoria Nile with Lake Albert to the southern shores of Lake Victoria over the Tanganyika border. The Bakonjo of the Ruwenzori region have their own language, while in the southwest of Kigezi the Rundi language is spoken. The Alur, Acoli. Lango, etc., speak Luo or Gang. A Nilo-Hamitic group along the southern borders of the Sudan (the Kakwa and Kuku) speak Bari, a Hamitic language, while Madi is spoken in the north of West Nile district. Nilo-Hamitic languages are spoken by the Iteso, Karamojong, Sabei, etc.

In Buganda court and clan traditions are better preserved than elsewhere. The dynasty can be traced back through 23 generations, probably to the early 15th century. Its legendary founder, Kintu, may perhaps have been of Hamitic descent. The term Hamitic, strictly a linguistic one, is used to imply people with Caucasoid or Mediterranean physical features. The aboriginal inhabitants of Uganda were presumably of pygmy type, and there has been a complete assimilation between the Hamitic and Negro element. In the Lunyoro-speaking parts, the amalgamation was less complete than in the case of the Luganda-speaking areas, and the division between the Hamitic pastoral class and the Bantu-speaking agriculturalists has broken down only recently The former (the Bahima) are characteristically very tall and lean, with fine bone structure, long, narrow faces and noses, with reddish-brown skins; these cattle keepers contrast strongly with the prognathous negroid agriculturalists. Before the foundation of the royal Buganda dynasty, the semilegendary Bachwezi (probably Hamites) had made themselves supreme in the country now known as Uganda. During the late 15th century they were ousted by a Nilotic invasion from the north which brought the present dynasty (the Babito) to Nyoro country and left its traces in the physical appearance of the population. Over hundreds of years there was incessant warfare between the Baganda and the Banyoro; during the 19th century the latter gradually decreased in power and territory and their southern provinces were claimed by Buganda and Toro. Until the coming of the European, bark cloth was worn as a rule, especially in the western forest lands, while goat and sheep skins were more characteristic of the eastern savanna country; many tribes were entirely naked. In Buganda the men commonly wear an ankle-length cotton garment (the *kanzu*) with a European jacket, and the women long cotton dresses. Christianity has been adopted everywhere in Buganda.

Education. — African education remains largely in the hands of voluntary religious agencies under the general direction of the government. Makerere college, at Kampala, received recognition as a university institution in 1949, when courses were initiated to lead to University of London degrees. Most of the undergraduates are Africans.

Administration. — The protectorate is administered on crown colony lines; the governor is assisted by an executive council and (since 1921) by a legislative council. For more than 20 years, the legislative council had no representation of African interests, but by 1950 the African members equalled the European and Asian nonofficials together. Most African members are elected by their district councils, but those from Buganda are nominated by the governor because of the independent attitude adopted by the *lukzko*. In 1954, the legislative council consisted of 17 official members (all of the colonial service), 28 representative members (14 of whom were Africans, 7 Europeans and 7 Asians) and 11 "cross-benchers" who could speak and vote freely except on issues of confidence.

The executive council deals with important questions of policy; it includes six nonofficial members (two each of Europeans, Africans and Asians). The Buganda government collects taxes and deals with its own administration. Similar arrangements to those of Buganda (in which the kabaka is assisted by a ministry and the lukiko) exist in the states of Bunyoro, Ankole and Toro. In regions where no well-defined native state existed, administration under recognized chiefs has been built up wherever possible.

ECONOMY

Agriculture. — Agriculture and livestock form the basis of the protectorate's economy: 90% of the population is engaged in farming or in trades dependent on it; 6,500,000 ac. (10,000 sq.mi.) is cultivated and 75% of the country's income is derived from the land. Land is not alienated to non-Africans except for residential purposes or where it is judged that agricultural or industrial undertakings will promote the economic or social welfare of the inhabitants. There are three staple diets among the Africans: plantains (bananas) in the wetter areas around Lake Victoria in Buganda; grain, chiefly millet, with peas and beans, on the drier plains and uplands of Ankole, Toro and Bunyoro; and the diet of milk and blood of the pastoralists of southwest Uganda, which is now supplemented by grain and other foods. Sweet potatoes are grown everywhere, while cassava, sugar cane and maize in the south are other common food crops.

African cultivation is still based mostly on the hoe, though tractor hire services are now in great demand. Except for the initial clearing of the land, the women do all the work of hoeing, planting and harvesting. Ever-increasing measures are being taken to combat soil exhaustion and erosion; dams and boreholes are being constructed in large numbers. There were 2,750,000 cattle in the protectorate in 195j, mostly of the short-horned zebu type, but including also the long-horned cattle of Ankole; there were 3,500,000 sheep and goats. Cattle keeping and ox ploughing is only possible in tsetse-free areas. By the late 1940s, the tsetse fly area had advanced to one-third of the land area of the protectorate, but following the formation of the tsetse control department in 1947, more than 4,000,000 ac. were reclaimed by 1955. Locust control is also very costly.

More than half the total cultivated acreage is under food crops for domestic consumption; the remaining area is under cash crops of which the most important are cotton: coffee. tobacco, maize and oil seeds (the last two are exported only after internal needs have been met); 1,500,000 ac. are maintained annually under cotton. In 1952, the exports totaled 377,200 bales, valued at £29,942,764. Of the 140 ginneries working during the 1952–53 season, most were owned by Indians; 8 out of an agreed total of 20 ginneries passed to African co-operative unions in 1953.

Coffee was first exported from Uganda in 1902. In 1952, 39,426 tons were exported, valued at £12,345,092. Tobacco is cured by fire. air and flue; in 1953, 3,160 tons were cured. Of the oil seeds. peanuts are the most important; more than 80,000 tons are produced annually, of which more than 10,000 tons are surplus to internal food requirements. Tea grown in Cganda is not of the highest quality, but local African consumption of this commodity is rising; in 1953, 8,000 ac. were planted with tea, yielding 4,500,000 lb. (an increase of 300% since 1939). The production of sugar cane (which matures all the year round in Uganda) was 47,972 tons in 1953; this was still not enough for domestic consumption: and no more exports of sugar were allowed. The maize crop in 1953 reached the record figure of 1,400,000 bags.

Trade and Industry. — In 1901, when trade returns were first compiled, the value of exports was about £50,000, the chief articles being rubber, ivory, skins and hides. From 1910 onward, cotton was the leading export, nhile coffee first figured to a notable extent during World War I. Between 1904 and 1917, exports increased from £60,000 to £1 076,000. Over the same period. imports increased from £190,000 to £1,296,000, cotton goods being the largest single item. Soon after the end of World War I, exports began to exceed imports in value. During World War II. the increase in world prices of cotton and coffee created a national wealth unknown before. Subsequently, there was a spectacular advance in the economic position: exports in 1946 amounted to £9,657,000; in 1952, they were valued at £47,222,802. Over the same period imports increased from £3,000,000 to £25,000,000. The fall in the price of cotton in 1953 is reflected in the value of Uganda's exports for that year — £33,378,662 (£14,000,000 less than in 1952, when the value of external trade reached an all-time record). Exports go chiefly to India, the U.K. and Germany. More than half the imports come from the U.K., followed by India and the U.S. Road vehicles and tractors, machinery and apparatus are the chief imports, followed by cotton piecegoods.

Before 1936 (when there was a marked recovery from slump conditions) the government of Uganda discouraged commercial enterprise. When war broke out in 1939, for instance, the importation of industrial machinery was on a very limited scale and textiles formed 31% of the total value of imports (in 1953, textiles formed only 16.5% of imports). After 1949, the demand for industrial machinery increased enormously as a result of the modernization of the cotton and coffee industries, the needs of the new hydroelectric scheme, the building of a cement industry and the development and mechanization of mining. The first electric power station was opened at Kampala in 1936; as late as 1948, the maximum demand of the only two power stations was only 1.600 kw. The hydroelectric scheme initiated at Jinja was expected to revolutionize industry in Uganda, as well as supplying power to Kenya. The Owen Falls dam, opened by Queen Elizabeth II in April 1954, would also serve to store water for the Sudan and Egypt. Ten turbines were to be installed, with a combined capacity of 150,000 kw. The dam is 2,500 ft. long and 100 ft. high and is about a mile from the now submerged Ripon falls where Speke discovered the Nile's source in 1862. New industries in the postwar period included metal working, cement manufacture, furniture making and brewing. A textiles mill at Jinja began production in 195j. Fisheries and crocodile trapping are worth £1,000,000 a year; the most important economic species of fish is Tilapia, which abounds in the lakes (Lake George is particularly productive).

Wolfram was the most important mineral in the 1950s, though world prices declined severely in 1953. Tin production was declining. Columbite-tantalite ores in Ankole and Kigezi were becoming increasingly important; gold production in Eastern province was also increasing. Mica! phosphate and lead are worked on a small scale. Large pyrochlore, magnetite and apatite deposits in the Sukulu hills were awaiting development in the mid-1950s. The Kilembe mines in Toro district (at the foot of Ruwenzori) anticipated a production of 18,000,000 lb. of copper and 900,000 lb. of cobalt a year (beginning in late 1955), which were expected to increase the value of the country's exports by £2,500,000 annually.

Finance. — Revenue is derived from customs duties, export taxes, income tax and African poll taxes. The figures for 1926 were: revenue £1,389,000, expenditure £1,295,000; in 1937, revenue totalled £1,959,534 and expenditure £1,740,887; in 1948. revenue was £6,405,000 and expenditure £6.530,000; in 1953, revenue amounted to £17,905,000 and expenditure £18,393,000. During 1953, the largest amounts in the history of the protectorate were spent on education (£1,838,677) and on medical services (£1,051,373). Of the total expenditure, urban services and public utilities accounted for 39%, social services 20.5%, administration 16% and the development of national resources 15.5%. The Uganda Development corporation is an essential part of the economic life of the protectorate.

Communications. — The public works department maintained 2,847 mi. of all-weather roads in 1953, mostly of murram or gravel, but including 220 mi. of bituminized highways radiating out of Kampala. Buganda and other local governments maintained a further 8.300 mi. of roads. some only passable in dry weather, for which they receive grants from the protectorate government.

Access to the sea at Mombasa (879 mi. from Kampala) was provided by the completion of the railway from that port to Kisumu on Lake Victoria in 1902 and thence by steamers across the lake. With the great development of the cotton trade after World War I, it became imperative to avoid transporting goods across the lake; a railway was built from Nakuru on the Mombasa-Kisumu line to a point on the Busoga railway (this was begun in 1921 and completed in 1928). Its usefulness was increased by the building of a railway from Jinja to Kampala in 1929. Extension of the railway westward from Kampala was begun in the 1950s to serve the Kilembe mines.

Uganda is also well served with air communications. (S. M. C.)

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UGRO-FINNISH LANGUAGES: see Finno-Ugric Languages.

UHLAND, (JOHANN) LUDWIG (1787–1862), German romantic poet, the author of historical ballads and lyrics of "folk" simplicity, was born at Tiibingen on April 26, 1787, and from 1802 to 1808 studied law, classical and medieval literature there. At Tübingen he wrote his first poems, and his *Vaterlandische Gedickte* (1815, 1817) was an effective collection inspired by contemporary political developments in Germany. In 1815 he also published another collection of *Gedichte;* nearly 50 editions of this appeared during his lifetime and to almost every one he added some fresh poems.

However, Goethe's prophecy that "der Politiker wird den Poeten aufzehren" (the politician will gobble up the poet) became increasingly true. From 1812 to 1814 he was secretary in the ministry of justice in Stuttgart and then worked as a barrister. He soon began to take part in the political struggles for the renewal of parliamentary democracy in Wurttemberg (*q.v.*). (Happily, his marriage in 1820 to Emilie Vischer brought him a fortune which enabled him to pursue his political and literary interests.)

From 1819 he represented Tübingen in the *Ständeversammlung* and from 1826 Stuttgart. In 1829 he was appointed professor in Tiibingen but when in 1832 the authorities refused him leave of absence to sit as a liberal in the *Landtag,* he resigned his chair (1833). In 1848 he was a member of the German national assembly in Frankfurt.

The national spirit of German romanticism inspired not only much of Uhland's poetry and his political services but also his researches into the literature of the German past. In 1810 he spent eight months studying manuscripts in Paris and in 1812 published the fruits of his work in his essay *Über das altfranzosische Epos*. In 1838 he withdrew from politics (except for his membership of the national assembly) and devoted himself to German philology. He was in fact the founder of modern German medieval studies and his works on *Walther von der Vogelweide* (1822) and *Minnesang* (1824) were contributions of permanent importance. In the field of German mythology and folklore he published *Der Mythus von Thor nach nordischen Quellen* (1836) and *Sagenforschungen* (1836) and he produced an edition of *Alte hoch-und niederdeutsche Volkslieder* (1844 *et seq.)*.

Uhland's fame, however, rests on his poetry. He uses the classical form developed by Goethe and Schiller but his style, with its naïveté, precision and grace, is his own. He is at his best in his historical ballads and romances ("Roland"; "Taillefer"; "Graf Eberhard"; "Bertram de Born," etc.). Some of his poems ("Ich hatt' einen Kameraden"; "Der Wirtin Tochterlein") have passed into the language as folk songs. Others ("Frühlingsglaube," "Schafers Sonntagslied") are best known in their settings by Schubert and other composers. Uhland also wrote two unsuccessful historical plays *Ernst, Herzog von Schwaben* (1818) and *Ludwig der Bayer* (1819). He died at Tiibingen on Nov. 13, 1862.

Uhland's collected works, ed. by H. Fischer, were first published in 1892 in 6 vol.

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UIGUR, the name of a Turkish tribe and dynasty who came from the east and ruled in Kashgaria from the 10th to the 12th century. They used a variety of the Syriac alphabet. *See* Turks or Turkic Peoples.

UIST, NORTH AND SOUTH, islands of the Outer Hebrides, Inverness-shire, Scot. (*See* also Hebrides, The) In the mid-1950s only seven of the islands were inhabited. The district of North Uist (pop., 1951, 2,221) includes the islands of North Uist (1,890), Boreray (7), Leiravay, Ronay, Grimsay (236), Baleshare (75), Kirkibost, Heisker, the Monach group 8 mi. W., Vallay composed almost entirely of shell sand, etc. The district of South Uist (pop., 1951, 3,764) contains South Uist (2,462), Benbecula (924), Wiay, Eriskay (330), etc. In 1951 90% of the people spoke Gaelic; in North Uist 129 and in South Uist 294 spoke Gaelic only.

The North Ford bridge was begun in 1955 between North Uist and Benbecula, which is linked to South Uist by the South Ford bridge built in 1940. A ferry service connects South Uist with Eriskay and Barra to the south. Regular steamers ply between Kyle of Lochalsh, Lochboisdale, Lochmaddy and Mallaig, and between Oban and Lochboisdale. The civil airport at Benbecula connects with Glasgow and with Stornoway and Inverness.

North List, with its deeply indented coast line, is 13 mi. from north to south and 17 mi. east to west; a road runs round the island. Ben Eavel, in the southeast, is the highest point (1,138 ft.) and Loch Scadavay the biggest inland loch. On the east is swampy moorland, but the west is more fertile. The chief industries are cattle and sheep rearing, weaving and lobster fishing; in 1955 a seaweed-processing factory was begun. There are many archaeological remains. Lochmaddy, on the east coast, is the chief village.

South Uist is 22 mi. from north to south and $7\frac{3}{4}$ mi. in extreme width; a road runs the length of it. The east side, where Ben More rises to 2,034 ft., is mountainous and has poor soil with much peat and heather and a very indented coast line, but on the west is a belt of good arable land. Agriculture—mostly stock raising—is the main industry. The many fresh-water lochs are well known to anglers, and the sea produces lobsters, herring and whitefish and also seaweed from which chemicals, cattle-feeding stuffs, etc., are extracted. Tweeds are woven in the island. Lochboisdale, on the east coast, is the chief village.

Along the Atlantic coasts of most of the islands are great stretches of shell sand. Gray seals breed on the shores and graylag geese inland. There are many sea birds, ducks and waders.

UITENHAGE, a city of South Africa, 21 mi. from Port Elizabeth. Pop. (1951) 38,748, including 14,272 whites; 16,942 natives; 373 Asiatics; and 7,161 coloured. The town was founded by De Mist in 1804, on the Zwartkops river. Water courses flow along the sides of the streets, which are lined with trees. On the banks of the river are two large wool-washing establishments. In the town are railway workshops, the main industry of the place.

UITOTOAN (Witotoan), South American Indians of southeastern Colombia and adjoining Peru speaking a branch of the Macro-Tupi-Guarani linguistic phylum. Although settled farmers, the several Uitotoan groups were more primitive culturally than most Amazon basin Indians. They lacked canoes, had rudimentary fishing techniques and made cloth of bark.

A village consisted of about 100 persons related through the male line and occupying a single large house. The use of hollow-log signal drums, blowguns, and bark cloth have interesting old world parallels. (J. H. Sd.)

UJIJI, a town of Tanganyika, on the east side of Lake Tanganyika. African pop. (1957) 11,739. Ujiji was the meeting point of merchants and the terminus of a caravan route from Dar Es Salaam. The Zanzibar Arabs made it their headquarters in the first half of the 19th century and it became a slave and ivory mart. In 1858 Richard Burton and J. H. Speke reached Ujiji, being the first white men to see Lake Tanganyika. David Livingstone, coming from the south, reached *Ujiji* in 1869, and it was there that H. M. Stanley found him on Oct. 28, 1871. The first steamer on the lake was launched at Ujiji in 1884. Soon afterward it became part of German East Africa and was chosen as the lake terminus of the railway (completed in 1914) from Dar Es Salaam. Ujiji harbour has become very shallow and the terminus of the railway is at Kigoma, 4 mi. to the north. Ujiji was occupied by Belgian Congo troops in 1916, and in 1921 was transferred to Great Britain as part of the mandated territory of Tanganyika. It is the centre of the lake fishing trade.

UKRAINE. A soviet republic of southeastern Europe bounded on the south by the Black sea, on the southwest by Rumania and the Moldavian Soviet Socialist Republic, on the west by Rumania, Hungary, Czechoslovakia and Poland, on the north by Byelorussia and on the northeast and east by the Russian Soviet Federated Socialist Republic.

Physical Geography. — Underlying much of the country is the granite gneiss Azov-Podolian or Ukrainian shield which constitutes the structural foundation on which Palaeozoic and later geological formations were laid. This shield has a large outcrop in the Azov heights but is only revealed elsewhere in the deeper valleys of the Podolian plateau. Palaeozoic rocks with important coal measures are found in the Donets region where an east-west anticline bringing lower Carboniferous rocks to the surface is flanked by synclines containing coal. The principal surface structures, however, are the series of late Cretaceous and Tertiary strata dipping southward as cuestas sloping gently toward the Black sea. From the Don valley these plateaus are in successively younger strata; Cretaceous gives way to Eocene overlooking the Don, Oligocene in the Donets plateau and overlying the Podolian part of the shield, and Mio-Pliocene in the south.

From the point of view of surface relief, the Ukraine falls into three major divisions; part of Polesie, the marsh and forest zone in the north: the plateaus comprising most of the country, and a section of the Carpathians in the southwest. Polesie is a region of swamps, lakes and meandering rivers continuous with the Pripet marshes on the north, and with the lower similar land on the left bank of the Dnieper north of Kiev. The area contains much fluvioglacial sand, some in the form of fossilized dunes of the Pleistocene period. Pine grows on the sands, but isolated islands of oak-spruce forest are more characteristic of the region as a whole. On peat soils Pontic azalea (Rhododendron *flavum*) occurs.

The Volhynian-Podolian plateau forms the largest unit in the relief of the Ukraine. It rises generally to about 1,300 ft. in the west where also is a karstic region of Miocene reef limestones. River valleys cut deeply into the plateau often 300 ft. below its surface, exposing the crystalline rocks of the shield. At Krivoi Rog rich haematite ores appear in the Ingulets valley and in the Dnieper valley manganese at Nikopol. Thick loess. on which forms the rich black-earth soils, overlies the plateau and particularly where the vegetation is disturbed by deforestation or overgrazing, it is easily eroded into vertical-sided ravines. On its lower left bank the Dnieper has cut several terraces. and extensive flooding in spring helps to confine agriculture to the plateau tops. Spurs from the central Russian uplands enter this Dnieper lowland from the north and are widely covered with glacial sands, moraines and loess. Eastward again the Donets 'heights reach 1,184 ft. forming a rolling plateau, once an island of forest in the southern steppes but now cleared for agriculture and a rich source of coal and salt.

Toward the south the plateau slopes down to the Black sea lowlands, a monotonous flat plain, interrupted here and there by ravines and presenting to the sea a cliffed coast sometimes broken by stretches of lagoons protected seaward by sandspits. Sands are widespread on the lower left bank of the Dnieper and its estuary. In southeastern Ukraine the coastal lowlands rise quickly to Azov heights, an extensive outcrop of crystalline rocks, rising to more than 1,000 ft.

The vegetation in the plateau zones varies from forest steppe in the north to true grass steppe in the south and east. The typical plant assemblage in the forest steppe is oak-ash forest with groves of hornbeam, though on sands, pine is characteristic. Alternating with the forest, and probably formerly dominant, are areas of meadow steppe, in which broad-leafed grasses form a continuous cover in the moister north, becoming more tussocky southward. In marshy parts, sphagnum, cotton sedge, cranberry and other northern plants are found. Elk, roebuck, squirrel and marten are representative among the fauna, but human settlement continues to cause the wealth of wild life to diminish.

In the true steppe narrow-leafed grasses (*Stipa* species), fescue and *Koeleria gracilis* and many polyns (Artemisia) constitute the main cover. Forest patches occur on higher damper tracts as formerly on the Donets plateau but are more common on the floodplains (poplar, willow, elm, maple and alder) and sands (pine).

The Carpathian mountains (*q.v.*) lying within the Ukraine may conveniently be divided into the foothills in the northeast, the Carpathians proper, and a small section of Transcarpathia comprising part of the upper Tisa valley. Some oil, natural gas, salt and potash are found in the Carpathian Ukraine. The hills are thickly wooded; beech in the foothills merges into mixed forest between 1,000 ft. and 2.000 ft.. above which comes spruce until in the highest parts above 4,000 ft. subalpine meadow occurs. In the Tisa valley oak forest is more usual. An abundant fauna persists in the forest; *e.g.*, bear, roebuck, lynx and wolf.

The climate of the Ukraine is continental, tempered in the south by the Black sea and proximity to the Mediterranean. Winters are cold, the north having 120 days below freezing point, and only the Black sea coast fewer than 50 days. There snow lies 40 days in the year, the figure increasing to 100 in the north. The January mean increases from 21° F. at Kiev to 26° at Odessa. The heat of summer is best expressed in the July mean temperature of Kiev (66.7") and Odessa (72.7°) and in the fact that all the Ukraine has more than 30 days with temperatures above 68°, and much of it twice as many. Rainfall is abundant only in the Carpathians (40–60 in.), the sea coasts having less than 16 in., the north more than 20 in. and Kiev 21 in. The summer months show the highest fall, but the Black sea coast has a secondary maximum in winter, caused by the penetration of Mediterranean influences.

(B. L. C. J.)

HISTORY

Kievan **Rus.**—In the territory known in the 20th century as the Ukraine there existed in the 9th century a political organization called *Rus*, which belongs to the history of both the Russian and Ukrainian nations. It originally covered the areas of Kiev (Kyiv), Chernigov and Pereyaslavl, under the suzerainty of a duke of Varangian origin. These Varangians were called Rus by the surrounding Slavonic tribes. The name was borrowed from the Finns for whom the people from the other side of the Baltic were Ruotsi. The conquerors became Slavicized. St. Vladimir, who accepted the Christian faith from Byzantium in 988, was no longer a Varangian konung but a Slavonic knez or duke. This Kievan state extended westward and northward during the 11th and 12th centuries but was destroyed in the Tatar invasion of 1237–41 (see RUSSIA).

A century before the fall of the Kievan state two principalities existed with capitals at Wlodzimierz (Wlodzimierz-Wolynski or Volodymir) in Volhynia and Halicz (Halych) on the Dniester. Prince Roman of Volhynia, a direct descendant of St. Vladimir, united the two principalities in 1199 and founded a local dynasty which became extinct in 1323. The succession passed, by family ties, to a Polish prince of the Piast dynasty, Boleslaw of Mazovia, and, in 1340, to King Casimir the Great, who incorporated into his kingdom the principality of *Galiciae* et Lodomeriae.

Polish Expansion. — Meanwhile, Lithuania was extending rapidly eastward and southward. The dynastic union of Poland and Lithuania in 1386 opened up the Ukraine to Polish expansion. The frontier moved steadily eastward across the vast, sparsely populated *ukraina* (u-"at," *-kraj* "land" or "border"). A new social order was also being created, for the peasants were subject to their local lords for whom they were obliged to work. But it was easy for men to escape farther southeast into the great no man's land, and such a fugitive was called *kozak*, an adaptation of the Turkic word kazakh, meaning "outla " or "adventurer." These Cossacks (*q.v.*) were escaping "beyond the cataracts" (za porohy) on the lower Dnieper. Thus was born the *Zaporizhska* Sich or Zaporozhian clearing.

At the beginning of the 16th century, to protect their states against the incursions of the Tatars, both the Polish kings and the Muscovite grand dukes started to organize military colonies manned by the Cossacks; at the end of that century the Dnieper and the Don Cossacks alike owned land and led a settled life. When the Polish-Lithuanian union became a real one in 1569, the Ukrainian territory was separated from Lithuania and incorporated into Poland. The Cossacks believed that as warriors they were free from all serfdom. But for the estate owners Cossacks escaping to Zaporozhe were rebels and by trying to enforce obedience the landowners aroused resentment. This social antagonism had also a religious foundation, for landlords, sheriffs and magistrates were almost exclusively Roman Catholics. Slowly a national separatism was being born. This evolution was not stopped by the religious union achieved by the synod which met at Brzesc (Brest-Litovsk) in 1j96. Nine out of ten Orthodox bishops recognized in matters of doctrine the full primacy of the Holy See, but they retained the ancient oriental rite. As a result of the union of 1596 the population of the Ukraine became divided into three religious groups: the Roman Catholics of the Latin rite, who were generally identical with Poles; the Uniate Roman Catholics, who often called themselves gente Ruthenus, natione *Polonus;* and the Orthodox (*i.e.,* the Cossacks). From 1578 there existed a small standing force of "registered" Cossacks in Polish service, while all others were counted either among the feudal peasantry or formed the so-called self-governing Zaporozhian Cossacks. In 1630 the registered Cossacks were increased to 8,000 and the claims of the Orthodox population were in part fulfilled by dividing the high offices of the church between Uniates and Orthodox. But when Poland built the fortress of Kudak at the cataracts to keep the Sich in dependence, rebellions broke out between 1635 and 1638, but were all suppressed. The Polish sejm in 1638 passed an act reducing the registered Cossacks to 6,000 and aiming at the suppression of self-governing Cossacks.

The Chmielnicki Insurrection. — An officer of registered Cossacks, Bogdan Khmelnitsky or Chmielnicki (*q.v.*), who had suffered injustice at the hands of a local Polish official, went "underground" in 1646 and two years later was elected hetman (commander in chief) of the Zaporozhian Cossacks, gathered several thousand men, took Kudak by surprise, obtained help from the Tatars and in May 1648 defeated the Poles in the battles of Zhovti Vody and Korsun. He moved into Poland, won a fresh victory on Sept. 23 at Pilawce, took Lwow and besieged Zamosc. The slaughter of landlords, of the Latin and Uniate clergy and of the Jews spread throughout the conquered countryside. In the meantime, the king of Poland promised that he would send a commission of inquiry to the Ukraine. The hetman stopped fighting and in October entered Kiev to be greeted as liberator.

Meanwhile, in Warsaw, the party of conciliation was opposed by all the Ukrainian magnates, who were for repression by force. In March 1649 Chmielnicki resumed operations. The Poles again suffered defeat and in August, at Zborow, the king reached an agreement with Chmielnicki by which the number of registered Cossacks was raised to 40,000 and all officials of the crown in the provinces of Kiev, Chernigov and Bratslav were to be Orthodox. The Zborow agreement was criticized by both the Polish gentry and the Cossacks, the former objecting to the creation within the frontiers of Poland of what amounted to an autonomous Ukrainian principality and the latter resenting the return of Polish landlords to their estates. Since a ferment was spreading among the Cossacks against Chmielnicki's statesmanship, he started another campaign in the spring of 1651, but in June was defeated at Berestecsko. On Sept. 28. at Bila Tserkva, the hetman was compelled to accept a new agreement: the registered Cossacks were reduced to 20,000 and the provinces of Chernigov and Bratslav ceased to be Cossack territory. The Cossack rada (council) also rejected the new agreement, resolving in May 1652 to renew hostilities against Poland and to ask Tsar Alexius (Aleksey) Mikhailovich for protection.

Search for a Protector. — The second Romanov saw his chance to regain the Kievan Rus which the Muscovites called Malo-Rossiya (Little Russia). On Oct. 11, 1653, the Moscow council of state decided to grant Chmielnicki's request and to declare war on Poland. A deputation headed by Vasily Buturlin met Chmielnicki and the secretary-general of the rada, Ivan Vyhovsky, at Pereyaslavl. On Jan. 18, 1654, took place the act of submitting the Ukraine to "the tsar's hand," with the general reservation "of all rights and privileges" for the Cossacks. A Russo-Polish war, complicated by Swedish aggression, followed and was ended by an armistice in 1656. On Chmielnicki's death in 1657 Vyhovsky succeeded him as hetman. The new hetman decided to throw off Russian protection. On Sept. 16, 1658, an agreement was signed at Hadyach which created a commonwealth of the Poles, Lithuanians and Ruthenians. A second Russo-Polish war followed. It lasted eight years and was ended on Jan. 31, 1667, by the treaty of Andruszow, under which the Ukraine was partitioned between Poland and Russia along the Dnieper, and the two governments outlawed Petro Doroshenko, the then hetman, whom neither trusted.

Doroshenko conceived the plan that the Ukraine should form a vassal state of the Porte, and in Dec. 1668 Sultan Mohammed IV took the Ukraine under his protection. In 1672 a Turkish army marched against Poland, took Kamieniec Podolski and on Oct. 18 imposed the peace of Buczacz by which the "right-bank" or Polish Ukraine came under Ottoman suzerainty. Only in 1684, a year after his spectacular victory of Vienna, was John III Sobieski able to clear the Polish Ukraine of the Turks, but they remained at Kamieniec until 1699.

In the "left-bank" or Russian Ukraine, Ivan Mazepa (*q.v.*) became hetman of the Cossacks in 1687. He served Tsar Peter I, but planned to unite the two parts of the Ukraine. In 1708 he concluded an alliance with Charles XII of Sweden according to which the Ukraine was to become an independent state with Mazepa as ruler. Peter's victory over the Swedes at Poltava (June 27, 1709) put an end to this new Ukrainian orientation. There were three further hetmans, all of them Russian nominees. Kyrylo Razumovsky, the last, was the younger brother of Elizabeth Petrovna's morganatic husband. Catherine II forced him to resign in 1764.

Under Tsarist Rule. — In 1775 the Sich was suppressed, the Cossacks were disarmed and the Russian Ukraine was divided into three gubernyas. In 1793, at the second partition of Poland, the Ukraine was again united, but as part of Russia. Its political autonomy and even its name disappeared. In 1846 about 30 Ukrainian patriots founded in Kiev the secret Brotherhood of St. Cyril and St. Methodius. This marked the rebirth of Ukrainian nationalism. Its most prominent members were two historians, Mykola Kostomarov (1817–8j) and Panteleymon Kulish (1819–97), and Taras Shevchenko (1814–61), a poet, who in his poem The Dream accused Peter I of "crucifying" the Ukraine and Catherine II of "finishing off his victim." The brotherhood was discovered the following year, and its members were arrested and deported to other parts of Russia. In 1861, however, Osnova ("The Outset"), a periodical in Ukrainian, was authorized to appear in St. Petersburg, with Kulish and Volodymir Antonovich (1834–1908) as principal contributors. Two years later they returned to Kiev where a society called Hromada (Group) was formed. Their historical research led them to certain contradictory conclusions. Antonovich believed that placed between an autocratic Russia and an aristocratic Poland the Ukrainians represented a true democracy. Kulish, however, maintained that the Cossacks were anarchist rather than democratic. In 1876 the tsarist government forbade the use of Ukrainian in schools and for the printing of journals or books. Myhaylo Dragomanov (1841–95), a professor of Kiev university, moved to Geneva where he began publishing the Ukrainian periodical Hromada.

Galician "Piedmont." — After 1876, Lwow became the centre of Ukrainian nationalism. It was the capital of Galicia (*q.v.*), annexed to Austria in 1772, at the time of the first partition of Poland, and the name was thus extended far to the west, to include Cracow; in eastern Galicia, however, the rural population was mainly Ruthenian. The Vienna government had to recognize Polish supremacy in Galicia, but it also supported the Ruthenians. A Shevchenko Scientific society was founded in Lwow in 1873. Five years later the educational society *Prosvita* (Enlightenment) came into being. In 1890 a chair for the history of southeastern Europe was instituted at Lwow university and Myhaylo Hrushevsky (1866–1934), a Russian subject and a pupil of Antonovich, was appointed to this post. In 1898 he started publication of his ten-volume History of the *Ukraine-Rus* in which he defended the view that fhe Kievan Rus was the cradle of the Ukraine-Rus, while Moscow was the centre around which the Russian state was built. After 1905 the publication of journals and books in Ukrainian was again permitted in Russia and Hrushevsky returned to Kiev.

World War I and After.—In the eyes of the tsarist government the population of eastern Galicia and sub-Carphthian Ruthenia (*q.v.*) was "Russian." Count Gheorgy Bobrinsky, the newly appointed governor-general. affirmed this in Lwow (Lemberg) in Sept. 1914 when the Russian army entered the city. But tsarist Russia was defeated and plunged into revolution. The Ukrainians felt that once more history was presenting them with a chance to achieve unity and independence A National Ukrainian congress met in Kiev in April 1917 and elected a central council (rada) headed by Hrushevsky. On June 23 the rnda proclaimed that an autonomous Ukrainian republic had come into being with Hrushevsky as president. On July 16 a government was formed with Volodymir Vinnichenko (1880–1951) as premier and Simon Petlyura (1879–1926) as war minister. On Nov. 20, the rada announced the convocation of a freely elected Ukrainian constituent assembly. The Russian Communist government replied to this on Dec. 27 by forming a Ukrainian Soviet government in Kharkov. On Jan. 22, 1918, the rada proclaimed a "free and sovereign" Ukrainian republic.

On Feb. 9, 1918, the Central powers concluded a separate peace with this republic at Brest-Litovslr. On the following day the Communists captured Kiev, while the rada fled to Zhitomir. The German and Austrian armies occupied the Ukraine and soon came into conflict with the mda, which was too democratic for their liking. On April 24, they staged a coup d'état. appointing Pavlo Skoropadsky hetman of the Ukraine. After the collapse of the Central powers, a directorate of five, with Vinnichenko as chairman and Petlyura as commander in chief, assumed power in Kiev (Dec. 14, 1918).

Meanwhile, on Nov. 1, 1918, in Lwow, the last Austrian governor, Count Huyn, armed the Ukrainians, who proclaimed an independent Republic of the Western Ukraine. (See also POLAND: Poland Restored.) The Poles freed the town on Nov. 22, and the Ukrainian government headed by Evhen Petrushevych retreated to Stanislawow. There, on Jan. 22. 1919, the union of the two Ukraines was proclaimed; but on the same day the Red army reoccupied Kiev. While the directorate, now headed by Petlyura, moved to Vinnitsa, Christian Rakovsky (q v) formed in Kiev, on March 14, a government of a Ukrainian S S.R. In May 1919 the whole of eastern Galicia was in Polish hands and in the summer the Russian White army of Gen. A. I. Denikin started to advance toward Moscow. On Sept. 1 the White Russians and the Petlyurians entered Kiev, and the directorate suggested a common struggle against the Communists, but Denikin refused to negotiate with "separatists." Denikin was subsequently defeated, and on Dec. 20 Kiev was e acuated and almost the whole of the Ukraine was in the hands of the Red army.

On Dec. 28, 1919, Nicolai Lenin addressed an open letter to the workers and peasants of the Ukraine in which he recognized the equality of the Russian and Ukrainian peoples and suggested a treaty of alliance between the two. Such an alliance was concluded in Moscow on Dec. 28, 1920, and was signed by Lenin and Rakovsky; it was an act of incorporation, unifying the chief people's commissariats.

Petlyura retreated with the remnant of his army to Kamieniec Podolski and went to Warsaw to ask Marshal Joseph Pilsudski, head of the Polish state and commander in chief, for help. On April 22, 1920, Pilsudski signed a treaty of alliance with Petlyura, and three days later a Polish offensivestarted in the Ukraine. On May 6 the Poles occupied Kiev. Pilsudski dreamed of building a commonwealth of Polish, Lithuanian and Ukrainian nations and hoped that the Ukraine would answer Petlyura's call. It soon was obvious that it would not.

The fortunes of war forced Poland to sign the Riga peace treaty (March 18, 1921) with the Communist Russian and Ukrainian governments. Eastern Galicia and Volhynia (*q.v.*) were recognized as part of Poland. On May 25, 1926, in Paris, Petlyura was shot by a Communist agent.

Ukraine in the U.S.S.R.—On Dec. 30, 1922, the central executive committee of the U.S.S.R. voted a plan of federation between the four original Soviet Socialist republics, the Russian, Byelorussian, Ukrainian and Transcaucasian. The final constitution was published on July 6, 1923. This was the period of the New Economic policy and, in the Ukraine, the period of Ukrainization. A Language act of Aug. 1, 1923, proclaimed the priority of Ukrainian over Russian and many Ukrainian *émigrés* decided to go home to help the process of Ukrainization. Hrushevsky had shown the way and was appointed president of the Ukrainian Academy of Science founded in 1918. In 1928 J. V. Stalin abandoned the N.E.P., stopped the policy of Ukrainization and introduced Russian as the second official language of the republic. In 1930 the first Ukrainian political trial took place in Kharkov: 45 intellectual leaders, headed by Serhiy Yefremov, were accused of high treason; 13 were sentenced to death; and the rest were deported. Hrushevsky was not tried but was deported and died in 1934. In 1931 the trial of the "National centre" was staged; this time the accused were politicians headed by Vsevolod Holubovych, and all were sentenced to death. Another trial followed in 1933, when the O.G.P.U. (Soviet secret police) purported to have discovered a military conspiracy: Yury Kotsiubinsky, deputy premier of the Ukrainian Communist government, and many others were shot, while Mykola Skrypnik, another deputy premier, committed suicide. None of their accusers nor any of the Ukrainian Communists who helped Moscow to purge the Ukraine of "bourgeois nationalism" survived. Two successive Ukrainian premiers, Panas Lyubchenko and Vlas Chubar, were shot in 1937 and 1939 respectively.

World War II and After.—Between World Wars I and II there existed in Poland an underground Ukrainian Military organization (U.V.O.), and the Organization of Ukrainian Nationalists (O.U.N.), both with Col. Evhen Konovalets (b. 1891) as leader. On May 23, 1938, he was killed in Rotterdam (Neth.) by a Soviet agent and was succeeded by Col. Andriy Melnyk. When Germany started World War II, differences of opinion as to the best tactics to employ created a split in the O.U.N. Stefan Bandera became the leader of the majority and Roman Shukhevych (Lt. Gen. "Taras Chuprynka") was appointed chief of the U.V.O. For years the Ukrainian Nationalists looked to Germany for the realization of an independent Ukraine. Now they hoped to provoke a Ukrainian revolution in the Soviet empire.

On June 30, 1941, shortly after the occupation of Lwow by the German army, the O.U.N. proclaimed the "restoration of the Ukrainian state" and formed a government headed by Yaroslav Stetsko with the idea of waging war against the U.S.S.R. Bandera, Stetsko and most of the "ministers" were arrested, however, by the Germans, who did not wage a war of liberation. Walther Funk, German minister of economics, declared in Dec. 1941 in Prague that the Ukraine, this "promised colonial land" had become accessible to "European" exploitation. Erich Koch, the German *Reichskommissar* for the Ukraine, went so far as to praise Stalin's forcible collectivization of agriculture. In a circular dated Aug. 25, 1943, he wrote that only through a collective farm system was it possible "to squeeze anything from the Ukrainians."

In 1943 Shukhevych formed an underground Ukrainian Insurgent Army (U.P.A.). He remained in the Polish Ukraine after the Soviet occupation and on March 4, 1950, was killed by the Soviet security forces at Bilohorshcha, near Lwow.

As a result of World War II, the Ukrainian S.S.R. considerably enlarged its territory. The Soviet army occupied the eastern parts of Poland on Sept. 17, 1939. On Oct. 22, 1939, a plebiscite was organized in the "Western Ukraine" in which, according to Soviet sources, 92.83% of the electorate went to the polls, while 90.93% voted for the official candidates to the people's assembly. The assembly met in Lwow on Oct. 28 and unanimously voted for the incorporation of eastern Galicia and Volhynia into the Ukrainian S.S.R. After the war, a Soviet-Polish treaty, signed in Moscow on

TABLE I.—*Areas and Populations of the Ukraine**

Territories	Area (sq. mi.)	Nationalities (in thousands)					
		Ukrainians	Russians	Poles	Jews	Others	Total
Pre-1939 Ukraine	171,930	20,772	6,780	joo	2,200	708	30,960
From Poland	34,749	4,350	30	1,850	550	169	6,949
From Rumania	8,031	740	50	100	150	525	1,565
From Czechoslovakia	4,981	653			85	112	850
Crimea	9,993	113	490		83	441	1,127
Totals	220,684	26.628	7,350	2,450	3,068	1,955	41,451

*Areas as given in the *Bolshaya Sovietskaya Entsiklopedia*, 1st ed , vol. 55 (Moscow, 1947). They produce a total slightly less than that given in another volume of the same *Entsiklopedia:* S.S.S.R. (Moscow, 1948). According to the latter source the total area of the Ukraine in 1947 was 222,625 sq.mi., which, together with the Crimea, would give 232,618 sq.mi. According to the 1957 year book of the same *Entsiklopedia* (Moscow, 1958) the area of the Ukraine is 232,046 sq.mi. Population estimates in the table are those of 1939 (*i.e.*, before the changes in its composition caused by World War II, namely such as compulsory transfers, mass deportations, war losses and extermination of the Jews remaining under German occupation).

Aug. 16, 1945, confirmed the new frontier. Sub-Carpathian Ruthenia had to be ceded to the U.S.S.R. by the Soviet-Czechoslovak treaty of June 29, 1945. Rumania was forced to accept a Soviet ultimatum of June 27, 1940, and cede Bessarabia (*q.v.*) and northern Bukovina (*q.v.*) to the U.S.S.R. The new frontier was confirmed by the Rumanian peace treaty signed in Paris on Feb 10, 1947. Northern Bukovina and the Bessarabian districts of Hotin and Izmail were incorporated into the Ukraine.

The most unexpected addition to the Ukraine was the transfer to it of the Crimea (*q.v.*). This Russian gesture was made on Feb. 19, 1954, to mark the 300th anniversary of the Russo-Ukrainian union. (See Table I.)

Government-in-Exile.— After the peace of Riga a Ukrainian government-in-exile was formed in Paris with Andryi Livytsky as president of the republic. After World War II this government moved to Munich. Ger. Livytsky died in Feb. 1955, and on March 6 the Ukrainian National council elected Stefan Vytvytsky as his successor.

Population.— The Ukrainians (Ukraintsy) formerly called Ruthenes (*Rusyny*) are an eastern Slavonic nation sometimes erroneously described as Little-Russians (*Malorosy*). (See UKRAINIAN LANGUAGE.) In physical type just under half the population is Dinaric (*i.e.*, tall, round-headed, long-faced and dark); just under a quarter is Alpine (*i* e., short, round-headed, round-faced and dark); and the remainder are Nordic, Mediterranean, Armenian or Mongoloid in various combinations.

TABLE 11.—*Population of Major Cities in the Ukraine*

City	1939	1959	City	1939	1959
Kiev (Kyiv)	846,293	1,102,000	Lugansk	213,007	274,000
Kharkov (Kharkiv)	833,432	930,000	Krivoi Rog	197,621	386,000
Odessa	604,223	667,000	Nikolayev	167,108	224,000
Dnepropetrovsk	500,662	658,000	Dneprodzerzhinsk	147,829	194,000
Donetsk	462,395	701,000	Simferopol	142,678	189,000
Lvov (Lviv, Lemberg)	318,000	410,000	Poltava	130,305	141,000
Zaporozhye	289,188	435,000	Sevastopol	111,946	148,000
Makepevka	240,145	358,000	Chernovtsy (Czernowitz)	109,698	145,000
Zhdanov	222,427	284,000	Gorlovka	108,693	293,000

There is a rich indigenous folk culture with influences from other Slavonic peoples and also from Rumanians and Hungarians Each area has its own particular costume, richly embroidered. Dancing, singing and storytelling are popular.

Within the pre-1939 frontiers of the Ukraine, the population by mid-17th century was estimated at 2,500,000, whereas at the time of the first Russian census of 1897 it had grown to about 23,500,000. According to this census, in the nine southwestern *gubernyas* later to form the Ukraine. 50% of the population were Ukrainians, 20% Russians and the remaining 30% Jews, Poles, Tatars, Germans, Rumanians, Bulgars, Greeks, etc.

The Soviet census of 1926 revealed a total population of 29,042,934 which at the next census of 1939 had risen only to 30 960,221. The total number of Ukrainians in the U.S.S.R in 1926 was 31,194,976, of whom 23,084,226 (74%) lived in the republic. The 1939 census revealed only 28,070,404 Ukrainians in the U.S.S R, but no indication was given as to what percentage lived in the Ukraine. On the optimistic assumption that the proportion was still 74%, this would give 20,772,000 Ukrainians, or 66.7% of its total population. The progress of industrialization caused a great increase of the urban population, which was 36% of the total in 1939 compared with 19% in 1926. This process, together with forcible deportations of Ukrainian peasants to Siberia, undoubtedly helped the Russification of the country. In 1959 the population of the Ukraine S.S.R. was estimated to be 41,869,046. The largest cities are given in Table II.

Religion.—Until 1654 the Ukrainian (Ruthenian) Orthodox Church was autocephalous. After the treaty of Pereyaslavl, the patriarch of Moscow assumed the right to appoint Ukrainian Orthodox bishops. All trace of autocephaly disappeared on the partitions of Poland Roman Catholics of the Uniate rite mere at first tolerated: but in 1834 persecution by the Russian administration began, and in 1874 this rite was abolished. On Jan. 1, 1919, the Central Ukrainian rada re-established the Ukrainian Autocephalus Orthodox Church. In 1929 the Soviet government suppressed it by arresting, deporting or banishing the bishops and clergy. Autocephaly was reinstated in the Ukraine in 1942, under German occupation, but it was again suppressed in 1945 and the Ukrainian Orthodox returned under the jurisdiction of the Moscow patriarch.

In 1945–46 about 4,750,000 Ukrainian Roman Catholics of the Uniate rite living in eastern Galicia, northern Bukovina and sub-Carpathian Ruthenia were forcibly converted to Orthodoxy and the members of their hierarchy were arrested and imprisoned. including Mgr. Iosyf Slipyi, metropolitan of Halych (Halicz) and archbishop of Lviv (Lvov), and nine bishops; 2,950 priests and 520 monks were deported.

Education.—In 1953 there were 30,400 primary and secondary schools with 6,500,000 pupils, and 592 vocational schools with 233,700 pupils; there were also 4 universities (at Kiev, Kharkov, Odessa and Lvov) and 140 other institutions of higher education with a total of 177,100 students.

Ukrainian Communist Party.— In 1925 Stalin sent his friend L. M. Kaganovich to Kharkov. then the capital of the Ukraine (it was moved to Kiev in 1945), to be secretary-general of the U C.P. which had to be cleared of unreliable elements. At that time only 39 Ukrainians in every 10.000 inhabitants were members of the party. as against 88 Russians and 155 Jews.

P. P. Postyshev, a Russian, who succeeded Kaganovich in 1928, was shot in 1938. From then (with a short interval in 1947) this key-post was occupied by N S Khrushchev and from Dec. 1949 by L. G. Melnikov, both Russians. In June 1953, A. I. Kirichenko, a Ukrainian, succeeded Nelnikov At the time of the 19th congress of the Communist Party of the Soviet Union (Oct. 1952), its Ukrainian section had 676.190 members, including only 20.145 in the western (*i.e.*, formerly Polish, Czechoslovak and Rumanian) regions of the Ukraine.

Economy.— The Ukraine is the richest republic of the Soviet Union. Before World War II, although covering only 2% of the total area of the C.S.S.R. and embodying only 18% of its total population, the Ukraine produced three-quarters of the sugar and

TABLE 111.—*Bread Grain Crops in the Ukraine*
(In thousand metric tons, 1931–35 average)

	Wheat	Rye	Barley	Oats	Total
Ukrainian S.S.R.		5,420	3,720		20,470
percentage of Soviet production		25%	56%	.	30%
Western areas*	1,020	1,530	680		4,100
Total	10,120	6,950	4,400	3,100	24,570

*Estimated production of those Polish, Czechoslovak and Rumanian provinces which were annexed to the Ukraine in 1939–45.

TABLE IV.—*Livestock*
(In thousand head, with percentages of U.S.S.R. livestock totals)

	1928*	1933*	1941†	1953†
Cattle	8,600	4,400	10,751 (19.9%)	11,717 (20.7%)
Pigs	7,000	2,100	9,059 (33.0%)	9,030 (30 8%)
Sheep and goats	8,100	2,000	6,364 (6.9%)	8,343 (7.5%)
Horses	5,500	2,600	4,573 (21.8%)	2,469 (16.4%)

*In pre-1939 territory. †Figures given by A. I. Kirichenko, the first secretary of the Ukrainian Communist party, in his report to the Central committee (Oct. 14, 1953).

30% of the bread grain crops in the U.S.S.R. (see Table III). However, no reliable data were to be obtained for agricultural production of the Ukraine after 1935. The livestock figures are given in Table IV.

So much decentralization of the constantly growing Soviet industry had been achieved that the share of the Ukraine in the Soviet economy was considerably smaller in 1951 than in 1913. (See Table V.)

TABLE V. — *Contribution by Ukraine to Sosiet Industrial Production*
(*In* thousand metric tons; electricity in million kw.hr.; with percentages of the total Soviet output)

	1913*	1940*	
Coal	22,760 (78%)	83,728 (50%)	93,775 (33%)
Iron ore	6,388 (80%)	18,900 (60%)	[illegible] (48%)
Pig iron	2,832 (68%)	9,183 (62%)	10,836 (49%)
Steel	2,300 (55%)	8,622 (47%)	10,174 (33%)
Electricity	452 (24%)	11,938 (25%)	16,713 (16%)

*Figures taken from the *Bolshaya Sovietskaya Entsiklopedia: S.S.S.R.*, (Moscow, 1948).
†Estimates based on a report of L. G. Melnikov, first secretary of the Ukrainian Communist party (17th congress, Kiev, Sept. 24–26, 1952).

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UKRAINIAN LANGUAGE. This is the lineal descendant of the colloquial language of Kiev Russia and is less like Russian than is White Russian. Indeed, the last forms the link between them, as it has transitional dialects to both. On the other hand, there is no transitional dialect between Ukrainian and Russian. Ukrainian dialectal characteristics occur in mediaeval manuscripts as early as the 12th century, especially those originating in the west. They become very marked after the destruction of Kiev in the 13th century and the gradual incorporation of considerable parts of Ukrainian territory in the Grand Duchy of Lithuania, The official language of this state was White Russian (Byelorussian) till this was displaced by Polish in the 16th century. White Russian and Polish were used mainly in legal documents at that time, and Ukrainian figured in writs and private usage as it had since the 14th century. In the 16th the Reformation impinged on Ukrainian, as on White Russian and Polish, religious literature. The 17th saw a Ukrainian form of Church Slavonic in wide use among nationally minded Ukrainian scholars. But at the 'same time a more colloquial form of this language was used for scholastic verse and interludes. It is out of this colloquial style that modern literary Ukrainian emerged at the end of the 18th century with the *Enejida* of I. Kotljarevśkyj. Since then the language, like modern White Russian, has been used not only for literature but for academic and administrative purposes. Like White Russian, it has a large body of Polish words and expressions, although here again the fundamental linguistic features are of independent development.

Phonetically Ukrainian differs from Russian in its itacism or intermediate vowel between *i* and *u* (something like the English i in "sit"); the use of bilabial w, written v and found finally and before consonants (cf. buv "was," vovk "wolf" with Russian *byl, volk*); the affricates dz and *dž;* the glottal fricative h, as in White Russian; chv for f in many instances; hardened labials and final r, as in White Russian (cf. krov "blood" with Russian krov'); long soft consonants (cf. korinnja "roots," *žyttja* "life" with Russian koren'ja, *žit'jo*); and the retention of final voiced consonants (cf. *gorod* "town" with Russian *gorot*). Phonologically we have the alternation of *i/o* and *i/e* as in the nominative-genitive singular *vil/vola* "ox"; *pič/peči* "stove" (cf. Russian *vol/vola; peč/peči*), the closer vowel figuring in the closed syllable; and, as in White Russian. the alternation of *h/k/ch* with *z/c/s* (cf. nominative singular *noha* "leg," locative *na* nozi, with Russian noga, *na noge*). Ukrainian morphology is distinguished by retention of the vocative singular (*e.g.*, iinko! "woman!"), the extensive use of forms of the Old Church Slavonic *ŭ*-declension (cf. genitive singular *snehu* < *snih* "snow" with Russian genitive singular *snega*), contracted adjectival forms in the feminine and neuter nominative singular (cf. *zelena/zeleno* "green" with Russian *zeljonaja/zeljonoje*), a new future made by compounding the infinitive with the present tense of the auxiliary "to have" (cf. chodytymu "I shall go" with Russian budu chodit'), and the absence of the t-ending in the present tense of first-conjugation verbs (cf. nese "he/she carries" with Russian nesjot). Syntactically a notable feature of Ckrainian is the impersonal neuter passive construction, which is found also in Polish, but not in Russian and White Russian (cf. *dveri vidčineno* "the door has been opened" with Polish dano *trzecią potrawę* "the third course has been served").

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UKRAINIAN LITERATURE. A literary language. so-called Church Slavonic came to Kiev from Byzantium with Christianity (988). The first original works were the chronicle of Nestor and the Kiev Lavra hagiography and sermons. Among prominent later works were The Discourse on *Law* and Grace of Metropolitan Ilarion (11th century); Pilgrimage of Abbot Danylo; and Instruction to Children by Volodymyr Nonomakh (12th century) and The Lay of *Igor's* Campaign (see RUSSIAN LITERATURE: Kievan Period). The sack of Kiev (1169) by Andrey, prince of Suzdal, and the Mongol invasion (1240) caused a transfer of cultural activity to Volhynia and Galicia. The colorful *Galician*-Volhynian Chronicle (1205–92) is a monument of this period.

Delayed influence of the Renaissance and Reformation in western Europe stimulated a cultural revival in the Ukraine, with new translations of the Gospel, establishment of the first university schools (collegiate edition of Bible in Ostroh, 1581) and a wealth of religious polemics. Ivan Vyshensky (d. 1625) was the outstanding polemist of the time. Poetic songs and the oral historical dumy appeared. A new Cossack aristocracy revitalized culture in Kiev, where Metropolitan Petro Mohyla (1596–1647) founded his academy in 1633. The Baroque literary period developed there, flowering especially in the 18th century. Prominent writers included the poet, dramatist and author of the monumental Lives of Saints, Dmytro Tuptalo (1651–1709); the master of interludes, M. Dovhalevsky; the epigrammatist, I. Velychkovsky (d. 1726); and the poet and philosopher Hryhory Skovoroda (1722–94). Literary language, still adhering to the traditional church style, turned more frequently to the vernacular in this period.

Classical literature at the time could not develop because of political reasons. Theofan Prokopovich (1681–1736), a dramatist and literary theoretician, became the political philosopher of Tsar Peter I. Ivan Kotlyarevsky (1769–1838), in his comedies and his travesty of Virgil's Aeneid, used the vernacular exclusively.

Kharkov university (1805) became the centre of romanticism. The ethnographic publications of N. Tsertelev (1819) and M. Maksymovych (1827–49), and the first attempts to interpret Ukrainian history scientifically (D. Bantysh-Kamensky), plus interest in history and folklore (as in the works of I. Sreznevsky) gave an impetus to romantic poetry: L. Borovykovsky (1806–89), A. Metlynsky (1814–70) and Mykola Kostomarov (1817–85) and, in Western Ukraine, Mykola Ustyanovych (1811–85). But it took the genius of Taras Shevchenko (1814–61) to breathe a new national spirit into romanticism and into all of Ukrainian literature. Panteleymon Kulish (1819–97), translator of the Bible and of Shakespeare, poet, historical novelist and essayist, enriched and developed it. Marko Vovchok (1834–1907), a prose writer, and I. Karpenko-Kary (1845–1907), playwright, ended the romantic period and introduced that of modern realism.

Modern Ukrainian literature was first headed by Ivan Franko (1856–1916), a great writer, and by the outstanding dramatist and poetess Lesya Ukrainka (1871–1913). Masters of impressionist prose were Mykhailo Kotsiubynsky (1864–1913) and Vasyl Stefanyk (1871–1936). The best in pure lyricism was written by O. Oles (1878–1944).

World War I, with the fall of tsarism and the Ukraine's struggle against Soviet Russia (1918–22), gave literature a further impulse. Pavlo Tychyna (1891–) was a new type of lyricist. Founded on Kievan tradition, a poetic school of neoclassicists appeared, revering antiquity and Parnassianism; it was headed by the erudite Mykola Zerov (b. 1890, deported 1933) and Maksym Rylsky (1895–), the most outstanding poet of the period. Masters of the modern novel were Valerian Pidmohylny (b. 1901, deported *c.* 1934) and Yuriy Yanovsky (1902–54); a master of drama was Mykola Kulish (b. 1892, deported *c.* 1934).

The Soviets began suppressing Ukrainian literature in 1923, and by 1929–30 there was a mass liquidation of authors and removal of their works from circulation. The novelist and pamphleteer Mykola Khvylovy (1893–1933) made heroic attempts from 1925 to 1930 to stem this activity conducted in the name of Communism and to organize an opposition but in the end committed suicide.

As a result, literature could develop freely only in the west (Lwow and Prague). Prominent writers beyond the boundaries of the Soviet Ukraine were M. Cheremshyna (1874–1927), Olha Kobylanska (1865–1942) and the historical novelist Kateryna Hrynevych (1875–1947); the lyricists Yuriy Darahan (1894–1926), Oleh Olzhych (1909–44), Yuriy Lypa (1900–44), Yuriy Klen (1891–1947) and others; and the essayist-critic Dmytro Donzov (1883–).

See also RUSSIAN LITERATURE.

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UKULELE. A small guitar (*q.v.*) used by the natives of the Hawaiian Islands and adopted as a jazz and solo instrument in England and the United States.

ULAN BATOR (ULAAN BAATAR), until 1924 called Urga, capital of the Mongolian People's Republic, lies on the Tola river on a wind-swept plateau 4,294 ft. above sea level. Summer temperatures reach 80° F. while in winter the thermometer falls to −50° F. Pop. (1956 est.) 129,000.

The town came into existence in mid-17th century with the foundation of Da Khure monastery, the residence of the *bodgo-gegen* (sometimes called "living Buddha"), who ranked third among the dignitaries of the Buddhist-Lamaist religion. By mid-18th century Da Khure, known to the Russians as Urga, was a trading centre between China and Russia and the seat of a Chinese viceroy. When in 1911 Outer Mongolia recovered its autonomy, Urga became its capital. In 1918 Chinese troops entered the town, but on Feb. 3, 1921, it was captured by White Russians under Baron Roman von Ungern-Sternberg. He, in turn, was defeated in June 1921 by the Soviet army who on July 6 occupied Urga, which became the capital of an autonomous Mongolian state nominally headed by the *bodgo-gegen.* The last holder of this title, Jebtzun Damba, also called *khutukhtu* ("saint"), died on May 20, 1924, after which no new "reincarnation" was permitted and the "green palace" became a museum. Urga was renamed Ulan Bator, meaning "Red Hero."

With Soviet help a new city was planned and by the late 1950s its central feature was Sukhe-Bator square, opening off the east-west Stalin perspective. A neoclassic Palladian government building stands on the square, and in front of it a mausoleum containing the mortal remains of the two builders of Mongolian independence, Sukhe-Bator and Choibalsan. On this square also are the National theatre (1932) and Hotel Altai. On Choibalsan street stands the university (1942). In 1949 Ulan Bator mas linked by rail with the trans-Siberian trunk line, and with Peking in 1956. Five motor roads link the town with the U.S.S.R., with Dalan-Dzadagad in the south of the republic and with Peking. There is also an international airport. (K. SM.)

ULANOVA, GALINA (1910–), prima ballerina of the Bolshoi theatre ballet, Moscow, and people's artist of the republic, was born on Jan. 10, 1910, in St. Petersburg (now Leningrad). She was trained in the Leningrad State School of Ballet, where she studied under Agrippina Vaganova. A lyrical dancer who may be said to have descended from Anna Pavlova, she excelled in such roles as the title role in *Giselle* and Maria in R. V. Zakharov's *Fountain of Bakhchisarai,* and in her creation of Juliet in L. M. Lavrovski's *Romeo and Juliet* (1940). She danced at the Royal Opera house, London, in 1956, gaining an immediate popularity not equaled since the first appearance of Pavlova.

See V. Bogdanov-Berezovski, *Ulanova and the Development of the Soviet Ballet,* Eng. trans. by S. Garry and J. Lawson (1952). (A. L. HL.)

ULAN UDE (formerly VERKHNE-UDINSK), the capital of the Buryat Autonomous Soviet Socialist Republic, Russian Soviet Federated Socialist Republic, U.S.S.R. It is on the Uda river at its confluence with the Selenga. Pop. (1959) 174,000.

The town was on the 18th-century Siberian road and was formerly a great centre for the tea trade from Mongolia via Kiakhta. *See* TROITSKOSAVSK.

ULCER, a lesion of the skin or any mucous membrane characterized by a loss of surface epithelium and more or less of the underlying connective tissue. The term is also applied to lesions of the aorta and valves of the heart in which there is a loss of the lining endothelium. An ulcer has a depressed floor or crater surrounded by sharply defined edges that are sometimes elevated above the level of the adjoining surface. The floor of an ulcer is formed by granulation tissue that is usually infected from bacterial contamination. It is most important to the patient to know whether the ulcer is benign or malignant. Benign ulcers are usually caused by infections or nutritional disturbances. The ulcers on the legs of persons with varicose veins are caused by the slow circulation of the blood in the skin. Any infection under the skin such as a boil, carbuncle or tuberculous lesion may break through the surface and form an inflammatory ulcer.

The significance of an ulcer is best explained by a separate consideration of the different regions of the body in which ulcers develop. When an ulcer of the skin has been present for a month or longer, the possibility of cancer must be considered. If the edges of the ulcer are hard and the patient is past middle life, the probability of cancer is great. Ulcers on the vermilion border of the lower lip in elderly men are frequently cancers; women rarely develop cancer in this site. Such cancers must be recognized and treated early before they spread and become inoperable. Superficial ulcers on the lips, the ordinary cold sores (*q.v.*), are caused by a virus and are not serious.

Ulcers in the mouth and throat are frequently caused by infection but are sometimes cancerous, especially in older persons. Malignant ulcers usually have hard edges. In diphtheria there is often extensive ulceration of the throat. Ulcers in the esophagus tend to be cancerous.

Peptic ulcer refers to an ulcer in the part of the intestinal tract bathed by gastric juice; *i.e.,* the stomach and the first segment of the duodenum. (These are discussed in a separate article, GASTRIC AND DUODENAL ULCER.) Ulcers do not occur in the duodenum below the ampulla where the alkaline bile and pancreatic secretion enter and neutralize the gastric acid.

Ulcers in the small intestine occur chiefly in the terminal portion not far from its entrance into the large bowel. The commonest causes of ulcers in the terminal ileum are typhoid fever and tuberculosis. In the large bowel, single large ulcers are usually cancers. Cancerous ulcers occur most frequently in the rectum but may develop in any part of the colon. They cause pain, constipation and blood in the feces, are highly malignant and can be successfully removed only when recognized in an early stage. Ulcerative colitis is a disease in which hundreds of small ulcers develop in the mucous membrane of the large intestine. Some cases are caused by amoebic dysentery and some by bacillary dysentery, but in the majority of cases no cause can be established. The cases of unknown causation are most difficult to treat, and it is sometimes necessary to remove the entire large intestine.

Ulcers developing in the urinary bladder may be inflammatory or cancerous in nature. Cancers of the bladder are highly malignant and few cures are effected.

Ulceration of the valves of the heart occurs in bacterial endocarditis. Bacteria, usually streptococci, lodge in the valve leaflets and produce an inflammation that destroys the surface of the valves and forms an ulcer. Many cases of bacterial endocarditis have been cured by penicillin. (E. T. BE.)

ULEMA, the learned of Islam, theologians, canon lawyers, professors, judges, muftis, etc., all who, whether in office or not, are versed theoretically and practically in Moslem science in general. In a narrower sense, Ulema is used, in a Moslem state, of a council of such learned men, holding government appointments. If all conception of intermediary priesthood is eliminated, the Ulema may be said to be equivalent to the secular clergy of Roman Christendom (*see* DERVISH). Opposed to them, again, are the *'ārifs,* to whom religious knowledge comes in the vision of the mystic, not by tradition or reason (*see* ṢŪFĪISM).

ULFILAS (*c.* 311–383), the apostle of Christianity to the Goths, and, through his translation of the Scriptures into Gothic, the father of Teutonic literature, was born among the Goths at the trans-Danubian provinces about the year 311.

The Arian historian Philostorgius (*Hist. eccl.* ii, 5) says that his grandparents were Christian captives from Sadagolthina in Cappadocia, who had been carried off to the lands beyond the Danube in the Gothic raid of 264, and became so naturalized that the boy received a Gothic name, *Wulfila* (Little Wolf). An authoritative record of the outlines of his life was only discovered early in the 19th century in a writing of Auxentius of Milan, his pupil and companion. At an early age Ulfilas was sent, either as an envoy or as a hostage for his tribe, to Constantinople, probably on the occasion of the treaty arranged in 332. Ulfilas may therefore have been a convert to Christianity when he reached Constantinople. But there probably he came into contact with the Arian doctrines which gave the form to his later teaching. For some time before 341 he worked as a lector (reader of the Scriptures). From this work he was called to return as missionary bishop to his own country, being ordained by Eusebius of Nicomedia and "the bishops who were with them," probably at Antioch, in 341.

He was then 30 years of age, and his work as "bishop among the Goths" covered the remaining 40 years of his life. For seven of these years he worked among the Visigoths beyond the Danube, till the success which attended his labours drew down the persecution of the still pagan chief of the tribe. To save his flock from extinction or dispersion, Ulfilas decided to withdraw both himself and his people. With the consent of the emperor Constantius he led them across the Danube, "a great body of the faithful," and settled in Moesia at the foot of the range of Haemus and near the site of the modern Trnovo (349).

The life of Ulfilas during the following 33 years is marked by only one recorded incident (Sozomen iv, 24), his visit to Constantinople in Jan. 360, to attend the council convened by the Arian or Homoean party. The part played by Ulfilas in these troublous times has not been determined with certainty. It may have been he who, as a "presbyter christiani ritus," conducted negotiations with Valens before the battle of Adrianople (378); but that he headed a previous embassy asking for leave for the Visigoths to settle on Roman soil, and that he then, for political motives, professed himself a convert to the Arian creed, favoured by the emperor, and drew with him the whole body of his countrymen—these and other similar stories of the Orthodox church historians appear to be without foundation. The death of Valens, followed by the succession and the early conversion to Catholicism of Theodosius, dealt a fatal blow to the Arian party within the empire. In 383 he was sent to Constantinople by the emperor. A split seems to have taken place among the Arians at Constantinople. Ulfilas was summoned to meet the innovators and to induce them to surrender the opinion which caused the dispute. No sooner had he reached Constantinople than he fell sick, "having pondered much about the council," and before he had put his hand to the task which had brought him, he died, probably in Jan. 383.

The Arianism of Ulfilas was a fact of pregnant consequence for his people and indirectly for the empire. It had been his lifelong faith, as we learn from the opening words of his own confession—"Ego Ulfilas semper sic credidi." If, as seems probable from the circumstances of his ordination, he was a semi-Arian and a follower of Eusebius in 341, at a later period of his life he departed from this position and vigorously opposed the teaching of his former leader. He appears to have joined the Homoean party, which took shape and acquired influence before the council of Constantinople in 360, where he adhered with the rest of the council to the creed of Ariminum. His version of the Scriptures is his greatest monument. By it he raised a barbarian tongue to the dignity of a literary language; and the skill, knowledge and adaptive ability it displays make it the crowning testimony of his powers as well as of his devotion to his work. For the linguistic value of the Gothic version of the Scriptures by Ulfilas *see* GOTHS: *Gothic Language.* It is preserved, though only in a fragmentary form, in the famous *Codex Argenteus* at Uppsala.

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(C. A. SC.; X.)

ULIANOVSK (formerly Simbirsk), a town in the *oblast* of the same name, in Russian S.F.S.R., founded in 1648, lying on a hill 560 ft. above the Volga at a point where the Svyaga closely approaches it, in 54° 23' N., 48° 25' E. Pop. (1959) 205,000. The town has sawmills, flour mills, breweries, distilleries and brickyards. The historian N. M. Karamzin was born there in 1766 and Nicolai Lenin in 1870. Ulianovsk was the scene of much fighting during the civil war of 1917–1920. The former province of Ulianousk was divided among the Gorki, Penza and Kuibyshev regions and the Tatar A.S.S.R. and Chuvash A.S.S.R.

ULLATHORNE, WILLIAM BERNARD (1806–1889), English Roman Catholic missionary to Australia and later bishop of Birmingham, who exposed the transportation of convicts, was born at Pocklington, Yorkshire, on May 7, 1806, in descent from Sir Thomas More. After a hard training at sea as a cabin boy he joined the Benedictines at Downside abbey (near Bath) in 1823 and was ordained priest in 1831. He volunteered to serve the convicts in Australia where he was sent in 1832 as vicar-general. He was the first chaplain to visit Norfolk Island where the worst criminals were imprisoned. In 1838 he revisited England to give evidence in parliament which helped to abolish transportation. He left Australia in 1840 to work in Coventry, where he remained until his appointment in 1846 as vicar apostolic of the western district, with residence in Bristol. In 1848 he was made vicar apostolic of the central district and bishop of Birmingham in the new hierarchy he had himself helped to found.

With Margaret Hallahan he founded the Dominican convent at Stone, Staffordshire, in 1853. At the Vatican council in 1870 he voted as a moderate for papal infallibility. He was the close friend as well as the diocesan of J. H. Newman, whom he defended from H. E. Manning and for whom he helped to secure the cardinalate in 1879. He resigned from his diocese in 1888, and was made titular archbishop of Cabasa.

He died at Oscott, March 21, 1889.

See Ullathorne's autobiography, *From Cabin-boy to Archbishop* (1941), ed. by Shane Leslie; E. C. Butler, *The Life and Times of Bishop Ullathorne,* 2 vol. (1926).
(SH. L.)

ULM, a city of Germany, in the *Land* of Baden-Württemberg, on the left bank of the Danube, at the foot of the Swabian Alps, 58 mi. S.E. of Stuttgart by rail and 63 mi. N.W. of Munich. Pop. (1950) 71,132. Ulm is mentioned as early as 854; it became a town in 1027 and was soon the principal place in the duchy of Swabia. Although burned down by Henry the Lion, it soon recovered from this disaster and became a free imperial town in 1155. Its trade and commerce prospered and in the 15th century it attained the summit of its prosperity, ruling over a district about 300 sq.mi. in extent and having a population of about 60,000. In 1803 Ulm lost its freedom and passed to Bavaria, being ceded to Wiirttemberg in 1809. In Oct. 1805 Gen. Karl Mack with 23,000 Austrians capitulated there to Napoleon. Ulm is remarkable in the history of German literature as the spot where the Meistersinger lingered longest, preserving without text and without notes the traditional lore of their craft.

Ulm still preserves the appearance of a free imperial town and contains many medieval buildings of historic and of artistic interest. Among these are the town hall, of the 16th century, in the Transition style from late Gothic to Renaissance; the Kornhaus; the Ehingerhaus or Neubronnerhaus, containing the industrial museum; and the commandery of the Teutonic order, built in 1712–18 on the site of a habitation of the order dating from the 13th century, and later used as barracks. The magnificent early Gothic cathedral, begun in 1377, and carried on at intervals till the 16th century, was long left unfinished; but in 1844 the work of restoration and completion was begun, being completed in 1890. The tower (528 ft.) in the centre of the west façade was completed in 1890. The Danube, joined by the Iller just above the town and by the Blau just below, becomes navigable, so that Ulm occupies the important commercial position of a terminal river port.

The market for leather and wool is important, and the manufactures include wire ropes, borax, paints, cheese, jute, leather, lace, perfumes and cement. Brewing and weaving, iron- and brass-founding are carried on as well.

ULMACEAE (elm family), a family of deciduous trees and shrubs, the best-known and most important members of which are the elms (*q.v.*), forming the genus *Ulmus*. The family, which contains about 15 genera and about 130 species, is widely distributed in both temperate and tropical regions around the world. *Celtis australis* is the nettle tree, the fruit of which is edible. C. *occidentalis* is the hackberry (*q.v.*), of the eastern U.S. and southern Canada.

ULMANIS, KARLIS (1877– ?), Latvian statesman, was born on Sept. 4, 1877, at Berze, Zemgale, a province of Latvia. He studied agriculture in Germany and helped to improve Latvian dairy farming and cattle breeding. In 1905, at the time of the first Russian revolution, he promoted Latvia's movement for political autonomy. After the revolution Ulmanis went into exile in the United States. Having been granted an amnesty, he returned to Latvia in 1913. Shortly after the Russian revolution of 1917 he founded the Latvian Farmers' union, claiming Latvia's independence. With other Latvian leaders he formed a Latvian National council which on Nov. 18, 1918, proclaimed the independence of Latvia and appointed him the head of the provisional government. He remained in power until June 18, 1921, his period of office coinciding with years when freedom had to be defended not only against the Russian and Latvian Communists but also against the Germans. With a Latvian army formed by Gen. Janis Balodis, he liberated the country and organized the election of the constituent assembly which convened at Riga on May 1, 1920. Peace with Soviet Russia was concluded on Aug. 11, 1920. Ulmanis was again premier from Dec. 1925 to May 1926, and from March to Dec. 1931. Since in the Latvian *saeima* (parliament) of 100 deputies there were 24 political parties, every government was necessarily a somewhat unstable coalition. Ulmanis returned to power for the fourth time on March 17, 1934, at a time of great political tension created by the Communists and right-wing nationalists (the Perkonkrustiesi or Thundercrosses). A third element of disloyalty was the nazified German minority. On May 15 he suspended the constitution and, backed by the army, established an authoritarian regime. On April 11, 1936, Ulmanis became president of the republic also, with General Balodis as vice-president.

In June 1940 he accepted a Soviet ultimatum to form a "friendly" government headed by August Kirchensteins. Ulmanis and Balodis were arrested on July 21, 1940, and deported to the U.S.S.R. Their fate remained unknown. (K. SM.)

ULMUS: *see* ELM.

ULPIAN (DOMITIUS ULPIANUS) (d. A.D. 228), Roman jurist from Tyre, Phoenicia, whose writings supplied one-third of the total content of Justinian's *Digest* and his edictal commentary alone about one-fifth. He served as assessor when Papinian was *praefectus praetorio* and was himself a member of Septimius Severus' council. He was *magister libellorum* under Caracalla and *praefectus praetorio* under Alexander Severus from A.D. 222, until he was murdered by his own underlings in A.D. 228. His literary activity lay before his accession to the praetorian prefecture.

Ulpian was a prolific writer and made numerous contributions to a wide range of legal literature. His principal works are his commentaries *Ad Sabinum* (51 books) and *Ad edictum* (81 books) in which he aimed to restate comprehensively the interpretation of the civil law and edictal law. He also wrote monographs on, *e.g.*, particular statutes and on *fideicommissa* ("will trusts"), elementary handbooks (*Institutiones* and *Definitiones)*, opinions *(Disputationes, Opiniones, Responsa)* and treatises on various offices, notably his *De officio proconsulis* (10 books) which provides an exposition of the criminal law. Ulpian also wrote seven books of *Regulae:* the somewhat doubtful work, *Tituli ex corpore Ulpiani*, purports to preserve another *Liber singularis regularum*. Ulpian prized elegance and his works are characterized by lucidity of language, style and presentation. As a jurist, he is remarkable for his familiarity with the works of his predecessors: indeed, his merits lie in exposition and in compilation rather than in original thought. Not that he is a mere reporter: his criticisms of the views he relates are invariably sound.

See F. Schulz, *History of Roman Legal Science* (1946) ; W. Kunkel, *Herkunft und soziale Stellung der romischen Juristen*, pp. 245 ff. (1952). The most recent edition of the *Tituli ex corpore Ulpiani* is in *Fontes Iuris Romani Anteiustiniani*, vol. ii (1940). (J. A. C. T.)

ULRICH, SAINT (*c*. 890–973), bishop of Augsburg, the first person known to have been canonized by a pope, was born at Zurich, Switz., of the noble house of Dillingen, related to the imperial family of the Ottos. He studied at the monastic school of St. Gall, and was then trained by Adalbero, bishop of Augsburg. Upon the death of the latter in 910 Ulrich returned home and remained there for 13 years, at which time he was appointed bishop of Augsburg by King Henry I. He was throughout a loyal supporter of the emperor, and acted as mediator in the struggle between Otto I and Ludolf of Swabia. He also enabled Augsburg to withstand a siege by the Magyars until the emperor arrived (Aug. 955). He was granted the right to coin money, a privilege previously unknown for a German bishop.

On the morning of July 4, 973, Ulrich had ashes strewn on the ground in the shape of a cross and himself placed on them; he died as the litany was chanted. He was canonized by John XV in 993, and his feast day is July 4.

Ulrich was a strong personality. He was devoted to his duties, deeply concerned with the education of his clergy, the religious life of the people and particularly concerned with care for the poor.

See H. Thurston and D. Attwater (eds.), *Butler's Lives of the Saints*, vol. iii, p. 16 (1957). (Fs. P. C.)

ULSTER, EARLS OF. The earldom of Ulster was the first title of honour in Ireland of English creation, and for more than a century was the only one. It dates from a grant to Hugh de Lacy in 1205. Hugh de Lacy, 1st earl of Ulster (d. 1242?), was descended from Walter de Lacy (d. 1085), who fought for William the Conqueror at Hastings. The first earl was the brother of Walter de Lacy (d. 1241), who succeeded his father as lord of Meath in 1186. In 1203 Hugh de Lacy drove John de Courcy out of Down and was rewarded by grants of land and in 1205 by the earldom of Ulster. He was then invested with quasi-viceregal authority, but in 1207 war broke out between the earl and the king's justiciar. King John came to Ireland and banished the earl to Scotland. He returned to Ireland in 1226, and died at Carrickfergus. On his death the earldom reverted to the crown.

A second creation followed, when Prince Edward (later Edward I) transferred "the county of Ulster" (*c*. 1255) to Walter de Burgh, lord of Connaught. The earldom remained in the family of De Burgh until the death of William, 3rd earl of this line, in 1333, when it passed to his daughter Elizabeth, who married Lionel, afterward duke of Clarence, son of Edward III. Lionel was succeeded in the earldom of Ulster by his daughter Philippa, who married Edmund Mortimer, earl of March. The third Mortimer earl of Ulster died unmarried in 1425, when his titles were inherited by Richard Plantagenet, duke of York, whose son Edward ascended the throne as Edward IV in 1461.

Since that date the earldom of Ulster, which then merged in the crown, has been held only by members of the royal family. In 1928 it was bestowed upon H.R.H. the duke of Gloucester.

ULSTER, the ancient northeastern province of Ireland, had a varying frontier and is now roughly coextensive with Northern Ireland. Uladh was its ancient Gaelic name. and the ending "ster" was of Norse origin. At the beginning of the Christian era a kingdom of Ulster stretched from the Shannon to the Boyne, with its chief stronghold near Armagh. By the close of the 4th century this had broken up and the name Ulidia was applied to an area roughly corresponding to the modern Down and Antrim. John de Courcy invaded the area successfully in the last quarter of the 12th century and contemporary writers referred to him as "Princeps Ulidiae" and "Conquestor Ultoniae" In 1205 King John deprived de Courcy of his territories and gave them to Hugh de Lacy with the title of earl of Ulster. In Tudor times the ancient provincial divisions of Ireland were used for administrative purposes. In 1585 Lord Deputy Sir John Perrot caused Ulster to be shired, defining the area of Ulster as the eight counties of Antrim, Down, Armagh, Monaghan, Coleraine, Donegal, Tyrone and Fermanagh. To this Sir Arthur Chichester added Cavan which had formerly counted as part of Connaught. By 1608 nine counties were regarded as making up Ulster. Coleraine became the county of Londonderry in 1613. The nine-county Ulster was made quite arbitrarily and did not correspond to the ancient kingdom or any earlier Ulster. It never had much reality as an administrative entity. The name Ulster has been generally used since 1920 as another name for Northern Ireland, appearing in the titles of many public bodies and institutions; but for a few purposes, including some forms of interprovincial sport, the name still indicates nine counties. The three counties of Cavan, Donegal and Monaghan form Ulster province (3,123 sq.mi.; pop., 1956, 235.863) in the Republic of Ireland. (Hu. S.)

ULTIMATUM is a technical diplomatic term, derived from the Latin word for "last." It signifies a formal, categorical declaration, addressed by one state to another to the effect that if certain demands are not met. serious consequences will ensue. These consequences may range from the rupture of the particular negotiations, economic measures, breaking-off of diplomatic relations or threat of force, to the actual application of force in the form of war. An ultimatum is called simple if it does not indicate the measures to be taken by the government sending it. It is called qualified if it indicates the nature of the measures to be taken. Art. i of convention iii, adopted by the second Hague conference (1907), regulates in detail the formalities to be observed with regard to an "ultimatum with a conditional declaration of war." The practical importance of these provisions was greatly diminished by the provisions of the covenant of the League of Nations and of the charter of the United Nations, limiting the right of the member states to use war as an instrument of national policies. It was also diminished by the disregard with which many states treated these provisions. (H. J. Mu.)

ULTIMOGENITURE, the custom by which the youngest son inherits the homestead, is known in English law as Borough English. In England it obtained in parts from Gloucester to Cambridgeshire. Under the name of Mainète and Jungerrecht it was known in northern France and northern Germany. In Assam it is found among the matrilineal Garos who possess the dual organization and speak a Tibeto-Chinese language, among the matrilineal Khasias who speak an Austric language, among patrilineal Lusheis, Meitheis, Kagas and Kachins, speakers of Tibeto-Chinese languages. Cases are known in Africa.

This custom has been regarded as derived from the *jus primae noctis*, the youngest son being of undoubted paternity. This view has been successfully traversed by Blackstone, Westermarck and Frazer. It has been ascribed among settled peoples, such as Nagas and Meitheis, to the custom of making provision for the elder sons as they marry and set up house independently. The rule requiring elders to marry before juniors is found among communities which do not now practise ultimogeniture. Among people like the Lusheis, who practise shifting cultivation, it is due to the custom by uhich the sons of chiefs, on marrying, swarmed off to found new villages. The view that it is connected with domestic worship is supported by the Khasi evidence, where the youngest daughter "inherits the religion"—in organic association with the homestead. With the Garos it is inseparably connected with the general system of marriage.

ULTRACENTRIFUGE: **see** CENTRIFUGE.

ULTRAMARINE is the colour principle of the gem lapis lazuli (*q.v.*) which, besides its use as an ornament, formed the blue pigment used by painters in the middle ages. Ore containing the colour was ground and the powdered lapis lazuli separated from the other mineral matter by an oil pasting process. The blue pigment so obtained is said to have been literally worth its weight in gold. The fact that the product was imported into Europe gave it its name—ultramarine, "beyond the sea."

The value of the material caused great efforts to produce it artificially and these succeeded in the late 1820s. It appeared on the market almost simultaneously in France and Germany. The ultramarine of those early days was a weak product from the present point of view, but it was the start of a development leading to the pigment of today.

Ultramarine is manufactured from more or less equal amounts of china clay, sulfur and soda ash (sodium carbonate), together with considerably smaller amounts of silica and rosin or pitch. Variations in the proportions of the ingredients are used to cause variations in the shade of the product from a greenish to a reddish blue. The mixture is very finely ground and loaded into crucibles with porous walls. More than 1,000 of these are stacked in a single furnace, which is then slowly fired up to a top temperature of about 750° C. Many and complicated reactions occur among the ingredients of the mix. When the top temperature has been reached, the fire is drawn, and the furnace is sealed and allowed to cool over a period of about two weeks. During this cooling period the atmosphere of the furnace exerts an oxidizing action upon the crucible contenfs, this action being of much importance to the character of the product. The crude ultramarine is removed from the crucibles, washed free from salts, very finely ground and separated by successive sedimentations from water suspension into a series of particle sizes. The varying characteristics required for different uses of ultramarine are satisfied by selection of the desired shade and particle size. For some purposes, the product requires further special surface treatments.

The uses of ultramarine are in paints and lacquers, calcimine, linoleum, paper (both in whitening and colouring), coloured roofing material and laundry blueing. It has a particularly brilliant blue colour, is very light-fast and is resistant to mild alkalies, but not to acids. The structure of ultramarine was a matter of much controversy until F. M. Jaeger finally settled the matter in 1929 by the use of the X-ray. The ultramarines consist of a lattice of cubical form with truncated corners, built up of aluminum and silicon atoms joined to one another through oxygen atoms. The ratio of aluminum to silicon atoms can vary within limits, but their combined number is always 12. Commonly the silicon atoms outnumber the aluminum atoms. The connecting oxygen atoms number 24. Within the lattice and in the spaces formed by the truncated corners of adjacent lattices are atoms of sodium and sulfur not rigidly fixed as to number or position.

Silicon	17.75 to 20.0% by weight
Aluminum	12.3 to 15.5% by weight
Sodium	12.8 to 15.3% by weight
Sulfur	10.0 to 14.0% by weight
Oxygen	Balance (except for small amounts of water and impurities)

It is clear from the above why there is a family of ultramarines and why variations in composition exist. The usual percentage limits within which the components fall are shown in the table.

The shades and properties of the ultramarines vary with changes in the proportions of the components. (A. P. B.)

ULTRAMICROCHEMISTRY. The term "ultramicrochemistry" refers to a set of chemical techniques by which chemical analyses and other chemical manipulations are performed on the most minute amounts of material. If a standard analytical method requires about 0.1 gram or sample, the micromethod for the analysis would require about 0.001 gram and the ultramicromethod about 0.00001 gram. It is less ambiguous, then, to term ordinary scale or macro-operations as "decigram methods," micromethods as "milligram methods" and ultramicromethods as "microgram methods" (1 microgram = 0.000001 gram = about 0.000000035 oz.). Microchemistry is then "milligram chemistry" (1 milligram = 0.001 gram) and ultramicrochemistry is "microgram chemistry." It is also termed "drop analysis" because a sample of blood or other solution being analyzed is usually less than a drop.

Systematic ultramicrochemistry originated in the Carlsberg laboratory in Copenhagen about 1930. The techniques developed there were used chiefly to analyze traces of enzymes, or biological catalysts, in tiny slices of tissues of plants and animals. The techniques applied to this purpose became known as "enzymic histochemistry." They were widely employed by K. Linderstrom-Lang and his co-workers of the Carlsberg laboratory, as well as by many others, to the solution of fundamental biological problems.

A broader chemical approach was made by Paul L. Kirk and his co-workers at the University of California, starting about 1933. Instead of specific applications to limited types of biological problems, the aim of the California group was to make all kinds of chemical operations practical with microgram quantities so that any chemical study could be made, regardless of the type of material studied. Although the chief applications of these techniques were also expected to be biological in nature, the general applicability was demonstrated when they were used to develop the chemistry of plutonium, the element used as an explosive in the atomic bomb. Microgram manipulation was made necessary in this case by the fact that only microgram quantities of plutonium could be made by methods then available, and larger amounts could not be manufactured until extensive chemical information was available. Virtually the entire chemistry of plutonium was elucidated before there was as much as a milligram of the pure material in existence and huge production plants were constructed with a scale-up of more than a billionfold—an all-time industrial record.

Up to about 1940, the strictly chemical techniques were largely confined to volumetric operations; *i.e.,* measurement of liquid volumes as a means of analysis. This was true of both the Copenhagen and California groups as well as several other laboratories in which microgram chemistry was being studied or used. Included in these developments were methods for study of chemical changes through gasometric methods depending on measurement of gas volumes, respiration of single cells and of very small organisms or bits of tissue, enzyme catalyzed reactions in droplets and various manipulative techniques. During World War II further advances occurred in ultramicroweighing, submicrogram chemical analysis through colour measurement and chemical study of reacting systems containing only a few micrograms of material through improved manipulative techniques.

Liquid Volumetric Techniques.—Analytical methods depending on measurement of volumes of liquids were peculiarly adaptable to ultramicroanalysis and were the first techniques developed. Titrations were readily performed with burets made from fine capillary tubes which delivered small volumes of reagent solutions with an accuracy of ± 0.02 microlitres or better (1 microlifre = 0.000001 litre; 1 litre = approx. 1 quart). Liquid samples were measured with the same accuracy by use of the same fine graduated tubing. The blood of a grasshopper or a droplet from a child's fingertip could then be measured accurately and its constituents accurately determined by titrating this bit of blood with a capillary buret. Operations other than titration usually needed to be done. If so, techniques for spinning down the corpuscles, removing the protein, ashing the blood, filtering it, stirring it or boiling it were developed and could be used without ever having a greater volume than about one drop of liquid. By such means, quantitative analysis for nitrogen, urea, sugar, amino acids, lactic acid, ammonia, chloride, sodium, potassium, calcium, phosphorus and other common constituents of blood could be performed. Adaptations of these procedures are applicable to the analysis of all types of materials other than blood.

They can be valuable in the clinical laboratory by avoiding the difficulty of obtaining large amounts of blood from patients; *e.g.,* from infants. They are useful to the research worker who can study insects, some single cells, small plants and animals and their parts which by common methods could not be analyzed at all. They can also be used for the study of minute amounts of inorganic material such as the radioactive isotopes obtained by the nuclear physicist. The dangers of radioactivity are less with the small sample, and very often only the smallest samples can be obtained.

Gasometric Ultramicromethods.—Methods depending on gas volume changes have been chiefly useful in measuring the respiration rate of cells, tissues and small organisms. Some of these devices have been made sensitive enough to measure the minute trace of oxygen used by single invisible protozoan cells. Several such instruments could determine the rate of oxygen consumption with slightly larger organisms or tissues. One ingenious device which has been widely used both for respiration and enzyme studies is the Cartesian diver micromanometer which was first described by Linderstrom-Lang.

Gas analysis also was highly developed as an ultramicrotechnique during World War II. Most significant were the methods of P. F. Scholander and his associates who succeeded in analyzing as little as ten microlitres of gas mixtures for their constituent gases with approximately the same accuracy as is possible with large samples. These techniques were applied to various physiological studies.

Weighing.—Although very sensitive balances were developed early in the 20th century, little refinement or use had been made of them until 1942. P. L. Kirk, Roderick Craig and J. Gullberg succeeded that year in combining earlier weighing principles and refining them in a quartz fibre balance which could carry a total load of about 100 milligrams and weigh a sample of 0.3 milligram with a sensitivity of about 0.005 microgram. A human breath weighs about 750,000 micrograms; a dime, 2,500,000. With little loss in load capacity, the sensitivity could be increased by about tenfold. This instrument for the first time made weighing a prac. tical technique of ultramicroanalysis and opened the way for development of all types of investigation of ultrasmall samples which require weight determination.

See BALANCE.

Colorimetric Submicrogram Analysis.—Most significant of developments in ultramicrochemistry during World War II was the initiation of submicrogram analysis by means of the spectrophotometer. By using specially designed capillary absorption cells, the sensitivity of the colorimetric methods could be so increased as to allow the accurate analysis of amounts of many materials as low as one or a few millimicrograms (1 millimicrogram = 0.001 microgram = 0.000000001 gram). Little application was immediately made of this type of technique in practical research work, but the field of application is so broad in all phases of chemistry, biochemistry and biology that developments along this line were expected to outdo all past efforts toward chemical study of the microscopic world.

Miscellaneous Techniques.—The development of fine manipulative methods for separating and handling minute objects, such as the nuclei of cells, has progressed markedly to supplement the quantitative techniques which constitute the foundation of ultramicrochemistry. Improved microscopic methods using fluorescence from ultraviolet light and improved methods of staining certain constituents of cells and tissues for identification purposes have come into use.

For the first time in history, the ultramicrochemist possesses the tools with which he can carry chemical investigations into the cells, the very seat of life processes of plants and animals, and elucidate their nature. He can elaborate the complete chemistry of a new synthetic element before the amount of it on earth is the size of a small pin head. He can facilitate or make possible all sorts of research investigations which were completely impossible without these extremely delicate techniques. Medicine, agriculture, radiochemistry and biology can now advance in their basic chemical knowledge just as they advanced as a result of the invention of the microscope, except that now it is chemical vision which is magnified, and now it is possible to see not only what is present and how much and how it is composed.

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ULTRAMONTANISM, the name given to a certain school of opinion in the Roman Catholic Church (Lat. *ultra,* beyond, *montes,* the mountains). The expression *ultramontane* was originally no more than a term of locality, characterizing the persons so described as living—or derived from—"beyond the mountains"; but from the very beginning we find it used as a party appellation to describe those who looked "beyond the mountains" in order to obtain a lead from Rome, who represented the papal point of view and supported the papal policy. Thus, as early as the 11th century, the partisans of Gregory VII were styled ultramontanes, and from the 15th century onward the same name was given to the opponents of the Gallican movement in France.

It was not until the 19th century that "ultramontane" and "ultramontanism" came into general use as broad designations covering the characteristics of particular personalities, measures and phenomena within the Roman Catholic Church. At the present time they are applied to a tendency representing a definite form of Catholicism within that church; and this tendency, in spite of the individual forms it has assumed in different countries, everywhere displays the same essential features and pursues the same ends. It follows, from the very nature of ultramontanism, and from the important position to which it has attained, that the official organs of the church and all the people interested in the continuance of the actual state of affairs deny that it exists at all as an independent tendency. It is indisputably legitimate to speak of ultramontanism as a distinct policy, but it is very difficult to define its essential character.

(1) The first and fundamental characteristic of ultramontanism is its carrying to a logical issue the concentration of all ecclesiastical power in the person of the Roman Pontiff. (*See* PAPACY.) To the *curial system,* so evolved, continually fortifying its position in the domains of theology, ecclesiastical law, and politics, the *episcopal system* stands in opposition. The system admits that the pope represents the unity of the church, and acknowledges his primacy, while at the same time it claims on behalf of the bishops that, in virtue of the divine ordinance, they possess an inalienable right to a share in the government of the church (*see* FEBRONIANISM).

The struggle between these two systems continued well into the 19th century; and, though episcopalism was not infrequently proscribed by the Curia, it still survived, and until the year *1870* could boast that no oecumenical council had ventured to condemn it. This was done for the first time, in *1870,* at the Vatican council (*q.v.*), whose decrees, recognizing the universal episcopate and the infallibility of the pope, marked the triumph of that doctrine by which they had been long anticipated. The Catholic church, in all countries, has become more and more dependent on the Curia: the bishops have lost their autonomous standing, and their position is little more than that of papal delegates, while all important questions are referred to Rome or settled by the nuncios.

(2) A second peculiarity of ultramontanism is that it claims for the Catholic church the functions of a political power, and asserts that it is the duty of the secular state to carry out its instructions and wishes. Since the conditions of the age no longer allow the pope to depose a temporal sovereign, the practical application of this conception of the relationship between the spiritual and temporal powers has taken other forms, all of which, however, clearly show that the superiority of the church over the state is assumed. This may be seen in the attitude of ultramontanism toward secular law. It assumes that God has conferred on the individual and on society certain rights and competences as inalienable possessions. This "natural law" ranks above all secular law, and all state legislation is binding only in so far as it is in harmony with that law. As to the provisions of this natural law, and the consequences they entail in individual cases, these can be decided only by the church, *i.e.,* in the last resort, by the pope. Thus, even at the present time, the opinion is very clearly expressed in ultramontane quarters that, in the event of the state issuing laws contravening those of nature or of the church, obedience must be refused. The attitude of ultramontanism, for instance, toward the right claimed and exercised by the state to make laws concerning marriage is wholly negative; it recognizes no marriage laws except those of the church, the church alone being regarded as competent to decide what impediments are a bar to marriage, and to exercise jurisdiction over such cases.

(3) Since ultramontanism cannot hope to realize its political ambitions unless it succeeds in controlling the intellectual and religious life of Catholic Christendom, it naturally attempts to extend its sphere of influence in all directions over culture, science, education, literature and the forms taken by devotion The development of these efforts may be easily traced from decisions of the congregation of the index and the holy office in Rome. Ultramontanism, too, labours systematically to bring the whole organization of education under ecclesiastical supervision and guidance.

(4) In the fourth place, ultramontanism is the embodiment of that intolerance toward other creeds which is the logical consequence of the authoritarian claims of the Catholic church. The general presupposition involved is that a man cannot be saved except within the Catholic church. Since, however, on the one hand—in virtue of a theory advanced by Pius IX against the emperor William I of Germany, in a letter which has since become famous—every Christian, whether he will or no, belongs to that church by baptism, and is consequently pledged to obey her, and, on the other hand, since the state lies under the obligation to place the "secular arm" at its disposal whenever one of its members wishes to secede, the most far-reaching consequences result. In the past this principle led to the erection of the Inquisition (*q.v*) and, even at the present day, there exists in the Curia a special congregation charged with its application. The gradual separation of state and church, a process traceable in its various degrees in all countries of Europe, has resulted in rendering impossible the strict application of a system to which human nature itself has rightly or wrongly, taken exception. As a result of this situation, the Catholic condemnation of heresy—though as stringent as ever in principle—has assumed forms less physically dangerous for the heretic.

(5) Lastly, ultramontanism opposes the nationalization of Catholicism. This peculiarity is connected, though not identical, with the above-mentioned tendency toward the Romanization of the church. Just as in Protestant countries there has often been an amalgamation of evangelical belief with national feeling, so many Catholics desire that Catholicism shall enter into the sphere of their national interests, and that the activities of the Catholic church should rest on a national basis. These aspirations have been proclaimed with especial emphasis in France, in Germany (*Reformkatholizismus*) and in the United States (*Americanism*) but they are everywhere met with a blank refusal from the ultramontane side. Ultramontanism fears that any infusion of a national element into ecclesiastical life would entail the eventual separation of the people in question from papal control, and would lead to developments fraught with danger to the supremacy of the papacy.

The relationship of ultramontanism to Catholicism is a much-disputed problem. The ultramontane maintains that there is no justification for distinguishing between the two; but, even within the pale of the Roman church, the identification provokes dissent, and is repudiated by all who are shocked by the effects on the life of the church of an overcentralized political Catholicism. It was on these grounds that in Jan. *1904,* it was proposed in the chamber of the Bavarian Reichsrath that the clergy should be deprived of the suffrage. The years between the Treaty of Frankfurt *(1871)* and the outbreak of World War I witnessed a growing difficulty on the part of Catholic Germans to reconcile ultramontane doctrine with the political and industrial development of united Germany. This was the real background of what is known as the *Kulturkampf* (*see* GERMANY, *History*).

The collapse of Germany after World War I (1914–18) tended, on the whole, to stimulate ultramontanism (*e g*, in Bavaria; ; but the republican elements which combined in *1919* to uphold the constitution of Weimar, proved strong enough to resist the more extreme manifestations of this tendency.

It may be admitted that for all the principal contentions of ultramontanism, analogies may be found in the past history of the Catholic church. Thus, in the middle ages, we find extremely bold pronouncements with respect to the position of the papacy in the universal church; while political Catholicism had its beginnings in antiquity and found very definite expression, for instance, in the bull *Unam sanctum* of Boniface VIII. Again, the attempt to subordinate all intellectual life to ecclesiastical control was a feature of the mediaeval church, and the fundamental attitude of that church toward heresy was fixed during the same period. But since then much has been altered both in the church and her secular environment. The state has become independent of the church, legislates on its own sole authority, and has recognized as falling within its own proper sphere the civilizing agencies and social questions formerly reserved for the church. Again, education, science, art and literature have been secularized; the printing press carries knowledge into every house, the number of illiterates diminishes from year to year in every civilized country, and the clergy are no longer the exclusive propagators of culture, but merely one factor among a hundred others.

The origin of modern ultramontanism is preceded and conditioned by the collapse of Catholicism in the period of the French Revolution. Pius VI and Pius VII were expelled from Rome, deprived of the papal states, and banished to France. In that country the church almost completely lost her possessions; in Germany they were at least considerably curtailed; in both the hierarchical organization was shattered, while the Catholic laity surveyed the catastrophe in complete passivity. But from this severe fall the church recovered with comparative readiness, and the upward movement is contemporaneous with the rise of ultramontanism. The birth of that system, however, cannot be fixed as a definite event by the day and the hour; nor was it created by any single personality. Rather it was the product of the first post-revolutionary generation. Neither is it merely fortuitous that the reaction proceeded from France itself. For in no other country had hostility to religion attained such a pitch or assumed such grotesque forms; and consequently in no other country did the yearning for religion manifest itself so unequivocally, when experience had demonstrated the necessity of a return to law and order. And in the other states of Europe there existed, more or less, a similar desire for peace and an equal dread of a fresh outbreak of revolutionary violence. In contrast to the struggle for an ideal freedom, which was at first hailed with tempestuous delight only to reveal itself as a dangerous tyranny, men became conscious of the need for a firmly established authority in the reconstruction of society. At the same time, the repression of idealism and sentiment during the period of "illumination" was amply revenged, and the barren age of reason gave place to Romanticism. These tendencies in contemporary opinion favoured the renovation of the Catholic church.

The papacy signalized its reinstation by restoring the Society of Jesus (1814) and re-establishing the index. In Germany ultramontanism had to contend with great difficulties; for here ecclesiastical affairs were not in so desperate a case that the most drastic remedies possessed the most powerful attraction; while, in addition, the clergy were unwilling to renounce all scientific work. The result was that a series of struggles took place between the old Catholicism and the new ultramontanism. But even here ultramontanism gained ground and derived inestimable assistance from the blunders of government after government. The growth of Jesuitical influence at Rome—more especially after the return of Pius IX from exile—implied a more definite protection of ultramontanism by the papacy. The proclamation of the dogma of the Immaculate Conception in 1854 was more than the decision of an old and vexed theological problem; it was an act of conformity with a pietistic type especially represented by the Jesuits. The Syllabus of 1864, however, carried with it a recognition of the ultramontane condemnation of some aspects of modern culture (*see* PIUS IX). Finally, in the Vatican council, the Jesuits saw another of their favourite theories—that of papal infallibility—elevated to the status of a dogma of the church (*see* VATICAN COUNCIL and INFALLIBILITY).

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ULTRASONICS. The name ultrasonics is given to that branch of acoustics dealing with periodic sounds whose frequencies lie above the audible range; *i.e.,* are greater than approximately 20,000 cycles per second. The development of electronically controlled sound sources after World War I made possible the production of this high-frequency sound on a practical basis. Prior to 1935, the subject was generally referred to as supersonics, but confusion arose because of the use of the adjective supersonic to refer to fluid-flow velocity exceeding the velocity of sound. Since the above date, the term ultrasonic for high-frequency sound has become well established. In the late 1950s the maximum practically attainable ultrasonic frequency was about 10^9 cycles or 1,000 mc., corresponding to a wave length in air of about 3.4×10^{-5} cm. and in water 1.5×10^{-4} cm. In 1959, ultrasonic radiation of frequency 10,000 mc. was produced at the General Electric Research laboratory, though not in usable form. These small wave lengths and high frequencies lead to interesting characteristic effects on matter traversed by the ultrasound, particularly when the intensity is high. Prominent among these are cavitation phenomena in liquids or the appearance of bubbles in the path of the sound beam with associated light production and chemical action; the production of emulsions of immiscible liquids; the coagulation of aerosols and numerous others.

Because of their short wave length, ultrasonic waves travel in much sharper beams and can form sharper shadows than audible or low-frequency sound waves. Hence they can be used to detect solid obstacles present in liquids or gases. By appropriate devices such beams can be focused in small regions and produce considerable local heating as well as very large and rapid changes in density. This makes ultrasonic radiation very useful in studying living organisms and suggests its value in medical therapy. These and other uses of ultrasonics are discussed in detail below.

Sources and Detectors of Ultrasonic Radiation.—The standard ultrasonic sources are piezoelectric and magnetostrictive oscillators (see SOUND: *Electroacoustic Sources*). Both of these are electroacoustic devices whose flexibility depends on the possibility of designing oscillating electrical circuits to almost any frequency and power specification (see E. G. Richardson, *Technical Aspects of Sound,* vol. ii, ch. 2 [1957]).

Quartz and Rochelle salt are satisfactory and widely used piezoelectric crystals for ultrasonic transducers. During and after World War II, the search for other piezoelectric materials led to the employment of ammonium dihydrogen phosphate (ADP), ethylene diamine tartrate (EDT) and dipotassium tartrate (DKT). A particular advantage of ADP is that it is piezoelectrically more sensitive than quartz and at the same time more rugged than Rochelle salt, since it has no water of crystallization. These materials, however, were generally displaced after 1950 by the polycrystalline ceramic barium titanate which after having been polarized by the application of a static potential difference will vibrate mechanically on application of the usual alternating voltage. This substance is called a ferroelectric since it possesses electrical properties (dielectric constant, etc.) analogous to the magnetic properties of ferromagnetic materials (*see* MAGNETISM). A practical advantage of barium titanate is that it can be molded into practically any shape required. For example, to concentrate ultrasound in a small region a spherically shaped cup of the material may be used as a transducer. The Curie temperature of barium titanate, *i.e.,* the temperature above which the material ceases to show its equivalent piezoelectric or electrostrictive effect, is 120° C. (as compared with about 575° C. for quartz). The addition of small amounts of lead and calcium titanate raises the Curie point somewhat. Lead zirconate-titanate ceramics were introduced in the mid-1950s and because of their much higher Curie temperatures gave promise of widespread transducer use.

As equation III. 11–1 of the article on SOUND indicates, the production of high ultrasonic frequencies demands very thin plates of piezoelectric materials, as long as the fundamental resonance frequency is employed. Higher harmonics can be used to produce much higher frequencies from crystals of manageable thickness. Thus a quartz crystal of thickness 1.1 mm. corresponding to a fundamental frequency of 3 mc. can be driven at its 100th harmonic to produce radiation of 300 mc. Very thin crystals, however, are difficult to prepare with absolutely uniform thickness. One of the unsolved problems of acoustics in the late 1950s was to find a convenient way of producing usable ultrasonic radiation of high intensity and at arbitrarily high frequency, *e.g.,* up to 10,000 mc. The upper practical limit at that time was about 1,000 mc.

Magnetostrictive oscillators are discussed in SOUND: *Practical Sound Sources,* as are the siren and the Hartmann oscillator, which are other powerful sources of ultrasonic radiation.

Any reversible source of sound like a piezoelectric or magnetostrictive transducer can be used equally well as a receiver or detector. In the early stages of development the ceramic type (*e.g.,* barium titanate) molded in the shape of a cylinder was the most popular detector for nondirectional reception. Another method of detection, useful in optically transparent media, is based on the Debye-Sears effect: a progressive ultrasonic wave in such a medium with its associated density changes constitutes a diffraction grating for a beam of light directed at right angles to the direction of sound propagation. The theory of this effect connects the spacing in the optical diffraction bands with the "spacing" in the acoustic grating, *i.e.,* the sound wave length, and hence permits the evaluation of the ultrasonic velocity from a measurement of the band spacing and the sound frequency. An estimate of the sound intensity can also be read from the diffraction pattern and hence the method can be used to measure ultrasonic absorption. The accuracy, however, is not high. This optical diffraction technique works because the wave length of the ultrasonic radiation is so short, *e.g.,* 1.5 mm. for 1 mc. radiation in water, and the velocity of light is so much greater than that of sound.

Special Properties of Ultrasonic Radiation. — By focusing ultrasonic radiation on a small space by the use of a curved radiator, very high intensity can be achieved (*e.g.,* up to 5,000 w. per square centimetre). Striking physical phenomena are associated with such radiation. Thus when an intense ultrasonic beam is directed from below at the free surface of a liquid like transformer oil, the radiation pressure produces a fountain which can rise several centimetres from the surface. If a beaker containing a small amount of a volatile liquid like benzene is held partly immersed in an oil bath so as to be irradiated by an intense beam of ultrasound, the liquid is rapidly volatilized and the beaker fills with fog. This is attributed to the rapid formation in the liquid of vast numbers of bubbles, a phenomenon known as cavitation. This can also be produced by nonacoustical means as, for example, in the whirling of a ship propeller in water. In the latter case, the production of bubbles is due to the fact that the water in contact with the rapidly moving blade is unable in its flow to follow the blade; hence the pressure falls to or below the vapour pressure of the liquid and bubbles of vapour are formed. Their collapse produces violently destructive forces in the neighbourhood of solid surfaces.

Ultrasonic cavitation is of two kinds: (1) If the irradiated liquid contains dissolved air or other gases, the large and rapid changes in pressure produced by the sound cause the gas to come out of solution; this is called pseudocavitation; (2) If the liquid is completely degassed, bubbles can still be formed if the pressure change is great enough to overcome the tensile strength of the liquid. The latter is termed genuine cavitation. The excess acoustic pressure amplitude necessary to produce it (the so-called cavitation threshold) increases with the viscosity of the liquid. It ranges from about 1.5 atm. for liquids of very low viscosity like carbon tetrachloride to about 4 atm. for very viscous liquids like castor oil. The threshold also increases as the frequency increases. Thus in water at 15 kc. the threshold is about 1 atm. At 0.5 mc. it is 15 to 20 atm.

The inception of cavitation depends on the presence of nuclei on which the bubbles can form. The precise nature of these nuclei was not clear. One theory supposed that they are very small solid particles of foreign matter to which the dissolved gas may adhere. Another view assumed that the nuclei are genuine gas bubbles too small to be seen and whose persistence in the unagitated liquid despite surface tension is due to the protection of a monomolecular organic layer or skin. This theory checked well with the existence of a cavitation intensity threshold, since it will obviously take a certain radiation intensity to break the skin so that the gas may diffuse into the bubble and cause it to grow.

Ultrasonically produced cavitation leads to interesting effects in liquids. At acoustical intensities near the cavitation threshold, the bubbles tend to collect at the pressure nodes of a standing wave pattern and hence can be used to determine the wave length and velocity of the radiation. At high powers cavitation can bring about the complete mixing of otherwise immiscible liquids, such as water and oil, into a rather stable emulsion. Emulsions of mercury in water can also be produced by intense ultrasound, but because of the high density of mercury this result is not achieved by means of cavitation. Rather, the ultrasound is thought to force the water into the mercury with the formation of water droplets coated with thin layers of mercury. The mechanism whereby ultrasonic cavitation produces emulsification was not wholly understood at mid-20th century but was believed to be connected with the large forces released in the collapse of the bubbles. Another explanation advanced is the hydrodynamic streaming produced near cavitation bubbles by the acoustic radiation. This may, for example, have much to do with the biological action of ultrasonics in liquids; *e.g.,* its effects on living cells.

Emulsions of solid particles in liquids can be formed by the ultrasonic bombardment of a piece of the solid (*e.g.,* lead or silver) while immersed. This would appear to be due to the straightforward destructive action of cavitation in the liquid on the immersed solid.

Certain liquids become luminescent when irradiated by ultrasound, the intensity of the light being approximately proportional to the product of the viscosity and the electric dipole moment. Some thought that enough electric charge may be produced by friction between the cavities and the surrounding liquid to build up the electrostatic potential necessary for a discharge. On the other hand. it was believed that chemical action might be involved. It is a fact that in the collapse of a cavitation bubble very high local temperatures are produced (*e.g.,* of the order of 10,000° C.) and these may be sufficient to cause ionization of the contained gas with resultant emission of radiation. This ties in well with the observation that certain types of chemical reactions are promoted by ultrasonic radiation. Thus in water containing dissolved oxygen, hydrogen peroxide is formed; free chlorine is produced in the reaction of water with carbon tetrachloride in the presence of dissolved gases. These reactions appear to be best explained as gas phase reactions in the cavitation bubbles. Oxidation processes in general are stimulated by ultrasonic radiation. The accelerated aging of wine and distilled liquors is a practical application.

An important ultrasonic effect not associated with cavitation is the coagulation of aerosols like smoke and mist. The small particles, in following the vibrations set up in the medium, collide more frequently and tend to stick together, producing larger particles which gradually clear the field. This has an important industrial application to precipitation.

The heat effect of ultrasound can be very considerable; particularly when intense radiation is focused on a small region. Thus C. H. Allen and J. Rudnick, by irradiating 2 cm.^{3} of wax for 10 sec. with radiation of frequency 250 kc., observed a rise in temperature of 44" C. Experiments with the ultrasonic siren have shown that when the hand is held in a high intensity beam, a decided feeling of warmth is felt between the fingers. Heat resulting from an intensity of from 1 to 3 w. per square centimetre at 20 kc. is sufficient to kill small animals.

Other properties of ultrasound are discussed below under *Applications of Ultrasonics.*

APPLICATIONS OF ULTRASONICS

Technical and Industrial Applications. — The properties of ultrasound mentioned above have led to numerous important industrial and other technical applications, some of which have already been suggested. One interesting case is that of the ultrasonic delay line. If one has an electrical signal in the form of a pulse which one wishes to use for a certain purpose, but only after an appropriate time interval, it may be transformed into an equivalent ultrasonic pulse, fed into a suitable solid rod (preferably, of course, one with a low attenuation coefficient such as fused quartz) and allowed to travel back and forth until its presence is desired, when it is picked up and transformed back into an electrical signal. Since the velocity in the rod is accurately known, any desired time delay can be precisely provided. Liquid delay lines, *e.g.,* mercury in which the attenuation is relatively low, are also feasible. These delay lines have proved useful in radar installations as well as in high-speed electronic computers.

Since sound of sufficiently high frequency can be made to travel in a beam with little spreading, such a beam can explore a material medium and detect nonhomogeneities in it by reflection. This is the principle of the ultrasonic reflectoscope, invented by F. A. Firestone, in which an ultrasonic beam or pulse penetrating a metal, for example, produces an echo when it strikes a flaw which has different acoustical properties from the surrounding material. This echo can be detected by the same transducer which emits the original pulse. This device is the basis of the important industrial technique of nondestructive testing of metals and other solid bodies. It is important to note that electromagnetic radiation is not suitable for this purpose in conductors since it is so readily absorbed by them.

Another important industrial application of ultrasonics is the machining of very hard materials. If an abrasive paste is inserted between an ultrasonic vibrator and a brittle material, the latter is worn away rapidly as the paste and vibrator tip penetrate it. Effectively one has an ultrasonic drill, which since it does not rotate can produce holes of any shape.

Ultrasonic radiation in liquids can be used for cleaning metal parts (*e.g.*, the teeth in cutting tools) by removing all traces of foreign matter adhering to the metal in otherwise inaccessible places. It is found that frequency of the order one megacycle is desirable. The action has been attributed to cavitation, but the acoustic streaming mentioned above as well as the large accelerations due to the high-frequency vibrations at the liquid-solid interface may also play important roles. In the 1950s research was under way in the textile industry to determine whether ultrasonic radiation of synthetic fibres would lead to more efficient taking up of dyestuffs.

The soldering of aluminum by tin is made more efficient by an ultrasonic soldering iron which by removing the oxide scale from the aluminum produces a better bond without the need for fluxes.

In the production of alloys, it is found that ultrasonic irradiation of metal melts produces much finer and more uniform texture. The ability of high-frequency sound to disperse large pieces of metal into very small ones is back of this action, which has great metallurgical possibilities. Similar techniques have been employed in glass manufacture to degas melts.

The chemical effects of ultrasonics, already mentioned, have been put to extensive practical use. One of these is the depolymerization of high polymers. For example, when a solution of polystyrene in toluene was irradiated with 284 kc. ultrasound with an intensity of about 5 w. per square centimetre, the molecular weight of the long-chain molecule was reduced from 100,000 to 50,000 in 30 minutes. The exact mechanism was still a subject of controversy in the late 1950s. Another related effect is the action of ultrasound in thixotropic gels. Such a substance is a gel (*i.e.*, a colloidally dispersed system normally in solid form) which when agitated turns to a liquid and then returns to its solid state when the agitation ceases. It is found that ultrasonic radiation serves the same purpose as ordinary mechanical agitation in the gel-sol transition.

Biological Effect and Applications.—Through its direct heating action, through cavitation and related action and through direct mechanical action connected with the large accelerations and rapid changes in excess pressure and tension, it would be expected that ultrasound would prove a useful biological tool. By the mid-1950s, this expectation had been fully realized though fully accepted explanations of many of the observed actions were not at hand.

Bacteria and other microorganisms may be destroyed by ultrasonic radiation of sufficient intensity. Actually if the intensity is low, growth is stimulated. At a certain threshold, usually lower for large organisms than for small, destruction sets in and proceeds logarithmically with the time. This suggests the action of cavitation when the organisms are in a liquid environment. However, ultrasound is also lethal for some organisms in air, where cavitation cannot operate.

Ultrasound of frequency 1 mc. and intensity about 4 w. per square centimetre produces obvious necrosis of living animal tissue (*e.g.*, the tail of a mouse) if continued long enough; *i.e.*, around 30 minutes. Experiments indicate that this damage is due almost entirely to the heating effect produced in the absorption of the ultrasound by the tissues. Other investigations deal with the action of high-frequency sound on nerve tissue; *e.g.*, part of the spinal chord of a frog. It is found that with one megacycle radiation, irreversible paralysis of the hind legs takes place in a time which is inversely proportional to the excess pressure amplitude of the radiation. W. J. Fry, who made these studies up to intensities as high as 1,000 w. per square centimetre, concludes that the effect can be attributed neither to local heating of the nerve cells by the sound nor to cavitation. Whether the ultrasound produces its action by the physical disruption of the giant macromolecules in the cell because of the enormous forces it involves or whether some more subtle influence on nerve cells is at work was not clear in the late 1950s

The ability to focus very intense ultrasound in a small space without disturbing the surrounding tissue makes it a very plausible tool in neurosurgery. The full exploitation of this had not been realized in the late 1950s. However, its use in medical diagnosis had already proved successful and the development of equipment for the detection of nonhomogeneities in the macrostructure of soft tissues was under way. Here it was expected to be successful in areas for which X-rays are. completely inadequate. Also envisaged was the development of an ultrasonic microscope for the study of the actual structural distribution of proteins in living cells.

Ultrasonics has been employed extensively in medical therapy since 1939 and many types of applicators have been developed for irradiating different parts of the body. Clinical success has been claimed in many cases of arthritis, muscular rheumatism and sciatica. The precise therapeutic mechanism remained in doubt in the late 1950s, but most authorities leaned toward the view that it is due to selective heating in the interfaces between tissues of different physical properties. There were indications that more purely bioacoustical studies were needed. By mid-20th century, this had become a growing co-operative activity of biologists and physicists.

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ULTRA-VIOLET RAY: *see* LIGHT *AND* RADIATION IN RELATION TO HEALTH.

ULVERSTON, a market town and urban district in the Morecambe and Lonsdale parliamentary division, in the Furness district of Lancashire, just south of the Lake district, Eng., 9 mi. N.E. of Barrow-in-Furness and 37 mi. N.W. of Lancaster by road. Pop. (1951) 10,076. Area 5 sq.mi. Ulverston occurs in Domesday Book, where Vlureston is named as a manor. Early in the 12th century the manor passed to Stephen, count of Boulogne, who gave it to Furness abbey. In 1196 the abbot granted the vill of Ulverstone with the inhabitants to Gilbert Fitz-Reinfred, who granted it a charter and made it a free borough. The lordship became divided. One part passed to the Harringtons and finally to Henry Grey, duke of Suffolk, on whose attainder in 1553 it was forfeited to the crown; the other, returned to the abbey at the Dissolution, was surrendered to the crown. Early in the 17th century the crown alienated the manor, which descended to the family of Buccleuch. In 1280 Roger de Lancaster obtained a charter from Edward I for a weekly market and an annual fair. The council maintains the markets and the fairs are still held annually at Whitsuntide and Martinmas. The Church of St. Mary, founded in 1111, retains the original (Transitional) south door, but is mainly Perpendicular in style with an altar-tomb of 1588. Swarthmoor hall, former home of George Fox and a centre of the Quaker movement, is in the care of the Society of Friends. The lighthouse monument on Hoad hill is to the memory of Sir John Barrow, the explorer, author and secretary to the admiralty, who was born in the parish. Conishead priory, 2 mi. S.E., a mansion on the site of a priory founded in the reign of Henry II, is a convalescent home for mineworkers. Ulverston's former iron and steel works and the chemical and paper works have disappeared and the principal industries now include the manufacture of antibiotics, electrical accessories, leather tanning, light engineering and clothing.

ULYSSES: *see* ODYSSEUS.

UMBELLIFERAE (carrot or parsley family). a diverse family of herbs recognized since the time of Theophrastus (3rd century B.C.). The 2,500 species world-wide in distribution, primarily in temperate areas, include both familiar food plants and poisonous species. Important foods are the carrot (Daucus), celery (*Apium*), parsley (Petroselinum) and parsnip (*Pastinaca*) Cryptotaenia, Lomatium and other genera have been used locally as foods. Arracacha (Arracacia) is cultivated in northern Andean South America for its edible roots, which resemble parsnip in size. form, texture, colour and odour. They have a high starch content and serve as a substitute for potato. Propagation of arracacha is by offsets from the rootstock planted in well-fertilized and mulched soil; harvesting is from 10 to 14 months after planting. The varieties cultivated require the uniform day length of the tropical latitudes. but the best-quality roots are produced in the mountains with optimal growing temperatures of 15°–20° C.

Condiments belonging to the Umbelliferae are anise (*Pimpinella*), caraway (Carum), chervil (Anthriscus). dill (Anethum), fennel (Foeniculum), lovage (*Levisticum*) and angelica (Angelica). Gum resins are obtained from Ferula (galbanum, ammoniacum and asafetida) and *Dorema* (ammoniacum). Some genera have been used medicinally (*Ammi, Coriandrum, Ferula, Foeniculum*). Other genera possess poisonous alkaloids, especially in the

ROCHE

Sweet cicely (Myrrhis) showing flowers, fruit and leaves

roots and fruits, and may cause death if eaten (water hemlock or Cicuta, poison hemlock or Conium and fool's-parsley or Aethusa). A few have been grown as ornamentals—Queen Anne's lace (*Ammi*), blue lace flower (*Trachymene*), cow parsnip (*Heracleum*), sea holly (Eryngzum). angelica (Angelica) and goat weed (Aethusa). Two genera, Laretiu and Azorella, form large woody mounds, "vegetable sheep." used as a fuel in the Andes.

The family is closely related to the Araliaceae (ginseng family) and probably derived from the same stock. The Cmbelliferae differ in being predominantly herbaceous with sheathing petioles or leafstalks, and with a dry fruit, the schizocarp, that splits at maturity into two dry segments. The two families are placed in the order Umbellales to which some authors also refer the Cornaceae (dogwood family) and Nyssaceae (nyssa family).

The plants are annual or perennial aromatic herbs, rarely woody (Astericium, Azorella, *Bupleurum, Gymnophyton*, Laretiu, Trachymene, etc.) or treelike (*Myrrhidendron* and some species of Eryngium). They are dicotyledonous, bearing two seed leaves. The stems are commonly ribbed and hollow between the nodes. The leaves are alternate, or basal, or rarely opposite, usually much divided and incised and aith sheathing petioles. Species of *Eryngium* and Aciphylla have monocotyledonoid leaves resembling those of the bromelia family (Bromeliaceae). The flowers are small, regular, usually white, yellow or purplish. with separate petals arranged in simple or compound umbels that may be flat-topped, globose or somewhat concave. The umbels and umbellets are frequently subtended by bracts and bractlets. The umbel may be spreading with the outer flowers radiant as in *Ammi* and Heracleum, capitate as in Eryngium, or rarely reduced to a single flower (*Asciadium*). The flowers are mostly bisexual but are sometimes unisexual with occasionally entire umhellets being male or staminate. Both staminate and perfect flowers (with both stamens and pistils) may occur in the same cluster; or the flowers may be monoecious, bearing stamens and pistils on separate flowers (Echinophora) ; or unisexual or dioecious (as in Arctopus). Cross-pollination is general and the umbels are visited by a variety of beetles and small flies. The calyx lobes or outer floral leaves are small or absent The five free petals, each usually with an inflexed tip, alternate with five stamens inserted on a nectar-secreting disk. The pistil is composed of two united carpels and the inferior ovary is two-celled. Each cell contains one ovule. The tno styles are often swollen at the base. The fruit is a schizocarp, *i.e.*, composed of two dry segments that usually separate at maturity and are suspended from the apex of a carpophore, or part of the floral axis. The fruit characters are very diverse and have been used extensively in the classification of the family. The segments are united by their faces and may be flattened laterally (at right angles to the face) as in Carum and Apium, dorsally (parallel to the face) as in Lomatium and Peucedanum, or may be almost terete, circular in transverse section, as in Foeniculum. Each segment has five primary ribs which may be inconspicuous or may be developed into broad thin or corky wings. Oil tubes are usually evident in the intervals between the ribs and on the face and may occur in the ribs. Recorded haploid chromosome numbers are 5,6,7,8,9,10 and 11. Polyploidic and aneuploidic variations in chromosome numbers occur.

Three subfamilies are recognized: the Hydrocotyloideae with 270 species widely distributed particularly in the southern hemisphere (Azorella, *Bowlesia*, Centella, Hydrocotyle, Trachymene); the Saniculoideae with 260 species primarily in the northern hemisphere but with a few bipolar genera (Eryngium, Sanicula); and the Apioideae (1950 species) likewise best developed in the northern hemisphere but with a few bipolar or southern hemisphere genera. The Apioideae include many of the common genera such as Angelica, Apium (celery), Arracacia, *Bupleurum*, Carum (caraway), Cicuta (water hemlock), *Conium* (poison hemlock), *Cymopterus*, Daucus (carrot), Ferula (asafetida, galbanum), Heracleum (cow parsnip), *Ligusticum*, Lomatium, Oenanthe, Oreomyrrhis, *Osmorhiza*, Pimpinella (anise), Peucedanum, Prionosciadium, Seseli, *Sium, Smyrnium* (alexanders) and Tauschia.

See also Alexanders; Anise; Ammoniacum; Carrot; Celery; Water Hemlock and other articles on individual plants mentioned. (Md. E. M)

UMBRELLA, an accessory of dress, is a covering carried in the hand to ward off the rain. The original purpose of the umbrella was that of a sunshade and as such it is traced back to ancient Egypt and Nineveh uhere it early became a symbol of honour and authority. Ancient Egyptian art depicts the Pharaoh enthroned beneath an umbrella.

From the far east also come many interesting accounts and legends of the umbrella. There its use was permitted only to royalty and those of high office.

The Greeks are credited with introducing the umbrella as a sunshade into Europe. Paintings on Greek vases suggest that it was in common use. Roman sunshades were similar to those used by the Greeks. It is believed, however, that the Romans were the first to use the umbrella as a protection against rain.

The use of the umbrella almost disappeared during the middle ages but it appeared again in Italy in the latter half of the 16th century when it was regarded as a symbol of distinction and power by the pope and the clergy. By 1680 the umbrella appeared in France and later in England. The use of the umbrella was general in Italy, France. Britain, Germany and the Setherlands by the 18th century, by which time it was generally employed as protection against the rain. The general construction of umbrellas has changed little through the centuries; however, with the introduction of the steel frame in 1850, the weight was reduced considerably.

Though the umbrella, especially the handle, varied in style with the changes of fashion, it was generally black in colour. In the 20th century women's umbrellas were produced in a variety of colours though men's umbrellas continued to be black.

See Katherine Morris Lester and Bess Viola Oerke, Accessories of Dress (Peoria, Ill., 1940); Carolyn G. Bradley, Western World Costume (New York, 1954); Millia Davenport, *The* Book of Costume (New York, 1948; London, 1951). (M. B. K.)

UMBRELLA BIRD, the name for a species of the genus *Cephalopterus,* belonging to the American family Cotingidae. The males are black and bear a peculiar umbrellalike crest from which characteristic the name is derived. They also have long, plumed wattles depending from the throat.

UMBRELLA MAGNOLIA or UMBRELLA TREE, common names applied to *Magnolia* tripetala, a deciduous tree of the U.S. with spreading branches and an open head that grows to 40 ft. and bears pointed, oblong to broadly oval leaves one to two feet long that are pale green and are soft-hairy beneath. The flowers are cup shaped, white, ten inches across, pungently scented and appear when the leaves are well developed. It is native from Pennsylvania to Alabama and Arkansas.

See MAGNOLIA. (J. M. BL.)

UMBRELLA MAGNOLIA (MAGNOLIA TRIPETALA)

UMBRIA, an ancient and a modern district of Italy.

1. The ancient district was bounded in the period of the Roman supremacy by the Ager Gallicus (in a line with Ravenna) on the north, by Etruria (the Tiber) on the west, by the Sabine territory on the south and by Picenum on the east. The Via Flaminia passed up through it from Ocriculum to Ariminum; along it lay the important towns of Narnia (Narni), Carsulae, Mevania (Bevagna), Forum Flaminii, Nuceria Camellaria (Nocera) and Forum Sempronii; and on the Adriatic coast Fanum Fortunae (Fano) and Pisaurum (Pesaro). To the east lay Interamna (Terni), Spoletium (Spoleto), Fulginium (Foligno—on a branch of the Via Flaminia nhich left the main road at Narnia and rejoined it at Forum Flaminii) and the important town of Camerinum on the side of the Apennines toward Picenum. On the side toward Etruria lay Ameria (Amelia) and Tuder (Todi), both on the direct road from Rome to Perusia, Iguvium. which occupied a very advantageous position close to the main pass through the Apennines, and Hispellum (Spello). Not far off was Asisium (Assisi), while far to the north in the mountains lay Sarsina. Under the empire it formed the sixth region of Italy.

The name Umbria is derived from the Umbri, one of the chief constituent stocks of the Italian nation. The origin and ethnic affinities of the Umbrians are still. like their geographical location in early times (1200–1000 B.C.), unknown, but their language proves them to have been an Aryan people closely allied with the Oscans and in a remoter degree with the Latins.

The process by which the Umbrians were deprived of their traditional predominance in upper and central Italy and restricted to their confines of historic times cannot be traced in detail. Their easternmost territory in the region of Ancona was perhaps wrested from them by the Picenes, a branch of the Sabine stock; and it is probable that they were partly displaced in the valley of the Po by the Gaulish tribes which began to pour across the Alps from about 500 B.C. But their chief enemies were undoubtedly the Etruscans (*q.v.*), who eventually drove them into that upland tract athwart the Apennines to which the name of Umbria belonged in historical times without eradicating the Umbrian element of population in the conquered districts. In Etruria proper the persistence of the Umbrian stock is indicated by the survival of numerous Umbrian place names, and by the record of Umbrian soldiers taking part in Etruscan enterprises; *e.g.,* the attack on Cumae in 524 B.C. Indeed it is not unlikely that the bulk of the population in Etruria continued to be of Umbrian origin. and that the Romanization of this country was facilitated by the partial absorption of the Etruscan conquerors into the Umbrian multitude.

Against the Romans the Umbrians never fought any wars of importance. After the downfall of the Etruscan power they made a belated attempt to aid their Samnite kinsmen in their decisive struggle against Rome (308 B.C.); but their communications with Samnium were impeded by the foundation of a Roman fortress at Narnia (298 B.C.), and at the great battle of Sentinum (295 B.C.), which was fought in their own territory, the Umbrians did not lend the Samnites any substantial help. It is perhaps on account of this defection that in zoo B.C. they received from the Romans a portion of the Ager Gallicus reconquered from the Senonian Gauls. They offered no opposition to the construction of the Via Flaminia through the heart of their country, and in the second Punic War withheld all assistance from Hannibal. In the Social War (90–89 B.C.), they joined the rebels tardily and were among the first to make their peace with Rome. Henceforth they no longer played an-independent part in Italian history.

The material prosperity of Umbria. in spite of its unfavourable position for commercial intercourse, was relatively great, as a result of the fertility of the numerous small valleys which intersect the Apennine system in this region. The chief products of the soil were olives, vines and spelt; the uplands harboured the choicest boars of Italy. The abundance of inscriptions and the high proportion of recruits furnished to the army attest its continued populousness. Among its most famous natives were the poets Plautus (b. at Sarsina) and Propertius (b. at Assisi).

The Umbrians in addition to the city (tofu) had a larger territorial division in the *tribus* (triju, acc.) as is gathered from Livy (xxxi, 2). Ancient authors describe the Umbrians as leading effeminate lives, and as closely resembling their Etruscan enemies in their habits. There is conclusive proof of strong Etruscan influences in Umbria, and their alphabet is undoubtedly of Chalcid-Etruscan origin, while the language, which is known from one or two inscriptions from Fulginium and Tuder, and from the so-called *Iguvine* Tables, the earliest parts of which may go back to the 5th cent. B.C. (see IGUVIUM), is a dialect which sprang from the Oscan, but is marked by some phonetic changes. Etruria also taught the towns near it (*e.g.,* Tuder and Iguvium) the art of minting, for they alone had a coinage. The Umbrians counted their day from noon to noon. But whether they borrowed this likewise from the Etruscans is not known. In their measuring of land they employed the *vorsus,* a measure common to them and the Oscans, 33 of which went to the Roman jugerum.

2. The modern territorial division is situated in the middle of the peninsula, between Tuscany and the Marches on the north and east, and Lazio (Latium) and the Abruzzi on the south and west, and comprising the two provinces of Perugia and Terni, with an area of 3,267 sq.mi.; pop. (1951) 803,918. Umbria and the provinces of Ancona and Pesaro and Urbino taken together form an area slightly more extensive than that of the sixth region of Augustus. The surface is mountainous, but affords good pasture, and there are numerous fertile valleys. Many treasures of

art and architecture are preserved, making Umbria one of the most interesting regions of Italy. *(See* PERUGIA.) Modern Umbria formed down to 1860 a part of the states of the church.

Three main lines of railway run through the territory. One from Florence to Rome skirts th'e borders of the province on the west, running north and south. Another Rome-Florence line bisects the territory north and south, while the Rome-Ancona runs across the province from northeast to southwest. The cross communication is given by three branch lines.

The steelworks of Terni (*q.v.*), the chloride factory at Nera Montoro near Narni, the chemical manure works at Narni. Foligno and Assisi, the wool and jute works of Terni and Foligno, the cotton spinnery of Spoleto may all be mentioned, while the hydroelectric plants of Umbria, which are concentrated at Terni, are of great importance, and help those of Lazio and Tuscany. (T. A.)

UMBRIAN LANGUAGE. The dialect in which the *Iguvine Tables (see* IGUVIUM) are written is usually known as Umbrian, as it is the only monument we possess of any length of the tongue spoken in the Umbrian district before it was Latinized. The language is that of a certain limited area, which cannot yet be shown to have extended very far beyond the eastern half of the Tiber valley (from Interamna Nahartium to Urvinum Mataurense).

Umbrian has diverged from Oscan in the following matters: (1) The palatalization of k and *g* before a following *i* or *e*, or consonant *i* as in *tiçit* (i.e., *diçit*) = Lat. *decet; muieto* past part. passive (pronounced as though the *i* were an English or French *j)* beside Umb. imperative *mugatu*, Lat. *mugire.* (2) The loss of final *-d, e.g.,* in the alb. sing. fem. Umb. *tōtā* = Osc. *toutād.* (3) The change of *d* between vowels to a sound akin to *r,* written by a special symbol ꟼ (*ḍ*) in Umbrian alphabet and by RS in Latin alphabet, e.g., *teda,* in Umbrian alphabet = *dirsa* in Latin alphabet, "let him give," exactly equivalent to Paelignian *dida.* (4) The change of *-s-* to *-r-* between vowels as in *erom,* "esse" = Osc. *ezum,* and the gen. plur. fem. ending in *-aru* = Lat. *-arum,* Osc. *-azum.* To this there are exceptions, *e.g., asa* = Lat. *ara,* which are generally regarded as mere archaisms. Unfortunately the majority of them are in words of whose origin and meaning very little is known, so that (for all we can tell) in many the *-s-* may represent *-ss-* or *-ps-* as in *osatu* = Lat. *operato, cf.* Osc. *opsaom.* (5) The change of final *-ns* to *-f* as in the acc. plur. masc. *vitluf* = Lat. *vitulōs.* (6) In the latest stage of the dialect the change of final *-s* to *-r,* as in abl. plur. *arver, arviis; i.e.,* "arvorum frugibus." (7) The decay of all diphthongs. (8) The change of initial *1* to *v,* as in *vutu* = Lat. *lavito.*

Save for the consequences of these phonetic changes, Umbrian morphology and syntax exhibit no divergence from Oscan that need be mentioned here, save perhaps two peculiar perfect-formations with -1- and *-nçi-;* as in *ampelust,* fut. perf. "impenderit," *combifiançiust,* "nuntiaverit" (or the like).

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UNAKA MOUNTAINS is the name frequently applied to the mountains in Avery and Mitchell counties in North Carolina and Unicoi and Carter counties in eastern Tennessee. The Unaka mountains are actually the southwestern segment of the Blue Ridge Mountain system. The range runs between the Great Appalachian valley (to its west) and the Blue Ridge escarpment (to its east) along the Tennessee-North Carolina boundary, and extends into southwestern Virginia and Georgia. Elevations range from 2,000 to 6,000 ft. with the main ridges averaging 5,000 ft. Included in the Unaka Mountain range are: The Great Smoky mountains with Clingmans Dome (elevation 6,644 ft.); also Iron mountains (2,500–4,000 ft.); Chilhowee (1,500–3,000 ft.); Unicoi (5,472–5,600 ft.); Stone (3,400 ft.); Brasstown Bald (4,784 ft.); and the Holston ranges (2,500–4,000 ft.). The Unakas have been severely dissected by stream erosion; in general 80% to 90% of their area consists of steep slopes and deep, narrow valleys. Extensive geological faulting and folding along their western margins also has contributed to the development of their complex topography.

Most of the Unaka system is covered by national forests, including Pisgah, Nantahala, Jefferson and Cherokee. The forests consist principally of hardwoods and abound with wildlife.

(M. C. P.)

UNAMUNO, MIGUEL DE (1864–1936), Spanish scholar and writer, and one of the most influential Spanish thinkers of his time, was born of Basque parents at Bilbao on Sept. 29, 1864. He studied the classics and philosophy at Madrid, and in 1891 became professor of Greek at Salamanca. Most of his life was spent there: he was appointed rector of the university in 1901, removed for political reasons in 1914, re-elected in 1931, made rector for life in 1934, but again removed in 1936. In 1924 he was deported to Fuerteventura, in the Canary Islands, for his attacks on the dictatorship of Gen. Primo de Rivera: thence he fled to France, where he remained until the fall of the dictatorship in 1930. An opponent of the decadent Spanish monarchy, he was an independent Republican deputy to the *Cortes,* 1931–33. On the outbreak of the civil war, he at first declared in favour of the nationalists, but later denounced both sides, and was confined to his house in Salamanca, where he died on Dec. 31, 1936.

The eldest of the "generation of 1898," Unamuno early made his influence felt. Significantly, his first literary labour was the translation of Carlyle's *The French Revolution,* in which he "did violence to Spanish" to match Carlyle's "violation of English." His first published work, essays entitled *En torno al casticismo* (1895) on the theme of Spanish anachronism and isolationism, was the earliest effective questioning of Spain's place in an industrial and scientific world. His first novel, *Paz en la guerra* (1897), based on his childhood memories of the Carlist siege of Bilbao, may be regarded as the first "existentialist" novel. It was followed by several books of essays. In 1905 appeared *Vida de Don Quijote y Sancho* (Eng. trans., *Life of Don Quixote and Sancho,* 1927), a detailed analysis of Cervantes' characters, whose intrinsic reality and immortality was, Unamuno considered, greater than that of their author. The book is also a profession of a faith in quixotism, a plea for redemption through spiritual extravagance.

At the heart of Unamuno's view of life is his personal and passionate longing for immortality, most poignantly expressed in his masterpiece *Del sentimiento trágico de la vida* (1913; Eng. trans., *The Tragic Sense of Life in Men and in Peoples,* 1921), which explores the chasm between faith and reason. In *La agonia del Cristianismo* (first published in French, 1925; in Spanish, 1931; Eng. trans., 1928) he developed his philosophy of anguish and doubt, and, although he always called himself a Catholic, these two books express such a sense of uncertainty that they were later placed on the papal index.

Deeply concerned with man as an individual, not as "a social animal," Unamuno wrote innumerable essays, which, if they have any common theme, are calls to preserve personal integrity, however paradoxical this may seem in a compromised society, to search for one's own truth, however agonizing, and to a faith in faith itself, however doubt-ridden. Himself, as he said, a "sower of doubt and agitator of consciences," Unamuno preached the need to strive against fate and to deny annihilation. In his later novels his heroes are "agonists" rather than protagonists. They live in a world of passionate problems which they have created for themselves, immune from trivialities because of their tragic attitude. *Amor y pedagogía* (1902) describes a father's attempt to bring up his son scientifically, ending in failure and the ruin of the son. *Niebla* (1914; Eng. trans., 1928) demonstrates Unamuno's belief that a character in fiction may be as real as a man in the world of reality. *Abel Sánchez* (1917; Eng. trans., 1956), is a modern version of the tragedy of Cain, which censures all the ['petty Abels" for their smugness. His last, and perhaps his greatest novel, *San Manuel Bueno, mártir* (1933; Eng. trans., 1956), the story of an unbelieving priest, takes up again the characteristic themes of the agony of unbelief and the longing for immortality.

See J. Marias, *Miguel de Unamuno* (1943); J. B. Trend, *Unamuno* (1951). *(Ay. K.)*

UNAO (correctly UNNAO), a town and district of India, in the Lucknow division, Uttar Pradesh. The town is 10 mi. N.E. of Kanpur. Pop. (1951) 25,240.

The DISTRICT OF UNNAO has an area of 1,774 sq.mi. It consists of a flat alluvial plain, lying north of the Ganges. Rich and fertile tracts, studded with groves, alternate with stretches of waste land and plains of barren *usar,* the whole being intersected by small streams used for irrigation. The Ganges is the only navigable river in the district, while the Sai forms its northeastern boundary. Pop. (1951) 1,067,055.

UNCERTAINTY PRINCIPLE, THE. This principle, which was formulated by Werner Heisenberg (in 1927), and which plays a fundamental role in quantum mechanics (*q.v.*) states that it is impossible to specify or determine simultaneously both the position and velocity of a particle as accurately as is wished. It is, to be sure, possible to fix either of these quantities as precisely as desired, but only at a price, for the greater the precision in one, the greater the inevitable lack of deftniteness in the other. A more exact formulation is as follows: there is no way in which quantum-mechanicallanguage permits us to say that a co-ordinate x and its conjugate momentum p_x simultaneously have values x' and p'_x with arbitrarily small uncertainty. Instead, if Ax and Δp_x denote the uncertainty in x and p_x respectively, there exists the inequality

$$\Delta x \Delta p_x \geq \frac{h}{4\pi} \qquad (1)$$

where h is Planck's constant 6.62×10^{-27} ergs$\times$sec. It is to be emphasized that the restrictions imposed by the uncertainty principle apply only to a pair of dynamical variables which are canonically conjugate. There is no limit in principle to the precision with which values can be assigned to a co-ordinate and a momentum conjugate to another independent co-ordinate, as, for example, the x component of position and the y component of momentum.

Because h is so small, the indeterminism caused by the uncertainty principle is of no consequence in ordinary experience. For instance, the resulting error in the position or velocity of a rifle bullet would be completely inconsequential even for the most refined ballistic calculation. On the other hand, the Heisenberg uncertainty principle is of great interest and importance in the interpretation of atomic experiments, and has startling philosophical implications.

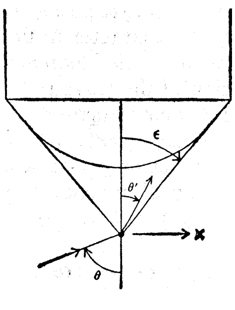
For discussion of the place of the uncertainty principle in the general scheme of things in quantum mechanics see QUANTUM MECHANICS: Statistical Significance. A quantitative definition is given there of the uncertainty in terms of root mean square deviation, as well as an outline of how the uncertainty principle is derived from the basic equations of wave mechanics, of which it is a necessary consequence.

A standard illustration of the uncertainty principle is furnished by the resolving power of a microscope, which shall be taken as an example.

Let the particle be at such a distance that the cone of rays scattered by the particle and entering the lens of the microscope have an angular opening ϵ, as shown in the figure. It is shown in optics that the resolving power of the instrument is

$$\text{Ax}= \frac{\lambda}{\text{sine } \epsilon} \qquad (2)$$

where λ is the wave length. In order for the particle to be observed it must scatter at least one quantum of light into the microscope. (If more than one quantum is scattered, the particle will receive extra recoil kicks, and the uncertainty will be even greater than with the estimate.) The theory of the Compton Effect (*q.v.*) and related subjects shows that a light quantum of frequency ν is endowed with a momentum $h\nu/c$, where c is the velocity of light. Consider for simplicity the case where the initial and scattered quanta fall in the same plane as the axis of the microscope, and make angles % %' with the latter, as shown in the figure. Since momentum is conserved in the interaction between the particle and the light quantum, the x component of momentum imparted to the particle is $(\text{sine } \theta - \text{sine } \theta')\frac{h\nu}{c}$ (Here the Compton change of frequency on scattering has been neglected, but this is a second order effect.) As θ' is comprised within the limits $\pm\epsilon$, in order to enter the microscope, the x component of momentum imparted to the particle may be anywhere between



$$(\text{sine } 0 - \text{sine } \epsilon)\frac{h\nu}{c} \text{ and } (\text{sine } \theta + \text{sine } \epsilon)\frac{h\nu}{c}$$

Hence the observation inherently introduces an uncertainty in the momentum of the particle amounting to $\Delta p_2 = 2 \text{ sine } \epsilon \cdot \frac{h\nu}{c}$. Combining this result with (1) and remembering that $\lambda = \frac{c}{\nu}$, it is seen that $\Delta p_x \Delta x = 2h$. The fact that ϵ does not appear in this result illustrates the futility of trying to defeat the uncertainty principle with any choice of aperture.

Too much significance should not be attached to the fact that the error is apparently 8 π times the minimum allowed by (1), for the estimate (2) of resolving power is accurate only to order of magnitude,

In classical mechanics, if the initial position and velocity are known, together with the forces acting, then a particle's path can be computed for all future time. On the other hand, the uncertainty principle prevents specification of the initial conditions in quantum mechanics, and as a result the future of a particle cannot be definitely predicted. Because of this the law of cause and effect ceases to apply, though the ambiguity is, of course, important only on the atomic scale. Instead the future of a particle can only be statistically predicted in quantum mechanics, but the type of information supplied is just that needed to describe actual experiments. For instance. in the theory of the scattering of alpha particles, quantum mechanics gives directly the formula for the distribution-in-angle of the scattered particles, without correlating a particular scattering angle with a particular distance of closest approach to a scattering centre. Such a correlation is involved in classical theory, but it is necessary to integrate over all distances of approach, and the latter are supernumerary quantities not capable of being observed in the experiment; hence it is unimportant that they are uncertain in the quantum-mechanical interpretation. In fact, it must be regarded as an element of strength in quantum mechanics that the statistics governing the distribution of distances of approach is self-contained in the formalism, and not introduced as an additional hypothesis as in the classical treatment.

It is to be emphasized that in making observations on a system, it is necessary to exchange energy and momentum with it. This exchange of necessity spoils the original properties of the system. The resulting lack of precision with which these properties can be measured is the crux of the uncertainty principle. In the microscope example, for instance, the momentum of the particle was rendered uncertain by the impact with the light quantum by which it was being observed.

The fact that there are intrinsic limits to the precision of experimentation obviously has profound philosophical significance. In particular, metaphysicians can argue whether nature inherently lacks determinism, or is instead completely deterministic. With the latter view, the ambiguity involved in the uncertainty principle, or the apparent breakdown of the law of cause and effect is to be considered as arising only by virtue of the "spoiling" by the experimentation.

It is in a certain sense a meaningless question which view is correct, as the properties of nature that are inherently incapable of observation have no realistic significance. In this connection it is well to quote a few sentences from an article by P. W. Bridgman in Harper's Magazine, vol. 158, pp. 443–451 (1929):

The immediate effect [of the uncertainty principle] will be to let loose a veritable intellectual spree of licentious and debauched thinking. This will come from the refusal to take at its true value the statement that it is meaningless to penetrate much deeper than the electron, and will have the thesis that there is *really* a domain beyond, only that man with his present limitations is not fitted to enter this domain. . . . The existence of such a domain will be made the basis of an orgy of rationalizing. It will be made the substance of the soul . . . the principle of vital processes will have its seat here; and it will be the medium of telepathic communication. One group will find in the failure of the physical law of cause and effect the solution of the age-old problem of the freedom of the will, and, on the other hand, the atheist will find the justification of his contention that chance rules the universe.

The safest conclusion is perhaps that man should remain humble in the face of nature since there are inherent limitations to the precision with which he can observe the latter.

See W. Heisenberg, ***The Physical Principles of the Quantum Theory*** (1930). The uncertainty principle was first formulated by Heisenberg in the ***Zeitschrift fur Physik,*** vol. 43, pp. 172–198 (1927), and somewhat amplified by Niels Bohr in ***Nature,*** vol. 121, p. 580 (1928). An interesting popular article on the philosophical implications of the uncertainty principle is that by P. W. Bridgman in ***Harper's Magazine,*** vol. 158, pp 443–451 (1929). (J. H. V. V.)

UNCLE SAM, the popular name for the United States. The origin of the name is unknown, but is not very credibly attributed to the initials U S.. placed on property of the government. It came into existence about the time of the outbreak of the War of 1812, spread rapidly and within a few years was recognized universally.

UNCONSCIOUS. Sigmund Freud. about 1885, began an era of thought by stating that ideas, feelings and memories outside consciousness may affect a person's behaviour even though he cannot report upon them. William James called this the most important step forward in the time he had been studying psychology.

Just as the activities of all units of an army are not always integrated, so all aspects of the mental processes and behaviour of an individual are not co-ordinated. Some mental systems which affect behaviour unconsciously are independent of and unrecognized by the controlling part of the personality.

Disparate and sometimes conflicting uses of "unconscious" occur in popular and scientific writings. The word has been used synonymously with "inanimate" or "subhuman" to describe whatever is incapable of discriminating or behaving. Individuals have been termed unconscious under many different circumstances —when unresponsive to stimulation because of absentmindedness, day-dreaming, hypnosis, sleep, anaesthesia, etc.; when not discriminating between different stimuli; when acting sheerly on the basis of conditioned responses (see below); when not sensing, because one or more factors are preventing adequate stimuli from affecting their nervous systems. A person may also be called unconscious if he is not attending to something; if he lacks insight into the nature of a situation involving him; if he forgets something; if his actions are purely instinctive; if he does not recognize the character of the determinants of his behaviour; if some of his acts are involuntary; if he cannot communicate all he is aware of, by word, gesture, facial expression or other means; if he deliberately ignores facts he knows; or if he makes discriminations but is unaware that he does.

The actions, ideas, emotions, needs or drives of a person are also often called unconscious in many of the above meanings, as well as in another sense—not mental. Various theoretical schools deny that unconscious processes exist, on the grounds that consciousness and mind are equivalent, that what is unconscious is therefore not mental, and that hence the concept of unconscious mental processes is self-contradictory. Freud contended that this apparent paradox arises from misunderstanding the psychoanalytic use of "unconscious," which refers to processes that (1) are dynamically repressed away from awareness, the organ of perception; (2) can be brought to awareness only by special techniques like hypnosis and psychoanalysis; and (3) are not controllable voluntarily.

The numerous uses of the word "unconscious" reflect great theoretical disagreements, and sometimes the same process is conscious in one sense and unconscious in another. For example, after a bell has been sounded routinely one minute before repeated feedings, the salivation that normally occurs upon presentation of food can eventually be elicited by the bell—a conditioned response. Psychologists who do not accept introspective reports as valid consider that behaviour indicating discrimination between the presence and absence of a stimulus is evidence of consciousness. Hence a conditioned response is such evidence—a sign, in the example, of consciousness of the bell. Other psychologists do not agree that mental processes are merely neural function evidenced by discriminatory behaviour, believing they also involve awareness of this discrimination. Some of the latter group hold that this consciousness is associated with every mental process, and since conditioned responses are often given a purely neurophysiological explanation, they are not mental—unconscious.

Various schools explain how it is determined which mental processes are conscious and which unconscious by using one or both of two concepts—the economy principle and the pleasure principle. The economy principle is that ordinarily one, or at most a few, thoughts or acts are attended to at a time. The organism appears to function most efficiently when it does not dissipate the energy of attention but concentrates this consciousness on a restricted range of activities, allowing the rest to be relatively or completely automatic. Moreover, certain activities, including composing, complex judgments and highly practised muscular acts, are often accomplished best automatically. If unattended processes develop unusual characteristics or threats to the organism's welfare, a guarding mechanism swiftly turns attentive consciousness to them. Along with this change appear expressions indicating surprise, characteristic objective signs of the onset of the new state of consciousness. Presumably this is associated with increasing "neural vigilance," a phrase of Henry Head meaning high-grade physiological efficiency in a part of the nervous system, which he postulated as developing as consciousness turns to the functions of that part.

Subjectively, various levels of unconsciousness merge imperceptibly into one another. The ordinary waking state differs from hypnosis which differs from sleep which differs from deep anaesthesia. Functional levels of the nervous system also exist, each with its own threshold. Stimuli may be strong enough to cross the threshold to one level and affect behaviour, without being capable of reaching the level of highest neural vigilance. Thus, behaviour may be affected and awareness not be. There is a range of intensity of stimulation at which perception and learning occur without awareness.

Freud described how the pleasure principle operates, thrusting painful thoughts and desires into unconsciousness and permitting pleasant ones to remain conscious. He considered painful those which produce shame, guilt or injury to self-esteem. These are repressed into unconsciousness, which psychoanalytic theory sharply delimits from consciousness, recognizing little merging. They are censored and kept from consciousness unless altered into dream symbols, slips of the tongue, jests or some other acceptable guise.

Because dreams seem distorted and for other reasons, unconscious processes are frequently called irrational. Clinical evidence indicates that one class of these is not illogical but shrewdly devoted to fulfilling socially unacceptable, anarchic desires for independence and self-centred pleasure. Other classes are not irrational either, but are determined by subthreshold stimulation, unconscious conditioning or forgotten events. They elicit unaccountable behaviour because they are not available to awareness. Society forces us to explain our acts, so we make them appear to ourselves and our fellows to arise logically from accepted principles of our culture. That this mechanism is called rationalization does not mean unconscious processes are irrational.

(Ja. G. M.)

UNDERGROUND RAILROAD, a term used popularly to designate an organized system existing in the northern states of the United States prior to the Civil War by which slaves were secretly helped by sympathetic northerners and in defiance of the Fugitive Slave laws (*q.v.*), to make their way to Canada, and thus to freedom. The name arose from the exaggerated use of railway terms in reference to the conduct of the system. Levi Coffin and Robert Purvis were the "presidents" of the road. Various routes were known as "lines," stopping places were called "stations," those who aided along the stages of the route were "conductors" and their charges were referred to as "packages" or "freight." The system reached from Kentucky and Virginia across Ohio, and from Maryland across Pennsylvania and New York or New England. The Quakers of Pennsylvania perhaps initiated the system; the best known of them, Thomas Garrett (1789–1871), is said to have helped 2,700 slaves to freedom. One of the most picturesque conductors was Harriet Tubman, a Negro woman called "General" Tubman by John Brown, and "Moses" by her fellow Negroes. who made about a score of trips into the south, bringing out with her perhaps 300 Negroes altogether. Levi Coffin, a native of North Carolina. in 1826 settled at New Garden (now Fountain City), Ohio, where his home was the meeting point of three "lines" from Kentucky. In 184; he removed to Cincinnati, where he was even more successful in bringing out slaves. Estimates of the number of slaves who reached freedom through the system vary from 40.000 to 100,000.

See W. H. Siebert, *The Underground Railroad* (1898), a scholarly study containing maps of routes and bibliography. W. Still, *The Underground Railroad* (1872); *R* C. Smedley, *History of the Underground Railroad* (1883); and *Reminiscences of Levi Coffin* (1880) are personal records of participants

UNDERWOOD, FRANCIS HENRY (1825–1894), U.S. author, one of the founders of the *Atlantic Monthly*, was born in Enfield, Mass., on Jan. 12, 1825. He attended Amherst college, Amherst, Mass., for a year and then studied law in Kentucky, being admitted to the bar in 1847. In Kentucky his original antipathy to slavery was heightened by close observation, and he eagerly returned to Massachusetts in 1850. After a year of law practice, and two years as a clerk of the state senate, he became literary editor for the Boston publishing house of Phillips, Sampson and company. He soon conceived the idea of initiating a New England magazine similar to *Harper's Magazine* in New York, in which the Free Soil movement could find a voice. He entered into correspondence on the matter with his friends, among them the most distinguished writers of the day — Emerson, Lowell, Holmes, Longfellow, Charles Eliot Norton and Whittier. By 1853 he had contracted for publication with John P. Jewett and Company. but the firm failed before a beginning was effected. With the help of Harriet Beecher Stowe he persuaded his firm to become publishers of the new magazine named the *Atlantic Monthly;* the first number appeared in Nov. 1857 with James Russell Lowell as editor and Underwood as his assistant.

In 1859, upon purchase of the magazine by Ticknor and Fields, Underwood's association with it was ended and he became clerk of the superior criminal court of Boston. a position he held for seven years. He was twice appointed U.S. consul in Scotland by Pres. Grover Cleveland, in 1886 and in 1893. He died in Edinburgh, Scot., Aug. 7, 1894.

Underwood wrote several books, of which the best known is *Quabbin, the Story of a Small Town* (1893), a novel of the Enfield of his boyhood. Other works include biographies of Longfellow, Lowell and Whittier; handbooks of English and American literature; *Cloud-Pictures* (1872), a volume of short stories; and the novels *Lord of Himself* (1874), *Man Proposes* (1885) and *Doctor Gray's Quest* (1895).

UNDERWOOD, OSCAR WILDER (1862–1929), U.S. politician, was born at Louisville, Ky.. on May 6, 1862. He studied at the University of Virginia, Charlottesville (1881–84), was admitted to the bar in 1884 and practised law thereafter in Birmingham, Ala.

From 1895 to 1915 he was a member from Alabama of the national house of representatives, and during his last two years chairman of the committee on ways and means. After the Democrats came into power in 1913 he had a large share in framing the tariff bill passed the same year. In 1914 he opposed the Panama Canal Tolls Repeal bill, but supported the resolution authorizing the president to use armed force in Mexico. He was opposed to the woman suffrage amendment to the federal constitution. holding that the question was a state issue. He also opposed the national prohibition amendment. In 1914 he was elected to the U.S. senate, and in 1920 re-elected. In 1919 he favoured the antistrike clause of the Cummins railway bill. A strong supporter of the peace treaty of Versailles, in Dec. 1919 he offered a resolution in the senate providing that the president of the senate should appoint a committee of ten senators to work out some acceptable plan for adopting the peace treaty; but this was blocked by Senator Lodge. In April 1920 he was chosen Democratic leader in the senate. He was a U.S. delegate at the Washington Conference on the Limitation of Armaments, which assembled in Nov. 1921.

At the Democratic national convention held in New York city, June 1924, Senator Underwood was an unsuccessful candidate for the presidential nomination. In 192; he was made a member of the U.S. delegation to the Pan-American congress. He published *Changing Sands of Purty Politics* (1927). He died at Woodlawn, Va., on Jan. 2j, 1929.

UNDERWRITING: *see* INSURANCE.

UNDSET, SIGRID (1882–1949), Norwegian writer and Nobel prize winner in literature. was born at Kalundborg. Den.. on May 20, 1882. After completing her studies at the Christiania Mercantile college. Mme. Undset entered a city office in 1899 and remained a clerk until 1909. She thus gained an intimate acquaintance with the empty and unenlivened existence of the girls with whom she came into contact, and used her experience in her first literary works, initiated in 1907 by *Fru Marta Oulie.* In 1912 she achieved fame by the great Christiania novel. *Jenny* (Eng. trans., 1920), remarkable for its courageous treatment of the erotic problem.

After revealing in one of her minor works (1919) the religious crisis in her mind which in 192j caused her to join the Roman Catholic Church. Mme. Undset published *Kristin Lavransdatter* (1920–22), Eng. trans.. part i. *The Bridal Wreath* (1923), part ii, *The Mistress of Husaby* (1925), part iii, *The Cross* (1930), a remarkable novel of the 14th century.

Mme. Undset's work shows psychological depth and an ability to appraise the mind and temper of bygone ages. Her work *Olav Audunsson,* a novel of the 13th century (192j), Eng. trans., *The Axe* (1928), has the same qualities. Other works are *In the Wilderness* (1929); *The Burning Bush* (1932); *The Faithful Wife* (1937); and *Men, Women, and Places,* an autobiography (1939). She was awarded the Nobel prize in 1928. She died at Lillehammer, Nor., June 10, 1949.

See J. Bing, *Sigrid Cndset* (1924).

UNDULANT FEVER: *see* BRUCELLOSIS.

UNEARNED INCREMENT, in economics, a term frequently applied to that part of the value of land which is due to the growth and development of the community using it, to the construction of buildings, roads, railways. canals, docks, harbours, upon it, or to the working of minerals beneath it. Thus a piece of land in one part of a country, although beautiful or fertile, may be worth very little, while in another part of the same country a piece of land of similar area required for a railway, or by a railway made accessible for residential purposes, may rise in value by a hundredfold or a thousandfold. The gains thus made by some landowners are so obvious and so great that the specific taxation of the unearned increment has been often proposed and in some countries carried into effect *(see* article on LAND TAXES). Among others, John Stuart Mill favoured a progressive tax on land.

Henry George's tax amounted to a proposal to absorb the whole of the surplus value *(see* SINGLE TAX).

UNEMPLOYMENT. The population of a modern industrial nation can be divided for labour market purposes into three groups: those who are actively engaged in producing economic goods and services; those who are able and willing to engage in such activities and, lacking at the moment the opportunity to do so, are looking for work; and those who are not engaged in such activities and have at the moment no intention of doing so.

The first group can be designated as the employed. using that term in its broadest sense to include not only employees receiving a wage or salary. but also all other persons producing for income or profit. The second group are the unemployed, while the third group may be designated as the nonproducers or the nonworkers. The first two groups constitute the labour force of a nation, which includes those who are actively in the labour market. The total labour force of a nation includes the armed forces as well as the civilian labour force, although for many economic analyses, the figure for the latter is used. In some countries, the numbers in the armed forces are not made known to the general public in any precise terms.

While these three groups seem quite clear and distinct as loosely defined above. in actual practice there are a good many knotty problems in defining the exact limits of each. Thus the employed are those who are engaged in some kind of economic activity for pay, income or profit. The great majority of these are readily identifiable because they are actually at work and are represented on some kind of a payroll. However there are a few areas of uncertainty which have to be taken into account when actual measurements are attempted.

For example. at any one time there may be a considerable number of employed persons on holiday or vacation with pay. It is obvious that such persons are not at the time actually working, yet they are employed, they draw income and they cannot be considered as withdrawn from the labour force entirely. In many statistical tabulations, these persons are listed as "having a job, but not at work." There are a considerable number of groups of workers in this category: the temporarily ill or disabled, employees on strike who may be picketing the establishment but not working in it, and other such groups.

Farmers and farm workers are sometimes marginal in this employed group, as during winter they may be taking care of the farm, or doing maintenance work for board and room, but without current income.

In another group which is difficult to classify are those who work without pay in a family business or on a farm, usually a wife or a child of working age. On the farm a youth may work with his father in the fields without receiving regular pay; in a small shop, the proprietor's wife may alternate in attending customers without pay. Such persons are considered to be in the employed labour force because they are engaged in selling or in producing for sale in the market.

At the other extreme, the group excluded from the labour force also contains some types which are difficult to classify. The counterpart of the unpaid family workers who are counted as employed are the housewives and other members of the family who are homemakers.

This group, mostly women, is not counted in the labour force. There is no question about the usefulness and productive worth of the homemaker's activities. If she were not doing the housework required, it \\-ould be necessary to hire a domestic servant. The difference is that the domestic servant is in the labour market working for pay, while members of a family do not ordinarily maintain strict economic relationships with each other Children often receive allowances, and the homemaker usually spends most of the chief wage earner's money, but these exchanges of funds are not governed by the bargaining which occurs in a paid job.

There are in fact many kinds of volunteer activities carried on by the so-called nonproducing members of society. In social welfare work, in community activities and in education, there are many unpaid people who work as hard and as usefully as those who work for pay. However, where there is no economic evaluation placed on the activity in the form of pay, there exists no basis for including such people in the labour market.

Between these extremes are the unemployed who constitute a small but important class of people. The usual type of unemployment is not hard to describe. The chief wage earner of a family has been working on a job, but, because of a decline in business, he loses his job and with it his income. The best solution for his problem is to find another job with an income attached to it. During the period he is out of a job, he is clearly unemployed.

However, in this group there are many marginal situations in which it is sometimes difficult to decide just what the labour force status of a person is at a particular time. One example is that of the housewife who takes a job in the canning factory during the summer months. She joins the employed labour force when she takes the job, but when the canning season is over and she returns to housework, is she unemployed or has she withdrawn from the labour force? A similar problem arises in connection with the numerous temporary workers who are employed during the Christmas shopping season but laid off in January.

When the laid-off worker is the chief wage earner of the family and actively seeks other work immediately, there is no difficulty in defining him as being unemployed. But a woman who resumes her housework and makes no effort to obtain another paid job has obviously withdrawn from the labour force. The problem is that a person's labour force status sometimes depends upon the worker's intentions. which may not be easy to discern.

Some difficult problems of classification arise in the small, one-industry town in which the plant closes down. In such cases, there may be few other employment opportunities in the district and many of the unemployed do not actively seek work since none is available locally. Under these circumstances, a common-sense definition is usually applied, and such people are considered to be truly unemployed, even though they are presently making no efforts to get jobs.

All these marginal cases are further complicated by the fact that people's activities and intentions vary widely over a period of time. In June of each year, several million high school and college students leave school for the summer and many of them seek paid jobs. In the U.S. and Canada, as well as in some other countries, such young people would be counted as unemployed when they start looking for work. On the other hand, in some countries, a new entrant into the labour force is not considered to be unemployed until he has first held a paid job and thereby demonstrated the capacity of being attached to the labour market. The result is that the unemployment trends for the summer months differ quite markedly in different countries.

There are many examples of people shifting back and forth to and from the labour force. During wartime, many millions of women enter the labour market to replace young men withdrawn for the armed forces. At the end of World War II, some of them remained in the labour force, while many others withdrew and returned to homemaking. From one season of the year to the next, large numbers of people shift their activities and enter and withdraw from the labour force at will.

Some idea of the magnitude of this shift may be obtained from figures published in 1956 in the U.S. by the bureau of the census. During the year 1955 the average civilian labour force was approximately 65,000,000 persons, but the total number who were in the labour force at one time or another during the year amounted to about 75,000,000.

As might be expected, the vast majority of these shifting workers were women. The average number of women in the U.S. labour force during 1955 was about 20,000,000, but the total number of women who were in the labour force at one time or another during the year was nearly 28,000,000. These figures demonstrate that the women of the U.S. constitute a reserve labour supply which becomes available on a short-time basis in seasonal industries, and on a long-term basis during a national emergency.

These borderline cases are cited, not to undermine the validity of labour force statistics, but to emphasize that the figures contain margins of haziness which should be taken into account when using them. The theoretical concepts of the employed, the unemployed and the nonworkers are quite clear, and the bulk of the population definitely falls into one or another of these groups.

METHODS OF MEASURING UNEMPLOYMENT

Prior to World War I, even though unemployment was becoming a growing problem in many industrial countries, there were no satisfactory statistics of unemployment. The earliest data on the subject came from trade-union reports of unemployment existing among their members. Union officials issued periodic statements on the proportion of their membership which was unemployed. Table I shows the average percentage of unemployment among the members of certain trade unions in Great Britain over the period 1881–1926.

These figures were useful, although their significance is limited. In many cases, they were undoubtedly rough approximations made by local trade-union secretaries. Furthermore, they do not give an indication as to the unemployment situations among the vast numbers of workers who were not members of .trade unions.

TABLE *I.—Average Yearly Percentage of Unemployed Among Members of Certain Trade Unions, Great Britain*

Year	Per cent	Year	Per cent	Year	Per cent	Year	Per cent	Year	cent
1881 .	3.5	1891 .	3.5	1901 .	3.3	1911 .	3.0	1921 .	14.8*
1882 .	2.3	1892 .	6.3	1902 .	4.0	1912 .	3.2	1922 .	15.2*
1883 .	2.6	1893 .	7.5	1903 .	4.7	1913 .	2.1	1923 .	11.3*
1884 .	8.1	1894 .	6.9	1904 .	6.0	1914 .	3.3	1924 .	8.1*
1885 .	9.3	1895 .	5.8	1905 .	5.0	1915 .	1.1	1925 .	10.5*
1886 .	10.2	1896 .	3.3	1906 .	3.6	1916 .	0.4	1926 .	12.2*
1887 .	7.6	1897 .	3.3	1907 .	3.7	1917 .	0.7		
1888 .	4.9	1898 .	2.8	1908 .	7.8	1918 .	0.8		
1889 .	2.1	1899 .	2.0	1909 .	7.7	1919 .	2.4		
1890 .	2.1	1900 .	2.5	1910 .	4.7	1920 .	2.4		

Note: Persons on strike or locked out, or sick or superannuated, excluded. Percentage for some earlier years based on expenditure on unemployment benefit. Series discontinued after 1926.

*Figures from 1921 exclude pottery trades; from 1924 exclude building trades.

Source: 19th *Abstract of* ***U.K.*** *Labour Statistics,* Cmd. 3140 (London, 1928).

The first governmental approach to the problem of measurement came through statistics of employment, usually in the form of reports from business concerns that showed the number of persons on the payroll from month to month. In the U.S. certain state governments began to collect employment and payroll reports from employers immediately before and after World War I. The bureau of labour statistics in the U.S. department of labour began a systematic collection of such employment statistics in 1915. Since that time this type of reporting has been expanded and extended until it is now a common practice in many countries. These figures are useful in connection with unemployment, not as direct measures of the number of unemployed, but as indicators of the industries and communities where unemployment may be increasing because of declines in employment.

During the 1920s there were no official unemployment estimates in the U.S. In 1926, when the bureau of labour statistics was called upon to make an estimate, the bureau used the employment statistics to derive a measure of the decline in unemployment which had occurred from a previous date. This was the closest approximation that could be obtained at that time to the number of unemployed in that country.

The development o, unemployment insurance systems brought about a definite improvement in the methods of measuring unemployment. All workers protected by unemployment insurance laws were required to register at local employment exchanges or

TABLE *11.—Percentage of Unemployed Among Insured Workpeople, Great Britain*

Year	Wholly	Tempo-rary	Total	Year	Wholly	Tempo-rary	Total
1921 . .	..	..	17.0	. .	9.5	2.5	12.0
1922 . .	..	.	14.3	. .	8.0	1.5	9.5
1923 . .	..	..	11.7	1940 . .	5.0	1.0	6.0
1924 . .	..	..	10.3	1941 . .	1.5	0.5	2.0
1925 . .	..	..	11.3	1942 . .	1.0	..	1.0
1926 . .	8.7	3.8	12.5	1943 . .	0.5	..	0.5
1927 . .	7.4	2.3	9.7	1944 . .	0.5	..	0.5
1928 . .	8.2	2.6	10.8	1945 . .	1.0	..	1.0
1929 . .	8.2	2.2	10.4	1946 . .	2.5	..	
1930 . .	11.8	4.3	16.1	1947 . .	2.0	1.0	3.0
1931 . .	16.7	4.6	21.3	1948 . .	1.6	..	1.6
1932 . .	17.6	4.5	22.1	1949 . .	1.6	..	1.6
1933 .	16.4	3.5	19.9	1950 .	1.6	..	1.6
1934 . .	13.9	2.8	16.7	1951 . .	1.2	0.1	1.3
1935 . .	12.5	2.2	14.7	1952 . .	1.7	0.4	2.1
1936. .	11.2	1.9	13.1	1953 . .	1.7	0.1	1.8
1937 . .	8.5	1.5	10.0	1954 . .	1.4	0.1	1.5

Note: Includes agriculture after 1937. Excludes men at government training centres after 1940. Excludes persons classified as unsuitable for ordinary employment, 1941–47. After that only excludes disabled persons requiring employment under sheltered conditions. After July 1948 includes all persons registered as unemployed at employment exchanges and not simply insured persons.

Temporarily stopped includes persons on short time or otherwise laid off on the understanding that they are to return to their employment within six weeks of date of suspension. For the years 1921–34, figures refer to persons aged 16–64; 1935–39, figures refer to persons aged 14–64; 1940–54, figures refer to males aged 14–64 and females aged 14–59.

Source: International Labour Office, *Year Book of Labour Statistics,* 15th issue (Geneva, Switz., 1955), and previous issues.

employment offices as a condition of obtaining benefits. Thus the administration of the system brought about a full count of those unemployed workers covered by unemployment insurance. The earliest comprehensive reports of this kind were those in Great Britain, which are shown in Table II.

These figures did not constitute a completely accurate measure of total unemployment in Great Britain, but the coverage of that unemployment insurance system is so comprehensive that the statistics have served as a guide to national policy.

In the U.S. unemployment insurance did not come into existence until the depression of the 1930s. Consequently, the volume of insured unemployment in the U.S. has been known only since 1940. Table III shows the number and percentage of insured unemployed in the United States over the period 1940–55, including the unemployment in the railroad system and the ex-servicemen drawing veterans' unemployment benefits.

The insured unemployed in the U.S. do not constitute as large a proportion of the total unemployed in that country as do the total insured unemployed in Great Britain, where the unemployment insurance system covers a larger proportion of the working population. In years of downward trends in business, such as 1949 or 1954, the insured unemployed in the U.S. make up about three-quarters of the total unemployed, whereas in prosperous years the

TABLE *111.—Insured Unemployment in Continental United States,* * *Weekly Average, 1940–55*

(in 000s)

Year	All programs†	State programsf	
		Number	Per cent of covered employment
. . . . . .	1,330	1,281	5.6
1941	841	813	3.0
1942	661	649	2.2
1943	149	147	.5
1944	111	105	.4
1945	714	589	2.1
1946	2,803	1,294	4.3
1947	1,803	1,008	3.1
1948	1,461	999	3.0
1949	2,470	1,970	6.2
1950	1,599	1,498	4.6
1951	996	966	2.8
1952	1,064	1,019	2.9
1953	1,058	988	2.8
1955	2,039	1,857	5.2
	1,388	1,248	3.5

*Represents the number of unemployed workers covered by unemployment insurance programs who have completed at least one week of unemployment. †State, veteran, Railroad Retirement and federal employee programs. ‡State unemployment Insurance programs during the period shown excluded from coverage agricultural workers, government employees, domestic servants, workers in nonprofit organizations, unpaid family workers, the self-employed and (in most states) workers in very small firms.

Source: United States Department of Labor, Bureau of Employment Security.

proportion drops to as low as one-half.

Of course, these proportions hold good only during short periods of business recession. In a deep depression many of the insured unemployed exhaust their benefit rights and fall into the uninsured class. This happened in Great Britain during the 1920s. It was then considered necessary in that country to devise a system of extended benefits in order to assist the large numbers of workers who had exhausted their unemployment insurance rights before they obtained jobs.

Some efforts have been made to measure unemployment by means of the registrations at employment offices, that is, the total registrations, including those not covered by the unemployment insurance system. Canada, in addition to its other statistics of unemployment, issues a monthly figure on the number registered for work at the employment offices. In the U.S. during the 1930s some attempts were made to obtain measurements of this kind. These figures, while useful for many administrative purposes, are not wholly accurate as measures of unemployment. The insured unemployed are required to register and the count of that group can be accurately made.

However, the uninsured, if convinced that the employment offices could not help them, might fail to register at all; or, even if they do register, they might let their registration lapse while still being unemployed. Then, a moderate number of employed persons, currently dissatisfied with their jobs, register at the employment offices in the hope of obtaining better ones. This group is not unemployed.

Finally, when a registered worker gets a job, he may not report that fact to the employment office, at least in countries such as

Canada and the U.S. where workers do not carry workbooks. In Great Britain, where the unemployed person is required to deposit his workbook at the employment exchange as a condition of obtaining unemployment benefits, his taking of a job is immediately recorded administratively. However, at any one time the employment office registrations in the U.S. and Canada contain the names of a considerable number of workers who are in employment.

The most effective statistical method of measuring the unemployed is the sample population census, which is used in the U.S. and Canada, as well as in a few other countries. When a full population census is taken in a country, it is possible to obtain (on the basis of reports by the people themselves) the employment and unemployment status of the entire working population. In the U.S. the 1930 census was the first decennial census in which this question was asked. Since that time, it has become a regular feature of the population census. While decennial census figures provide useful detailed breakdowns, they become out of date as economic conditions change. Consequently, for obtaining current unemployment information some system had to be devised, which was done by establishing a measurement system based upon a small sample of the nation's population.

In the United States this type of measurement was begun in the late 1930s, primarily for the purpose of determining the number of workers needing jobs under the government's work programs. Until the spring of 1956, a sample of 21,000 families was considered large enough to provide reasonably accurate information for the country as a whole, though with limited details. At that time the sample was enlarged to 35,000 families and the number of local areas represented was increased to 330. Canada later adopted this same system of measuring unemployment. Table IV shows the unemployment figures for the U.S. and Canada based upon this method of measurement.

TABLE IV.—*Unemployment in Continental United States and in Canada, Annual Average, 1940–55*
(in 000s of persons 14 years of age and over)

Year	United States	Canada
1940	8,120	418
1941	5,560	193
1942	2,660	134
1943	1,070	75
1944	670	62
1945	1,040	72
1946	2,270	143
1947	2,142	98
1948	2,064	102
1949	3,395	135
1950	3,142	166
1951	1,879	106
1952	1,673	129
1953	1,602	137
1954	3,230	232
1955	2,654	230

Note: These estimates are derived from a sample survey and are subject to sampling error

Source United States Department of Commerce, Bureau of the Census, *Annual Report on the Labor Force*, Dominion Bureau of Statistics, *Canadian Statistical Review* (1955 Supplement and March 1956).

The chief limitation in measuring unemployment by means of a sample census is that it is applicable primarily to large countries. The method is an expensive one, since a visit to the family by a census agent is necessary in order to obtain accurate information. If less populous countries could use proportionately small samples, the expense would not be a serious handicap, since it would be reduced proportionately. Unfortunately, such a practice is not statistically possible. A very thin sample of the total number of families in the country is quite feasible for a large nation like the U.S., but in small countries having only a fraction of the U.S. population, the sample would have to be relatively larger. The smaller the country, the larger the proportion of the population that would need to be included in the sample to obtain accurate data.

Therefore, while this method is undoubtedly the best yet devised for obtaining reasonably accurate information on the unemployment situation in a country with a large population, it is not likely to come into general use because of the comparatively high cost to small countries.

CAUSES OF UNEMPLOYMENT

Unemployment is not the result of any one factor. It arises from a wide variety of circumstances, some in the worker himself, some in the individual business concern and some in general economic conditions. However, it is possible to classify the major factors producing unemployment.

Seasonality.—One of the most obvious of the short-run factors is the seasonality of industry and agriculture. Crops are usually planted in the spring and harvested in the summer and early fall, with comparatively little farming activity during the winter months. As a result, there is a heavy seasonal demand for labour in agriculture.

In the U.S. the reports from the bureau of the census show that between the low point of employment in mid-winter and the peak of employment in summer, there is a range of about 2,500,000 workers each year. In the period 1950–55, the average farm employment in February was about 5,500,000 while the average in June was about 8,000,000.

After the season of high employment, the workers are no longer required. They are laid off, and some are considered to be unemployed and have to find other work during the off season. In many cases, however, these seasonal workers withdraw from the labour force entirely at the end of the season. Housewives returning to housework and students returning to school in September generally withdraw from the labour force when the work stops; that is, they shift from employment into nonemployment rather than to unemployment. When they attempt to join the labour force the following spring or summer, they may experience a period of genuine unemployment before they find a job for the next season.

Building and construction activities are another example of high seasonality. In the U.S. the reports of the bureau of labour statistics show that employment in contract construction varies by about 500,000 workers from the low point in midwinter to the high point in midsummer. Among the manufacturing industries there are similar examples in fruit and vegetable canning, logging and lumbering, slaughtering and meat packing and a number of others. In retail trade and in the post offices, there are sharp increases in employment during the Christmas season, with heavy layoffs immediately afterward.

Some individual firms and industries attempt to even out their seasonal variations by producing for inventory or by developing additional products to stabilize production during the year. Many workers who need year-round employment manage to shift jobs during the year. However, in spite of all the efforts which have been made, there is still a considerable amount of seasonal unemployment, even in the most prosperous years.

Industrial and Technological Change.—Unemployment may also arise from a series of factors associated with industrial shifts and economic change. One major factor is the change in consumer demand. When the motorcar became the popular form of transportation, the carriage industry declined. The demand for tractors on the farm has resulted in the growth of the agricultural implement industry, but it has reduced the need for raising draught horses and mules. The consumer demand for television sets has reduced to some extent the demand for radios, although fortunately for the manufacturers and workers concerned, these are generally produced in the same industry.

TABLE V.—*Employment in Selected Nonagricultural Industries in the United States, Annual Average 1939, 1947 and 1955*
(in 000s)

Selected industries	1939	1947	1955
Coal mining	477	505	246
Automobiles	466	776	921
Chemicals and allied products	406	694	813
Textile-mill products	1,232	1,335	1,075
Leather and leather products	383	409	382
Wholesale and retail trade	6,612	9,196	10,728

Source United States Department of Labor, *Bureau* of Labor Statistics, *Handbook of Labor Statistics* (1950); 1955 figures in *Employment and Earnings* (Feb 1956).

Table V shows for selected years the volume of employment in certain industries in the U.S. The table shows that while some industries are expanding and therefore hiring more labour, other industries may be in a long-run decline.

Geographic shifts of industry for one reason or another may leave pockets of unemployment in the declining areas, as was dramatically illustrated in the U.S. where, even in years of peak total employment during the postwar period after World War II, some local areas suffered heavy unemployment because of the decline of industries located there or the shift of some of the industries to other parts of the country.

The bureau of employment security in the U.S. department of labour officially classifies the major areas in the continental United

TABLE VI.—*Classification of Major Labour Market Areas in Continental United States According to Relative Adequacy of Labour Supply, May 1956*

Labour supply group	Number of major areas
Total, all groups	145
Group A	0
Group B	44
Group C	81
Group D	14
Group E	3
Group F	3

Note: Generally speaking, the classification groupings indicate a ratio of unemployment to total labour force in the following ranges:

Group A..... less than	1.5%
Group B.............	1.5%— 2.9%
Group C.............	3.0%— 5.9%
Group D.............	6.0%— 8.9%
Group E.............	9.0%—11.9%
Group F.............	12.0% or more

The extent of unemployment in a particular area is only one of several factors used in determining the appropriate area classification for each locality. Consideration is also given to the area's employment outlook, as reflected by local employer estimates of their manpower requirements; to the significance of essential activities; to the relationship between labour supply and demand; to the seasonal pattern of employment and unemployment fluctuations; and to several other factors.

Areas classified in categories D, E and F under this classification system are regarded as areas of substantial labour surplus or areas of substantial unemployment.

Source: United States Department of Labor, Bureau of Employment Security, *Bimonthly Summary of Labor Market Developments in Major Areas* (May 1956).

States with reference to the percentage of unemployment in each. In May 1956 there were 20 areas listed as having a substantial labour surplus. Unemployment in these areas generally represented 6% or more of the local labour force. In a few communities unemployment amounted to 12% or more. Table VI shows the classification of 145 major areas in the continental United States in May 1956.

Another related factor that causes unemployment is change in the method of production, that is, changes in technology which reduce the amount of labour required to manufacture a given product. Employers are always engaged in seeking new and cheaper methods of production; new materials, new processes, new machines. The result is the displacement of labour from certain jobs and occupations, accompanied by the creation of new jobs and occupations. Labour displacement brought about by these changes in production methods does not necessarily result in unemployment, because the workers displaced may be absorbed in the new jobs. However, some unemployment may result if the displacement is very large, or if some firms fail to keep up with the technological progress of the industry.

Unemployment resulting from technological change is only temporary, though it may last longer than seasonal unemployment. For example, in nearly all western industrial countries there has been a tremendous gain in productivity (that is, in output of product per man-hour of labour) in the half century from the early 1900s to the early 1950s. Yet, at the end of that great technological advance, most of those countries are experiencing practically full employment. Technological progress creates jobs as well as eliminating them. However, individual workers may suffer loss of jobs and earnings because of their inability to adjust to the change.

Labour Market Imbalance.— There is a continuing volume of unemployment due to a series of factors which are often characterized by such general terms as frictional, transitional, personal or even normal. However, this catchall group of causes can perhaps be best summarized as a short-term imbalance of labour demand and supply (excluding seasonal variations).

Unemployment of this type may be due to factors affecting the business concern and the demand for labour, or in workers themselves and the supply of labour. In a competitive economic system, business concerns are continually failing, while others are starting up. When a concern closes down it necessarily lays off the workers who have been employed. New or expanding firms are at the same time in the market looking for workers. Nevertheless, considerable unemployment may develop from this change-over because the new industries find it difficult to use the experience and skills of the displaced workers.

Thus the closing of a textile mill would result in the layoff of a great many women workers; a large construction project in the community would require many men workers. Unemployment in the one case could not be solved immediately by the employment created in the other.

Some of this short-term unemployment is due to actions or handicaps of the workers themselves. For example, during periods of prosperity and high employment levels there is a heavy volume of labour turnover due to quits, that is, to the voluntary job changing by the workers themselves. Workers dissatisfied with their current jobs often quit in the hope of obtaining better-paying jobs elsewhere. During this transition they may undergo varying periods of unemployment before they succeed in finding other jobs.

New entrants, that is, those previously not in the labour force, flow into the labour market almost continuously. These workers may undergo a period of unemployment before they find a satisfactory job.

A more general factor is the short-term immobility of the workers and their families. Working wives who become unemployed cannot leave their husbands and families to take a job in another community. Young workers cannot readily leave home. Health reasons may limit the kind of work an unemployed man can accept.

There is no need to elaborate further on this general point. There are many reasons why job opportunities and unemployed workers cannot be matched up quickly and completely. Among these are the factors of geography, sex, age, skill, legal restrictions, union rules and many others.

In Great Britain and Canada, efforts have been made to measure the significance of this labour market imbalance by counting the number of job vacancies which exist in all the employing business concerns. However, great caution needs to be exercised in interpreting any such figures as the jobs which are open may not at that time be suitable for the workers who are available. These job opportunities may need to be filled either by new entrants into the labour force or by a shift of workers now employed elsewhere. This shift in turn might vacate a job which could be filled by one of the unemployed.

There are many signs that this problem is growing in importance. One is the aging of the working population. In the 18th century, before the Industrial Revolution, economic change proceeded at a slow pace. Occupations remained unchanged for many decades. At the same time, life was short, and a comparatively small proportion of the labour force reached the age of 45 years or over. Thus there was a comparatively rapid turnover of the labour force, with the average worker serving perhaps 25 or 30 years at the most.

In the 1950s the situation is very different. On the industrial side, there are many new technological developments, including those which are usually summarized under the heading of automation. These developments presage exceedingly rapid changes in industrial processes and in production methods. Then also, under the improved conditions of health and medical care, the working population has a greater life expectancy.

In the U.S. the estimates of the National Office of Vital Statistics show that, as of 1950, a young man age 20 had a prospect of living until age 69, a period of nearly a half century. The bureau of labour 'statistics, using its Tables of Working Life, shows that this young worker is likely to be in the labour force until age 63, a total of 43 years. In the coming decades, if present trends continue, both the average life and the average working life are likely to increase further.

The problem is then that older workers are less flexible and adaptable to new jobs and new occupations than young workers. Thus the increasing rapidity of industrial change coupled with the gradual aging of the working population has the effect of lengthening the time required to readjust displaced workers, especially older ones, thereby enlarging to some extent the pool of unemployed.

Some institutional factors are also operating in this direction. In the period after World War II, in a number of countries and especially in the U.S. and Great Britain, there grew up a large number of private industry pension plans designed to produce retirement benefits for workers when they reached the end of their productive capacity.

These plans tend to lessen labour turnover and thereby produce steady employment for older experienced workers. However, they may also have the effect of limiting the employment opportunities of older workers who are seeking work. Some of this rigidity can be overcome by "vesting." which is the device of permitting a worker, after a certain limited period of service. to acquire pension rights and retain them even though he shifts to another firm or another industry. Also, insured pension plans can be written in terms which will not increase the employer's costs if he hires an older man instead of a younger.

Business Cycles.—Finally, the most serious cause of unemployment is the swing in general business conditions between various stages of prosperity and depression. This factor is of greater significance than all others combined. In the great depression of the 1930s, the volume of unemployment in the U.S. and Germany, both of which were highly industrialized economies which had previously enjoyed high levels of employment in the 1920s, amounted to fully one-third of the total labour force in each country. In Germany this economic disaster was a major factor in the rise of Hitler and naziism. In the U.S. it produced many far-reaching changes in social and economic policies.

The experiences of Great Britain with unemployment after World War I were the stimulus for the theoretical work of John Maynard Keynes. the economist whose theories about the causes of unemployment have profoundly influenced economic thinking since his time.

Theories of Cyclical Unemployment.—Since the Industrial Revolution, economic thinkers have been deeply concerned with the reasons for the periodic and occasional business depressions which have accompanied the development of the modern industrial system of production. Soon after the close of the Napoleonic Wars, analyses of business cycles appeared in economic literature and many theories were evolved. Some thinkers, especially the socialists, postulated that instability mas inherent in the economic system and that the only solution was the ownership of the means of production by the government. The presumption was that the government could manage industry in such a way as to prevent unemployment. Karl Marx based his confidence in the further triumphs of socialism on his belief that ever-increasing and ever-deepening business crises (depressions) would eventually bring about the collapse of the capitalistic free enterprise system. Evidence of the continued survival of this type of thinking was found in the official belief of the soviet government that the economic readjustments after World War II would produce a major business depression in the U.S. and other countries of the western world.

More orthodox economic thinkers in the 19th century attributed the depressions to the round-about system of production which is inherent in modern industry, in that the basic cause of the business cycle was the lack of co-ordination in production. A business boom is a period in which many businessmen expand capital development; a depression is a period in which the existing plant and equipment can produce all the goods that consumers are able to demand.

Other economic thinkers looked more to the money and credit problems which lie behind the processes of production. Statistical analysis of the different phases of the cycle showed that a considerable number of financial problems developed as production increased. The theory was that financial stresses eventually brought the boom to an end because prices and credit had become too far out of line with other factors in the economy.

The short but sharp depression in 1920–21 is one example of this type. In the U.S. the expansion of credit had reached the limitations established by law, and the rediscount rate in the federal reserve system was raised to 7%. The result was a swift deflation of commodity prices, stock prices, land values, etc. Much more disastrous was the world-wide deflation of 1929, during which the drop in the world's commodity markets, stock markets and bank assets produced the deepest and longest depression the world had yet seen.

Lord Keynes made an attempt to synthesize from all these ideas a comprehensive theory which would satisfactorily explain the economic factors contributing to the business cycle. His *General Theory of Employment,* Interest and Money (1936) is a landmark in economic theory. and economic thinking since the publication of his great book has been influenced by his ideas.

It is not necessary here to elaborate details of Keynes's theory, but it can be summarized briefly. People either spend or save income. Then businessmen planning to expand their plants and equipment require funds with which to do so. Funds so applied from income or savings are termed investment. The operation of the economic system brings together the investment and the savings.

Keynes pointed out that when investment exceeds savings, there is an expansion of credit which makes up the difference, and this brings about a rise in business activity. On the other hand, if savings exceed investment, there is a loss of purchasing power which produces a business decline. The problem, therefore, becomes one of trying to maintain as even a balance as is practicable in a changing economic system.

REMEDIES FOR UNEMPLOYMENT

In some respects, unemployment is the price of economic progress. In a competitive industrial society. new business concerns are started at the same time that other concerns are closing down. Whole industries are on the upgrade. while other industries are on the downgrade. With many thousands of firms employing millions of workers engaged in a competitive struggle, it is inevitable that some unemployment will always exist, no matter how prosperous a nation may be. Under the pressure of World War II shortages, unemployment in the U.S. seldom fell below 1,000,000 workers, or a little less than 2% of the labour force.

Even in the most prosperous years following World War II, unemployment in the U.S. seldom fell below 1,500,000 workers at any one time. The complete elimination of unemployment would be practically impossible; and if it were to be pursued as a goal, the result would be to limit the growth of the economy and to reduce it to a static state.

Furthermore, some unemployment is the result of the free choice of the workers themselves—a calculated risk, so to speak. A free economy means that workers are free to quit their jobs, either because they have decided to leave the labour force or because they are looking for a better job. In this situation it is not a case of the employer laying off a worker who is clinging to his job, but rather a worker who is exercising his own free enterprise by leaving the employer who may be very eager to keep him.

This aspect of unemployment is shown in the statistics of labour turnover. In times of prosperity and high-level employment, the great majority of separations from jobs occur through the voluntary quit by the worker. At certain times from two-thirds to three-fourths of all separations are on the worker's initiative. In addition, the unemployed worker in good times may exercise a great deal of caution in choosing another job. Unskilled. unpleasant and lev-paid jobs may be going begging, while skilled and semi-skilled workers elect to look around for a job in line with their previous experience.

When business turns down and job opportunities are less plentiful, the quit rate declines. It is then that the employer becomes the initiating factor in job separations. When his sales decline, he lays off workers. At those times, the layoff rate becomes the major factor in unemployment.

Also, since job opportunities are not plentiful, an unemployed worker is more likely to remain out of work for much longer periods of time. It is unemployment of this kind which produces social and economic problems.

The earnings from work constitute the main support of the average family. Any prolonged interruption of those earnings will generally cause destitution. The objective of social policy should be to limit the amount of involuntary unemployment as much as possible. Some methods are discussed below.

Stabilization by the Individual Firm. — Many employers have attempted to limit unemployment by stabilizing the employment in the individual firm. A remarkably high degree of employment stabilization has been achieved by some firms. A classic economic example in the U.S. is the integration of the coal and ice business, which matches winter and summer activities. Concerns engaged in producing Christmas cards, which sell during a very short demand season. have managed to round out the year by taking on other kinds of business. Many firms manufacture to stock during the slack season. When a concern finds itself with a declining product, it is often able to take on a new line which is expanding.

A few employers have devised the system of paying the worker a regular weekly wage, but varying the hours of work in accordance with production needs. Some employers prefer to have their employees work overtime, even at premium rates of pay, when production schedules are heavy, rather than to hire additional workers. When production falls off, they cut back to the standard weekly hours, or even share the work at reduced hours, in order to keep a stable labour force.

Despite all the achievements which have been made by individual concerns in pursuit of stabilized employment, these are only a partial solution of the problem. Many businesses cannot be stabilized. An employer in a declining industry may not find any way to prevent reduced employment. Manufacturing to stock has definite limits.

Unemployment Insurance. — Another suggested solution is the establishment of a system of unemployment insurance which will pay benefits to a worker when he is out of work through no fault of his own. Unemployment insurance is based on the principle that a certain amount of unemployment is inevitable. If it cannot be prevented, at least a worker and his family can be protected. Since the primary problem in unemployment is the loss of income. the provision of benefit payments overcomes some of the worker's difficulties. (For the workings of various systems see also UNEMPLOYMENT INSURANCE.)

In many countries, unemployment insurance is financed by contributions from the employed workers, the employers and the government. This type of insurance is based on the theory that unemployment is not the fault of either the employer or the worker, but that it is a natural consequence of the operation of the free enterprise system, the cost of which should be shared by all.

In the U.S., however, a somewhat different system has been developed. The theory in that country is that the employer, within certain limits, can control the amount of unemployment experienced by his workers. Therefore, the total cost of unemployment insurance is borne by employers only, and among them the rates are varied in accordance with the amount of unemployment attributed to their individual firms. The effect of this is to enable some employers to achieve comparatively low rates of contributions, while other employers pay higher rates, each based on his own experience. An additional argument for this system is that the variation of the individual employer rates will exercise some influence in stimulating an employer to stabilize his own employment insofar as it is possible.

Whatever the system of employment insurance, its chief advantage is that it permits the economic system to operate in accordance with competitive economic principles. This means that employers are free to expand or contract, to hire workers or to lay them off. Economic progress can take place at any desired rate. The insurance simply protects the workers and their families against some of the consequences of this progress.

Public Works Programs. — In times of business depression, the initiation by the government of a public works program is generally popular with all. There are several reasons for the popularity of this program. One is that public works are a governmental responsibility, and people look to the government for help when the private economy is not doing well. A second is that government can take a long view, inaugurating and carrying out projects which may not pay off for many years. Third, there is the belief that government construction activities could help counterbalance in some degree the swings of prosperity and depression in the private economy.

This general idea of public works as a partial remedy for unemployment received official sanction in the U.S. in 1923 when the Committee of the President's Conference on Unemployment published a report recommending the expansion of public works in times of business downturn as a countercyclical measure. During the great depression of the 1930s this idea was put into practice. In the U.S., beginning in 1933, an expanded public works program was begun under the Public Works administration. Two years later, the Works Progress administration was established for the specific purpose of providing jobs for the millions of the unemployed by means of special state and local projects, such as parks, schools and public buildings of various kinds. While these WPA projects were not wholly made work, they were definitely selected in such a way as to provide the maximum number of jobs per dollar of expenditure and to be of a character that would not interfere with the regular public works program. The Civilian Conservation corps was established to provide jobs for young men in forest conservation and similar types of activity.

In many countries throughout the world, similar types of programs were instituted, though seldom on a scale comparable with that in the U.S.

The experience of the 1930s led to a re-examination of the part which a public works program can play in the relief of unemployment. The limitations of such a program have been more clearly recognized. In the first place, the volume of public works constitutes only a small proportion of total economic activity. Even in times of great construction activity, the volume of construction constitutes only about 10% of the nation's gross national product. Employment on public works, even during peak periods, amounts to only a few per cent of the labour force.

Furthermore, public works construction has become in recent decades much more mechanized, with the result that it creates fewer direct jobs per dollar of expenditure. Increased mechanization in turn leads to greater skill requirements and to greater specialization of labour in construction. This condition became apparent in the U.S. during the WPA program when projects were held up for lack of the necessary skilled labour, although there were many thousands of unskilled workers available for jobs. As a result, more thought was given after World War II to the idea of establishing long-range public works programs and maintaining stability in these programs rather than attempting to use them to counterbalance changing business conditions.

Monetary Policy. — It has long been recognized by economists that periods of prosperity coincide with expansion of the money supply, while depressions have been accompanied by a contraction in money and credit. By law or custom the supply of paper money and credit instruments has generally been tied to the gold reserve in the central banks or in government vaults.

The gold standard was an automatic regulatory device. If a business boom in a given country went too far. the available supply of paper money reached the upper legal limit and could not be expanded further. In addition, an outflow of gold to other countries often required a contraction of money and credit in the expanding country. In a business downturn, the mechanism operated in reverse and an inflow of gold provided an opportunity for business recovery.

The gold standard in its old form broke down during the depression of the 1930s when all countries ceased redeeming their paper currency in gold on demand. A modified international gold standard has developed since that time, but most governments do not permit gold to operate as an automatic control mechanism, either domestically or internationally.

In the meantime, during the quarter century following 1930, strong support developed for the theory that government agencies and central banks can operate a somewhat flexible monetary policy, designed to regulate in some degree the supply of money and credit for business, without subjecting the economy to the rigid automatic operation of the old gold standard. The theory is that a central bank, by regulating the reserves required to be kept by commercial banks, or by buying and selling securities in the open market, can govern to some extent the available supply of credit. Since the government in nearly all countries either controls the central bank or has considerable influence on it, this control or influence effect means the operation of a conscious policy of regulating credit with a view to avoiding excessive business booms and subsequent depressions.

The import of this for unemployment is that a smoothing of the business cycle would avoid some of the worst aspects of unemployment.

MAINTENANCE OF ECONOMIC GROWTH AND STABILITY

The experience of prolonged unemployment during the depression of the 1930s, followed by the full employment of World War II, made many people apprehensive about the possibility of severe unemployment during the postwar readjustment. This problem received the attention of the governments of many different countries, but it received special consideration in the U.S. Western European countries had nearly all suffered severe war damage and were faced with the urgent task of restoring prewar production levels as soon as possible.

The U.S., on the other hand, had not suffered any such destruction, and the government in that country considered that the dismantling of the war industries might lead to considerable temporary unemployment. As the result of this concern, in 1946 a law was passed which established a council of economic advisers in the executive branch of the federal government. Among the functions assigned to this council were the preparation of periodic reports to the president of the U.S. and to congress on current economic conditions within the country, and the making of recommendations for the maintenance of high employment conditions. A council of three members was appointed in 1946. Congress, on its part, created a joint committee on the economic report, the function of which was to evaluate for the members of congress the analyses and advice provided by the council of economic advisers. The council issued semiannual and annual reports and became over a period of ten years one of the most influential agencies in the U.S. government. In general the objectives of the council have been to recommend policies to the government, as well as to industry and labour, designed to maintain economic stability while achieving economic growth.

Most countries with free enterprise economic systems have adopted similar policies. While the government agencies are not exactly the same as in the U.S., there does exist in most western countries some agency of government charged with the responsibility of devising policies to assist in the maintenance of full employment.

The significance of these developments for the problem of unemployment is that there now exist, on a scale never before seriously contemplated, government programs for dealing with cyclical unemployment. Furthermore, these programs are supported by public opinion and by government resources sufficiently large to have a marked impact on the private economy. Therefore, the statistics of unemployment, inadequate as they may be, have become one of the key figures for the determination of economic policy.

Up to the mid-1950s this program was apparently successful. Business downturns occurred in 1949 and 1954 in the U.S. Some moderately heavy unemployment existed at times during the postwar period in Belgium, western Germany and Italy. But there was no world-wide postwar depression and no serious prolonged depression in any western country. Nevertheless. questions were raised by economists and others as to whether this was due more to good luck than to good management.

The western world was engaged after World War II in making up wartime shortages and in rebuilding after wartime destruction. Some thinkers questioned whether the western world was yet returned to normal peacetime business conditions and whether, when it uas, the various government economic planning agencies would be as successful as they had been.

However, on one point there was no doubt. If ever and whenever a serious business downturn occurred involving heavy unemployment. the governments would not only be deeply concerned, but would be able to set in motion a whole series of policies and programs designed to offset the decline. The prevention of unemployment had definitely become a matter of national policy.

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UNEMPLOYMENT INSURANCE. Although the first suggestion for providing financial assistance to persons involuntarily unemployed was made in Switzerland in the late 18th century, the introduction of national systems to provide this assistance came only in the 20th century. Such systems from the very beginning involved workers, employers and governments. singly or in varying degrees of co-operation; some were voluntary while others were compulsory. Unemployment insurance resulted from a shift from the opinion that lumped the unemployed and the unemployable together as the objects of charity to the 20th-century concept that involuntary unemployment is a matter for serious concern in terms of the health of the entire economic system.

This article is concerned primarily with the methods of financing, requirements for eligibility and general aims of the various national systems. For theoretical considerations and earlier attitudes, see UNEMPLOYMENT: *Remedies for Unemployment;* POOR LAW; SOCIAL SECURITY. (X.)

UNITED STATES

The first U.S. unemployment insurance law was passed in Wisconsin in 1932. Before that, U.S. experiments with unemployment insurance were limited to plans either initiated by employers or adopted by agreement between labour unions and employers.

The cornerstone of unemployment insurance in the United States was laid by the enactment of the Social Security act in 1935, which imposed a payroll tax on all employers having eight or more employees in "covered" employment. However, 90% of this tax could be offset if the employer paid unemployment insurance taxes under a state law meeting certain general standards. It also provided for federal grants to the states for the total cost of administering unemployment insurance laws if certain general statutory and administrative standards were met. These inducements were strong enough to bring about the enactment of unemployment insurance laws in every state, the District of Columbia, Alaska and Hawaii before July 1937.

Later, in 1938, a special federal system was adopted for the railroad industry. In Sept. 1954 amendments to the federal Unemployment Tax act extended coverage to employers of four or more workers as of Jan. 1, 1956, and a new title of the Social Security act provided benefits to federal civilian employees for unemployment beginning Jan. 1, 1955.

Unemployment insurance protected the regularly employed who became unemployed because of lack of work and were able and willing to accept suitable employment. It provided income as a matter of right in the form of a weekly benefit related to prior wages. This income was intended to cover the workers' nondeferrable expenses without reducing work incentives.

The objective was to provide benefits for a period long enough to tide most workers over spells of unemployment between jobs and help maintain their purchasing power to prevent the spread of secondary unemployment. Funds were accumulated during periods of high-level employment for use when benefit expenditures increased. Continuous contact with public employment offices facilitated absorption of claimants into employment.

The system involved close co-operation between the federal and state governments. Except for railroad and federal workers and special temporary programs for veterans, there was no national unemployment insurance law. Federal worker benefits, financed by federal funds, were paid by state agencies under their own benefit formulas.

Federal Responsibility. — The Social Security act of 1935 created a Social Security board to administer the various provisions of the act. After June 1939 the board exercised its function under the direction of the administrator of the Federal Security agency. Operational responsibilities were carried on by the bureau of employment security of that agency.

The United States employment service, created by the Wagner-Peyser act of 1933, was transferred by congress from the U.S. department of labour to the Federal Security agency in July 1948, and combined with the unemployment insurance program as the bureau of employment security. In 1949 the bureau was transferred back to the department of labour.

The bureau administered the federal part of both the employment service and unemployment insurance, maintaining direct relations with state administrative agencies through regional offices. Its primary responsibilities were to see that the state laws conformed with requirements of the federal acts and to determine, within the amounts authorized by congress, the amounts to be granted to the individual states for the administration of the state laws. A clearinghouse and service agency, the bureau promoted efficient administrative methods and made studies and recommendations to improve provisions for economic security.

Among the requirements that a state law had to meet to enable employers to secure credit against the federal tax were the following: that benefits be paid through public employment offices; that all taxes collected under the state law be deposited to the state's credit in the trust fund in the United States treasury from which they could be withdrawn only for the payment of benefits; that unemployment insurance could not be denied "to any otherwise eligible individual for refusing to accept new work under any of the following conditions: (1) if the position offered was due directly to a strike, lockout or other labour dispute; (2) if the wages, hours or other conditions of the work offered were substantially less favourable to the individual than those prevailing for similar work in the locality; (3) if as a condition of being employed the individual would be required to join a company union or to resign from or refrain from joining any bona fide labour organization."

To determine that a state was entitled to federal grants for the costs of administration, the secretary of labour had to find in the state law methods of administration reasonably calculated to ensure the full payment of benefits when due. These included the establishment and maintenance by the state of personnel standards on a merit basis and provisions for a fair hearing to anyone whose claim for benefits was denied. The secretary also had to find that there had not been a denial of benefits due under a state law in a substantial number of cases.

Grants to the states for the administration of unemployment insurance and the employment service were made quarterly. By the latter 1950s they totaled more than $220,000,000 annually.

State Responsibilities. — The state agencies collected and recorded taxes, received and passed upon claims for benefits. paid benefits, adjudicated disputes over benefits and managed state budgetary functions connected with the administration of unemployment insurance. They also furnished to the secretary of labour such reports as he might require. A nation-wide system of public employment offices was affiliated with the United States employment service of the bureau of employment security. Financed by federal funds, it was operated by the state agencies.

The states were free to enact unemployment insurance laws with such coverage, financing and benefit provisions as they desired. However, the state laws were strongly influenced by the provisions of the federal Unemployment Tax act.

Coverage. — This federal act originally taxed only employers of eight or more workers in 20 weeks in a calendar year. It remained unchanged in this respect until Sept. 1954 when it was amended to apply, as of Jan. 1, 1956, to employers of four or more workers. By 1956 all states covered employers of four or more workers; 23 states covered employers of fewer than four workers; 18 of these covered employers of one or more. About 80% of the work force was protected by unemployment insurance.

The growth in the labour force and in employment had increased the number of insured workers from 20,000,000 in 1938 to 36,000,000 at the beginning of 1955. The extension of coverage to federal workers in that year, and to firms employing four to seven workers in 1956, added another 4,000,000. The 12,000,000 wage earners still excluded in 1956 were in agriculture, domestic service, nonprofit religious, educational and charitable organizations and in state and local governments.

Benefits. — All state laws provided that weekly benefits be related to the weekly wages of the individual beneficiary. not based on claimants' sex and age, as in Great Britain. The original goal was to provide about 50% of wages, but the rise in wages immediately before and following World War II outstripped statutory maximums, and weekly benefits fell below that ratio in all states.

Pres. Dwight Eisenhower's economic reports of 1954 and 1955 suggested that states strengthen the benefit provisions so that most beneficiaries could receive half their weekly earnings for 26 weeks of unemployment.

During 1955, 32 states increased their basic weekly benefits. Maximum basic weekly benefits (without dependents' allowances), which had varied from $15 to $26 at mid-century, ranged from $24 to $45 after the 1955 amendments went into effect. Almost 70% of the covered workers lived in 32 states with maximum basic weekly benefits of $30 or more. About 73% of the covered workers lived in 27 states where the maximum potential duration of benefits was 26 weeks or more.

These changes did not fully achieve the president's goal. After they became effective, only seven states, with one-eighth of the covered work force, provided maximum basic benefits equal to half the state-wide average weekly wage.

The maximum potential benefits available to a claimant during a year varied widely. Fourteen states allowed potential benefits for the same number of weeks to all eligible workers. Thirty-six states limited the worker's total benefits to a fraction of his annual earnings, or limited the duration by a fraction of the number of weeks worked. In terms of money. maximum annual potential benefits (without dependents' allowances) ranged from $384 to $1,170 during 1956.

After mid-century, total annual benefit payments throughout the nation ranged between $840,411,000 in 1951 and $2,027,000,000 in 1954.

Dependents' Allowances. — By 1956 only 11 states had adopted provisions to increase the weekly benefits of claimants with dependents. The definition of dependent and the amounts of the allowances varied greatly from state to state. The laws usually provided an allowance of a specified weekly amount for each dependent, varying from $1 to $5, with a ceiling on the total allowance.

Disqualifications. — The major causes of disqualification from benefits were voluntary separation from work, discharge for misconduct, refusal of suitable work and unemployment arising from a labour dispute. The results of disqualification varied greatly from state to state. In some, benefit payments were postponed for a specified number of weeks on the theory that, after a time, the reason for a worker's unemployment resulted more from the general conditions of the labour market than from his disqualifying act. In other states, the disqualification lasted for the duration of the period of unemployment, and in some of these, all prior wage credits were cancelled, tending to put the claimant out of the system. Many states imposed penalties of varying severity for the different causes.

State Administration. — Certain administrative arrangements were common to all states. Every claimant filed his application for benefits at a public employment office and at the same time applied for work.

A report from the employment service or an employer that an applicant had refused suitable employment held up his right to benefits until it could be determined whether the refusal was justified. Each state law defined "suitable employment."

Procedures to settle disputed claims in all states authorized either the claimant or an interested employer to request a hearing before an appeal body on any decision denying or allowing benefits. Decisions of the appeal tribunals might be appealed further either to the state administrative agency or an independent review board, according to state law. Further appeal might also be made to the courts.

Financing. — Until 1954 federal unemployment tax collections went into the general treasury. The Employment Security Administrative Financing act approved in Aug. 1954 earmarked the proceeds of the federal tax for the employment security program. The annual excess of the federal collections over the costs of administration were automatically appropriated to the federal unemployment trust fund account. This account was to be maintained at a level of $200,000,000 for loans to states with depleted reserves. The excess collections beyond $200,000,000 were to be returned to the states for use in financing benefits and, under certain circumstances, for financing administration.

Experience Rating. — The federal law provided that employers could receive tax offset credit not only for the state taxes they paid, but also for those waived under a state experience rating system. Accordingly, all state laws provided for modifying employers' tax rates according to their experience with unemployment "or other factors directly related to unemployment risk."

As a result of the high payroll and employment levels during most of the program's history, and especially after 1941, many states reduced employer tax rates sharply from the 2.7% rate at which they began. Average tax rates fell to about 1.2% by 1947 and were at about that level in 1956.

World War II Servicemen's Readjustment Allowances. — The Servicemen's Readjustment act of 1944 provided veterans' allowances of $20 for each week of involuntary unemployment, up to 52 weeks. It also provided benefits to "self-employed" veterans trying to establish businesses or professions. The state agencies paid the benefits as agents of the federal government. More than 9,500,000 of the 15,100,000 World War II veterans filed claims for these benefits and were paid $3,800,000,000 in the five-year period of its major operations.

Unemployment Compensation for Veterans. — In Oct. 1952 a program providing unemployment compensation for veterans with military service between June 27, 1950, and Jan. 31, 1955, became effective under the Veterans' Readjustment Assistance act of 1952. Known as UCV, this program provided payments of $26 a week for each week of involuntary unemployment up to a maximum of $676. If a veteran qualified for unemployment insurance under any other law he could receive under the UCV law only the difference between $26 and the amount he was entitled to receive under the other program. To be eligible for these benefits, veterans had to meet all requirements of the law of the state through which the payment was made. Between Oct. 1952, when the program began, and Dec. 1955, benefits under this program totaled $240,000,000. During this period more than 1,000,000 veterans had filed claims for UCV benefits, about 750,000 of them had received at least one benefit payment and 139,000 had exhausted their $676.

Unemployment Compensation for Federal Employees. — Federal civilian workers became eligible for unemployment compensation on Jan. 1, 1955. Financed by federal funds, this program, like the veterans' programs, was administered by the state agencies. Unemployed federal workers were paid benefits in the same amounts and under the same conditions as workers in private employment in the applicable jurisdiction, which was usually the state in which the federal worker had his last official station. During 1955, the first year of operation, more than 165,000 claims were filed. Approximately 93,000 unemployed federal civilian workers received nearly $29,000,000 in benefits.

Temporary Disability Insurance Co-ordinated With Unemployment Insurance. — During the 1940s four unemployment insurance programs were expanded to provide weekly cash benefits to workers whose unemployment was due to inability to work as well as to those unemployed because of lack of work. Enacted in 1942 (Rhode Island), 1946 (California), 1947 (the federal Railroad act) and 1948 (New Jersey), these four temporary disability insurance (or cash sickness insurance) laws covered the same workers as the unemployment insurance laws with which they were jointly administered. The Rhode Island and California programs were financed by a 1% worker tax which had formerly been paid for unemployment insurance. In New Jersey workers paid one-half of 1% and employers, one-fourth of 1%. The railroad program was financed by an employer tax formerly paid for unemployment insurance.

Temporary disability benefits were paid under these laws to workers unable to perform their usual work because of illness or accident. California, New Jersey and the railroad program excluded disabilities covered under the workmen's compensation laws; and the California and New Jersey programs also excluded disability due to pregnancy.

California and New Jersey permitted individual establishments to substitute private group insurance for the state plan. Nearly half of the covered workers in California, and about two-thirds of those in New Jersey were under such private plans by 1956. In that year about 6,000,000 workers were covered by the four plans. In addition, in 1949 New York enacted a disability benefit law not co-ordinated with unemployment insurance. Under the New York program, private insurance was emphasized and the worker derived his rights to benefits from the insurance contract rather than from the law. Those coming within the law could be prosecuted for not having provided the insurance, either by self-insurance or by the purchase of insurance from private companies or a state-owned corporation. But this did not automatically protect the worker. (R. C. Gn.)

GREAT BRITAIN

Great Britain was the first country to establish a national system of compulsory insurance by the National Insurance act of 1911. Later the same policy was followed in many other countries. The act of 1911 covered only a few industries and 2,250,000 workers. Very few women were covered. Employers and workers each contributed 2½*d.* a week and the exchequer grant was equal to one-third of the total receipts from employers and employed. The rate of benefit was 7*s.* a week for adults. half rates for persons between 17 and 18 years of age. A one-week waiting period was followed by a right to draw a week of benefits for every five contributions paid up to a maximum of 15 benefit weeks in one year. To obtain benefit a person had to show that he had worked in an insured trade in 26 weeks during the preceding five years, had applied at the employment office for work, had since been continuously unemployed, was capable of work and had not exhausted his right to benefit. He could be disqualified if idle voluntarily through misconduct or because of a labour dispute. An insurance officer decided upon his application subject to power of appeal to a court of referees and final reference to an umpire appointed by the crown. The scheme was administered by the board of trade until it was taken over by the ministry of labour in 1917. A national system of employment exchanges had been established as an essential factor in the new scheme.

After World War I unemployment was severe and the insurance scheme was inadequate to meet the situation. Accordingly the Out-of-Work Donations act was passed in 1918 to provide assistance out of general taxation.

The Act of 1920. — The next major alteration was effected by the Unemployment Insurance act, 1920. which brought into insurance an additional 8,000,000 persons above the 4,000,000 already covered. The scheme was then made applicable to all persons of 16 years of age and upward employed under a contract of service or apprenticeship (except apprentices without a money payment), save those in certain excepted employments, mainly agriculture, private domestic service, government service, local government, railway and general utility companies. Nonmanual workers in receipt of remuneration exceeding £250 a year were also excepted. The waiting period was reduced to three days. Benefit and contribution rates and conditions for the receipt of benefits were altered.

Twenty Acts (1920–30). — Various alterations were made in the scheme by 20 acts of parliament during the next ten years. These were influenced considerably by mass unemployment and removed some of the restrictions on the granting of benefit. Provision was made for uncovenanted benefit for those whose rights under the main scheme had been exhausted. Rates of benefit and contribution were both increased and reduced several times but the debt on the insurance fund continued to increase and reached £25,000,000 in March 1927.

Following an examination of the whole subject by a committee under the chairmanship of Lord Blanesburgh the Unemployment Insurance act of 1927 was passed which made a number of alterations, including the creation of a class of young persons between 18 and 21 years of age and the abolition of extended benefit.

Drain on the Insurance Fund. — The unemployment insurance fund became still more insolvent. In 1931 benefits cost £125,000,000 while the contributions of employers and workers were less than £30,000,000. Benefits were reduced, later restored, and generally the operation of the scheme was made more stringent. This situation caused many unemployed men to apply for outdoor relief from the boards of guardians. The cost was, however, spread unevenly throughout the country, and the government was compelled to take action by providing a new form of relief called "transitional payments," subject to a means test. This scheme was administered by the boards of guardians at the cost of the national exchequer. Deep resentment by many people followed by considerable agitation caused the financial assistance of the unemployed outside the insurance scheme to be made a national responsibility by the establishment of the Unemployed Assistance board by the Unemployment Assistance act, 1934. It then became the duty of the board to provide assistance for all persons between the ages of 16 and 65 who were out of work whose normal occupation was an employment in respect of which contributions were payable under the national insurance schemes and who were capable of and available for work. Unemployment assistance (or national assistance as it was called later) continued to be available in supplementation of the national insurance scheme.

Effect of the Beveridge Report. — The comprehensive scheme provided by the National Insurance act, 1946, resulted from the report of the interdepartmental committee on social insurance and allied services presided over by Lord (then Sir William) Beveridge. The minister of national insurance was made responsible for the administration of the scheme. Coverage was extended without any exceptions to all persons aged 16 to 6j (60 for women) employed under a contract of service. This scheme brought in about 4,000,000 new contributors. Benefit became payable, after a three-day waiting period, at the rate of 26*s.* a week for persons over the age of 18; 20*s.* for married women; and 15*s.* for persons under the age of 18. In the case of a married woman or young person entitled to an increase for an adult dependent, or in the case of a married woman with a dependent child, the rate was 26s. An additional 16*s.* a meek was payable for an adult dependent and 7*s.* 6d. for the first child (the others being covered by the family allowance scheme). The conditions for receipt of benefit were the payment of 26 contributions between entry into insurance and the day for which benefit. was claimed, with an average of 50 contributions paid or credited (for periods of unemployment, sickness, etc.) in the last contribution year. Benefit continued to be payable weekly in cash at employment exchanges, which continued to be operated by the same ministry as before, which was now called the ministry of labour and national service.

Standard maximum duration of benefit was 180 days; after five years' coverage this duration might be gradually increased for additional contributions (not offset by benefits) up to 130 days more. Extended benefit might then be awarded by local tribunals after taking into account the claimant's circumstances but without imposition of means test (the right to extended benefit was later withdrawn).

Provision was made for claims for benefit to be decided by an insurance officer in the ministry of national insurance who might refer the question to a local tribunal. This tribunal consisted of (1) one member representing employers and persons other than employed persons; (2) one member representing employed persons; and (3) a chairman appointed by the minister. A claimant could appeal to the tribunal against a decision of the insurance officer. In certain circumstances there was a further right of appeal to the national insurance commissioner.

A person who lost his employment by reason of a stoppage of work due to a trade dispute at his place of employment was disqualified (subject to certain exceptions) during the stoppage except where he had meanwhile become bona fide employed elsewhere in his usual occupation or regularly engaged in some other occupation. A person was disqualified for a period not exceeding six weeks if (1) he had lost his employment through his misconduct or voluntarily left it without just cause; or (2) he had refused or failed without good cause to apply for suitable employment notified to him by an employment exchange; or (3) he had neglected to avail himself of a reasonable opportunity of suitable employment; or (4) he had without good cause refused or failed to carry out any reasonable written recommendation given by an officer of an employment exchange to help him find suitable employment; or (5) he had without good cause refused or failed to take reasonable opportunity of receiving approved training to make him or keep him fit for regular employment.

The National Assistance act, 1948, continued the responsibility of the board (now called the Assistance board) to grant assistance to insurable unemployed persons not qualified for unemployment benefit and to persons receiving such benefit who found it insufficient for their needs.

By the National Insurance act, 1954, benefit rates were increased to 40*s.* with an increase of 11*s.* 6d. for an only child or the eldest child; 3*s.* 6*d.* for each additional child and 25s. for an adult dependent. The rate for a person under the age of 18, with no dependent, was fixed at 23s.

(See also GREAT BRITAIN: Industrial and Social Conditions.)

OTHER COUNTRIES

Unemployment insurance schemes had been adopted by 23 nations at mid-20th century, including the limited-coverage scheme in Chile (for salaried employees only), Greece (where the arrangements were restricted to certain areas) and Uruguay (with special schemes in the wool and hide and cold storage industries, as well as pensions for unemployed persons with long coverage under the retirement system). Nineteen plans were compulsory and four (Denmark, Finland, Sweden and Switzerland) were government-subsidized trade-union schemes.

Europe. — The European countries with schemes in operation were Austria, Belgium, Bulgaria, Denmark, the Republic of Ireland, Finland, France, German Federal Republic, German Democratic Republic, Greece, Italy, Netherlands, Norway, Sweden and Switzerland. In Spain the voluntary plan formerly in existence had been replaced by public works. In the U.S.S.R. unemployment insurance was discontinued in 1930; in Czechoslovakia, in 1948.

The European schemes generally provided for rates of benefit according to the size of the family. But in Denmark provision was also made for fuel and rent allowances where there was prolonged unemployment. In the German Democratic Republic the scheme provided a basic benefit of one-fifth of the previous earnings of the unemployed person subject to a minimum and a maximum daily rate. This was supplemented by a housing allowance varying according to the size of the town or village in which the person was living. In Sweden, where unemployment insurance was voluntary, an unemployed person not so covered received unemployment relief through public works or cash assistance granted by the state or by municipalities subsidized by the state.

Outside Europe. — Outside Europe, by mid-20th century, unemployment insurance schemes had been adopted by Canada, Japan, United States, Union of South Africa and Uruguay.

Canada. — The existing unemployment insurance scheme in Canada came into operation in July 1941 and provided for a contributory scheme administered by the unemployment insurance commission. Regional and local officers throughout the country dealt both with applications for employment and claims for unemployment insurance benefit. All persons employed under a contract of service were insured unless specifically excepted. The exceptions included such employment as agriculture, fishing, domestic service, schoolteaching, etc. Employers and insured workers contributed equally, contributions being based on the wages earned. The federal government added one-fifth of the total employer-employee contribution and paid administrative costs.

Australasia.—*In* New Zealand unemployment benefit was subject to a means test as in the case of other social security benefits. The scheme was administered by the social security department.

In Australia no contributory unemployment insurance scheme existed in the mid-1950s but unemployment benefit was payable under a means test to persons who had been in Australia for 12 months and intended to reside there permanently.

General Characteristics.—Other schemes both in and outside Europe varied in detail but through the influence of international bodies such as the International Labour office and the United Nations there was a tendency for them to follow a somewhat uniform pattern. The conditions to be satisfied under the various national systems differed in points of detail, but there were broad lines of resemblance in most of them. For instance, the unemployment against which the worker was insured was involuntary unemployment. Nor would he be paid benefit under the schemes if there was suitable employment which he could take up. In this connection it was worthy of note that in countries which had instituted compulsory systems employment offices had been established by means of which the existence of suitable employment might be known and jobs offered to the unemployed. The loss of work through a labour dispute in which the worker was involved was commonly a reason for disqualification although there were various refinements on this point; *e.g.*, the duration of the disqualification might be for the period of the dispute or for any period after it had ended until the worker was again employed. Voluntarily leaving work without good cause and dismissal for misconduct were also generally grounds for refusal of benefit.

The financing of the various schemes differed in some respects but in most schemes the employer, the insured person and the government contributed. In a few the employer was the only contributor and in others the government made no contribution.

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UNESCO: *see* UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION.

UNGARETTI, GIUSEPPE (1888–), whose innovations in form and language mark the true beginnings of modern Italian poetry, was born at Alexandria, Egy., the son of an Italian from Lucca, Feb. 2, 1888. In 1912 he went to study in Paris, where he became a friend of Guillaume Apollinaire. During World War I he served in Italy and France, and wrote his first published poems, *Il porto sepolto* (1916, included in his first collection, *Allegria di naufragi,* 1919) in the trenches. *Allegria* was followed by *Sentimento del tempo* (1933), *Il dolore* (1947), *La terra promessa,* a lyrical epic inspired by Vergil (1950) and the slighter *Un grido e paesaggi* (1952). In 1936 Cngaretti became lecturer in Italian literature at São Paolo, Brazil, and in 1942 he was appointed professor of modern Italian literature at Rome.

Ungaretti's first poems—brief fragments ivritten in language purged of traditional ornament, in which each word is charged with its original power and intensity—crystallized the revolution begun in Italian poetry by the Futurists and the *Vociani* (contributors to the periodical La *voce*), and placed him in the forefront of the "hermetic" movement. From the excessive brevity which sometimes impaired *Allegria,* he later developed a use of more elaborate and traditional forms, although he retained his emphasis on the need to restore to words their effective essence.

Ungaretti's poems were edited by E. Mondadori as *Vzta d'un uomo* (1947); and there is an English translation of a large selection, by A. Mandelbaum, in *Life of a Man* (1958).

See A. Capasso, *Incontri con Ungaretti* (1933); F. Flora, *La poesia ermetica* (1936). (F. DI.)

UNGAVA, native name for the region south of Hudson strait; part of historic Rupert's Land (*q.v.*) The name was adopted officially, Oct. 2, 1895, for a district of the Northwest Territories. The Boundaries Extension act of 1912 annexed Ungava to the province of Quebec. *See* LABRADOR-UNGAVA; QUEBEC.

UNGER, FRANZ (1800–1870), Austrian botanist, prominent in the early development of paleobotany, was born near Leutschach in Steiermark on Nov. 30, 1800. He received a medical degree at Vienna in 1827. In 1836 he became professor of botany at Graz, and in 1850 professor of plant anatomy and physiology at Vienna. After retirement in 1866 he moved to Graz, where he died on Feb. 13, 1870.

Unger's numerous publications cover many areas of botany. He was the first to call attention (1855) to the resemblance between plant protoplasm and the animal sarcode. His observations on cell formation (1841, 1844) were of fundamental importance in the development of knowledge of this process, and he was among the first to admit the evolution in plants (1852). His *Anatomie und Physiologie der Pflanzen* (1855) was an early botanical textbook.

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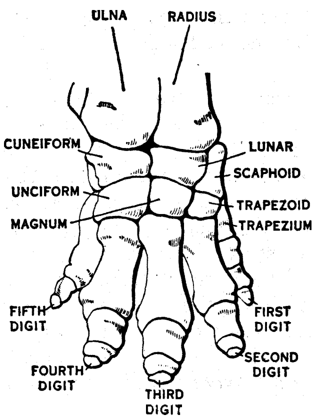
UNGULATA, an order or superorder of placental mammals including the hoofed herbivorous quadrupeds. Aristotle in his work on *The Parts of Animals,* in describing the extremities of the viviparous quadrupeds, says that ". . . some are bifid and have hoofs instead of nails, as the sheep, the goat, the elephant, the hippopotamus; and some have undivided feet, as the solid-hoofed animals, the horse and the ass. . . ."

After the Renaissance, E. Wotton (1552), following Aristotle, divided the viviparous quadrupeds into the many-toed, double-hoofed and single-hoofed. In 1693 John Ray divided the viviparous quadrupeds into two grand divisions, the Ungulata, or hoofed. and the Unguiculata. or clawed, forms. The former were subdivided into: (1) the Monochela, or Solidipeda, with solid hoofs, including the horse, the ass and the zebra; (2) the Dichela, or Bisulca, with cloven hoofs; and (3) the Tetrachela or Quadrisulca, including the rhinoceros and hippopotamus. The Dichela were again subdivided into the Ruminantia, or ruminants, and the Non-ruminantia, or swine; the Ruminantia were finally divided into those with permanent horns, namely the cattle, sheep and goats, and those with deciduous horns, of the deer kind. Here then was a usable and nearly correct classification of the ungulates before the beginning of the 18th century.



RIGHT FORE FOOT OF INDIAN ELEPHANT, SHOWING PARTS

Subsequent discoveries have added to the Ungulata a great many extinct and some recent groups which were wholly unknown to Ray. Thus in Osborn's *Age of Mammals* (1910) the "Cohort Ungulata" includes no less than 13 "orders" of hoofed mammals. While each of these is a more or less natural group of animals related by descent from a common ancestral stock, the derivation and interrelationships of the orders themselves are still far from clear. It is well established that the typical ungulates, namely the Perissodactyla (horses, tapirs, rhinoceroses, etc.) and the Xrtiodactyla (ruminants. swine, etc.) were wholly distinct from each other in the Lower Eocene, some 50 to 60 million years ago. It is indeed not improbable that the ungulate, or hoofed herbivorous type, was evolved several different times from different families of placental mammals of the Cretaceous period. or in other words. that many of the resemblances between ungulate orders are examples of either parallel or convergent evolution.

Order **Condylarthra.**—In the Basal Eocene formations of New Mexico and in the Lower Eocene of Wyoming have been found the fragmentary jaws and teeth, and very rarely more or less entire skeletons, of small hoofed mammals which on the whole were structurally intermediate between the oldest creodonts or flesh-eaters, and the true ungulates. Of these the most primitive was the genus *Mioclaenus,* known chiefly from the conical-cusped upper molars, which recall those of such primitive carnivores (creodonts) as *Tricentes* and Claenodon. Somewhat higher in the scale was the group of species of the genus *Hyopsodus*; these little animals were about as large as a hedgehog, the skull being of remarkably generalized type. The dental formula, (Incisors $\frac{3}{3}$ Canines $\frac{1}{1}$ Premolars $\frac{4}{4}$ Molars $\frac{3}{3}$)$\times 2=44$, was that of other very primitive placental mammals. The crown-patterns of the molar teeth were advancing ever further away from the primitive tritubercular type toward the more typical condylarth types presently to be described.

By far the most famous condylarth was the Lower Eocene *Phenacodus primaevus,* an animal about as large as a Newfoundland dog, which has figured in many textbooks as the "five-toed ancestor of the horse." But W. D. Matthew has advanced decisive evidence against this view. For in *Phenacodus* (*q.v.*) each quadrangular upper molar had four conical main cusps and two very small intermediate cusps or conules; whereas in the contemporary ancestors of the horse family the oblique crests of the molars were progressively developed. Even in the Lower Eocene genus Ectocion, which was related to Phenacodus, the detailed patterns of the upper and lower molars were not quite right to be structurally ancestral to the molars of the primitive horses. Another Eocene condylarth, the genus *Meniscotherium,* had more complex upper molar patterns of the type known as buno-lopho-selenodont (*i.e.,* with cones, ridges and crescents), which in some respects foreshadow the general molar types of such later ungulates as the hyracoids, the chalicotheres and the litopterns.

The foot structure of the condylarths was likewise of interest. In the five-toed hind foot the ankle bones were much like those of a contemporary creodont, with a ball-and-socket joint at the lower end, an arrangement to which the name Condylarthra refers. In the fore foot of Phenacodus the two rows of carpal bones were placed directly above each other, "like unstruck bricks," whereas in typical ungulates a more displaced, or alternating arrangement, was the rule. E. D. Cope supposed that Phenacodus was in this respect also ancestral to later ungulates but Matthew showed that in both Phenacodus and the later ungulates the contrasting arrangements of the carpal elements above mentioned were probably both derived independently from the still older interlocking creodont type.

Amblypoda.—In the basal Eocene of New Mexico occur the fragmentary remains of a diversified series of small hoofed mammals collectively known as Pantodonta or taligrade Amblypoda. Some of the smaller genera were hardly bigger than insectivores and with teeth suggestive of insectivore-creodont ancestry, while the larger taligrades (*Periptychus,* Pantolambda) were about the size and proportions of stocky badgers. The upper molar teeth in the smaller forms had three main cusps arranged in a triangle with the apex toward the inner side; the small intermediate cusps or conules were more or less circular; the main internal cusp was flanked by small cusps borne by the anterior and posterior ridges or cingula. In Periptychus the upper molar cusps were all subcircular and the enamel surface was pleated. The brain-cast indicates a brain of extremely primitive form with large olfactory lobes and a minimum development of the neopallium. In *Pantolambda* the upper molar crowns bore two sharp outer V's and a centrally placed conical internal cusp.

In all the taligrades the feet were short, especially so in *Pantolambda.* This feature becomes greatly emphasized in the later members of the order, the coryphodons and Dinocerata. *Coryphodon* is characteristic of the Lower Eocene of Wyoming and England. It was broad-headed and almost hippopotamus-like Related forms have recently been found in the Eocene of Mongolia. *Uintatherium,* Dinoceras and their allies were characteristic of the later Eocene. Their bodies were gigantic, larger than modern rhinoceroses, with massive, post-like limbs and extremely short stubby toes. They had sabre-like upper tusks, six or more horn-like bony outgrowths on top of the skull and a brain of low type.

Notoungulata.—The condylarths and taligrades disappeared from the fossil record of the northern hemisphere in early Eocene, but there is some reason to believe that some of them reached South America and there gave rise to the amazingly varied series of herbivorous mammals which are often referred to collectively as notoungulates. These flourished for millions of years in Patagonia and adjacent regions, while the perissodactyls, artiodactyls and other ungulates held sway in the northern world These notoungulates exemplified the law of adaptive radiation on a grand scale. Protected by geographical barriers from the deadly competition of their larger-brained northern analogues, they exploited all the economic possibilities for ungulates available in South America and gave rise to the wide diversity of forms that covered the ancient pampas. Some (the protypotheres) were small and swift-running like rabbits; others (the smaller litopterns) were like slender-limbed three-toed horses, some (*Macrauchenia*) paralleled the llamas and camels; others closely paralleled the rhinoceroses, while a few almost rivalled the elephants in bulk (Pyrotherium).

Litopterna (q v).—Among the most primitive of the entire series of notoungulates is the genus *Didolodus,* a small forerunner of the litopterns known only from the upper cheek-teeth, which in some ways recall those of the smaller taligrades. In the swift-footed proterotheres of the Miocene of Patagonia both cheek-teeth and feet suggest those of the Oligocene three-toed horses of the northern world. But in the upper molars the main inner cusp is central rather than anterior in position and the posterior cross-crests fail to meet the middle point of junction of the two main outer cusps, as they do in the three-toed horses, while the feet, although superficially horse-like, differ profoundly from the horses in the detailed arrangements and contacts of the tarsal elements. The larger litopterns (*Theosodon, Macrauchenia*), while in general appearance paralleling llamas and camels, yet are more nearly related to the horse-like proterotheres in their deeper characters.

Notioprogonia.—In the "*Notostylops* beds" of Lower Oligocene or Upper Eocene in Patagonia occur a strange group of ungulates, varying in size from a rabbit to a rhinoceros. Of these the most famous form, Notostylops, had a small skull in which the upper grinding teeth have oblique and flattened outer walls remotely suggesting those of recent rhinoceros. The lower molars bore long obliquely-placed blades on the hinder part or talonid. The skull as a whole suggests that of the recent Hyrax. In certain early members in which the feet are known there are five digits on the fore and hind feet, the terminal bones are cleft for the attachment of fairly large hoofs, the main ankle bone (astragalus) is more or less flattened. A single very small jaw, the genus *Arctostylops* of Matthew, found in the Lower Eocene of Wyoming, appears to be related to these South American Notioprogonia. Another apparently related type is found in the Eocene of Mongolia. These small jaws seem to increase the probability that the South American Xotioprogonia, like other members of the notoungulate series, had been derived from some basal Eocene or Upper Cretaceous forerunners of the taligrades and condylarths of the northern world.

The *Astrapotheria,* gigantic Santa Cruzian (Loner Miocene) forms nith long downwardly growing tusks, may be highly specialized derivatives of some early member of the Notoungulata.

Toxodontin — These uere perhaps the most numerous in species of all the notoungulate series One of the best known primitive toxodonts is the Santa Cruzian (Loner Miocene) genus *Homalodontotherium,* a larger form in which all the teeth had become high-crowned and all the incisors, canines premolars and molars were pressed together in a continuous series without break or interval. The Santa Cruzian (Lower Miocene) *Nesodon* was about the size of a rhinoceros but with the back curved and the limbs shorter. The front teeth were enlarged and flattened for cropping vegetation, the upper molar teeth had extremely long oblique outer walls and folded wearing surfaces. The three-toed feet, although rhinoceros-like in appearance, agreed with those of the litopterns in their fundamental characters. The Pampaean (Pleistocene) *Toxodon* was still larger, with a gigantic head and a huge curved back. This was one of the famous fossil South American mammals studied by C. Darwin (see *Voyage of the Beagle*).

Typotheria.—The smaller genera of this group, named protypotheres, included some that broadly resembled *Hyrax* and others that were rabbit-like. They were very abundant in the Lower Miocene of Patagonia. The extremely high-crowned molar teeth were much curved transversely, as in some rodents, and were adapted for grinding tough vegetation. The later form, *Typotherium,* from the Pampaean or Pleistocene of Argentina, had rodent-like incisors. It was about as large as a brown bear. This group is rather closely related to the toxodonts.

Pyrotheria.—In these curious animals the molars were bilophodont, that is they bore two cross-crests like those of tapirs and dinotheres. The skull in some ways resembled those of the Proboscidea (*q.v.*) and the same is true of the tusks, but on the whole it seems more likely that the pyrotheres are simply the South American analogues of the Proboscidea.

Hyracoidea (*q.v.*).—This characteristically African group is represented today by the "coneys" or dassies of southern and west Africa, Abyssinia, Arabia and Syria. These furry little animals have but slight external resemblance to ungulates but their jaws and teeth abound in resemblances to ungulates of many groups. The internal anatomy shows a curious mixture of resemblances to elephants and perissodactyls. There is no satisfactory evidence, however, of the relationship of *Hyrax* to any of the groups so far named. The hyracoids as a group must have been in Africa for many millions of years, since various forms of fossil hyracoids have been found in the Lower Oligocene of the Fayûm district in Egypt. In some of these very ancient hyracoids (*Megalohyrax*) the molar teeth recall those of Eocene titanotheres or of *Meniscotherium* among the condylarths. In its skull *Megalohyrax* was more or less swine-like.

Embrithopoda.—While the hyracoids played the part of the small ruminants in the ancient fauna of the Fayûm, the economic rôles of the rhinoceroses and elephants were assumed by gigantic beasts named *Arsinoitherium* in honour of an Egyptian queen. In these very strange animals the whole fore-part of the skull was surmounted by an enormous pair of bony horns, which in the front view rose to a great height. The folded surfaces of the molar teeth remotely recall those of the American Eocene amblypods, but the premolars rather suggest relationships with the hyracoids. The body was very massive and the skeleton shows a curious mingling of resemblances to elephants and amblypods, doubtless the results of similar adaptations to slow browsing movements and the support of the immense body weight. The existence of these highly specialized animals in Africa at such an early date as the Lower Oligocene and their apparent isolation, in spite of their adaptive resemblances to elephants and amblypods, all indicate a very long line of less and less specialized ancestors, traces of which may some day be discovered when still older fossil-bearing horizons are discovered elsewhere in Africa.

Barytherioidea.—Another strange type of extinct ungulate (named *Barytherium grave* by C. W. Andrews) was discovered in the Fayûm district of Egypt along with the fossil hyracoids, arsinoitheres and ancestral elephants. The only parts of the animal found were a large lower jaw, a humerus and a radius, all of which show a curious mixture of resemblances on the one hand to the primitive proboscidean *Moeritherium* and on the other hand to *Dinoceras* of the Amblypoda. In a general way it also resembles the ancient South American *Pyrotherium.*

Proboscidea.—The evolution and structure of the elephants (*q.v.*) are considered in the article PROBOSCIDEA, and further information can be found in H. F. Osborn's *Monograph* of this group. As to the remote origin of the Proboscidea, the fact that *Arsinoitherium,* in spite of its wholly different skull and dentition, shows so many curiously detailed resemblances to the Proboscidea in its limbs and backbone, lends some support to a view that the Paenungulata, a superordinal group, consisting of the Proboscidea, Hyracoidea, Embrithopoda, Amblypoda, may after all be a more or less natural assemblage of ungulates. In fact we may even advance the tentative hypothesis that some such small Lower Eocene condylarth as *Hyopsodus walcottianus* (described by Matthew and Granger), with short spreading feet, reduced canines, slightly procumbent incisors and bunodont molars, would have been an ideal starting-point for the entire subungulate series, including also the South American Pyrotheria and the Sirenia.

Sirenia (*q.v.*).—If "common sense" and superficial appearances were trustworthy, these surprisingly whale-like mammals would still be classified with the Cetacea (*see* WHALE) as they were by early naturalists. But De Blainville as far back as 1816 classified them as *"ongulogrades anomaux pour nager"*—anomalous ungulates adapted for swimming; in his later classification he brigaded them with the Proboscidea under "Gravigrades." Andrews in his description of *Eotheroides* (the oldest known sirenian, from the Upper Eocene of the Fayûm, Egypt) pointed out a number of significant features in which the skull of *Eotheroides* resembled that of *Moeritherium,* the oldest and most primitive known proboscidean from the same formation. He also cited a number of curious anatomical details in which even the modern Sirenia agree with the elephants in spite of the enormous difference in their external appearance and mode of life. On the other hand, R. Lydekker pointed out that the unworn molar teeth of certain extinct sirenians were curiously like those of certain extinct artiodactyls (*Merycopotamus*) and that this fact suggested the derivation of the Sirenia from very early Eocene artiodactyls; but one might equally say that the molar teeth of another extinct sirenian (*Miosiren*) suggest those of the Eocene rodent *Ischyromys* and that the order Sirenia had therefore been derived from primitive rodents. Either of these views would be hard, in the present meagre state of our knowledge of the subject, to disprove; but neither has nearly as much positive evidence in its favour as the view of De Blainville and Andrews that the Sirenia are an aquatic specialization from the Proboscidean stem.

Be that as it may, however, by the time of the Lower Oligocene *Eotheroides* was already definitely a sirenian in its dentition, skull and locomotor skeleton. Thereafter during the Oligocene, Miocene, Pliocene and Pleistocene epochs the changes in the skull and skeleton were comparatively slight and unimportant. The middle and late Tertiary sirenians (such as *Halitherium* and *Halianassa*) were for the most part considerably larger than the modern manatees and dugongs (*qq.v.*) and had a large vertically-placed pair of upper tusks, which have been retained by the dugongs but lost by the manatees.

The Sirenia are whale-like in their torpedo-like bodies and horizontal tail flukes, in the complete absence of external hind limbs and in their flipper-like forelimbs, which however still retain external nails or vestigial hoofs. They differ markedly from typical cetaceans in their relatively small heads, truncate flattened snouts with transversely expanded upper lips covered with very large bristles. The molar teeth are two-ridged—wholly unlike the conical teeth of toothed cetaceans. Their tusks when present are situated at the end of the muzzle and directed downward. They differ profoundly from cetaceans in their food and feeding habits, being the herbivores of the coasts and estuaries, whereas at least the typical cetaceans are essentially carnivores of the open seas. In their internal anatomy the sirenians likewise differ widely from cetaceans: the musculature of the forelimbs is less profoundly modified for aquatic life, the brain has a much less complexly convoluted surface and the digestive tract recalls that of the ruminants. The skeleton sirenians is peculiarly massive and dense, the swollen, heavy ribs serving apparently as ballast to keep these voluminous, gas-filled bodies below the surface.

Most of the many known extinct types of sirenians conform in essentials to the dugong type, but one extinct family, the Miocene Desmostylidae, is widely different from the rest. In these the large upper tusks almost suggest the earliest proboscidean types but the most remarkable peculiarity is found in the molar teeth, each of which consists of a closely packed cluster of cylindrical columns of circular cross-section.

Perissodactyla.—*See* PERISSODACTYLA.

Artiodactyla.—The Artiodactyla may be an offshoot of some forerunner of the mesonychid family of the creodonts, while the Perissodactyla may be related remotely to the Cretaceous ancestors of the condylarths.

Recent studies by Miss H. S. Pearson on the skull structure of the earliest artiodactyls have revealed that at a very early date the order was already subdivided into two series, one the amastoid series, in which the mastoid region of the periotic bone was completely covered by the squamosal and adjacent elements (as in the suines and their extinct relatives), and the other, the mastoid series, in which the mastoid was well exposed on the outer side, as in the Eocene Dichobunidae and all the ruminant artiodactyls. See also ARTIODACTYL.

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(W. K. G.; X.)

UNICORN, a fabulous beast, usually having the head and body of a horse, the hind legs of an antelope, the tail of a lion (sometimes horse's tail), sometimes the beard of a goat, and as its chief feature a long, sharp, twisted horn, similar to the narwhal's tusk, set in the middle of its forehead. The earliest description is that of Ctesias, who states that there were in India white wild asses celebrated for their fleetness of foot, having on the forehead a horn a cubit and a half in length, coloured white, red and black; from the horn were made drinking cups which were a preventive of poisoning. Aristotle mentions two one-horned animals, the oryx, a kind of antelope, and "the so-called Indian ass." In Roman times Pliny mentions the oryx, the Indian ass, and an Indian ox as one-horned; Aelian, quoting Ctesias. adds that India produces also a one-horned horse and says that the Monoceros was sometimes called Carcazonon, possibly a form of the Arabic *Carcadān*, rhinoceros.

The medieval conception of the unicorn as possessing great strength and fierceness is perhaps due to the fact that in certain passages of the Old Testament the Hebrew word R'em, now translated in the Revised Version "wild ox," was translated in the Septuagint monoceros, in the Vulgate unicornis or rhinoceros, and in the Authorized Version "unicorn," though in Deut. xxxiii, 17 it obviously refers to a two-horned animal. Isidore xii, 2, 12 tells how the unicorn had been known to worst the elephant in combat.

As a decoration on drinking cups, it symbolized the ancient belief in the efficacy of the unicorn's horn against poison, which in England remained, even in the time of Charles II, though Sir E. Ray Lankester mentions that a cup made of rhinoceros horn was then handed over to the Royal society for experiment, with the result of entirely disproving the superstition.

In the court ceremonial of France as late as 1789 instruments of "unicorn's" horn were still used for testing the royal food for poison.

In heraldry the unicorn was sometimes used as a device (see HERALDRY), but oftener as a supporter, and subsists in modern times as the left-hand support of the royal arms. This position it assumed at the Union, the Scottish royal arms having been supported by two unicorns. When the unicorn became a supporter of the royal arms both of England and Scotland, a royal crown was added on the head of the unicorn, in addition to the crown with chain and ring round its neck, but this crown was removed after the Hanoverian succession. In England after the Union the unicorn became the left-hand supporter, but in Scotland, as late as 1766, it was still put on the right.

UNICORN PLANT (Proboscidea *jussieui*), a North American plant of the family Martyniaceae, called also proboscis flower and devil's-claw, native from Indiana to New Mexico and southward to Mexico, cultivated for its abundant foliage, peculiarly shaped flowers and oddly formed fruiting pods. It is a coarse, sticky-hairy, half-prostrate annual, with thick, rounded leaves; large violet or purple flowers, $1\frac{3}{4}$ in. long; and hanging, hornlike, woody pods, with a thick body 3 in. to 4 in. long. ending in a curved beak of equal or greater length. When dry, the beak splits into two opposed hooklike or clawlike appendages.

ROCHE

UNICORN PLANT (PROBOSCIDEA JUSSIEUI) SHOWING FLOWERS, HORNLIKE FRUITING POD AND LEAVES

UNIDENTIFIED FLYING OBJECT (UFO), in military parlance, means any aerial object that fails to identify itself to, or to be identified by, trained ground or air-borne crews using visual or electronic detection methods. Since 1947, owing to a sequence of bizarre circumstances, UFO has become an omnibus term connoting any object or optical phenomenon, usually aerial, that the observer cannot readily explain. UFO frequently is used interchangeably with "flying saucer," a term coined in 1947 as a result of the reported sighting by a civilian pilot, Kenneth Arnold, of a series of disk-like objects over the mountain ridges in the vicinity of Mt. Rainier, Washington. As a result of the wide publicity given to this sighting, there followed a wave of reports of unidentified objects by observers in various parts of the U.S., as well as in other countries.

First regarded by many as a bizarre, peculiarly American psychological phenomenon that would quickly fade away, the UFO instead showed an amazing tenacity over more than a dozen years, and the U.S. air force was officially charged with investigating the reports. Often several reports were made to the air force in one day, and reports came also from France, Great Britain and other countries. Indeed, if account is taken of the smaller area of some of the countries and the greater percentage of cloudy weather they experience, the sightings "per square mile per day" often were more frequent there than in the U.S.

The UFO should not be regarded as something that came into being in 1947, even though the phenomenon burst suddenly upon the public consciousness in that year. History is full of references to strange sights in the sky. In ancient and medieval times a comet was a strange and terrifying sight, as was an aurora, and it would be impossible to say whether the pattern of sightings in those days was the same as in the 20th century. Certainly, in some respects it must have been different. There were no "sky-hook" research balloons, unusual types of aircraft or re-entering missiles or artificial satellites. A comet, though described in terms recognizable to us, was often regarded as a true visitation.

It is easy to imagine that there were many UFO's in those times, many stories of strange sightings in the sky; but since communication was poor and record-keeping almost nonexistent, such sightings became part of the underbrush of local folklore and old wives' tales. Certainly, in times when people believed that a woman could give birth to dogs and pigs. that witches could levitate and fly about, and when credulity ran high, it would be not at all surprising to find a similarly uncritical attitude toward ordinary—and today well-understood—aerial phenomena.

Reports since the birth of the "modern" UFO in 1947 generally occurred in waves, but on the average, during the period of the U.S air force study, they numbered more than one a day. If consideration is taken of the fact that many reported sightings were not made through official channels, but to newspapers and to civilian groups interested in the phenomena, the rate of observations may have been as high as two or three a day in the U S over a period of a dozen years. France, Italy, England and a number of Latin American countries also experienced minor waves of CFO reports.

The steady stream of sightings became a cause for concern to the air force, and detailed investigations were made to discover

TABLE.—*Reported Sightings,* * *1947–61*

Year	Number	Year	Number
1947	79	1955	404
1948	143	1956	778
1949	186	1957	1,178
1950	169	1958	590
1951	121	1959	364
1952	1,501	1960	514
1953	425	1961	488
1954	429	Total	7,369

*U.S. air force reported sightings during the 15-year period of the official study.

reasons for such reports. The objectives were to determine (1) whether the reported UFO's constituted a threat; (2) whether the phenomena had any intrinsic scientific value; arid (3) what role UFO's might play as a factor in the sky surveillance program. It was concluded after the many years of investigation that (1) the phenomena bore no hostile purport and did not constitute a security threat; (2) there was no compelling reason ti; believe thnt the great majority of sightings arose from anything other than misidentification of natural objects and phenomena. and that the real cause of these sightings generally lay in the conditions under which an object or phenomenon was seen; and (3) the continued evaluation of UFO reports is of scientific value. especially in relation to the rriilitary sky surveillance problem.

It was estabiished that many sightings arose from seeing startling natural objects for the first time; *e.g.*, very bright meteors. high-altitude scientific balloons (which can attain high velocity nhen caught in the jet stream) arid especially distant terrestrial or celestial objects seen under such unusual meteorological conditions as those that produce mirages, which can distort, displace and animate objrcts detected visually or by radar. Such meteorological conditions. some thoroughly understood (mirages) and some poorly understood (ball lightning), can easily cause even an experienced observer to ascribe what he sees to a tangible: nearby, self-propelled object.

Indeed. it is not at all surprising, with so many more people turning their attention skyward. that many (including the scientifically trained) are confronted with an aeria! phenomenon they cannot readily explain.

Virtually all the reports received by the air force were highly subjective. lacking such verification as pictures, material fragments, spectroscopic analysis of lights seen or precise technical data on trajectories. distances. accelerations, etc. As the investigation progressed. it became ciear that most reports could be correlated with the appearance of aircraft, birds, celestial objects, balloons. etc.. under special conditions. and the number of unexplained cases fell from an early value of more than 10% to as little as 2% or 3%. It was readily admitted that this small residue—as reported—defied logical explanation. For none of the extraordinary "unknowns," however, were there scientific data on which to base valid, definitive investigations.

The early difficulties in corning to grips with the successive waves oi sightings, coupled with concern that UFO reports, often made by pilots, might constitute a threat to military security (and the consequent, unfortunate air of secrecy imposed in the early years of UFO reports), had an electrifying effect on the imaginations and emotions of a surprisingly large number of people. It led to an inordinate interest in UFO's and a logical, albeit scientifically unsupported theory of UFO's, encouraged by the real possibility of life elsewhere in the universe, as well as by a strong. often unconscious, desire on the part of many people to believe in the probability of visitors from outer space.

This theory of UFO's, with its strong quasi-religious emotional appeal. holds it not. only logical to assume that other inteiligent beings exist in the natural universe, but that superior extraterrestrial civilizations might visit here periodically, as if to rnake periodic checks on a tribe of aborigines. The theory is seen to have support throughout history in accounts of strange apparitions in the sky. suggesting to some that the earth could have been visited many times in the past. Some believe such visits became more frequent as atomic arid hydrogen bombs increased extraterrestrial concern.

In the face of continued lack of empirical evidence, persistent attempts to link UFO reports with visitations from space merit socio-psychological study.

It is amply evident that UFO's and "flying saucers" exist as reports. This has led to the quip that UFO's are any aerial sightings that remain unexplained long enough for the preparation of written reports about them. It is the problem of the serious investigator to probe for stimuli that give rise to the reports.

U.S. air force investigators long recognized that most originators of UFO reports are sincere, interested in the welfare and security oi their country and honestly puzzled by the sightings they report. Their frequent readiness to ascribe a UFO to extraterrestrial sources, their emotional attachment to this explanation and their reluctance to take into account the failure of continuous and extensive surveillance by trained observers to produce such sightings is surprising. It appears unreasonable that spacecraft should announce themselves to casual observers while craftily avoiding detection by trained observers.

Sonetheless. it must be recognized that knowledge of the universe and of the physics of our atmosphere is still imperfect. UFO sightings. as long as they continue, will merit serious study and may lead to advances not only in physical knowledge but in the area of human behaviour as well. (J. A. H.)

UNIFIED FIELD THEORY attempts to extend the general theory of relativity (*q.v.*) to electromagnetic forces and the forces between nuclear particles. General relativity incorporates the gravitational field into the structure of four-dimensional space time. and in this sense gravitation becomes part of geometry. Unified field theory has attempted to extend this treatment to the other forces mentioned, and if this were achieved. all the fundamental fields of force would be described by the geometry of space time. It was also hoped that a unified field theory would overcome certain difficulties in electromagnetism and atomic theory; *e.g.*, in classical electromagnetism there is no explanation of how elements of like charge. which must repel each other. can cohere to form an electron or other fundamental charged particle; and in atomic theory the occurrence of probability as a fundamental notion was thought unsatisfactory. especially by Albert Einstein and Erwin Schrodinger. There was also a more philosophical reason. Physical reality is supposed to consist of particles of matter and fields of force. Einstein believed that it should be possible to eliminate the notion of a particle and to represent the whole of physical reality by means of a field. so that matter becomes nothing more than a region of high field intensity.

General relativity is a highly developed field theory which still contains the idea of a particle because there are regions of space time where the field equations break down. and these "singular regions" must be supposed to represent particles. In an entirely successful field theory there would be no singular regions. and every physical situation would be completely described by the field alone.

Of the many unsuccessful unified field theories put forward there were three main types. The gauge-invariant geometry of Hermann Weyl (1918) extended the class of transformations to which the geometrical quantities characterizing space time must be invariant: he could thus introduce four quantities identifiable with the potentials in classical electromagnetism. This theory is unsuitable because it leads to field equations of the fourth differential order. whereas there is reason to believe that the correct equations are of the second order. The second important class of theories, stemming from work of T. Kaluza (1921), are those using five-dimensional spaces. and although they achieved a formal unification of the fields, they did not solve any outstanding physical problems nor lead to important new ideas of physical significance. The generalized theory of gravitation, or nonsymmetric unified field theory, was independently developed by Einstein (1945) and by Schrödinger (1943). In this the fundamental tensor g_{ik} of general relativity is allowed to be nonsymmetric. which introduces an antisymmetric tensor of the second rank presumably identifiable with the electromagnetic field variables. The investigations of the theory seem to show that it does not agree with experiment since it does not predict correctly the observed motion of charged particles in an electromagnetic field. However, nonsingular solutions of the field equations. which Einstein believed to be the only significant ones, have not been discovered, nor are they known to exist.

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UNIFORMS (Lat. *unas*, "one." and *forma*, "form"), distinctive, homogeneous dress worn by naval, military and air services and other bodies.

BRITISH MILITARY UNIFORMS

From **Origins** to 1768.—The origin of the modern uniform, no doubt. was the armorial bearings and badges of the knight and his retainers. The first permanent body of troops was Henry VII's bodyguard. which exists today as the yeomen of the guard. First dressed in white and green coats. the Tudor colours, embroidered on breast and back with the crown and rose. they continued to wear this livery during the first part of the reign of Henry VIII, who later gave them a new dress of scarlet guarded with black. During the following reigns. the levies raised for various emergencies were frequently supplied with uniform coats of the same colour. sometimes ornamented with guards of coloured lace. During the Great Rebellion this custom continued. It seems, however, that there was no uniformity in the colour of the breeches; even in Cromwell's New Model army. although all were to wear red coats, the breeches were to be "grey or other good colour."

With the return of Charles II began the establishment of the regular army and regimental uniforms. The dress at first was still the short coat and the high-crowned buff-coloured felt hat. which soon gave place to a black one with a lower crown. The coal was made longer, reaching almost to the knees. It served also as an overcoat. which did not form part of the soldier's clothing. Regiments now began to have linings and cuffs of regimental colours, and the fall-down linen collar was replaced by a white neckcloth. Officers wore silk sashes. Sashes of different colours had formerly been used as a means of identification in the field and so became the emblem of military rank. The gorget was almost the last piece of mediaeval armour to be worn. It had now become a small semicircular object fastened round the neck with a ribbon, used as a badge of rank and worn to indicate that the officer was on duty. It survives as the staff officers' tabs.

In 1677 grenadiers were introduced and given a special headdress—:~baglike cap with a band of fur. The fur was later replaced by a cloth band and a stiffened front. on which was embroidered the sovereign's crown and cipher or the colonel's crest. The colour of a regiment's breeches and stockings now begins to be mentioned. The former became less voluminous and the stockings were worn pulled over the knees and fastened with a strap and buckle. Shoes and stockings were found impracticable for campaigning in the mud of the Low Countries; and spatterdashes or leggings reaching above the knee were introduced. The wide brim of the felt hat had been looped up on one side, then on two, and finally the three sides were fastened to the crown to form the three-cornrred cocked hat. In Great Britain at the end of the 17th century several regiments wore gray coats, the local homespun being the easiest cloth to obtain. These gray uniforms were discontinued by the end of the century, although they continued to be worn in the continental armies, especially by French regiments. who wore light gray uniforms for many years until they changed to those of a definite white cloth.

Cavalry. or "horse" as it was termed at the beginning of the Restoration. wore much the same dress as during the Great Rebellion. The buii coat was still part of its clothing but it became shorter and closer fitting until it developed into the "veste" or waistcoat. still retaining its buff colour. Cuirasses were worn up to 1697–98. The triple-barred helmet was soon replaced by a metal "skull." worn inside the crown of the felt hat as a protection against sabre cuts. Boots at first were made of brown or buff leather. but were soon replaced by the stiff black jack boot with wide tops to protect the legs and knees from being crushed in mounted action. The "horse" wore crimson coats with regimental facings and leather breeches. The dress of Marlborough's army remained more or less the same up to the reign of George II. when he and the duke of Cumberland made serious efforts to standardize regimental uniform. The single-breasted coat was changed to a double-breasted garment with half lapels, buttoned back for full dress or buttoned across for extra protection. The large cuffs were furnished with a laced slash and buttons. The linings. cuffs and lapels were of the facing colour, and each regiment had its own special pattern of lace. This strengthened those portions of the coat liable to extra strain such as the seams, buttonholes, edges of the cuffs, etc. The foot guards wore plain white lace. Nearly all regiments wore red coats and waistcoats. except the foot guards and royal regiments, who wore blue. The outer coat acted as an overcoat. The skirts could be buttoned back for parades or ease in marching, or allowed to fall loose as a protection.

The crowns of the grenadiers' and fusiliers' cloth caps were stiffened with pieces of cane. The fronts mere of facing cloth embroidered with the crown and cipher and scrolls or foliage, exceptions being the foot guards and those regiments entitled to special badges. During the Seven Years' War the grenadiers, in imitation of the European regiments, began to cover the front of their caps with fur, which finally developed into the bearskin caps authorized in 1768.

From 1768 **to** 1797.—The 1768 warrant made considerable changes in the army's dress. The coats were made closer fitting with fall-down collars and small round cuffs without the slash, the narrow lapels to the waist still retaining the loops of regimental lace. The linings. waistcoats and breeches were white. The three-cornered cocked hat usually had the front point raised into a more upright position. until finally it took the form of a two-cornered cocked hat. The long white leggings were now changed for black, with black leather tops. The fur cap of the grenadiers was furnished with a black metal plate with the devices in white, the crown at the back still showing the red cloth.

Light infantry had fallen into abeyance until the American Revolution. Their uniform was a short lapelled jacket, red waistcoat, white or buff breeches, stockings and the short spat-shaped gaiters which had come into general use during the war. The headdress was either the felt cap or one of jacked leather with a turned-up front and a black or green feather on the side.

In 1787 an attempt was made to issue clothing suitable for hot climates, and white round hats were given to the troops serving in the East and West Indies. In 1789 a complete kit was authorized, consisting of a white hat, jacket and trousers. The white hat was replaced by a black one shaped like a silk hat or later a "bowler," and often furnished with a fur crest as an extra protection against the sun. This was also worn by the light companies of the foot guards and the volunteers in 1794.

The style of the coats and hats of the cavalry and dragoons followed much the same changes as those of the infantry. The success of the light dragoons caused more regiments of heavy dragoons to change over. In 1784 their red uniform was changed to a short blue sleeveless jacket and underjacket, both heavily braided with white lace. The headdress was of black leather with a black bearskin crest and a turban of silk or leopard skin. The artillery and engineers in the 17th century came under the master general of the ordnance, the officers being commissioned by him. "The train of artillery," as it was called, was not a permanent force. The uniform of the gunners was red with a cocked hat, although grenadier caps were worn by some. William III's train for his Irish campaign wore blue with orange facings, however.

The red uniforms continued to the end of Marlborough's campaigns. In 1742 blue coats faced red took their place, and in 1778 all ranks wore white breeches ahd waistcoats, yellow lace having been added to the coats. In 1794 the cocked hat was changed to a flat-brimmed round hat with a tapering crown, the officers wearing the fur-crested hat.

The engineer officers were given their first uniform in 1757. This was scarlet with black velvet facings and was changed to blue with black facings in 1782 and to scarlet with blue facings in 1812. The engineers were a corps of officers only. In 1772 a separate company of military artificers was formed composed of noncommissioned officers and privates. The dress was a red jacket with orange facings and a cocked hat with a black feather. In 1787 blue coats with black facings and laced with yellow were adopted. Dark frocks with round hats were worn for working. After this the artificers, later the royal sappers and miners, followed the same styles as the infantry, although their lace remained yellow.

The success of the galloper guns of the light dragoons in India led to the formation of the royal horse artillery in 1793. Their uniform was at first a blue coat with red lapels and a iur-crested helmet. The coat was soon changed for a short yellow-braided jacket. which continued up to 1823. Their dress then followed the different styles of the light dragoons until 1846. when the hussar busby was adopted.

The drivers of the artillery were originally civilians hired with their horses by contract. In general they wore the smock frock, sometimes with the crown and cipher worked on it. Since they proved unreliable in action. a military unit was formed in 1806, called the corps of royal artillery drivers. Its members wore a helmet and uniform similar to that of the royal horse artillery.

Another driver corps raised in 1794 for the transport was the royal wagoners. They were dressed in red jackets with blue collars and yellow cuffs. blue breeches and a leather cap, the whole inspired by the Hanoverian train. A new corps was raised in 1799 named the royal wagon train, and dressed in blue jackets laced white and faced red, and a fur-crested helmet. In 1811 red jackets with white braid and a shako were approved. This dress with minor changes continued until 1831, when gold lace replaced silver for officers. The train was disbanded in 1833, and a new corps was hastily raised for the Crimea called the land transport corps, the uniform being a blue double-breasted tunic and black slouch hat. Reformed as the military train. it retained the blue tunic, but the facings were white. and a black shako (of French type) with black drooping plume and cap lines was added. This corps developed into the royal army service corps.

From 1797 **to** 1815.—In 1797 the coat was made to fasten down to the waist, the lapels, except for officers, were removed and replaced with lace loops. The cocked hat had now assumed its largest proportions, the lace edging was removed and a white tuft or feather with a red base became usual. The grenadiers and light infantry retained their white or green plumes. In 1800 a new short single-breasted jacket was introduced. Officers still wore the large cocked hat and the double-breasted lapelled coat; usually buttoned across. The men were given a tall cylindrical cap, first made of lacquered leather and soon changed to felt. It was also worn by the grenadiers and fusiliers when on active service,

During the Peninsular War. officers wore the same cap as the men with a short jacket. The general staff, however, wore the cocked hat, which became much reduced in height. In 1811 a new cap was made with the addition of a high front copied from that worn by the Portuguese troops. The white breeches and gaiters worn at home were replaced by slate-gray trousers and short gaiters in the field. Gray overcoats were issued in 1802. The Highland regiments wore the same type of jacket. The men's bonnets were covered with small feathers, and on service had a leather peak. Because the men lost their shoes in soft ground, short gray gaiters strapped under the instep were worn.

The coats of the cavalry and heavy dragoons followed much the same changes in style and cut as those of the infantry. Red cloth wings were added to the shoulder straps. In 1811 they changed to another short jacket, with bands of lace down the front instead of the bars of lace. It was fastened mith hooks and eyes, and a girdle of regimental colours was worn round the waist.

A helmet of black leather with metal comb and mountings replaced the cocked hat. The first pattern had a worsted crest, soon changed to a black horsehair tail in imitation of the French dragoons. The household cavalry, however, retained their red and dark blue worsted crest, and the Scots grays their fur caps. White breeches and high jack boots were worn in full dress, but on service slate-gray overalls with coloured stripes were worn. These had originally been worn over the white breeches and hoots to protect them from being soiled on the march. Later they became an actual garment by themselves.

From 1816 **to** 1854.—The poor appearance of the British infantry while stationed in Paris in 181j in comparison with the Allied troops led to the adoption of a shako copied from that of the French, but having a peak or neck covering at the back as well as the front. which was dispensed with in later patterns. The period following was the most elaborate for the dress of the army. The shako was first adorned with bands of gold or silver lace round the crown and base. then elaborate cap lines mere added which terminated in gold "flounders" or flat plaited knots fastened to the breast of the coat. Tall plumes were replaced in about 1835 by ball tufts. The short jacket was replaced by the long-tailed coatee and the Prussian or straight-up closed collar was introduced. The officers' wide lapels of facing colour curved to the waist, and had laced or embroidered buttonholes.

Black gaiters and breeches were abolished in 1822; white trousers were worn in the summer and light blue-gray in the winter, with gold or silver stripe for officers. An almost black cloth called Oxford mixture replaced the light blue. and a red welt was added to it. The white trousers were abolished (except for hot climates) in 1845. The bearskin cap of the grenadiers had been furnished mith a leather peak. cap cords and a brass plate. and these were gradually discarded until the cap was of fur only without any embellishments. In 1837 gold lace was to be worn by the regular army only. In 1843 a new shako was introduced. called the "Prince Albert." All bearskin caps except those of the foot guards and Scots grays were abolished. The rifle regiments wore green jackets and pelisses with bell-topped shakos and falling plumes, later changed to ball tufts. The jackets of the Highland regiments were similar to those of the line regiments, but the skirt tails mere small and short. The feathered bonnet was at its tallest and the sporran had large gilt fastenings and a long-haired covering with tassels and sometimes gilt fringes.

The heavy cavalry appeared in black japanned metal helmets with brass plates and ornaments: surmounted by large black bearskin crests. The light gray-blue overalls were full in the leg, becoming tight at the ankle in imitation of the Cossack garments. and so named after them. Later they were replaced by dark blue with coloured stripes. The helmet was again changed in 1834 for one similar in shape but of brass. For undress the fur crest could be removed and replaced by a brass crouching lion which fitted over the front and top of the comb. Later a brass helmet with an upright spike with drooping horsehair plume was adopted, resembling that worn by the household cavalry today. The household cavalry, about 1820, wore the same shaped helmet as the heavy cavalry but silver-plated with brass ornaments, and about the same time were again given their cuirasses. A little later, as well as helmets, they were given tall bearskin caps like those of the foot guards, reserved for ceremonial occasions. The dress of the light dragoons was still the short jacket. but the shako was more "bell-topped" with plaited cap lines and flounders, the officers wearing drooping plumes of feathers. the men's being horsehair. The hussars wore similar shakos in place of the busby.

William IV dressed the whole army in red except the royal artillery and rifle regiments. The hussars kept their blue dolmans, but wore scarlet pelisses, and the overalls for all cavalry had now been changed to dark blue. In 1840, the light dragoons, hussars and lancers were again dressed in blue, only the 16th lancers retaining their scarlet jackets. Some hussars retained their shakos and other regiments returned to the fur busby. During the Crimean War the overalls were again strapped with leather, which developed into the booted overall.

From the Crimean War (1853–56) **to** 1914.—During the Crimean War the coatee was found to give no protection to the loins and abdomen against cold and wet, so a Icing-skirted double-breasted tunic copied from the French was issued. A year or two later a single-breasted tunic and a more conical and lighter shako were issued.

Under the Card\\-ell system (see GREAT BRITAIN: Defense). to facilitate changing the facings of a man transferred from one linked battalion to another. the tunic was made red throughout, with only a patch of facing cloth sewn over the collar and cuffs. In 1870 the crown was worn on the men's collars and the regimental badge was placed on the shoulder strap. The crown, however, soon gave place to the regimental badge. In 1874 trousers of dark blue cloth instead of Oxford mixture were issued.

After the Crimean War the tunic was given to all cavalry regiments. the dragoons guards keeping their helmets of brass while dragoons were given helmets of white metal. Regiments began to have plumes of various colours. Light dragoons wore an upright shako. but changed to the French type with drooping plume. The royal artillery changed from the busby to the helmet in 1878, the horse artillery, however, still kept theirs. The royal engineers wore the busby up to 1870, when its shape was changed to one similar to that worn by rifle regiments, and in 1878 the helmet was adopted. After World War I there were changes in full dress. The royal artillery, royal engineers and royal corps of signals were again given the busby, the engineers having a blue bag and white plume, the corps of signals a red plume. The royal tank regiment was given a blue uniform with black facings.

Undress and Service Dress.—The forage cap of the mid-18th century consisted of a soft loose bag surrounded by a band of cloth, made irom pieces of the old discarded coat. During the 19th century a soft round cap made its appearance, which the foot guards in due course stiffened into the "pillbox," the cavalry, artillery and other corps following the same style. The infantry, on the other hand, wore the "pork pie"-shaped Kilmarnock with "touris" of different colours according to whether they were flank or battalion companies. This was replaced by the Glengarry, and in turn by the folding service cap. also worn by the cavalry and different corps in various colours according to regiment. At the end of the South African War the soft round cap of the 19th century reappeared and was known as the Broderick cap; sidepieces were added which could be let down as ear coverings. This was a replica of the "Marie Louise," worn by Napoleon's 1813 conscripts. Later this was stripped of its sidepieces, given a glazed leather peak and stiffened into the modern form. For field work a serge coat called a frock was worn with short leather gaiters over the blue trousers. Officers for many years had worn blue frock coats which were eventually authorized.

Khaki (dust colour) or a drab service dress was worn in the Indian mutiny and later became the universal service dress. worn with trousers or breeches and a topee or sun helmet. Sun helmets came into use in India; some of the first had a hollow comb or crest. the front of which was open. During the South African War the colonial slouch hat was worn by regular regiments. The cavalry in India began to wear chain mail on their shoulders, said to have originated from an officer's sewing curb chains onto his shoulder straps as a protection against sword cuts in the Afghan War. The modern battle dress of blouse, trousers and the resuscitated short gaiters. replacing the breeches and puttees which had been worn for a number of years. was evolved from various experiments before 1939. The steel shrapnel helmet was introduced during World War I. but the French had already given their artillery a steel helmet in 1902. After World War II, full dress. except for the household brigade and the king's troop. royal horse artillery, was declared obsolete. The only form of dress remaining to the army. therefore. was battle dress. The severity of this uniform was mitigated somewhat by the introduction, for other ranks. first of khaki collars and ties and second, and for more formal occasions. of a blue beret. At the same time the peaked forage cap was reintroduced for officers. while the wearing of swords and the prewar pattern service dress for ceremonial parades was made permissive.

It was intended. however. to equip the army with a blue uniform. described officially as no. 1 dress. This was modelled, largely, on the prewar officers' undress, or patrol jacket. with a stand-up collar, and was to be worn with a red sash. Regiments and corps would be distinguished by coloured piping on the shoulder straps and also by the colouring of the trouser stripes. This was to be worn with a blue forage cap, regiments and corps, in many instances, being distinguished by a difference in the colour of the hatband. The uniform was to be green for rifle regiments. while the style of the jacket was modified for Scottish regiments. The introduction of no. 1 dress was to be spread ovdr a number of years. but an early issue was made to bands. It was also provided for all detachments taking part in the coronation parade of 1953, but thereafter mas issued on a rank basis.

Officers wore the Sam Browne belt with no. 1 dress, but for ceremonial occasions they mere to wear a uniform known as no. 1 (ceremonial) dress. This consisted of the substitution of gold shoulder cords in place of the cloth shoulder straps on the no. 1 jacket and of a red sash instead of the Sam Browne belt. The sword would be carried in a plated scabbard suspended by gold sword slings, the hilt of the sword being decorated with a gold sword knot. For general officers. the general officers' pattern sword was restored, together with the gold and scarlet waist sash.

Women's Army Services.—Excepting the nurses of the military hospitals, the first British women's service unit appears to have been the First Aid Nursing yeomanry (F.A.N.Y.) formed at the end of the South African War. As this was a mounted unit, the dress was a scarlet tunic with white braid. blue riding habit with scarlet band and blue peaked cap. The uniform is now a khaki jacket and skirt.

The Women's Army Auxiliary corps (W.A.A.C.), formed in 1915, wore a khaki dress, coat and soft felt hat. When the title was changed to Auxiliary Territorial service (X.T.S.), a khaki uniform of tunic. skirt and peaked cap was worn. a flat service cap of brown and orange piped with green was also allowed. After World War II the service became the Women's Royal Army corps, and the uniform was changed to dark green with a green beret for the privates, but a peaked cap was worn by officers.

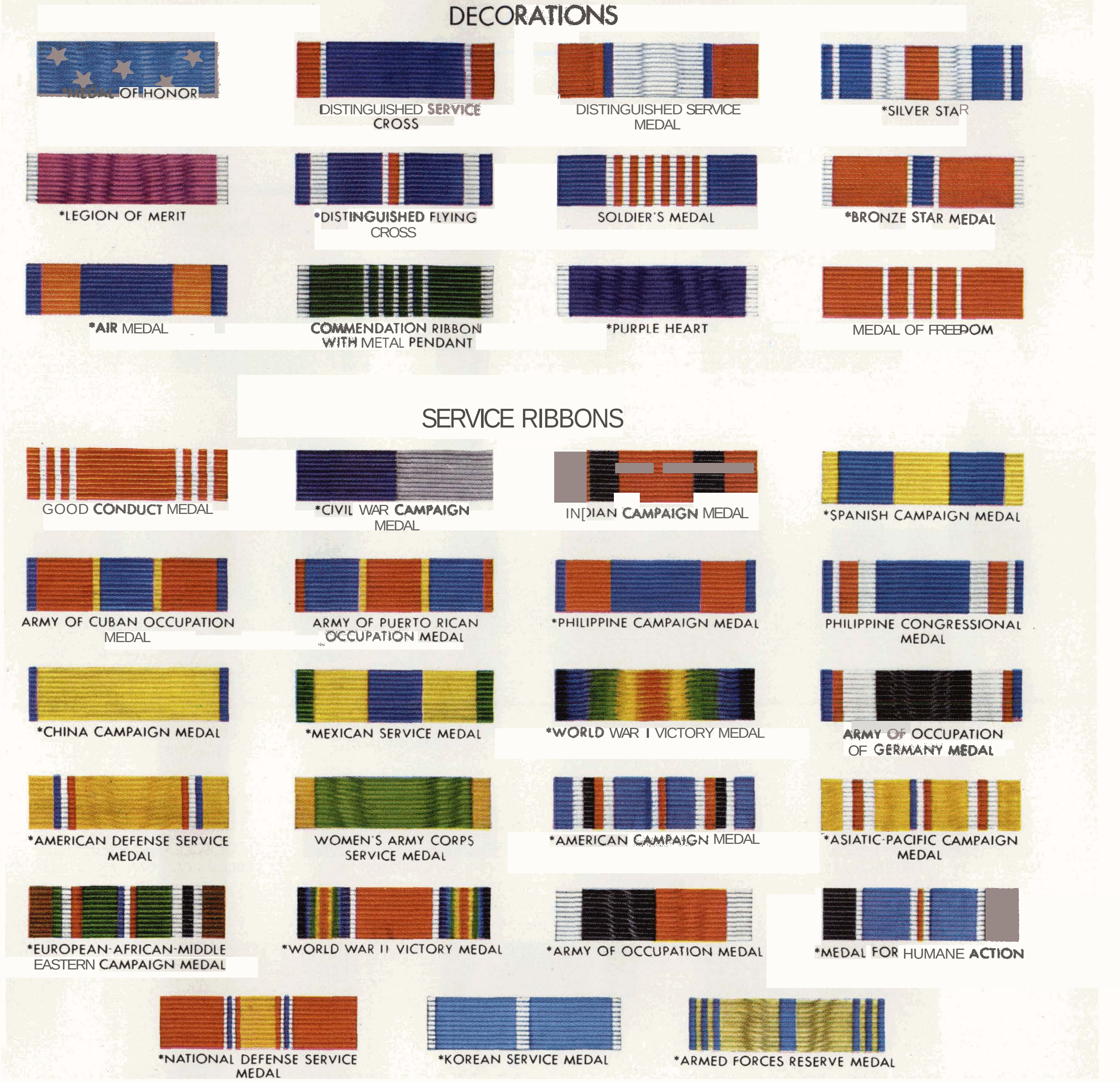
BRITISH NAVAL UNIFORMS

Although no regular dress was laid down for seamen, a naval costume had evolved irom the requirements of a seafaring life. From very early days clothing or livery had been provided for officers and men. Chaucer's seaman, in the 1480 edition of his *Canterbury Tales,* is shown wearing a sea gown of russet colour girt with a belt from which hang a knife and a leather wallet, and a loose red cap apparently edged with fur. The Cinque Ports in 1513 wore white coats with a red cross and "the arms of the Portis underneath, that is to say a halfe lyon and the halfe shippe." Elizabethan seamen are occasionally depicted. One book shows a master. 1590, wearing a loose cassock and full Venetian breeches, stocking and shoes and a fur or thrummed cap. Blue seems to have been often the colour of the jackets. The six principal masters of the king's ships in 1604 had the grant renewed for red livery coats guarded with velvet and embroidered with the crown, roses and ships.

The slop lists of 1663 mention red caps, Monmouth caps, stockings blue and white, shirts, cotton waistcoats and drawers, canvas suits and blue neckcloths. In 1690 wide canvas breeches striped crosswise with red are described; under these, canvas breeches fastened at the knees were worn. In 1706 orders were issued regarding the slop clothing to be supplied, which mention "grey Kersey jackets lined with red cotton with brass buttons, the button holes stitched with gold colour thread. red waistcoats, red breeches. shirts of blue and white checkered linen, leather caps faced with red cotton and shoes with brass buckles."

The officers of the "Kent" in 1748 all wore silver-laced gray coats faced with red. In 1748 a uniform was established for officers. It was to be blue faced with white, but as no details were issued. officers found great difficulty in closely conforming to it. The portraits of Lord Anson and Admiral Byng show them in blue gold-laced coats, with wide white cuffs but no lapels, while Admiral Boscawen's portrait shows a very similar uniform but with wide white lapels with gold-laced loops. The waistcoats in all three cases are white with wide gold lace, the breeches blue. With this the gold-laced cocked hat was worn.

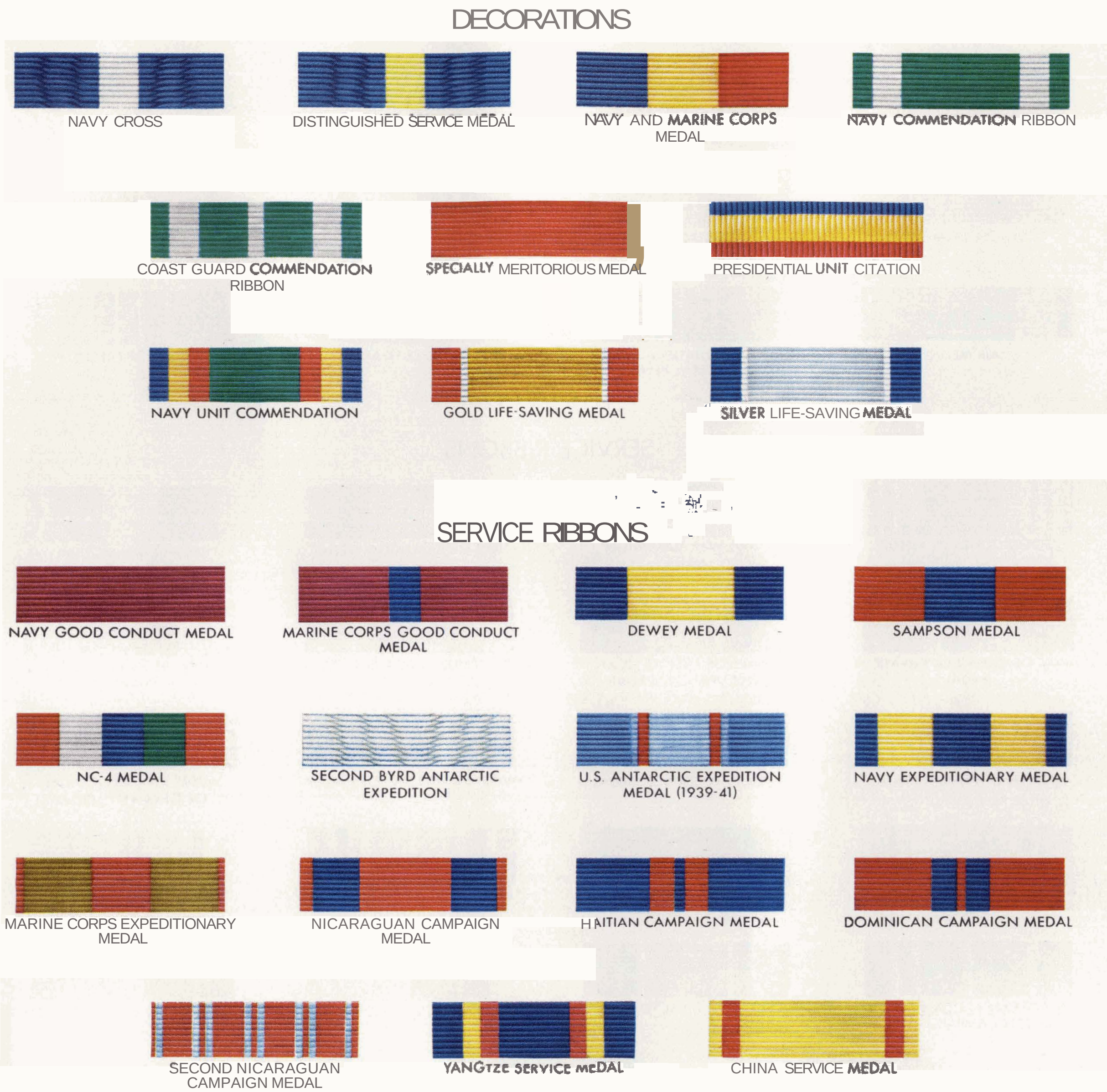
In 1767 and 1774 more definite instructions were issued. The coats were to have narrow white lapels to the waist, white cuffs, white waistcoats and breeches. the master and commander having blue lapels, the midshipman none. Rank was also denoted by the buttons being placed at regular intervals or by twos or threes. In 1783 rank was indicated by the rows of lace on the white cuffs of the full-dress coat and on the blue lapels of the frock by the



DRAWN FOR ENCYCLOPÆDIA BRITANNICA, INC., BY GEORGE ARMSTRONG

U.S. ARMY DECORATION AND SERVICE RIBBONS

*Decorations and ribbons common to all branches of the armed forces DECORATIONS IN ORDER OF PRECEDENCE.—(First row) Medal of Honor: For conspicuous gallantry and intrepidity in combat. Distinguished Service Cross: For extraordinary heroism in combat. Distinguished Service Medal: For exceptionally meritorious service in a duty of great responsibility. Silver Star: For gallantry in action not warranting the award of either the medal of honor or the distinguished service cross. (Second row) Legion of Merit: For exceptionally meritorious conduct in performance of outstanding services. Distinguished Flying Cross: For heroism or extraordinary achievement while participating in aerial flight. Soldier's Medal: For noncombat heroism. Bronze Star Medal: For heroic or meritorious service, not involving participation in aerial flight, against an armed enemy. (Third raw) Air Medal: For meritorious achievement while participating in aerial flight. Commendation Ribbon With Metal Pendant: For meritorious achievement or meritorious service. Purple Heart: for wounds received in action. Medal of Freedom: For a meritorious a d or service in combat, when the award of any other decoration is deemed inappropriate. SERVICE RIBBONS.—(Fourth row) Good Conduct Medal: For exemplary behaviour, efficiency and fidelity in an enlisted status. Civil War Campaign Medal, 1861–66. Indian Campaign Medal, 1865–91. Spanish Campaign Medal: Cuba, Puerto Rico, Philippines, 1898. (Fifth row) Army of Cuban Occupation Medal, 1898–1902. Army of Puerto Rican Occupation Medal, 1898. Philippine Campaign Medal, 1899–1913. Philippine Congressional Medal: For serving beyond date of normal discharge from Spanish-American War service. (Sixth row) China Campaign Medal, 1900–01. Mexican Service Medal, 1914–19. World War I Victory Medal, 1917–20. Army of Occupation of Germany Medal: Germany or Austria-Hungary, 1918–23. (Seventh row) American Defense Service Medal, 1939–41. Women's Army Corps Service Medal, 1942–45. American Campaign Medal, 1941–46. Asiatic-Pacific Campaign Medal, 1941–46. (Eighth row) European-African-Middle Eastern Campaign Medal, 1941–45. World War II Victory Medal, 1941–46. Army of Occupation Medal: Germany, Austria, Italy, Japan, Korea, 1945–52. Medal for Humane Action: Berlin air lift, 1948–49. (Ninth row) National Defense Service Medal, 1950–. Korean Service Medal, 1950–. Armed Forces Reserve Medal: For ten years' honourable service in a reserve component



DRAWN FOR ENCYCLOPEDIA BRITANNICA, INC., BY GEORGE ARMSTRONG

U.S. NAVY, MARINE CORPS AND COAST GUARD DECORATION AND SERVICE RIBBONS

(First row) Navy Cross: For extraordinary heroism in combat. Distinguished Service Medal: For exceptionally meritorious service in a duty of great responsibility. Navy and Marine Corps Medal: For noncombat heroism. Navy commendation Ribbon: For heroism or service performed. (Second row) Coast Guard Commendation Ribbon: For meritorious service resulting in unusual and outstanding achievement. Specially Meritorious Medal: For especially meritorious noncombat service during war with Spain, 1898. Presidential Unit Citation: For outstanding performance in action of nary and marine corps units. (Third row) Navy Unit Commendation: For outstanding heroism in action but not sufficient to justify a presidential unit citation, or for extremely meritorious noncombat service. Gold Life-Saving Medal: For heroic daring in saving or endeavouring to save lives at sea. Silver Life-Saving Medal: For acts of heroism not sufficiently distinguished to deserve the gold life-saving medal. SERVICE RIBBONS.—(Fourth row) Navy Good Conduct Medal: For above average conduct and performance, Marine Corps Good Conduct Medal: For above average conduct and performance. Dewey Medal: For participation in the battle of Manila bay, 1898. Sampson Medal: For participation in engagements in the waters of the West Indies and on the shores of Cuba during the war with Spain, 1898. (Fifth row) NC-4 Medal: For extraordinary achievement in making the first transatlantic flight, 1919. Second Byrd Antarctic Expedition, 1933–35. U.S. Antarctic Expedition Medal (1939–41): For valuable services in polar exploration and science. Navy Expeditionary Medal: For members of landing parties in combat on foreign territory. (Sixth row) Marine Corps Expeditionary Medal: For members of landing parties in combat on foreign territory. Nicaraguan Campaign Medal, 1912. Haitian Campaign Medal, 1915. Dominican Campaign Medal, 1916. (Seventh row) Second Nicaraguan Campaign Medal, 1926–33. Yangtze Service Medal, 1926–27 and 1930–32. China Service Medal, 1937–39 and 1945–

UNIFORMS

BRITISH DECORATIONS

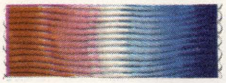
(First row) Victoria Cross: For some signal act of valour or devotion to their country in the presence of the enemy. George Cross: For acts of greatest heroism or the most conspicuous courage in circumstances of extreme danger. Order of the Bath. (Second row) Order of Merit: For very distinguished and conspicuous services in peace or war. Order of the Star of India: For important and loyal services to the Indian empire. Order of St. Michael and St. George: For services abroad or in the colonies. (Third row) Order of the Indian Empire: For services in India. Order of the Crown of India. Royal Victorian Order: For extraordinary, important or personal services to the sovereign or the royal family. Order of the British Empire (military): For services not warranting other orders or decorations awarded for services in the field or before the enemy. (Fourth row) Order of the British Empire (civil): For services to the empire at home, in India and in the dominions and colonies. Order of the Companions of Honour: For conspicuous service of national importance. Distinguished Service Order*: For distinguished services under fire or under conditions equivalent to actual combat. Royal Red Cross: For women rendering special devotion and competency in nursing duties with the armed services. (Fifth row) Distinguished Service Cross*: For meritorious or distinguished services in action (navy). Military Cross*: For gallant and distinguished services in action (army). Distinguished Flying Cross*: For an act of valour, courage or devotion to duty during aerial combat. Air Force Cross*: For an act of valour, courage or devotion while flying, or for distinguished services to aviation. (Sixth row) Distinguished Conduct Medal†: For gallantry in action (army). Conspicuous Gallantry Medal†: For conspicuous gallantry in action. Distinguished Service Medal†: For setting an example of bravery and resources under fire (navy and marines). Military Medal†: For individual or associated acts of bravery (army). (Seventh row) Distinguished Flying Medal†: For an act of valour, courage or devotion during aerial combat. Air Force Medal†: For an act of valour, courage or devotion while flying, or for distinguished services to aviation. George Medal: For gallantry not warranting award of the George Cross. Edward Medal: For persons in industrial employment who endanger their own lives in saving, or trying to save, the lives of others during such employment

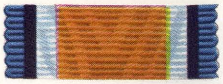
*Officers only.

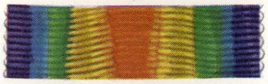
†Only noncommissioned officers and men.

UNIFORMS

BRITISH MEDALS AND OVERSEAS DECORATIONS


1914–15 STAR

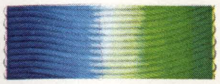

BRITISH WAR MEDAL, 1914–18


VICTORY MEDAL


GENERAL SERVICE MEDAL


INDIA GENERAL SERVICE, 1936


1939–45 STAR

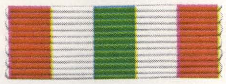

ATLANTIC STAR

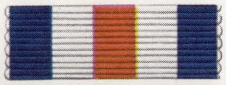

AIR CREW EUROPE STAR

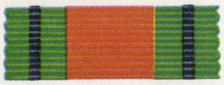

AFRICA STAR


PACIFIC STAR


BURMA STAR


ITALY STAR


FRANCE AND GERMANY STAR


DEFENCE MEDAL


1939–45 WAR MEDAL


KOREA MEDAL

EUROPEAN DECORATIONS


LEGION OF HONOUR


MÉDAILLE MILITAIRE


CROIX DE GUERRE


CROIX DE GUERRE (WORLD WAR II)


IRON CROSS


IRON CROSS (WORLD WAR II)


WAR CROSS


MILITARY CROSS


MILITARY MEDAL


CROIX DE GUERRE


CROIX DE GUERRE, 1940


ORDER OF LENIN


ORDER OF THE RED BANNER


ORDER OF SUVOROV


ORDER OF KUTUZOV

(First row) *1914–15 Star* (navy); *British War Medal, 1914–18; Victory Medal,* 1914–18; *General Service Medal* (army and air force). (Second row) *India General Service Medal:* For service on the northwest frontier 1936–39; *1939–45 Star; Atlantic Star,* 1939–45; *Air Crew Europe Star,* 1939–44; *Africa Star,* 1940–43. (Third row) *Pacific Star,* 1941–45; *Burma Star,* 1941–46; *Italy Star,* 1943–45; *France and Germany Star,* 1944–45. (Fourth row) *Defence Medal,* 1939–45; *1939–45 War Medal; Korea Medal.* (Fifth row) FRANCE.—*Legion of Honour:* For distinguished military and civil services; *Médaille Militaire:* For distinguished service in action or long and meritorious service in peace (army and navy); *Croix de Guerre:* For mention in dispatches; *Croix de Guerre**. (Sixth row) GERMANY.—*Iron Cross:* For bravery in battle; *Iron Cross**; GREECE.—*War Cross**. (Seventh row) BELGIUM.—*Military Cross:* For military service; *Military Medal:* For conduct and service of special distinction; *Croix de Guerre:* For mention in dispatches or for acts of courage, devotion and valour in combat; *Croix de Guerre**. (Eighth row) U.S.S.R.—*Order of Lenin:* For special services rendered to the socialist regime by individuals, collective bodies, institutions, undertakings and social organizations of the Soviet Union; *Order of the Red Banner:* For conspicuous bravery or self-sacrifice in time of war, special capacity for leadership or some action contributing decisively to the success of soviet arms (military or civil); *Order of Suvorov:* For distinguished leadership in combat; *Order of Kutuzov:* For distinguished leadership in combat

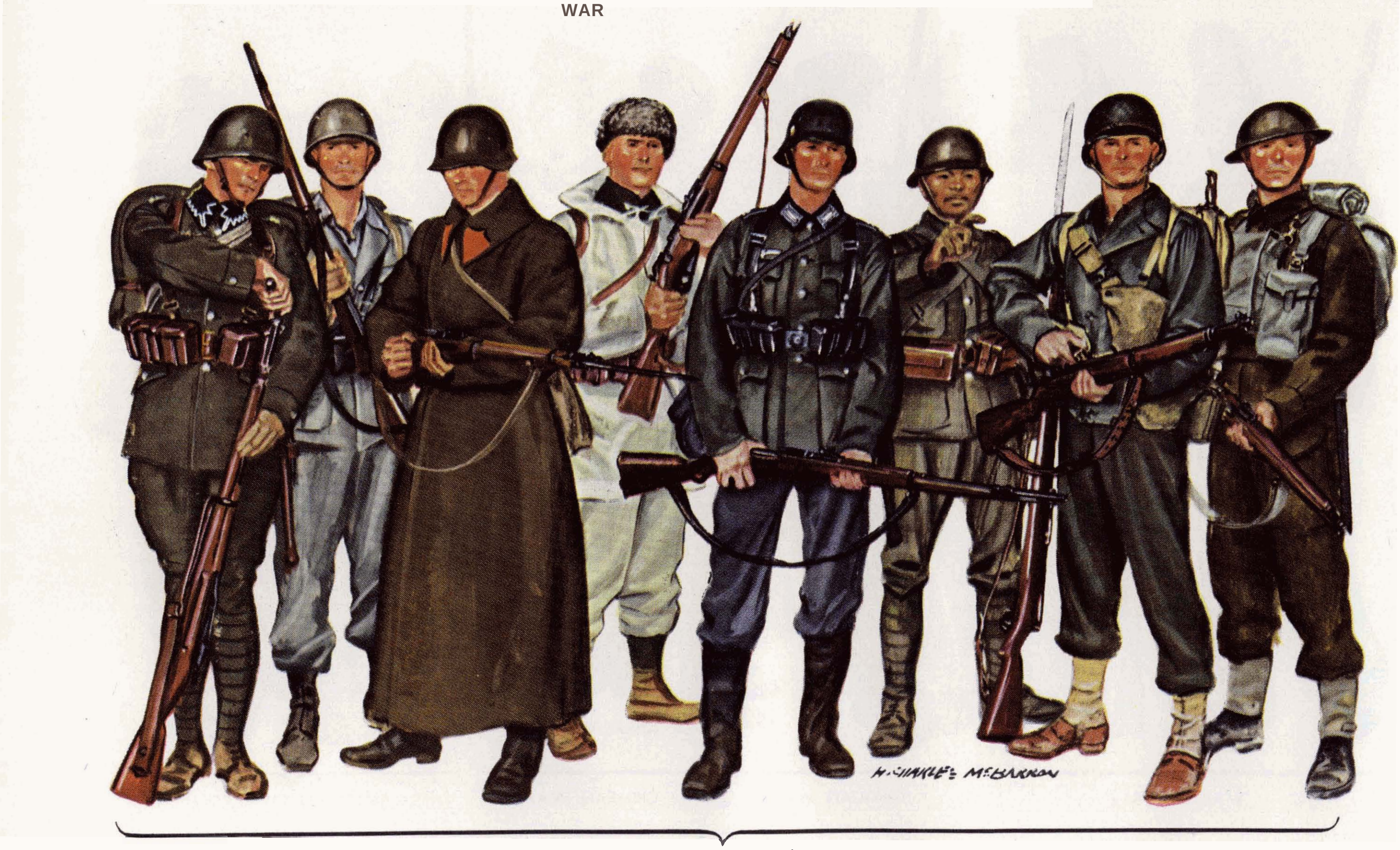
*World War II.

UNIFORMS OF THE 18TH AND 19TH CENTURIES

American Revolution: Grenadier regiment von Rall Hessian; British 17th regiment of foot; French Gatinois regiment; U.S. Patrick Henry rifleman. French Revolution: Revolutionary infantry. Napoleonic Wars: French 7th regiment hussar (1807); Prussian grenadier (1806); Russian Cossack type. War of 1812: U.S. infantry (1813–15); British 44th (East Essex) regiment. Mexican War: Mexican lancer, Activa cavalry regiments; U.S. infantry. Crimwn War: Russian infantry; British lancer, 17th regiment. American Civil War: Northern infantry; Southern infantry

UNIFORMS

FRANCO-PRUSSIAN WAR | SPANISH-AMERICAN WAR | WORLD WAR I



WORLD WAR II

UNIFORMS OF THE 19TH AND 20TH CENTURIES

Franco-Prussian War: French infantry; Prussian infantry. Spanish-American War: Spanish regular infantry; U.S. infantry. World War I (Infantry): German, 1916–18; U.S., 1917–18; French, 1916–18; British, 1916–18; Italian, 1916–18. World War *II* (Infantry): Polish, Italian, Russian, Finnish, German, Japanese, U.S., British arrangement of the buttons. In 1787 a uniform was authorized for warrant officers, which included masters, physicians, gunners, boatswains and carpenters. consisting of a blue coat with blue turned-down collar and cuffs.

Epaulettes were authorized in 1795. The ranks of admirals were indicated by one or more silver stars on their epaulettes. Hessian boots with white or blue breeches began to be worn about 1800.

About the middle of the 18th century the gray coats and red breeches of seamen began to give place to blue jackets, red or buff waistcoats, white breeches and canvas petit-coat trousers. The headdress was a tarpaulin hat with the brim tacked up or left flat or a felt hat with a bunch of blue ribbons. A blue Kilmarnock cap with a red touri was also worn. The modern cap was eventually evolved from this, the French seamen still wearing it with its original red touri. now a pompon.

From 1800 onward a tarred or painted canvas or leather cap edged with fur is shown in contemporary prints and paintings; this may have been a cap with fur-lined ear flaps. A hat of the "topper" shape, sometimes of straw, with a ribbon band is aiso depicted. In 1834 it is shown glazed, with a more conical crown, and the ship's name painted in it; after this a lower crowned black hat with a wider brim appears.

The men's jackets had become shorter and were often strengthened with strips of canvas sewn along the seams. The cuffs from the early days are shown slashed and with three or four black buttons. There was at first no collar. but coloured or black handkerchiefs were worn round the neck. About 1823 the jacket is shown with a turn-down collar, the blue and white striped coliar of the shirt being worn over it. The waistcoat is blue and the trousers plain white or blue.

New regulations were issued in 1825–27. The coats of officers were to have wide white lapels and cuffs. all laced with gold. High-ranking officers were to have their badges of rank on their epaulettes; masters, physicians, secretaries, pursers, etc.. blue coats: lapels and collars. with blue twist buttonholes. Each branch was indicated by distinctive badges on the collar, *e.g.*, masters: three anchors: physicians. anchor and serpent; secretaries, crown and anchor. The frock dress was all plain blue with turn-down collar. Cocked hats were worn fore and aft. but black glazed round hats and short jackets could be worn at sea. Undress caps were flat round caps with a wide top and black peak.

Seamen's dress had become standardized, the striped shirt collar being blue with two or more white stripes. The senet hat, sometimes painted black. was worn, or the Scotch cap, which developed into the soft edition of the modern cap. In 1857 this dress was officiallyauthorized, the blue collar was ordered to have two white tapes. but the men preferred three as more decorative, and so were allowed to retain them. In 1863 the curl was added to the top row of the lace on the cuffs of the executive officers. and later granted to all officers. Coloured stripes were added to the cuffs indicating the different branches of the service. the buttons on the single-breasted coatee being placed in twos with a white stripe for paymasters. threes and scarlet stripe for surgeons and fours and purple stripe for engineers. The men's blue jackets. the straw senet hats and the cocked hats and tail coats of the officers were later abolished.

By 1955 naval officers! standard day uniform for all occasions was the double-breasted reefer jacket and trousers, with peaked cap. Commissioned officers wore horizontal bands of gold distinction lace on the sleeve—one row and curl for a sublieutenant. four rows and curl for a captain, one broad row and four ordinary rows with curl for an admiral of the fleet. Full dress was in abeyance. For ceremonial dress officers wore medals and orders instead of medal ribbons. Ratings wore blue serge or cloth suits for full dress and blue serge blouse and trousers as normal working dress.

Women's Royal Naval Service.—The Women's Royal Naval service (W.R.N.S.), formed in 1917, wore blue jackets and skirts with a soft blue felt hat, changed during World War II to the seamen's cap. the officers wearing hats with the brims curled up to form a tricorne hat.

Royal Marines.—The maritime regiment of 1664 wore coats of a yellow colour with red facings. breeches and stockings. The regiment of 1684–89 had red coats faced yellow, gray breeches and white stockings. The next description is of red coats and grenadier caps. In 1742 the ten regiments of marines had various coloured facings according to the regiment. The fronts of the caps were different in shape from those of the grenadiers. At about 1750, the cap was the usual grenadier type with a white front on which was embroidered an anchor. The half lapels were edged and looped with a white lace with blue and red stripes. The dress resembled that of the infantry until 1802 when the glazed round hat replaced the cocked hats and Bank company caps, and the nhite facings changed to blue nhen the marines became a royal corps. In 1804 an artillery branch was added and wore the same dress as the rest of the corps, a short blue fatigue jacket with red facings was however. allowed. From 1820 the blue uniform was given, which was almost the same as that worn by the royal artillery. In 1923 the artillery were amalgamated, the whole corps nearing the scarlet tunic.

After World War II marines wore blue serge or khaki, but for working battle dress was worn and for mess dress, scarlet mess jackets. Full ceremonial dress consisted of blue tunics with medals or orders.

ROYAL AIR FORCE

The royal flying corps when formed in 1913 wore khaki tunics, which fastened down the right side of the chest, the breeches. puttees. dnd flat folding service cap being also khaki. The royal air force wore blue-gray tunics. breeches and puttees (later trousers) with a peaked cap, the officers for full dress wearing a leather cap with turned-up fur flaps. a gold and blue-gray plaited cap cord and a blue-gray plume. the whole based on the cap worn when flying.

After World War II, full dress was in abeyance; for ceremonial occasions a gold belt and snord were worn with service dress.

The dress of the Women's Royal Air force (W.R.A.F.) is a blue-gray tunic and skirt, blue-gray collar, black tie and peaked cap.

BIBLIOGRAPHY.—C. C. P. Lawson, *A History of the Uniforms of the British Army, Front the Beginnings to 1760*, 2 vol (London, Toronto, 1940–42); C. N. Robinson, *The British Fleet* (London, 1894); Society of Army Historical Research, *Journal* (London, 1921–).

(C. C. P. L.)

UNITED STATES

All the U.S. services, army, navy (including marine corps) and air force, have service uniforms for summer and winter and dress uniforms. Also special clothing and uniforms are authorized for individuals whose duties so require (*e.g.*, cooks and bakers; members of the army medical service. armed services police, personnel stationed in areas of extreme climatic conditions, etc.). Special clothing is also authorized for wear while engaging in sports.

Army.—Service *Uniforms*.—The army service uniform is of two types—an olive drab wool uniform for winter and a cotton or other fabric in khaki colour for summer. The coat is single-breasted, lapel design. with four buttons and four pockets (two patch breast pockets and two inserted lower ones). all covered with flaps. The winter coat has a matching cloth belt with a gold colour buckle. The winter trousers are of a lighter shade than the coat while the summer trousers are of the same colour as the summer coat. A service cap with leather visor or a garrison cap with cord edge braid is authorized for both uniforms. An overcoat is authorized for winter wear. Russet colour low quarter shoes are authorized for normal wear. Combat boots of the same colour are worn under combat or simulated combat conditions. The shirt is khaki and the necktie is olive drab.

Blue Dress *Uniform*.—The blue dress uniform is for winter wear. The coat is single breasted. with two upper and two lower inverted pockets. covered with flaps. The coat has shoulder straps on which insignia of grade and branch colour appear. The coat and cap are of matching dark'blue material. The cap visor for officers above the grade of captain is embroidered in gold with groups of gold leaves. The trousers are sky blue, except those for general officers. whose trousers match the coat. The shirt is white;

necktie is black four-in-hand type.

White Dress Uniform.—The white dress uniform is for summer wear. It is of cotton twill or duck. The design is in general the same as that of the blue dress uniform. Shoes, shirts and socks are white; the tie is black.

Mess Uniforms.—The blue mess uniform (for winter) consists of the mess jacket, trousers and cap of dark blue wool Gold colour shoulder knots are on the jacket. The vest is of white pique; tie is black, bow. with square ends. Shoes and socks are black. The white mess uniform (for summer) is of the same design as the blue mess.

Evening Dress.—Coat and trousers are of blue-black or black commercial type, tailed coat with army buttons. ornamentation and insignia. The wing collar is white; civilian commercial-type socks and shoes are black. Gloves are white. The cap matches the coat and trousers. The vest is single breasted, low cut, of white pique or other conventional-type commercial evening dress vest material.

Combat; Work Details.—For combat and for working parties where the service uniform would be inappropriate, a "fatigue" or "utility" uniform consisting of olive drab cotton jacket and trousers is issued.

Uniforms for Women.—The women of the army have service, semidress and dress uniforms. The service and semidress uniforms are taupe in colour; the dress uniform is white. The uniform consists of a cotton dress (for summer service), coat, skirt. hat (or cap). shirtwaist, shoes and handbag. The evening dress consists of dark blue skirt. jacket. white blouse and tiara.

Navy.—The U.S. naval officer's uniform in general corresponds to that worn by the officers of the various navies of the world. They are made readily distinguishable by the ornamentation, trimmings and insignia.

The dark blue uniform consists of a double-breasted wool sack coat, trousers without cuffs, white shirt, white cap cover, black belt, black tie and black shoes.

The white and khaki uniforms, worn in summer, are made of tropical worsted or cotton material. Khaki belt, shirt and cap cover and brown shoes and socks are worn with the khaki uniform. White shirt, cap cover, shoes and socks are worn with the white uniform.

The uniforms worn by enlisted men of the U.S. navy consist, in general, of the seaman's overshirt or jumper, with trousers that flare slightly at the bottom and a cap. Blue wool and white cotton uniforms are authorized.

The evening dress uniforms are similar to civilian dress with the exception of the ornamentation, buttons and insignia. The women have summer and winter service, semidress and dress uniforms. The uniforms are blue or white and consist of cotton dress (for summer), skirt, blouse, hat (or cap), handbag and shoes. The marine corps service uniforms are green (for winter) and khaki (for summer). The dress uniforms are blue; the coat, with a stand-up collar, is of a darker shade than the trousers. The women's uniforms are of green or white. The uniforms of the military sea transportation service are, in general, of standard navy pattern. However, the insignia, buttons, etc., are distinctive to this service.

Air Force.—The air force winter uniform is of blue and the summer one is tan. The uniform consists of a single-breasted coat, trousers and service cap with a leather visor. The flight cap (oversea type) and a single-breasted jacket are authorized for optional wear. Shoes are black; neckties and belts are dark blue. The overcoat is blue. The raincoat is single-breasted box-style model of dark blue nylon-rayon. Shirts are blue for winter and tan for summer. Evening dress uniforms are similar to civilian dress except for ornamentation, buttons and insignia.

The women have summer and winter service, semidress and dress uniforms. The uniforms are tan, light blue or white. The uniforms consist of cotton dress (for summer), skirt, blouse, hat (or cap), handbag and shoes. The service cap is designed so that removable and interchangeable crown covers may be worn (gray for winter service; cotton cord, blue, white and white stripe with summer uniform and white with white dress uniform). A blue wool flight cap is authorized for optional wear. (A. E. Du.)

UNION CITY, a city of Hudson county, N.J., C.S.. lies on the Hudson river adjacent to Hoboken and Jersey City just opposite Manhattan Island, with direct access to New York city via the Lincoln (auto) tunnel. The site, on the Palisades of the lower Hudson, was originally settled by the Dutch in 1640 as part of an ideal community to be known as Pavonia in honour of Michael Pauw, the leading colonizer of the area. It subsequently became known as West Hoboken (incorporated in 1884) and Union Hill (incorporated in 1808), which merged to form Union City in 1925.

It is an industrial manufacturing centre producing such products as automotive parts, electrical appliances and equipment, embroideries, novelties, paperboard, pharmaceuticals, rubber products, jewelry, textiles, and tobacco products. Despite its relatively small area (1.3 sq.mi.), it is also a residential community. The population in 1960 was 52,180; for comparative population figures see table in NEW JERSEY: Population. (D. N. A.; M. P. M.)

UNIONIST PARTY: see CONSERVATIVE PARTY (BRITISH).

UNION LEAGUE OF AMERICA, THE, was organized by a group of Ohio Republicans in 1862 when the Union armies were meeting defeat after defeat and the Democratic party was winning an uncomfortable number of local elections. Its purpose was to inspire "uncompromising and unconditional loyalty to the Union." It was to combat the Copperheads (*q.v.*) and other subversive groups and infuse new vitality into the slipping Republican party. The movement caught hold and spread rapidly to other states. It reached its most effective form in Philadelphia and New York city where it became a social as well as a political organization. Within a year it had spread to cities as widely separated as Boston and Chicago, and something of a loose federation had been developed between the different leagues. As time went on, the social idea became more and more important, but the membership continued to be primarily Republican.

As the Union armies moved southward in the last years of the war, the league followed them with teachers and organizers. Its efforts were concentrated primarily on the Negro. Military companies were organized and their expenses paid; supplies were sent to the field, and political literature was distributed. Even a few dissatisfied southern whites were attracted to the organization.

Its chief importance, however, came at the close of the war when talk of giving the Negro the vote and of disenfranchising the southern whites began to be heard. Officers of the Freedmen's bureau and northern adventurers in the south quickly saw the league as an agent both for spreading propaganda in favour of Negro enfranchisement and for controlling that vote if secured. State councils were created and a Grand National council set up in New York. A lobby was organized in Washington to support the radical reconstruction program and to oppose the more liberal efforts of Pres. Andrew Johnson. Tales of southern mistreatment of the Negro were widely circulated, and the impression was created that the Negro's future welfare depended entirely on his right to vote. Activities in the south were stepped up and membership rapidly increased in every state. The great object became one of creating a powerful Republican party in the south.

In its first days league membership in the south had been made up largely of white men—northern officials, carpetbaggers and southerners who had opposed secession or had fallen out with the Confederate government. Gradually, as the Negro gained the vote, southern whites withdrew and membership consisted almost entirely of Negroes under the direction of a few white politicians. By appeal to racial pride, past injustices and the chance for group activities, the league provided the kind of organization needed to bind the Negro to the Republican party and to hold him in line. Its nocturnal meetings were secret, with armed guards to drive away intruders. It initiated members with elaborate ceremonies in which an altar, the Bible, the flag, the Declaration of Independence and the constitution all came into play. To give a more practical turn, the sword, the ballot box, the shuttle, the anvil and other implements were introduced. Then, while members sang patriotic songs, the new members pledged their lives and fortunes to the preservation of liberty and union, the protection of each other, the maintenance of the constitution, the observance of the duties of citizenship and the support of those who did likewise. Then the password and the signs by which members could recognize each other were revealed.

The league proved an effective political agent and played an important part in southern affairs from 1866 to 1869. After that it declined rapidly as Negroes and white leaders quarreled over the spoils of office and discipline became too harsh It had, however, done its part in bringing the Ku Klux Klan (*q.v*) into being, put a heavy strain on race relations and brought the harsh reactions against Negro voting in the years after 1890 (AY. CN.)

UNION OF SOVIET SOCIALIST REPUBLICS, THE: *see* RUSSIA.

UNIONTOWN, the seat of Fayette county in southwestern Pennsylvania, U S , lies 70 mi. S E. of Pittsburgh. The county is noted for agriculture and is rich in coal deposits; coal mining. though greatly reduced, is the chief industry. Uniontown factories produce textiles. building and fire brick. glass, chemicals and explosives, gas and water meters, machinery and steel scaffolding. Limestone and sandstone deposits are located nearby and silica sand used in glass manufacturing is of local origin.

'The vicinity of Uniontown is rich in historical interest, especially the period of the French and Indian War. Jumonville, Ft. Necessity and Gen. Edward Braddock's grave are located only a few miles from the city. Uniontown was founded by Henry Beeson in 1769, incorporated into a borough in 1796 and became a city in 1916. For comparative population figures see table in PENNSYLVANIA: *Population.* (M. R. WO.)

UNITARIANISM, a system of Christian thought and religious observance, deriving its name from its doctrine of the single personality of God the Father, in contrast with the Trinitarian conception of His threefold being as Father, Son and Holy Spirit. The significance of the movement, however! is imperfectly indicated by its name and its true importance lies in its undogmatic approach to religious questions and its teachings concerning God, man. the nature and work of Jesus Christ and religious belief.

Origins. — The greatest single influence which led to the origin and growth of Unitarian Christianity was the free and independent study of the Bible in the Reformation and post-Reformation period. Criticism of the orthodox doctrine of the Trinity was voiced by a few advanced thinkers, the most notable of whom was Michael Servetus (1511?–53), who was put to death for his heretical opinions at the instigation .of John Calvin. Other outstanding names were Laelius Socinus (1525–62) and Faustus Socinus (1539–1604) and by the 17th century Unitarian communities had been established in Poland (now extinct) and in Transylvania. Sporadic anti-Trinitarianism was also to be found in England during the 16th and 17th centuries and was again the product of independent judgment in the interpretation of Scripture. John Biddle (1615 or 1616–62) is known as the "father of English Unitarianism" and during the Commonwealth organized meetings for worship and the study of the Bible,

Unitarian ***Church*** Life.—As a consequence of the Act of Uniiormity of 1662, more than 1,700 clergymen of the Church of England were deprived of their livings. It was among dissenting ministers and congregations for whom chapels were built in the years that followed the Toleration act of 1689 that Unitarian church liie had its beginnings although the act excluded Unitarians from its provisions. Although these chapels were almost always orthodox at the start, during the 18th century many of them came to adopt Unitarian opinions. This was made possible through the ireedom which was allcwed by their principle of nonsubscription to human creeds. Hence it was that approximately a third of the 323 Unitarian congregations existing in the British Isles in the mid-1950s had a continuous history from the last quarter of the 17th century. Many of the traditional doctrines of orthodox Christianity such as the Trinity, inherited guilt, eternal punishment and vicarious atonement were either abandoned or regarded as nonessential to the Christian liie. The most characteristic movement of thought was that which saw "Arian" or "Socinian" views of the person of Jesus Christ develop into acceptance of him as a purely human figure, though still central to the spiritual and devotional life. The rapid crystallization of Unitarian opinion at the end of the 18th century was mainly due to such commanding figures as Joseph Priestley (1733–1804), Theophilus Lindsey (1723–1808) and Thomas Relsham (1750–1829). Lindsey, aiter withdran·ing from the Church oi England, opened in Essex street, London, the first Unitarian chapel specifically so named. Although penal laws against those who impugned the doctrine of the Trinity were not repealed until 1813, Unitarian societies for the spread of literature and mission work had been formed in 1791 and 1806. Together with the Association for Civil Rights of 1819 these were amalgamated in the British and Foreign Unitarian association of 1825 as the first effective consolidation of Unitarian interests.

Changing Bases of Belief.—At the beginning of the 19th century Unitarian Christianity was, broadly speaking, a biblical religion, accepting miracles, and rejecting creeds, not as incredible, but as nonbiblical, resting its hopes on an external revelation and attaching·little importance to what it regarded as the uncertain influences and promises of "natural religion." This position was radically changed by the development of scientific knowledge and biblical and historical criticism, aided by the influence of new teachers and thinkers. As a result of the work in the United States of W. E. Channing (1780–1842) and Theodore Parker (1810–60) and, in England, of J. J. Tayler (1797–1869), J. Hamilton Thom (1808–94) and, above all, James Martineau (1805–1900), Cnitarianism became a spiritual religion which finds its supreme authority in religious history and experience, interpreted by the reason and conscience of mankind. It welcomes the findings of modern biblical criticism and seeks to understand non-Christian religions and to co-operate with them.

The 20th Century. — The 20th century witnessed further developments of Unitarian Christianity in organization and thought. The deeply felt need ior more effective corporate union was met by the formation in 1928 of the General Assembly of Unitarian and Free Christian Churches, which comprised all the principal related denominational organizations. The principles of nonsubscription to creeds and private judgment were steadfastly maintained and no official statement of belief binding upon all adherents has ever been issued. Unitarians and Free Christians are bound together by a common purpose, which has iound concise expression in a statement adopted by many congregations: "In the love of truth, and in the spirit of Jesus Christ, we unite for the worship of God and the service of man." Changes in the contemporary spiritual and intellectual climate led to the appointment by the assembly of a Commission on Doctrine which published its findings in 1943 in a volume entitled *A Free Religious* Faith. This contains a series oi papers by several writers on the beliefs which are commonly accepted by most Unitarians, though it is in no way an authoritative statement of those beliefs. (F. KY.)

UNITED STATES

Unitarianism in the United States followed essentially the same development as in England, and passed through the stages of Arminianism, Arianism, antitritheism, to rationalism and a modernism based on a large-minded acceptance of the results of the scientific and comparative stud:; of all religions. As early as the middle of the 18th century Harvard college represented the most advanced thought of the time, and a score or more of clergymen in New England were preaching what was essentially Unitarianism. The most prominent of these men was Jonathan Mayhew (1720–66), who was pastor of the West church in Boston, Mass., from 1747 to 1766.

The first official acceptance of the Unitarian faith on the part of a congregation was by King's chapel in Boston, which settled. James Freeman (1759–1835) in 1782, and revised the Book of Common Prayer into a mild Unitarian liturgy in 1785. Unitarian congregations were organized at Portland and Saco, Me., in 1792 by Thomas Oxnard; in 1800 the First church in Plymouth, Mass., accepted the more liberal faith. Joseph Priestley came to the United States in 1794 and organized a Unitarian church at Northumberland, Pa., in the same year, and one at Philadelphia in 1796. His writings had considerable influence. Thus from 1725 to 1825 a more tolerant belief was developing in New England, and to some extent elsewhere.

William Ellery Channing was settled over the Federal Street Congregational church. Boston, 1803; and in a iem years he became the leader oi the Unitarian movement. At first mystical rather than rationalistic in his theology, he took part with the "Catholic Christians." as they called themselves, who aimed at brinzing Christianity into harmony with the progressive spirit of the time. His essays, "The System of Exclusion and Denunciation in Religion" (1815) and "Objections to Unitarian Christianity Considered" (1819), make him a defender of Unitarianism. The Unitarian movement grew slowly; its influence has been chiefly exercised through general culture and the better literature of the country. Many of its clergymen have been trained in other denominations; the Harvard divinity school was distinctly Unitarian from its formation in 1816 to 1870, when it became an unsectarian department of the university. By 1950 there were four colleges and seminaries and two preparatory schools associated with the Unitarian denomination. One of the oldest Unitarian schools is Meadville Theolozical school, founded in Meadville, Pa., in 1844 and moved to Chicago. Ill., in 1926.

Periods of Unitarian Thought. — By mid-20th century Unitarian thought in the United States had passed through three periods. The first. from 1800 to 1815. was formative, mainlv influenced by English philosophy, semisupernatural, imperfectly rationalistic, devoted to philanthropy and practical Christianity. Channing was its distinguished exponent. The second, from 1835 to 1885, profoundly influenced by German idealism, was increasingly rationalistic, though its theology was largely flavoured by mysticism. The leaders were Ralph Waldo Emerson and Theodore Parker. The third, beginning about 1885, was one of rationalism, recognition of universal religion, large acceptance of the scientific method and ideas and an ethical attempt to realize the higher affirmations of Christianity. It was marked by harmony and unity to a great degree, by steady growth in the number of churches and by a widening fellowship with all other progressive phases of modern religion. During this period the influence of Emerson became predominant.

An International Council of Unitarian and Other Liberal Religious Thinkers and Workers was organized at Boston on May 25, 1900, "to open communication with those in all lands who are striving to unite pure religion and perfect liberty, and to increase iellowship and co-operation among them." In 1910 this organization became the International Congress of Free Christians and Other Religious Liberals, and in 1930, the International Association for Liberal Christianity and Religious Freedom. Beyond its own borders the body has obtained recognition through the public work of such men as Henry Whitney Bellows and Edward Everett Hale, the remarkable influence of James Freeman Clarke and the popular power of Robert Collyer.

In May 1960 the Universalist Church (*q.v.*) and the American Unitarian association. in Boston, Mass., approved consolidation of the two denominations, effective one year later. As the Unitarian Universalist association, the new denomination had about 200,000 adult members in the U.S., Canada and Mexico in about 800 churches and 300 lay fellowships. (J. H. L.; X.)

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UNITED ARAB REPUBLIC (AL-JUMHURIYA AL-ARABIYA AL-MUTAHIDA), the union of Egypt (*q.v.*) and Syria (*q.v.*) proclaimed Feb. 1, 1958, and ratified overwhelmingly in nationwide plebiscites Feb. 21. The two parts or regions of the United Arab Republic (U.A.R.) were not adjacent but were separated by about 150 mi., Lebanon, Israel and Jordan lying between them.

Particularly among the Syrians, Arab unity had long been a popular idea. Serious Egyptian interest dated from 1955 when formation of the Baghdad pact (*q.v.*) and evidence of Israeli military strength emphasized Egypt's growing isolation. A joint Egyptian-Syrian military command was established, conventions looking toward increased economic integration were signed and an agreement was made to co-ordinate educational processes. The Egyptian constitution of 1956 proclaimed Egypt to be "part of the Arab Nation." The Syrian constitution of 1950 had made the same proclamation about Syria. Negotiations toward union began in 1956; they became urgent late in 1957 when Syrian Pres. Shukri al-Kuwatli and leaders of the dominant Baath party sought Pres. Gamal Abdal Nasser's agreement on immediate and full organic union. Certain to be widely popular, it was felt that union under the strict no-party ban of the Nasser regime would negate the imminent threat of a Communist coup in Syria. Forestalled by their erstwhile Baathist allies, the Syrian Communists promptly went underground; their leader, Khalid Bagdash, left for Moscow. The U.A.R. was promptly recognized by other nations; it had but one vote in the United Nations in place of the two votes that Syria and Egypt had had before the union.

Government and Administration. — The provisional constitution of March 8, 1958, defined the new state as a "democratic, independent, sovereign Republic" based on a planned economy aimed at increasing national productivity and raising the standard of living. Private property and other rights and freedoms were explicitly endorsed "within the limits of the Law." Discrimination was proscribed and military service was made obligatory. Broad executive authority was vested in a president who was also to be head of the armed forces. He was given power not only to appoint and dismiss vice-presidents and cabinet ministers but also to appoint and dismiss members of the national assembly. He was empowered to initiate and promulgate legislation, convene and dismiss the national assembly, conclude treaties and enact decrees during legislative recess subject to subsequent reversal by a two-thirds assembly majority. Nasser was elected president by a nearly unanimous vote in the plebiscites on Feb. 21, 1958.

The assembly approved or rejected treaties and legislation, including taxes and budgets; interpellated cabinet ministers and could force their resignation by a vote of no confidence; and debated government policy. Judges were independent, subject only to the law; they could not be dismissed.

The citizenry participated in government at all levels through the national union, a single-party system intended to create a "socialist, democratic, and co-operative society." On July 8, 1959, Egypt's 6,500,000 and Syria's 1,500,000 voters elected 16,000 local council members, each representing about 500 voters. The local councils, designed to deal with local affairs and thus to encourage self-government, in turn elected 33 provincial councils to function as provincial legislatures under governors appointed by the president. These councils in turn elected a general congress of the national union from whom were appointed the members of the U.X.R. national assembly

The provisional constitution provided that the separate laws, administrations, treaties and budgets of each region were to remain operative until modified or repealed; executive councils for the two regions were appointed by the president. In the first U.A.R. cabinet of March 6, 1958, foreign affairs, education, armed forces, national guidance, *waqfs* ("religious endowments"), presidential affairs and Arab affairs were put under single ministers (all but one of whom were Egyptians) with separate interior, economy and commerce, agriculture, treasury, etc., ministries for each region. A program of gradual unification was envisaged, but the revolution in Iraq in July 1958 made that country more attractive to Syrians as an alternative to Egypt, and the pace toward centralized Egyptian control was accelerated. This was largely at the expense of Syrian Baathist leaders, many of whom had retained or gained high office under the new regime.

Disruption. — The United Arab Republic was brought to an end by the secession of Syria in Sept. 1961 as a result of a military coup. Egypt did little to oppose this move and an independent Syrian government was established. This government was-shortly afterward recognized by the leading powers and Syria resumed its seat as a separate member of the United Nations. *See* also ARAB LEAGUE; UNITED ARAB STATES. (R. H. N.; X.)

UNITED ARAB STATES (ITTIHAD AD-DUWAL AL-'ARABIYA), formerly a federal union of the United Arab Republic and the kingdom of Yemen proclaimed in Damascus on March 8, 1958. The charter, which was left open to acceptance by other Arab states. maintained the international personality and governmental system of each member but called for unified armed forces, a concerted foreign policy, a customs union, common currency and co-ordination of education. The heads of state constituted a supreme council that exercised authority in union affairs. A federation council of representatives with attached councils of defense, economics and culture prepared annual programs (*e.g.,* for Yemen's economic development) for ratification by the supreme council. The seat of the union was in Al Hudaydah, Yemen.

The federal association between Egypt and Yemen ostensibly continued for a time after Sept. 28, 1961, when Syria seceded from the United Arab Republic, but on Dec. 26, 1961, Egypt formally ended the federation. *See* also ARAB LEAGUE; EGYPT; SYRIA. (R. H. N.; X.)

UNITED CHURCH OF CHRIST: *see* CONGREGATIONALISM: *United States.*

UNITED FREE CHURCH OF SCOTLAND, a religious organization, representing the union made in 1900 between the Free Church of Scotland (except a dissentient section which separated and retained the name of Free Church) and the United Presbyterian Church. (*See* FREE CHURCH OF SCOTLAND and UNITED PRESBYTERIAN CHURCH.) The Free Church brought into the union 1,077 congregations, the United Presbyterians 599; the revenue of the former was £706,546, of the latter £361,743.

The minority of the Free Church which had refused to join the union lost no time in testing the legality of the act of the majority in entering it. Their summons, dated Dec. 14, 1900. claimed that in uniting with the United Presbyterian Church, which did not hold the principles of the Free Church, the majority had forfeited the right to the property of the Free Church, which must be judged to belong to the minority who remained faithful to the principles of the Free Church and were that church. In the Scottish courts the case was decided in favour of the union on Aug. 9, 1901, and on July 4, 1902; but, on appeal, the house of lords, on Aug. 1, 1904, by a majority of five to two, reversed these decisions and found the minority entitled to the funds and property of the Free Church.

Few legal decisions have occasioned such great consternation or such serious practical difficulties. At first sight it deprived the majority of the Free Church section of the United Church of all its material goods—churches, manses, colleges and missions, even of the provision for the old age of the clergy—and handed them over to a body which could have little prospect of making effective use of them. Nothing remained but to invoke the intervention of parliament to put an end to an impossible situation. In December a commission was appointed, consisting of Lord Elgin, Lord Kinnear and Sir Ralph Anstruther, to inquire into matters connected with the two churches, while the question of interim possession was referred to Sir John Cheyne, as commissioner, for inquiry and action.

The commission sat in public and in their report (April 1905) said that the state of feeling on both sides had made their work difficult. They had concluded, however, that the Free Church was unable in many respects to carry out the purposes of the trusts, which, under the verdict of the house of lords, was a condition of their holding the property, and that there was a case for parliamentary inference. They recommended that an executive commission should be set up by act of parliament in which the whole property of the Free Church, as at the date of the union, should be vested, and which should allocate it to the United Free Church, where the Free Church was unable to carry out the trust purposes. The Churches (Scotland) act, which gave effect to these recommendations, was passed on Aug. 11, 1905.

In Oct. 1929 most of the Cnited Free Church reunited with thr Church of Scotland. The joint group was renamed the Church of Scotland. At mid-20th century the combined organization was composed of a general assembly, 12 synods and 66 presbyteries in Scotland. 1 presbytery in England and 3 in continental Europe. There n-ere 2,360 congregations with 1.300.000 members and 2,900 Sunday schools with more than 300,000 scholars and teachers. Including natives, there were about 13.000 agents in the church's foreign missions, which had an annual income of more than £1,000,000.

The church was affiliated with four Scottish universities: Edinburgh, Glasgow, Aberdeen and St. Andrews.

In 1954 the United Free Church of Scotland, made up of those congregations from the then United Free Church which in 1929 dissociated themselves from union with the Church of Scotland, was composed of nine presbyteries. Its congregations in 1954 numbered 121, its ministers 83 and its communicant members 24,712. It is served by a number of missionaries in the foreign field. For the training of its ministers it maintains its on-n theological college conjointly with the Congregational Union of Scotland. Its general assembly meets annually in June at Edinburgh and Glasgow alternately.

See also SCOTLAND, CHURCH OF.

UNITED KINGDOM OF GREAT BRITAIN AND IRELAND, the title of the former political unity composed of England. Wales, Scotland and Ireland, officially adopted on Jan. 1. 1801, when the Act of Union between Great Britain and Ireland came into force. The name Great Britain has been used since the union of the kingdoms of England and Scotland in 1707 as the official designation of the united countries.

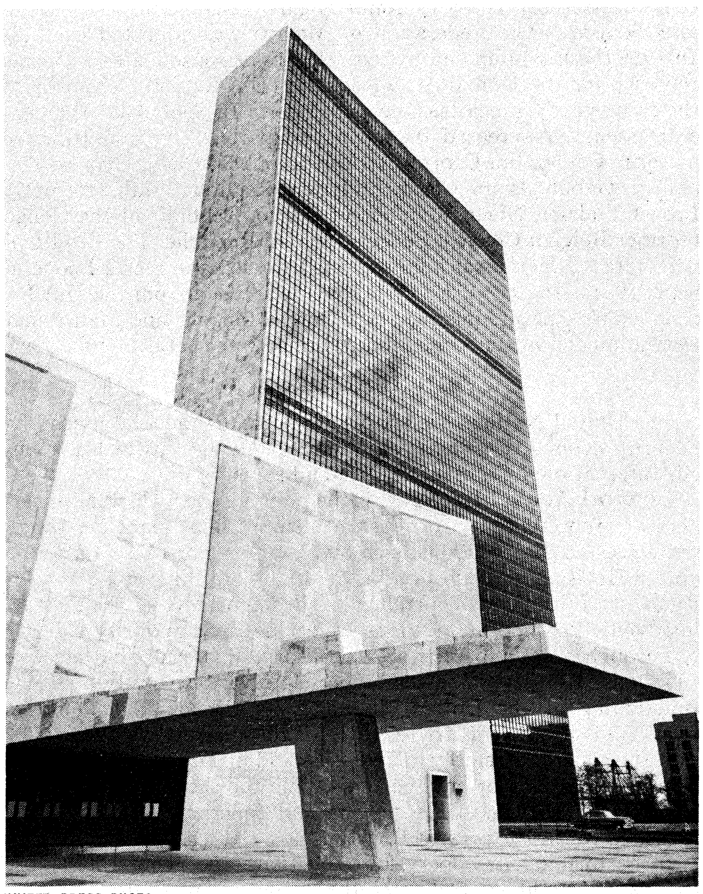
When, in 1922, 26 Irish counties mere severed from the United Kingdom and erected into a dominion of the British empire under the name of the Irish Free State (later Eire. Ireland), no pro!-ision was made in the act for any change in the royal style or in the title of the imperial parliament. From 1922 onward, however, the title of United Kingdom of Great Britain and Northern Ireland was frequently used in official documents to designate those parts of the British Isles represented in the imperial parliament, meeting at Westminster. In the report of the interimperial relations committee of the imperial conference of 1926 it was suggested that, in view of new constitutional developments. the words "United Kingdom" should be omitted from the royal style, which should run: "George V, by the Grace of God. of Great Britain, Ireland, and the British Dominions beyond the Seas King, Deiender of the Faith, Emperor of India."

By the Royal and Parliamentary Titles act, 1927 (17 Geo. 5, ch. 4). accordingly, the king was authorized to change the style and titles of the crown by royal proclamation. This was done. on May 13. 1927. by a proclamation adopting the recommendation of "the representatives of our Governments in Conference." and declaring that in the English style "Great Britain, Ireland and . . ." should henceforth be used instead of "the United Kingdom of Great Britain and Ireland." By the same act of parliament (2. 1) it was enacted that "Parliament shall hereafter be known as and styled the parliament of the United Kingdom of Great Britain and Northern Ireland." The accession of Queen Elizabeth II in 1952 provided an opportunity to bring the royal title into harmony with the parliamentary. On May 29, 1953, under the Royal Titles act, a proclamation mas issued by which the queen adopted the title of "Elizabeth II, by the Grace of God, of the United Kingdom of Great Britain and Northern Ireland. . . ."

See also ENGLAND; GREAT BRITAIN; IRELAND; IRELAND, NORTHERN; IRELAND, REPUBLIC OF; SCOTLAND; WALES.

UNITED NATIONS. Upon the basis of proposals submitted by China, the U.S.S.R., the United Kingdom and the United States, the Cnited Nations Conference on International Organization which convened at San Francisco. Calif.. on April 25, 1945, drafted the charter of the United Kations. It was signed at the conclusion of the conference June 26 and entered into force Oct. 24, 1945, when the above states and France, and a majority of the other 46 signatories had deposited their ratifications. (See also SAN FRANCISCO CONFERENCE [1945].)

Purposes **and** Membership.—The first article of the charter outlines the purposes of the organization. The primary objective is the maintenance of international peace and security. The organization also dedicated itself to the development of friendly relations among nations: based on the principle of equal rights and self-determination of peoples; to the achievement of international co-operation in solving international problems of an economic, social: cultural or humanitarian character; and to serving as a centre for harmonizing the actions of nations in the attainment of these common ends. Some of the basic principles of the United Kations, as outlined in art. 2 of the charter. are as follows: the United Nations is based on the sovereign equality of its members; disputes are to be settled by peaceful means; members undertake not to use force or the threat of force in contravention of the purposes of the Cnited Nations; each member must assist the organization in any action it takes under the charter; and states not members of the



UNITED PRESS PHOTO

UN GENERAL ASSEMBLY BUILDING SEEN FROM THE FIRST AVENUE ENTRANCE, NEW YORK CITY. THE SECRETARIAT BUILDING IS BEHIND IT

United Nations are required to act in accordance with these principles so far as may be necessary for the maintenance of international peace and security. Art. 2 also stipulates that the organization shall not intervene in matters within' the domestic jurisdiction of any state, except to take enforcement measures.

The original members of the United Nations mere as follows: Argentina, Australia, Belgium, Bolivia, Brazil, Belorussian S.S.R., Canada, Chile, China, Colombia, Costa Rica, Cuba, Czechoslovakia. Denmark. Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, France. Greece: Guatemala: Haiti, Honduras. India, Iran, Iraq, Lebanon, Liberia, Luxembourg, Mexico, the Netherlands, New Zealand, Nicaragua, Norway, Panamá, Paraguay, Peru, Philippines, Poland, Saudi Arabia, Syria. Turkey, Ukrainian S.S.R., Union of South Africa. Union of Soviet Socialist Republics, United Kingdom, United States, Uruguay, Venezuela and Yugoslavia.

Ne members are admitted to the United Nations on recommendation of the Security council by a two-thirds vote of the general assembly. They must be "peace-loving states." accept the obligations contained in the charter and be able and willing to carry out these obligations. The requirement of concurrence of the permanent members of the Security council has been a serious obstacle to the admission of new members. By 1950, only 9 of 31 applicants had been admitted: Afghanistan, Iceland. Sweden. Thailand (1946); Pakistan. Yemen (1947); Burma (1948); Israel (1949); and Indonesia (1950). A number of efforts had been made by the general assembly to break the deadlock. In the tenth assembly (1955) there was wide support for a "package deal" sponsored by 29 members, under the leadership of Canada. Though it became necessary to drop Japan and Outer Mongolia from the package, in modified form the proposal was approved by the Security council. and the general assembly voted to admit 16 new members: Albania. Austria. Bulgaria, Cambodia. Ceylon, Finland. Hungary, Ireland. Italy, Jordan, Laos, Libya; Nepal, Portugal, Rumania and Spain. In its 11th session (1956-57) the general assembly voted to admit Ghana, Japan, Morocco. Sudan and Tunisia. The Federation of Malaya was admitted in 1957. In 1958 the Egyptian and Syrian delegations ronsolidated into one, representing the United Arab Republic (U.A.R.); in December of the same year Guinea became a member. In Sept. 1960 the general assembly increased the membership to 98 by admitting 16 nations: Cameroon. Central African Republic, Chad, Cyprus. Dahomey, Gabon. Ivory Coast. Malagasy Republic. Mali (formerly French Sudan). Niger. Republic of Congo. Republic of the Congo (former Belgian Congo). Senegal. Somali Republic, Togo and Upper Volta. Nigeria was admitted in Oct. 1960 and Sierra Leone in Sept. 1961. In Oct. 1961 Syria. having seceded from the U.A.R., resumed its separate membership; Outer Mongolia and Mauritania were admitted in the same month, bringing the total to 103.

PRINCIPAL ORGANS

The United Nations has six principal organs: general assembly. Security council, Economic and Social council, Trusteeship council, International Court of Justice and secretariat.

General Assembly. — This is the only body on nhich all members are represented. Although a member inay send five representatives to the general assembly, each member has only one vote. Decisions on substantive questions are taken by a majority or two-thirds vote, depending on the importance of the matters involved. Procedural questions are decided by a majority vote

Through its deliberative, supervisory, financial and elective functions, the general assembly occupies a key position in the functioning of the United Nations. Its role as a deliberative organ finds its basis in art. 10 to 14 of the charter. Art. 10 states that the general assembly may discuss and make recommendations on "any questions or any matters within the scope of the present Charter or relating to the pouers and functions of any organs provided for in the present Charter."

In performing its supervisory functions, the general assembly exercises general control over the activities of United Nations organs in the economic and social fields and in dealing with the problems of nonself-governing territories. The general assembly receives annual reports from the secretary-general and the Security, Economic and Social, and Trusteeship councils, and may make recommendations to these organs. The Economic and Social council and the Trusteeship council operate under the authority of the general assembly. The assembly approves trust agreements and through the Trusteeship council supervises the administration of trust territories. It exercises general supervision and control over the operations of the secretariat. The financial power of the assembly is exercised through its control over the budget of the United Nations and the scale of assessments levied on members. In its elective capacity, the general assembly chooses all members of the Economic and Social council and the elective members of the Security and Trusteeship councils. Along with the Security council, it also participates in the election of judges of the International Court of Justice and the appointment of the secretary-general. The assembly shares with the council the power to initiate amendments to the charter as well as the right to convene a conference for the purpose of revising the charter.

During its first ten years, the general assembly progressively increased in importance as an organ of deliberation and influence in the political field. The decline in the influence and effectiveness of the Security council because of the inability of the permanent members to co-operate encouraged the greater use of the general assembly. The broad language of the charter permitted a substantial increase in the role of the general assembly beyond what nas originally envisaged and most members of the organization had an interest in encouraging this incresse. Members consequently became more and more concerned with ways and means of equipping the assembly, in organization and procedure, for the more effective performance of its growing responsibilities.

The assembly convenes annually; its rules permit special sessions on short notice. In performing its tasks, it works through a fairly complex structure of main committees. procedural committees, standing committees and subsidiary and *ad hoc* bodies.

Security Council. — The charter places on the Security council the primary responsibility for maintenance of international peace and security. Eleven members of the United Nations are members of the council, the five permanent members (Republic of China. France, the United Kingdom, the U.S.S.R. and the United States) and six nonpermanent members elected by the assembly for two-year terms. In selecting nonpermanent members, the assembly must strive for an equitable geographical distribution as well as consider their contribution to the maintenance of international peace and security. From the beginning. nonpermanent members of the Security council were elected with a view to giving representation to certain regions or groups of states. This practice ran into increasing difficulty as the number of United Nations members increased and there were not enough seats to distribute among the groups and regions desiring representation. This problem has led to a demand for additional nonpermanent seats.

Under the charter. all members of the United Nations agreed to carry out the decisions of the Security council. This agreement was interpreted to refer primarily to decisions under ch. vii of the charter. The council is authorized to investigate any dispute which might threaten international peace and security, and to make recommendations for its peaceful settlement. The council may also call on members of the United Nations to apply economic and diplomatic sanctions against any state which the council has found guilty of breach of the peace or act of aggression. It may also decide what military measures are to be taken by members, but this power did not become operative because of the failure to conclude agreements specifying the armed forces and facilities to be placed at the disposal of the Security council by members. The council may also make recommendations on the regulation of national armaments.

On procedural matters, decisions by the council are made by an affirmative vote of any seven of its members; on substantive matters. including the investigation of a dispute and the application of sanctions, seven affirmative votes including those of the five permanent members are required. A vote on whether a matter is procedural or substantive is itself a substantive question.

The council is required to be so organized as to be able to function continuously. Each member is represented at all times at the seat of the organization. The presidency of the council rotates monthly. Like the general assembly, the council has established a number of subsidiary organs to assist it.

Economic and Social Council. — The Economic and Social council is charged with directing and co-ordinating the complex system of economic, social, humanitarian and cultural activities of the United Nations. It comprises 18 members, elected by the assembly for three-year terms with the possibility of re-election. Although the council, unlike the Security council, has no permanent members, states whose participation is considered necessary to the work of the council have been regularly re-elected.

The Economic and Social council meets at least twice a year; it is directed by the charter to make or initiate studies and make recommendations with respect to the promotion of international co-operation in economic and social matters. It may prepare draft conventions for submission to the assembly and call international conferences for specific purposes.

The council is assisted in its work by functional and geographical commissions. The functional commissions carry out studies in the economic and social field and otherwise assist the council in the performance of its duties. They formulate resolutions, recommendations and international conventions on which the council and general assembly take action. Three regional commissions—on Europe, Asia and the far east, and Latin America—which were established to deal with specific regional economic problems assumed roles of considerable importance both as advisory organs and as organs with important operational responsibilities.

Trusteeship **Council.**—Acting under the authority of the general assembly, the Trusteeship council supervises the administration of trust territories by the administering states. The council is composed of those members of the Cnited Nations who administer trust territories; the permanent members of the Security council not administering trust territories; and as many other nonadministering members elected by the assembly for three year terms as are necessary to ensure an equal number of administering and nonadministering members in the total membership of the council. The Trusteeship council is authorized to send visiting missions of inspection into the trust territories to receive and examine petitions, to consider reports submitted to it annually by the administering authorities and to make recommendations with respect to all matters coming within its purview. The council is required to submit annual reports on its activities to the general assembly. *(See* TRUSTEESHIP SYSTEM.)

International Court of Justice. — The court is the principal judicial organ of the Cnited Nations. Its statute is an integral part of the charter of the United Nations. The 15 judges of the court are elected by the general assembly and the Security council voting independently. No two judges may be nationals of the same state. Representation of the main forms of civilization and of the major legal systems of the world is to be assured. Judges serve for nine years and are eligible for re-election.

The jurisdiction of the court comprises all cases which parties submit to it, and all matters specially provided for in the charter or in other treaties. States, by formal declaration, may accept the compulsory jurisdiction of the court in specified categories of disputes. The court may give advisory opinions at the request of the general assembly or the Security council, or at the request of other organs and specialized agencies authorized by the general assembly. *(See* INTERNATIONAL COURT OF JUSTICE.)

The Secretariat. — The secretariat is headed by the secretary-general and consists of such staff as the organization may require. The secretary-general is appointed by the general assembly upon the recommendation of the Security council. At the beginning of its first session in 1946, the general assembly chose Trygve Lie (Norway) for a term of live years, which in 1951 was extended for three years. This extension was bitterly opposed by the U.S.S.R., and in Nov. 1952 Lie resigned. In April 1953 Dag Hammarskjold (Sweden) succeeded him and was re-elected in 1957. In Sept. 1961 Hammarskjold was killed in an airplane crash in Northern Rhodesia and in November U Thant (Burma) was appointed his successor. The secretary-general is the chief administrative officer of the United Nations. He also has important political functions, being specially charged with bringing before the organization any matter that threatens or violates international peace and security. He and his staff perform secretarial functions for the various organs. He submits an annual report to the general assembly on the work of the organization during the preceding year.

DISPUTES AND SITUATIONS AFFECTING INTERNATIONAL PEACE AND SECURITY

By the terms of the charter, the members of the United h'ations conferred upon the Security council primary responsibility for the maintenance of international peace and security. At the San Francisco conference the basic assumption underlying the United Nations as an international security organization was that there would be co-operation among the five permanent members of the Security council on important questions. In fact, it was made a charter requirement that substantive decisions of the council could be taken only with the concurrence of the permanent members. The growing rift between the Soviet Union and the western powers after 1945 resulted in frequent use of the veto, which seriously reduced the effectiveness of the Security council in the discharge of its primary responsibility. As a result, there was an increasing tendency on the part of members to seek security through collective self-defense arrangements, such as NATO, concluded under art. 51 of the charter and, so far as United Nations action was concerned, to look to the general assembly to assume responsibilities in this field.

In 1936 the assembly was asked to deal with the Spanish question, originally brought before the Security council. The U.S.S.R. had vetoed a proposal dealing with Spain on the ground that it should have been more strongly worded, and the question was subsequently brought before the assembly which finally adopted a resolution on Dec. 12, 1946. In the summer of 1947 a Soviet veto prevented the adoption by the Security council of a resolution approving the findings of a commission which had been set up to investigate the disorders on the northern borders of Greece. The question was removed from the council's agenda, and the United States brought the question before the assembly.

In the Korean case, the absence of the U.S.S.R. from the council in protest against the allegedly illegal representation of China by the nationalist government enabled the council in June 1950 to take prompt action against the North Korean forces attacking the Republic of Korea. Realizing that this condition was not likely to be repeated in the future, the general assembly in Nov. 1950, on United States initiative, adopted the Uniting for Peace resolution by which the assembly assumed additional responsibilities for the maintenance of international peace and security. This resolution provided that the assembly should take action with reference to a threat or breach of the peace or act of aggression should the Security council fail to exercise its primary responsibility in that field. The resolution requested Cnited Nations members to set aside contingents in their national armed forces to be made available to the United Nations should the assembly recommend the use of armed force under this resolution.

The resolution also established the Peace Observation commission to observe and report on areas of the world where existing tension might impair international peace and security. The commission was directed to be at the disposal of the Security council or the assembly if the council was not exercising its functions. It also established the Collective Measures committee to study and report on methods which the assembly might use in strengthening international peace and security.

Iran. — The first situation to be brought before the United Nations m s Iran's complaint to the Security council of Jan. 19, 1936, that the Soviet Union was interfering with Iran's internal affairs by not withdrawing its troops from northern Iran. The council called on both parties to negotiate their differences. However, on March 18 Iran reported that the Soviet Union had not withdrawn its troops. On April 4, 1946, the council requested both parties to report by May 6 on progress made in withdrawal of Soviet forces. On May 6 Iran reported withdrawal of Soviet troops from all provinces except Azerbaijan where facts were not known.

Greece.—In Dec. 1946 Greece charged that Albania, Bulgaria and Yugoslavia were aiding Communist guerrillas in northern Greece, and asked the council to investigate this situation The council established the Commission of Investigation, which, after an on-the-spot examination of the alleged disorders, supported the Greek accusations by a majority vote. The council, unable to agree on a resolution, removed the question from its agenda on Sept. 15, 1947. The matter was brought before the general assembly by the United States. In its resolution of Oct. 21, 1947, the assembly requested all parties concerned to negotiate their differences, and established the United Nations Special Committee on the Balkans (UNSCOB) to facilitate peaceful settlement of the dispute. The Soviet Union and the satellite states refused to co-operate. In its first report to the assembly in 1948 the committee reported the continuation of aggressive interventionist activity by Greece's northern neighbours. The general assembly in Nov. 1948 called on Albania, Bulgaria and Yugoslavia to terminate their support of the communist guerrillas in Greece. It authorized the committee to continue its mediatory efforts. The situation had markedly improved by the end of 1948, largely because of United States aid to Greece and Yugoslavia's break with Moscow. The sixth session of the assembly terminated the Special Committee on the Balkans, and the task of observing and reporting condition; along Greece's northern frontier was delegated to the Peace Observation commission.

Indonesia.—In July 1947 Australia and India called the Security council's attention to hostilities which had broken out between the Republic of Indonesia and the Netherlands. Although the Netherlands argued that the United Nations could not act because the matter was within the Netherlands' "domestic jurisdiction." the council called on the parties to cease hostilities and settle the dispute peacefully and appointed a committee of good offices to facilitate a peaceful settlement. In Jan. 1948 both parties signed the "Renville" agreement, providing for a truce and setting forth the political principles to govern a final settlement. The Netherlands renounced the agreement in Dec. 1948 and resumed hostilities. In Jan. 1949 the Security council again called on both sides to terminate armed action, recommended the establishment of a federal. independent and sovereign United States of Indonesia at the earliest possible date, created a new commission for Indonesia and charged it to assist the parties in implementing this resolution. With the assistance of the commission, the parties involved finally reached agreement on the transfer of sovereignty from the Netherlands to the Republic of Indonesia at a round-table conference which met at The Hague from Aug. 23 to Nov. 2, 1949. The formal transfer of sovereignty took place on Dec. 27, 1949.

Palestine.—After World War II, because of the increased agitation on the part of the Jews for a national home and place of refuge and the deterioration of relations between the Jews and Arabs, Great Britain requested that the matter be considered by the general assembly. A special session, meeting from April 28 to May 15, 1947, established the United Nations Special Committee on Palestine (UNSCOP) to investigate possible solutions of this problem. After inspecting conditions in Palestine, the special committee submitted majority and minority reports to the general assembly in Nov. 1947. The majority report, violently opposed by the Arab states, proposed the partition of Palestine into an Arab and a Jewish state and the establishment of an international regime for Jerusalem. the three areas to be joined by an economic union. The minority plan called for an independent federal state. The general assembly accepted the majority plan and called on the Security council to take enforcement action should any interested party attempt to use force to alter the proposed partition. Great Britain announced its intention to terminate the mandate on May 15, 1948.

There was an increase in fighting between Arabs and Jews following the adoption of the assembly's resolution. The assembly, meeting in special session in April and May 1948, decided to invite the permanent members of the Security council to appoint a United Nations mediator. Count Folke Bernadotte of Sweden was subsequently appointed. He was directed to use his good offices to promote cessation of hostilities and a peaceful settlement of the dispute and also to assist the Security council's Truce commission which had been established previously.

On May 15, 1948, Britain terminated its mandate over Palestine, and the new state of Israel was proclaimed. The Arab states immediately had recourse to armed force. In a series of resolutions, progressively more insistent, the Security council called on the parties to cease hostilities. On July 15 the council passed its strongest resolution, warning the parties that, unless they desisted from military action; enforcement measures by the United Nations would be undertaken. Through the efforts of Count Bernadotte, agreements for a truce were finally reached on July 16 and 18. Following the assassination of Count Bernadotte by Jewish terrorists in Sept. 1948, Ralph Bunche of the United States was appointed acting mediator. During 1949 he was successful in negotiating armistice agreements between Israel and the Arab states.

In the autumn of 1948 the general assembly established the United Nations Conciliation commission to assist Israel and the Arab states to reach agreement on boundaries, repatriation of refugees and a general political settlement. This action, followed in Aug. 1949 by a Security council resolution relieving the acting mediator of further responsibilities under council resolutions! meant that responsibility for achieving a political settlement was placed on the commission, while the truce organization under the armistice agreements, headed by the chief of staff, and the Security council had responsibility for maintaining peace.

Failure to find an acceptable solution of the Arab refugee problem and the intransigent positions of both Jews and Arabs blocked all efforts of the Conciliation commission to achieve a political settlement. Complaints of armistice violations were numerous and became increasingly serious in 1954 and 1955. The announcement in Sept. 1955 of a Soviet-Egyptian trade agreement for the exchange of cotton for arms was followed by increased tension. Relations between Egypt and Israel were particularly acute and, following border clashes. the Security council in September called upon the two governments to withdraw their armed forces along the demarcation line to avoid further incidents. On April 14, 1956, the council directed the secretary-general to go to the area to assist in preserving peace.

After discussions with the governments concerned, the secretary-general reported to the Security council on May 10 that he had found a "general will to peace" and that unconditional cease-fire agreements had been established between Israel and its Arab neighbours. He stressed that further initiative rested with the governments concerned. However, during the summer and early autumn. relations between Egypt and Israel rapidly deteriorated. Finally, on Oct. 29, Israeli armed forces invaded the Sinai peninsula and quickly overran the peninsula and the Gaza strip. Israel cited in justification Egypt's blockade of Israeli shipping through the Suez canal, Egyptian president Gamal Abdel Nasser's threats and military plans and *fedayeen* ("Arab infiltrator") raids. On Oct. 30 the British and French governments demanded that Egypt and Israel agree to a cease fire within 12 hours, withdraw their armed forces from the vicinity of the Suez canal and agree to temporary British-French occupation of key points in the canal zone. Egypt refused, and the British and French began military action against Egypt.

On Oct. 29 the U.S. asked that the Security council consider the Israeli attack. On the 30th France and the United Kingdom vetoed a United States draft resolution calling for an immediate cease fire and the withdrawal of Israeli forces. The next day the Security council called a special session of the general assembly under the Uniting for Peace resolution to consider the Israeli, French and United Kingdom military actions. On Nov. 2 the assembly adopted a resolution calling for a cease fire, the withdrawal of troops and no introduction of military goods in the area. On Nov. 5 the assembly established a United Nations command for an emergency international force (UNEF), "to secure and supervise the cessation of hostilities," under Gen. E. L. M. Burns, chief of staff of the UN Truce Supervision organization. Israel, Egypt. France and the United Kingdom then agreed to a cease fire unconditionally and Egypt accepted UNEF. On Nov. 7 the assembly approved the recommendations contained in the secretary-general's report on the duties, organization and functioning of this force, to be composed of contingents from the smaller countries. The first contingents of UNEF arrived in Egypt on Nov. 15. British and French forces finally completed withdrawal on Dec. 22. By the middle of Jan. 1957 Israeli forces had been withdrawn from all occupied territory except the Sharm el Sheikh area and the Gaza strip. The UNEF withdrew from the Suez canal zone iollowing withdrawal of French and U.K. forces and was being used to facilitate the withdrawal of Israeli forces. Israel conditioned complete withdrawal on guarantees of future Israeli security.

Suez Canal Question. — The Egyptian. government first brought the question before the Security council in 1947 when a revision of the 1936 treaty with the United Kingdom was being sought. In 1954 an agreement was concluded between Egypt and the United Kingdom providing for the withdrawal of U K. forces from the canal zone. After Colonel Nasser nationalized the canal in July 1956, the United Kingdom and France first sought to get Nasser's agreement to a plan for the effective internationalization of the canal. Failing this, they brought the question to the Security council which, on Oct. 13, adopted a resolution setting forth six principles on which a settlement should be based. Failure of subsequent efforts to implement these principles was thought to be one reason for the British-French military action against Egypt on Oct. 30. Following the blocking of the canal by Egypt in opposing British-French military action, the UN, by agreement with Egypt, undertook the task of clearance.

Hungary. — Popular discontent in Hungary led in Oct.–Nov. 1956 to the use of Soviet forces to prevent an anti-Communist regime from being established. On Oct. 27 the United States, the United Kingdom and France asked that the Security council consider the situation. The Soviet Union vetoed a U.S. proposal calling on the U.S.S R. to cease and desist. The council requested an emergency session of the general assembly, but resolutions of that body calling on the Soviet Union to desist from military intervention and to respect the right of the Hungarian people to independence, affirming the desirability of free elections and requesting the secretary-general to carry out an investigation of conditions in Hungary were disregarded by the Soviet and Hungarian governments on the grounds that this was a domestic matter.

India-Pakistan Question. — The state of Jammu and Kashmir, located in the northern part of the Indian subcontinent between India and Pakistan, was given its choice, under the British Indian Independence act of 1947, to accede to either of its neighbours. Both India and Pakistan pressed their claims. In the autumn of 1947 Moslem tribal groups invaded Kashmir, and Indian forces were sent in at the request of the Kashmir government after it had elected to accede to India. India brought the situation before the Security council on Jan. 1, 1948, and demanded that the council order Pakistan to desist from encouraging and supporting hostilities in Kashmir. Pakistan, however, denied India's accusation and requested the council to appoint a commission to assist in ending hostilities in Kashmir and to facilitate the withdrawal of Indian and Pakistan troops so that a plebiscite could be held. On Jan. 20, 1948, the Commission on India and Pakistan was established by the council and was directed to place its good officesand mediatory services at the disposal of the two states.

A cease-fire agreement became effective on Jan. 1, 1949, and United Nations observers helped in its enforcement. The commission was unsuccessful, however, in its effortsto achieve a political settlement. In April 1950 Sir Owen Dixon of Australia was appointed by the Security council as United Nations representative to serve as mediator between the parties.

In April 1951 Frank Graham of the U.S. replaced Dixon. The commission and the representatives were able to narrow the area of disagreement but could not get full agreement on the two main issues. the demilitarization of Kashmir and the conduct of a free and impartial plebiscite.

Korea. — Shortly after the end of World War II the northern half of the peninsula of Korea was occupied by the U.S.S.R. while the area south of the 38th parallel was occupied by United States forces. When the Soviet Union and the U.S. reached an impasse in their negotiations to achieve a united democratic Korea, the U.S. requested the general assembly in Sept. 1947 to consider the question. The assembly passed a U.S.-sponsored resolution calling for elections in Korea under UN supervision preparatory to constituting a national government for that country. On May 10, 1948, elections were held in South Korea alone after the Soviet military authorities had refused UN supervision in North Korea, and a government of the Republic of Korea was established in the south. The general assembly in Dec. 1948 declared that this was the only government in Korea based on free elections. Meanwhile. Soviet authorities assisted in the establishment of a government in North Korea, known as the People's Republic of Korea. During 1948–49 both the U.S. and Soviet troops were withdrawn from Korea.

On June 25, 1950, the armed forces of North Korea invaded South Korea. On the same day the Security council called on North Korean authorities to withdraw their armed forces and demanded an immediate cessation of hostilities. When the North Korean authorities disregarded this resolution, the council on June 27 called on members of the United Nations to "furnish such assistance to the Republic of Korea as may be necessary to repel the armed attack and to restore international peace and security in the area " Led by the United States, many UN members gave material assistance to the Republic of Korea. On July 7 the council requested the U.S. to appoint a supreme commander for United Nations forces in Korea, and Gen. Douglas MacArthur was so designated. Following the Inchon landing in mid-Sept. 1950, the United Nations forces sought to drive the Communists from all of Korea. the general assembly in Oct. 1950 having implicitly approved this course. The assembly established the United Nations Commission for the Unification and Rehabilitation of Korea to carry out the original unification goal of the United Nations. In late Oct. 1950 contingents from the Communist Chinese army actively intervened.

After failing to achieve a cease fire and the peaceful settlement of the dispute, the assembly, on Feb. 1, 1951, labeled Communist China an aggressor and established an Additional Measures committee to consider the application of sanctions against that government. On May 18 the assembly recommended that members apply an embargo on arms, munitions and other implements of war against areas controlled by the Communists. Many states had already applied such measures.

After two years of negotiations a truce agreement was signed on July 27, 1953, which contained guarantees against future aggression and which provided for a line of demarcation in the vicinity of the 38th parallel that was more defensible than the original line. It recommended that within three months a political conference be held to arrive at a peaceful settlement of the Korean question. A conference for this purpose met at Geneva, Switz., in 1954, but ended in failure. While the Korean question was considered by the assembly at every subsequent session, the deadlock remained unbroken. The assembly in 1957 again called for the reunification of Korea under a representative government and as an independent and democratic state. (See also KOREAN WAR.)

Corfu Channel. — In Jan. 1947 Britain called the Security council's attention to a dispute with Albania concerning damage incurred by British warships and naval personnel as a result of the detonation of mines in the Corfu channel. The U.S.S.R. vetoed a resolution which placed the blame on Albania, and the council recommended that Britain and Albania submit the dispute to the International Court of Justice. The parties agreed to submit the dispute to the court. but Albania refused to carry out the court's judgment as to the amount of compensation.

Berlin. — In Sept. 1948 the Security council considered the question of the Soviet blockade of west Berlin which severed contact between the western powers and their zones in the German capital. The U.S.S.R. argued that the council had no authority to deal with this matter. and when the council, in Oct. 1948, voted to place the question on its agenda, the Soviet Union refused to participate in the council's discussions of the blockade. Although the council was unable to work out an acceptable solution to the question after several attempts, the United States and Soviet representatives on the council reached an understanding which permitted a settlement to be subsequently reached.

Italian Colonies. — After the Council of Foreign Ministers was unable to agree on the disposal of the former Italian colonies of Libya. Somaliland and Eritrea following World War II, a clause was inserted in the Italian peace treaty of 1947 to the effect that, in the event of continued disagreement, the matter would be referred to the general assembly for a final determination. When agreement was again found impossible, the matter was placed before the assembly in April 1949. In Nov 1949 the assembly decided that by Jan. 1. 1952, Libya should become an independent state and that until then it should be administered by a United Nations commissioner, advised by a council of representatives consisting of six United Nations members and four local inhabitants.

Under the guidance of Adrian Pelt, United Nations administrator. Libya was prepared for statehood: and on Dec. 24, 1951, became the first formerly dependent area to become an independent state under the aegis of the United Nations. Somaliland was placed under U S trusteeship, with Italy serving as the administering authority. The assembly declared that this former colony should receive its independence ten years after the assembly approved of the trusteeship agreement, which it did in Dec. 1950. The assembly decided in 1950 that Eritrea should be federated with Ethiopia, although it should retain as much local autonomy as possible. The United Kingdom was selected as the administering authority to prepare for federation. which took place Sept. 15, 1952.

Anglo-Iranian Oil Dispute.—Following Iranian nationalization of the properties of the Anglo-Iranian Oil company in May 1951 the United Kingdom asked the International Court of Justice to adjudicate. The court called upon Iran to take certain provisional measures and when Iran refused. the United Kingdom, on Oct. 1, asked the Security council to take action. The council deferred action until after the court had determined its jurisdiction. In July 1952 the court decided that it did not have jurisdiction and the dispute was subsequently settled by negotiation between the interested parties.

Tunisia, Morocco and Algeria. — In 1951, at its sixth session, and at succeeding sessions. the general assembly was asked by Asian and African members to consider the situation in Morocco resulting from the alleged denial by France of Moroccan national aspirations. In 1952 the assembly adopted a moderate resolution expressing the hope that the parties through continuing negotiations would reach agreement on the development of free political institutions in accordance with the principles of the charter. The question of Tunisia was brought first before the Security council and then the general assembly by the same Asian and African members. Assembly action was similar to that in the case of Morocco. When in 1955 the question of Algeria was brought before the assembly, the French delegation entered a more vigorous protest against United Nations jurisdiction than in the other cases. arguing that the question was clearly domestic since Algeria was a part of metropolitan France. When the assembly placed the question on its agenda. the French delegation left the general assembly and returned only when the assembly decided at a later date to remove it. France accepted the decision of the 11th session to include the question in its agenda. In 1957 the assembly passed a resolution expressing the wish "that in a spirit of effective cooperation discussions will be entered into, and other appropriate means utilized, with a view to a solution in conformity with the purposes and principles of the Charter of the United Nations."

Other Questions. — A number of other disputes and situations were brought to the attention of the United Nations during its first ten years. for the most part without any positive results being achieved. Early efforts by the general assembly to eliminate the Franco regime in Spain as a menace to the peace proved to be fruitless and were terminated in 1950. From the beginning the general assembly considered the question of racial discrimination in South Africa, first in its application to persons of Indian origin and then in its application to the native African population. The government of South Africa denied the competence of the assembly even to discuss these matters and disregarded assembly recommendations. In 1948 the Security council was asked to consider Soviet intervention in Czechoslovakia but action was prevented by Soviet use of the veto. In 1949 the assembly was asked to consider alleged violations of human rights in Bulgaria, Hungary and Rumania but, even when backed by an opinion of the International Court, the assembly resolution of condemnation was disregarded. Efforts by the Greek government in 1954 and 1955 to get general assembly consideration of its claim that the inhabitants of Cyprus were being denied the right of self-determination failed, the United Kingdom invoking the domestic jurisdiction principle. Indonesia likewise sought the aid of the UN in obtaining control of west New Guinea which it claimed the Netherlands was illegally occupying. This territory was formerly a part of Netherlands Indies, which upon independence became the Republic of Indonesia.

Art. 2(7) of the charter, which excludes intervention by the UN in "matters which are essentially within the domestic jurisdiction of any state." has been frequently invoked to deny the competence of the organs of the UN and to restrict their activities, but the appeal has almost invariably been rejected. Prime Minister Jan Christiaan Smuts for the Union of South Africa in 1946 vainly requested the assembly to submit the question of whether the treatment of Indians fell within domestic jurisdiction to the International Court of Justice, agreeing to abide by the decision. The organs of the UN have assumed the right to decide upon their own competence and are disinclined to ask the court for an advisory opinion on the preliminary question of domestic jurisdiction.

GENERAL QUESTIONS RELATING TO PEACE AND SECURITY

Regulation of Armaments. — The charter places responsibility on the Security council for preparing and submitting plans for the regulation of national armaments. The general assembly may discuss and recommend principles governing "disarmament and the regulation of armaments." "Regulation" implies the availability of armaments for United Nations purposes as well as limitation and reduction. The development of the atomic bomb during World War II and its use in Aug. 1945 created a situation in which it seemed to the United States and other governments that the international control of atomic energy demanded consideration even in advance of any perfection of collective security arrangements. Consequently, the first action of the United Nations was the establishment of the Atomic Energy commission by the general assembly in Jan. 1946 to prepare plans for the control of atomic energy. In Dec. 1946 the general assembly adopted a resolution providing for the urgent consideration of the control of atomic weapons and other weapons of mass destruction. and at the same time the consideration of practical measures for the regulation and reduction of all armaments and armed forces.

The Atomic Energy commission began its deliberations in June 1946. It soon became apparent that there was complete disagreement between the United States and the U.S.S.R. The commission submitted reports to the Security council in 1946, 1947 and 1948. The majority of the commission called for international managerial control or ownership of atomic energy activities, international inspection by a proposed international atomic development authority and the elimination of the veto from enforcement provisions of the agreement. The majority also insisted that the control system should be in operation before the existing stockpile of atomic bombs was destroyed. The Soviet Union, however. took an opposite view. It refused to agree to international ownership and to the kind of international inspection demanded by the majority; it demanded that the veto be applicable to enforcement measures under the plan and that the destruction of atomic stockpiles should accompany the establishment of a system of control. The commission recorded an impasse in negotiations in its 1948 report, though some agreement had been reached on matters of detail.

To deal with armaments other than weapons of mass destruction, the Security council organized the Commission for Conventional Armaments. Progress in this field was likewise blocked by disagreement between the U.S S R. and the western powers. Although the commission and the general assembly in 1949 approved a plan whereby each state would submit full information to the commission on its conventional armaments and armed forces, the refusal of the U.S S.R. to accept the plan prevented any implementation. By early 1950 it was clear that a hopeless deadlock had been reached.

At its fifth session in 1950 the general assembly considered a United States proposal to combine the work of the Atomic Energy and the Conventional Armaments commissions. In Jan. 1952 the assembly voted to merge the two commissions into a Disarmament commission, thus recognizing the interdependence of the various elements of the problem. The Disarmament commission, which consisted of the members of the Security council and Canada. was directed to prepare proposals for the regulation. limitation and balanced reduction of all armed forces and armaments, for the elimination of major weapons adaptable to mass destruction and for the effective international control of atomic energy to ensure its use for peaceful purposes only. The development of atomic and hydrogen weapons by the Soviet Union fundamentally altered the terms of the problem of the regulation and reduction of armaments and resulted in important changes in national positions. In spite of vigorous efforts to achieve constructive results through the commission and the general assembly itself, there was little progress in working out an acceptable plan.

In his annual report to the 12th assembly which convened in 1957, Secretary-General Hammarskjold stated that the year had witnessed "most sustained and intensive efforts by the members of the disarmament subcommittee to find common ground." Instead of attempting to work out a comprehensive, detailed, general disarmament plan there was a shift toward efforts to obtain a limited "first step" agreement. After over a decade of stalemate there was some hope that a limited agreement might be possible. Much attention was devoted to means of preventing surprise attacks; the United States urging acceptance of the Eisenhower "open skies" proposal for aerial inspection and exchange of military blueprints, and the U.S.S.R. supporting the Bulganin plan of ground posts at strategic centres. The United States suggested combining the two proposals.

The increased activity in the negotiations on arms limitation was reflected in the 12th general assembly which urged the Disarmament commission to give priority to six main provisions of a proposal submitted by the western powers in Aug. 1957: (1) immediate suspension of nuclear weapons tests with effective international control; (2) the cessation of production of fissionable materials for weapons; (3) the reduction of stocks; (4) reduction of nonatomic armaments and armed forces; (5) aerial and ground inspection to guard against surprise attacks; and (6) joint study of an inspection system designed to insure that sending of objects into outer space would be exclusively for peaceful and scientific purposes. The assembly also called upon the Disarmament commission and the secretary-general to co-operate in a world-wide publicity campaign on the need for a disarmament agreement with effective controls. (See also DISARMAMENT.)

Peaceful Use of Atomic Energy.—In Dec. 1953, in an address to the general assembly, Pres. Dwight D. Eisenhower offered a new approach to the question of atomic energy, proposing the establishment of an international agency to further the peaceful use of atomic energy. At its ninth session the general assembly, by unanimous vote on Dec. 4. 1954, expressed the hope that "the International Atomic Energy agency will be established without delay," and decided that an international technical conference should be held to explore the peaceful uses of atomic energy. The conference met in Geneva, Switz., Aug. 8–20. 1955, with delegates from 60 members and 23 other states participating. After preliminary work by a limited number of members a conference to draft a statute for the proposed new agency met in Sept. 1956 in New York. The statute for the International Atomic Energy agency was approved on Oct. 23 by the 82 states represented at the conference and went into effect July 29, 1957.

Holding of a Review Conference.—Under art. 109 of the charter, the question of holding a review conference was placed on the agenda of the general assembly at its tenth session. At its eighth session in 1953 the assembly had anticipated the need of advance preparations if a conference should be held and had directed the secretary-general to prepare certain documents, including a Repertory of Practice of *United Nations* Organs The assembly decided that a general conference to review the charter should be held at an appropriate time and that a committee consisting of all members of the United Nations should consider, in consultation with the secretary-general, the time, place, organization and procedures of the conference, and that the committee should report in two years. The assembly in 1957 voted to continue this committee and charged it to make a report with recommendations, not later than the 1959 session.

DEVELOPMENT OF INTERNATIONAL LAW

In Nov. 1947 the general assembly established the International Law commission of 15 members to make recommendations for the progressive development of international law and its codification. In setting up the commission, the assembly directed it to formulate the principles of international law recognized at the Nürnberg trial of Nazi war criminals and to prepare a draft code of offenses against the peace and security of mankind.

In 1950 the commission submitted its formulation of the Nürnberg principles, which covered crimes against the peace, war crimes and crimes against humanity. The commission presented to the assembly in 1951 draft articles on offenses against the peace and security of mankind, which enumerated 12 crimes against international law, including any act of aggression, threat of or preparation for aggression. annexation of territory and genocide. The commission prepared a draft declaration on the rights and duties of states which it had submitted to the assembly in 1949.

The commission made studies of the possibility of codifying certain branches of international law, giving priority to the law of treaties and the law of the sea. Also. it prepared a study on the legal aspects of reservations to multilateral conventions. Draft conventions were prepared on statelessness, the peaceful settlement of disputes and the law of the sea. The commission was also concerned about the subjects of arbitral procedure. offenses against the peace and security of mankind. and international criminal jurisdiction. A conference to consider two draft conventions on statelessness and one to consider the Law of the Sea were called to meet in 1958.

The UN made considerable effort to arrive at an acceptable definition of aggression. The League of Nations, the San Francisco conference, the International Law commission and special committees set up by the assembly failed to reach an agreement on a definition of aggression. 4 minority of states opposed attempting a definition chiefly on the ground that it could never be made completely comprehensive. The majority wanting a definition were divided over the form it should take; that is, whether it should be a general definition or a list of acts that constitute aggression. Failure to reach agreement on the definition of aggression delayed progress on the drafting of certain conventions. (See HUMAN RIGHTS; SELF-DETERMINATION.)

ECONOMIC AND SOCIAL CO-OPERATION

A major purpose of the United Nations is "to achieve international co-operation in solving international problems of an economic, social, cultural, or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms for all without distinction as to race, sex, language, or religion." The general assembly, the Economic and Social council, along with the council's commissions, the secretariat and the specialized agencies are the organs primarily responsible for action in this field. An important part of the United Nations activity consists of research, publication and the rendering of technical assistance to governments. The United Nations has no authority to legislate or to enforce measures of economic and social co-operation; it can only make recommendations which the member governments may or may not follow.

The Specialized Agencies.—Those who drafted the United Nations charter believed that many areas of econom c and social co-operation, while requiring an intergovernmental approach, could be more effectively covered by relatively autonomous functional organizations. Consequently, it was assumed that international co-operation in this field would find expression in a great variety of intergovernmental organizations. Of these. those with "wide international responsibilities" were to be brought into relation with the United Nations as specialized agencies. The charter provided that the general assembly and the Economic and Social council should undertake to co-ordinate the policies and activities of the specialized agencies. The general assembly may review and make recommendations subject to the administrative budget of an agency; both the assembly and the Economic and Social council map make recommendations with respect to program. Each specialized agency in fact concluded an agreement with the United Nations defining in general terms its relation to the latter.

The general structure of each specialized agency follo s a common pattern. There is provision for a general conference in which all members are represented. The conference elects an executive body which is charged with initiating proposals and carrying out decisions of the general conference. Each agency has a permanent secretariat, headed by a director. Many agencies have regional subcommissions operating in various parts of the world. Some of the specialized agencies were in existence before the United Nations was organized, some were in process of establishment during World War II and some agencies were organized under the auspices of the UN.

(For those agencies in operation in the late 1950s *see:* INTERNATIONAL LABOUR ORGANIZATION, THE; FOOD AKD AGRICULTURE ORGANIZATION; UNITED NATIONS EDUCATIONAL. SCIENTIFIC AND CULTURAL ORGASIZATION; INTERNATIONAL CIVIL AVIATION ORGANIZATION; BAKK FOR RECONSTRUCTION AND DEVELOPMENT. INTERNATIONAL; INTERNATIONAL MONETARY FUND; WORLD HEALTH ORGANIZATION; UNIVERSAL POSTAL UNION. For International Telecommunication union and World Meteorological organization *see* RADIO and METEOROLOGICAL SOCIETIES.)

Economic Reconstruction. — 'The devastation of large areas during World War II, and the dislocation of normal economic relations resulted in the need of concerted measures of relief, rehabilitation and reconstruction. The United Nations Relief and Rehabilitation administration, established in 1943, did much to alleviate the situation. To assist in dealing with special regional problems in Europe and the far east, the Economic and Social council established in 1946 the Economic Commission for Europe and the Economic Commission for Asia and the Far East. Particularly after 1947, the Economic Commission for Europe was hampered in its work by the "cold war"; notwithstanding, it provided a useful means of contact between European countries in dealing with their common problems. When war produced a similar need in Korea, the general assembly created the United Nations Korean Reconstruction agency to assist in the rehabilitation and reconstruction of that part of Korea accessible to it.

Technical Assistance. — A modest program of technical assistance was undertaken at an early stage. World attention became centred on the problem with the announcement of Pres. Harry S. Truman's Point Four program. The expanded program for technical assistance was approved by the general assembly in 1949. It was undertaken with a view to raising the standard of living and promoting economic assistance to underdeveloped areas.

Aside from the Technical Assistance administration, a branch of the secretariat, there are two other United Nations agencies with responsibilities in connection with the implementation of this program. The Technical Assistance board, composed of the secretary-general of the United Nations and the executive heads of the participating specialized agencies or their representatives, coordinates operations under the program and makes recommendations on proposed projects to the Technical Assistance committee. The committee, consisting of the members of the Economic and Social council, acts on the recommendations of the board and reviews the working relationships between the co-operating organizations.

The expanded program of technical assistance is financed by voluntary contributions from members. Pledges are made at an annual conference of members. At the seventh conference. 63 countries pledged more than $29,000,000 for the 1957 program, an increase over previous plrdges both in the number of countries participating and the total amount pledged. During the previous six years, $142,000,000 had been contributed.

In its ninth session in 1954 the general assembly approved a new procedure for the adoption of programs and the allocation of funds which was subsequently Introduced. This procedure provides for the development of programs on a country basis ii stead of on the basis of a fixed percentage of the available funds being allotted to each organization. It emphasized the responsibility of the recipient country for establishing priorities in drawing up its proposed program. and placed increased responsibility for coordination on the Technical Assistance board's resident representative in the recipient country.

Financing Economic **Development.**—The United Nations has given a great deal of consideration to ways and means of making capital available to underdeveloped countries for financing projects which are not self-liquidating or which do not meet the requirements of the International ("World") bank for loans. In 1954 the general assembly recommended that both capital-importing and capital-exporting countries examine their policies and practices with a view to encouraging the flow of private capital. In April 1955 the bank submitted to its members the draft charter of the International Finance corporation to come into operation as soon as ratified by 30 states and as soon as 75% of $100,000,000 capital had been subscribed. The corporation was to make direct loans to private enterprise without government guarantees and was to be allowed to make loans for other than fixed returns. The charter entered into force on July 20. 1956. To assist in the financing of nonself-liquidating development projects a proposal was submitted to the general assembly for a Special United Nations Fund for Economic Development (SUNFED). The proposal was considered by the tenth assembly but final action was deferred pending further study by governments and a special committee. The 12th assembly unanimously adopted a resolution to set up a separate fund to provide systematic assistance in fields essential to technical, economic and social development of less developed countries.

Refugees. — The International Refugee organization, a specialized agency which was established in 1946 and terminated its activities in 1952, took over the refugee functions of the United Nations Relief and Rehabiiitation administration which expired in 1947. The IRO was successful in resettling. repatriating. transporting and maintaining more than 1,000.000 European refugees. Since the IRO was conceived as a short-term emergency organization. a new refugee structure alas devised in 1951. A United Nations high commissioner for refugees was appointed and was directed to act under the Convention Relating to the Status of Refugees, which was drawn up by the Economic and Social council and approved by the general assembly in 1951. An Advisory Committee on Refugees was appointed by the council in 1951 to assist the high commissioner. The assembly in 1957 voted to continue the office of UN high commissioner for refugees for five years from Jan. 1959, appealed to member governments to aid Chinese refugees in Hongkong and urged them to meet the critical need for funds for Arab refugees. (See also REFUGEES).

Human Rights. — The general assembly in 1948 adopted the Universal Declaration of Human Rights. which was prepared by the Commission on Human Rights. In 1948 the commission began to draft a Covenant of Human Rights which. upon ratification by governments, would become legally binding upon them, Wide differences in economic and social philosophies hampered efforts to achieve agreement on a common text. but finally a Draft Covenant on Economic. Social and Cultural Rights and a Draft Covenant on Political and Civil Rights were completed'in 1954 and submitted to the ninth general assembly for its consideration. In the general field of human rights. the assembly also concerned itself with discrimination against Indian nationals in the Union of South Africa and the violations of civil-rights provisions of peace treaties by Hungary. Rumania and Bulgaria.

Control of Narcotics. — The Commission on Narcotic Drugs was authorized by the assembly in 1946 to carry out the functions entrusted by international conventions to the League of Nations Advisory Committee on Traffic in Opium and Other Dangerous Drugs. The agreements, conventions and protocols on the control of narcotic drugs concluded in 1912, 192j, 1931 and 1936 were amended in a draft protocol which was approved by the assembly in Nov. 1946 and subsequently came into force among its signatories. In addition to re-establishing the pre-World War II systrm of narcotics control, which had sufiered from the dislocations of the war. the UN concerned itself with new problems resulting from the development of synthetic drugs. Efforts were made to simplify the system of control by drafting one convention incorporating the provisions of all agreements in force.

Other Activities. — The United Nations has rendered an invaluable service in the economic and social field by publishing carefully prepared information, statistical data and surveys of recent developiiients in the economic and social fields. Among the more significant of its publications are :he *World Economic Report*, the *Statistical Yearbook*, the *Demographic Yearbook* and the *Yearbook on Human Rights.*

The general assembly established the United Nations International Children's Emergency fund !later styled the UN Children's fund but still officially called UNICEF) in Dec. 1946. to provide for the emergency needs of children in devastated areas. Financed by contributions from member states; UNICEF has neen effective in sustaining basic nutritional requirements for destitute children in more than 50 countries, preventing such communicable diseases as tuberculosis, whooping cough and diphtheria and providing for children's clothing and other needs. In 1953 it was made a permanent organization.

In addition to matters specifically mentioned above. the United Nations has been concerned with such questions as freedom of information. the status of women. genocide and social policy.

DEPENDENT AREAS

On two different levels. the United Kations maintains concern for people residing in nonself-governing territories: (1) under principles and procedures developed for making administering states internationally accountable for the treatment of their nonself-governing territories; and (2) under the United Nations trusteeship system applicable to certain territories placed under it.

Nonself-Governing Territories.--Under art. 73 of the charter. members of the United Nations with responsibilities for the administration of nonself-governing territories agreed to grant the people of such territories political, economic. social and educational advancement. just treatment and protection against abuses; to develop self-government; to further international peace and security; to promote constructive measures of development; and to transmit to the secretary-general information of a technical nature concerning the economic, social and educational conditions in their territories. In 1947 the general assembly created the Special Committee on Information Transmitted under Article 73e of the Charter to receive and analyze information on these territories and to make recommendations to the administering authorities on the basis of information received. An attempt to give the committee permanent status failed. In 1949 it was given a three-year term which was extended for a similar period in 1952 and 1955. In 1952 its name was changed to Committee on Information from Non-Self-Governing Territories.

Attempts of the Committee on Information to obtain political information on their territories from the sdministering states met with resistance. Only Australia, the Netherlands, New Zealand and the United States transmitted such information, the other administering states contending that the charter did not require the transmission of political information.

There was considerable controversy over the determination of the territories which were nonself-governing and when they ceased to be such. France soon ceased to transmit information on a number of territories on the ground that they had either become self-governing or had become an integral part of France. Later Great Britain ceased to send information on Malta and Ghana, the United States on the Panama Canal zone and Puerto Rico, Denmark on Greenland and the Netherlands on Surinam and the Antilles. Administering states claimed the sole right to decide whether art. 73(e) did or did not apply to one of their territories but this position was challenged by the assembly which in 1952 adopted a resolution containing a list of factors to serve as a guide in deciding whether a territory has obtained a full measure of self-government.

The general assembly placed emphasis on economic development. raising standards of nutrition and health, and land reform in nonself-governing territories. Furthermore, the assembly encouraged the administering authorities to co-operate with nongovernmental organizations and the specialized agencies in meeting the United Nations' objectives under art. 73. A notable achievement in this respect was the conclusion of an agreement in 1951 between the United Kingdom and the United Nations Technical Assistance board nhich provided for the application of the technical assistance program to dependent areas under British administration.

Trusteeship System. — For a discussion of the UN trusteeship systern, successor to the League of Nations mandate system of supervision of nonself-governing territories, see TRUSTEESHIP SYSTEM.

ADMINISTRATION AND FINANCE

Personnel. — The secretariat of the United Nations, serving under the secretary-general. is part of the United Nations machinery influencing the day-to-day work of the organization to a degree which the words of the charter would not indicate. The extent of this influence is in large measure a result of the fact that the secretariat memhers are permanent expert officials. The secretariat staff is recruited on a merit basis but with regard to equitable geographical distribution. Members of the organization are required to take an oath of loyalty to the United Nations and are not permitted to receive instruction from member governments. The staff of United Nations headquarters at the beginning of 1955 numbered approximately 3,200, with about 1,500 other members located in Geneva and other parts of the world In Nov. 1949 the general assembly established a United Nations Administrative tribunal to hear and pass on alleged violations of staff contracts and other conditions of employment in the secretariat.

A United Nations Field service and a United Nations Panel of Field Observers were organized by the assembly in 1949. The Field service performs security functions for United Nations missions in many parts of the world, and the Panel of Field Observers assists the various missions in supervising truces and observing plebiscites. Both are under the secretary-general,

Finance. — The secretary-general must submit an annual budget including estimated expenditures to the general assembly for approval. The United Nations' annual budget began at $19,390,000 for 1946, rose to $49,869,450 for 1953 and then declined slightly. The budget for 1958 was $jj.062 850.

The charter stipulates that the expenses of the organization shall be borne by members as apportioned by the general assembly. The Committee on Contributions prepares a scale of assessments for each member, based on the general economic level and capacity of each state, which is submitted to the general assembly for approval. The United States is the largest contributor, but a few members make a larger per capita contribution. The U.S. assessment began at 49% of the total but at the request of the United States government was steadily reduced until in 1958 it was 32 51%. The large increase in membership in 1955 dnd 1956 made possible a reduction in contributions of a majority of members.

Privileges and **Immunities.**—A General Convention on Frivileges and Immunitics of the United Kations approved by the general assembly in Feb. 1946 asserted that the UN possesses juridical personality. It provides for such matters as the immunity from legal process of the property and assets of the United Nations and for the privileges and immunities of the representatives of members, officials of the United Nations and experts on missions of the organization. A headquarters agreement between the UN and the United States was signed in June 1947, defining the privileges and immunities of the United Nations headquarters in New York city.

Headquartem--The general assembly decided during the second part of its first session in New York to locate its permanent headquarters in that city. John D Rockefeller. Jr., made a gift of land for a building site in Manhattan, and a loan of $65,000,000 from the United States permitted plans to be initiated for the construction of permanent buildings. Temporary headquarters were established at Lake Success on Long Island, N.Y. The permanent Secretariat building was completed and occupied in 1951. The building providing accommodations for the general assembly and the councils was completed and occupied in early 1952.

In 1947 the assembly adopted a United Nations flag. Its design consists of the official emblem of the United Nations in white, centred on a light-blue background. The assembly designated Oct. 24 as United Nations day. (L. M. GH.; A VH.)

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO), a specialized agency of the UN whose purpose is to contribute to peace by promoting co-operation within the fields of education, science and culture. It has its own constitution, member states and budget. In the late 1950s it had 79 member states and an operating annual budget of about $11,000,000. Its permanent headquarters are in Paris.

UNESCO was created as an agency of its member states and it did only what those states specifically authorized through resolutions of the biennial general conference. It is administered by a director-general and an international civil service of approximately 800 persons selected from among most of its member states. Over the director-general is an executive board of 22. representing nations selected by the general conference. Individual members are designated by the member states concerned.

Two special characteristics of UNESCO have been: (1) extensive reliance upon international nongovernmental organizations for carrying out its program; and (2) the constitutional requirement that member states establish national citizen commissions for UNESCO to advise on policy and to encourage citizen participation in activities that flow from UNESCO's purpose and program. The organization's varied field of interest includes the full range of education, science, culture and mass communications, in all of which areas the accomplishments and needs of the member states vary greatly in character and quality.

UNESCO sponsored activities might be classified as follows:

1. Emergency Aid and Reconstruction. — In the first two years after World War II. emergency aid was provided to war-devastated countries, an attempt being made to identify educational and cultural needs and to provide information for private fund-raising agencies. Subsequently, through its gift coupon scheme, UNESCO helped needy libraries, schools and individual scholars overcome financial difficulties in the acquisition abroad of materials requiring "hard" currency payments. UNESCO also helped develop and administer educational facilities for Arab refugees after 1948 and in Korea after 1950.

2. Advancement of Knowledge. — The advancement of knowledge has been encouraged by strengthening international professional nongovernmental organizations in the fields of education, science and culture; by maintaining a clearinghouse for exchange of information about international educational. scientific and cultural developments; by encouraging special publications for scientific abstracts; by maintaining offices in Montevideo, Cairo, New Delhi and Djakarta to stimulate the international exchange of knowledge; by helping maintain centres of social science research in Calcutta, Rio de Janeiro and Cologne; and by aiding the development of free public libraries. Other major contributions by UNESCO were the successful drafting of the Universal Copyright convention and a Convention for the Importation of Educational. Scientific and Cultural Materials.

3. Promotion of Human Welfare. — In the broad category of human nelfare activities the best-known activity is UNESCO's fundamental education program serving especially economically less developed countries and financed in part by UNESCO's normal budget and In part through the United Nations Expanded Technical Assistance program. In many countries UNESCO aided extension of free and compulsory education and the strengthening of secondary and higher education. A Center for Nuclear Research was established with UNESCO initiative in Geneva as was an International Computation centre in Rome. UNESCO encouraged basic research in cell biology, on ways of making arid and humid zones more inhabitable and productive and on the social impact of technological change.

4. International Understanding. — Furthering international understanding in many respects is the area in which the greatest need exists but it is most difficult to accomplish by direct means. Exchanges of persons are arranged. UNESCO's publication *Study Abroad* is the most comprehensive index to foreign study opportunities. Seminars of teachers on teaching methods produced limited results; a preparation for multivolume *A Scientific and Cultural History of Mankind* was begun; co-operative reviews of textbooks by teachers of different countries were undertaken on a very small scale with a view to removing national bias; research nas promoted on differences of national character, problems of immigrants and race relations; and there was a small effort to promote support for the United Nations. After 1956 a major project nas to increase understanding between Asian and western countries. Although the direct efforts to promote international understanding were modest and largely exploratory, UNESCO's other activities indirectly contributed to greater understanding by producing greater objective knowledge of each other among members.

Those western countries which were responsible for the creation of UNESCO supported only a modest program and budget and did not see a major role for UNESCO in lessening the tensions that kept nations after World War II preoccupied with fear of war. By contrast, newly developing countries of south and southeast Asia, the middle east, Africa and Latin America generally welcomed the opportunities provided by UNESCO for nations to meet on a basis of equality, irrespective of military and economic power, to discuss and to authorize assistance in developing economic, scientific and cultural resources.

See Walter *H. C.* Laves and Charles **A.** Thornson, ***UNESCO — Purpose, Progress, Prospects*** (1957). *See* also the numerous official publications of UNESCO. (W. H. C. **L.**)

UNITED NATIONS RELIEF AND REHABILITATION ADMINISTRATION (UNRRA), the administrative body for an extensive social welfare program under the UN, was created at a ceremony presided over by Pres. Franklin D. Roosevelt at the White House on Nov. 9, 1943, when the international agreement was signed by 44 nations.

UNRRA's operations concentrated primarily on assisting those war-ravaged nations in the greatest need and without resources to finance their own relief imports. The assistance consisted of relief supplies — food, clothing, fuel, shelter, medicines; relief services, with trained personnel; and agricultural and industrial rehabilitation supplies and services needed to strengthen the economy of the war-torn countries. In addition, UNRRA also provided camps, personnel and food for the repatriation or care of millions of the war's displaced persons.

UNRRA operated in about 25 countries and served the needs of more than 1,000,000,000 people whose countries had been occupied or ravaged by the war. It administered the largest peacetime shipping business in history and sent abroad 25,000,000 long tons of relief and rehabilitation supplies. The value of the goods and services furnished was nearly $4,000,000,000, and its staff at its peak numbered nearly 25,000 persons. UNRRA rigidly adhered to a policy of "helping people to help themselves." The principal supplies shipped are shown in Table **I.**

All member nations not invaded during World War II were asked to contribute 1% of their national income for the fiscal year ending June 30, 1943. The three largest contributors were the United States ($2,700,000,000), the United Kingdom ($624,650,000) and Canada ($138,738,000). The first director-general, elected by the unanimous vote of all the member nations, was Herbert H. Lehman, who served from Nov. 11, 1943, until he resigned on March 28, 1946. The second director-general was Fiorello H. LaGuardia, who was succeeded in Dec. 1946 by Maj. Gen. Lowell W. Rooks.

Missions to aid relief programs in Europe mere closed on June 30, 1947. Many of the activities carried on by UNKRA, but

TABLE I.—*Total Shipments Summary by Recipient Countries and Commodity Divisions** (gross long tons)

Commodity programs	Total	Food	Clothing, textiles, footwear	Medical and sanitation	Agricultural rehabilitation	Industrial rehabilitation	Take overs from military
Grand total all commodity programs	24,106,891	9,131,030	626,293	134,537	2,314,363	11,290,558	610,110
Subtotal for country programs	23,938,493	9,109,086	535,807	133,797	2,313,957	11,282,686	563,160
Albania	130,048	70,199	2,727	2,019	19,857	32,571	2,675
Austria	1,114,461	623,568	4,165	1,619	168,780	132,790	183,539
Byelorussian S.S.R.	141,853	101,396	5,784	646	8,050	25,977	—
China	2,360,915	1,091,617	169,339	41,024	395,014	663,921	—
Czechoslovakia	1,619,627	767,211	44,048	11,901	410,593	385,874	—
Dodecanese Islands	33,122	10,109	194	9	682	4,358	17,770
Ethiopia	1,551	11	†	631	831	78	—
Finland	5,623	1,681	407	36	2,785	714	—
Greece	2,830,138	1,536,710	28,485	8,628	363,176	664,428	228,711
Hungary	19,127	18,140	274	471	—	242	—
Italy	10,225,450	2,165,004	92,203	10,672	172,211	7,785,060	300
Korea	6,424	—	251	98	487	5,588	—
Philippines	47,160	42,306	560	310	3,527	457	—
Poland	2,241,889	1,164,883	82,084	33,826	495,052	466,044	—
San Marino	260	197	—	48	—	15	—
Ukrainian S.S.R.	467,049	315,748	16,225	1,837	38,069	95,970	—
Yugoslavia	2,693,796	1,200,306	89,061	20,822	234,843	1,01[illegible]	130,165
Subtotal for special programs	168,398	21,944	90,486	740	406	7,872	46,950
Displaced persons, China	8,633	8,170	412	50	—	1	—
Displaced persons, Germany	12,453	5,046	1,034	389	406	5,578	—
Drives, contributions of clothing and food	94,963	6,415	88,548	—	—	—	—
Mediterranean and North African camps	47,891	405	170	21	—	345	46,950
Northwest Europe emergency program	4,458	1,908	322	280	—	1,948	—

*Figures do not include supplies procured locally. †Less than one ton.

not yet completed, were turned over to the International Refugee organization (IRO) (*q.v.*), the United Nations International Children's Emergency fund (UNICEF) and the World Health organizations (WHO) (*q.v.*).

See REFUGEES; see also Index references under "United Nations Relief and Rehabilitation Administration" in the Index volume. (H. H. L.)

UNITED PRESBYTERIAN CHURCH (of Scotland). This Presbyterian organization, merged since 1900 in the United Free Church of Scotland, was formed in 1847 by the union of the United Secession and Relief Churches The general causes which led to the first great secession from the Church of Scotland. as by law established in 1688, are indicated in the article SCOTLAND, CHURCH OF Its immediate occasion rose out of an act of assembly of 1732. which abolished the last remnant of popular election by enacting that, in cases where patrons might neglect or decline to exercise their right of presentation the minister was to be chosen, not by the congregation, but only by the elders and Protestant heritors.

The act itself had been passed by the assembly, although the presbyteries to which it had been previously submitted as an overture had disapproved of it by a large majority; and in accordance with a previous act (1730), which had taken away even the right of complaint, the protests of the dissentient majority were rejected. The protests however were vigorously renewed by Ebenezer Erskine, minister of Stirling He was soon joined by other ministers. who in Dec. 1733 constituted themselves into a presbytery, disowning the authority of the general assembly. The members of the Associate Presbytery and its adherents steadily increased. until in 1745 there were 45 congregations under its jurisdiction, and it was reconstituted into an associate synod. A violent controversy respecting the religious clause of the oath taken by burgesses in Edinburgh. Glasgow and Perth ("I profess and allow with my heart the true religion presently professed within this realm and authorized by the laws thereof"), resulted in April 1747 in a breach, when two bodies were formed. each claiming to be the Associate Synod; those who condemned the swearing of the burgess oath as sinful came to be popularly known as "Anti-burghers," while the other party, who contended that abstinence from it should not be made a term of communion, were designated "Burghers."

The Associate (Anti-burgher) Synod held its first meeting in Edinburgh on April 10, 1747. It grew with considerable rapidity, and for purposes of organization was formed into four provincial synods, and took the name of the General Associate Synod. The Associate (Rurgher) Synod held its first meeting at Stirling on June 16, 1747. The number of congregations under its charge also increased; and in 1820 the General Associate or Anti-burgher Synod (to the number of 129 congregations) united with the 154 congregations of the Associate or Burgher Synod. The body thus constituted, the United Secession Church, increased by 1847 to 400 congregations.

In 1847 a union was formed between all the congregations of the United Secession Church and 118 of 136 Relief Churches, in what became the United Presbyterian Church. Doctrinally there was little difference between the United Presbyterian Church and the Free Church of Scotland, and in 1863–73 negotiations were carried on for a union, which were fruitless.

In 1896 the United Presbyterian Church again made advances and on Oct. 31, 1900, the United Free Church of Scotland was horn.

See also UNITED FREE CHURCH OF SCOTLAND.

UNITED PRESS INTERNATIONAL: see NEWS AGENCY.

UNITED STATES (OF AMERICA), the foremost nation of the western hemisphere in population and resources, composed of 50 states joined in a federal republic. The first official use of the name United States of America was in the Declaration of Independence: a facsimile of which is included in this article under that title. The name is usually abbreviated informally to "the United States."

The character of national institutions was molded largely by the pioneering spirit, which left a lasting imprint. (See AMERICAN FROSTIER. THE.) Another shaping factor was immigration, which had passed the 35.000.000 mark before the adoption of the quota system in 1921. The motives that brought the immigrants were similar to those of the early settlers, and widely varied ethnic strains have contributed to the formation of a distinctive national culture. (See Growfh *of the Nation* in *Population,* below; see also. MIGRATION: Migvation to *the* United States.)

The block of 48 states extending from the Atlantic to the Pacific is in the temperate zone. but within this area there are wide variations of regional climate. A unique degree of diversity has been attained in both agriculture and industry. Reports by U.S. department of agriculture experts have divided the country into more than 500 type-of-farming areas; such classifications, however, are subject to rapid obsolescence as regional production is adapted to new agricultural patterns and to shifts of population.

Isolation from European affairs, made possible by the approximately 3.000 mi. of the Atlantic ocean separating the east coast states from Europe, was an important factor in the nation's early development. The decline of this tradition after World War II is illustrated by the establishment of the headquarters of the United Nations in New York city. In the economic sphere, the nation is still much less affected than those of Europe by international trends; in the 1960s foreign commerce, though of great volume and of key importance to some industries, amounted to only a small percentage of national income. (See *Foreign Commerce,* below.)

The block of 48 states forms a broad belt across the North American continent, from approximately latitude 24' 30' to 49° N., and longitude 66° 57' to 124° 45' W. On the north it is bordered by Canada, the boundary in the west being an arbitrary line at the 49th parallel and in the east largely a natural one formed by the Great Lakes. The eastern half of the southern boundary is naturally defined by the Gulf of Mexico, but in the west the nation is separated from Mexico by an oblique line following first the Rio Grande river and continuing afterward generally west-northwest across the highlands to the Pacific ocean.

The west-coast states of Washington, Oregon and California are separated from the oriental nations of the far east by 5,000 to

6,000 mi., but Hawaii (*q.v.*), which became the 50th state in 1959, is situated approximately midway. Alaska (*q.v.*), which became the 49th state the same year, occupies the northwestern end of the North American continent and the adjacent islands. extending northward into the Arctic circle and westward beyond the 180th meridian. The distance from Alaska's southern continental boundary—the long, narrow coastal strip known as the Panhandle—to the northwestern tip of the state of Washington is approximately 500 mi. A more practical gauge of the distance from its sister states is the fact that about 1,200 mi. of the Alaska highway are on Canadian soil. (*See* YUKON TERRITORY.) In contrast, Alaska is separated from Soviet Siberia by only about 50 mi. of the Bering strait at the nearest mainland point, and about 2½ mi. between the U.S. and Soviet Diomede Islands.

Each of the 50 states is theoretically sovereign, joined to the others by a federal government to which the original 13 states delegated certain powers as outlined in the federal constitution adopted in 1787 and put in force in 1789. The total area of the nation is 3,615,208 sq.mi. Its population in 1960 was 179,323,175. Outlying possessions with a total area of 5,798 sq.mi. had a population in 1960 of about 3,445,000.

An individual article is devoted to each state and dependency. Also, regions of conterminous United States (the 48 states not including Alaska and Hawaii) are discussed in the following articles: MIDDLE WEST, THE; NEW ENGLAND; NORTH, THE; SOUTH, THE; and WEST, THE. (See also NORTH AMERICA.) A selected bibliography appears at the end of the article.

The article which follows is divided into these sections:

I. PHYSICAL GEOGRAPHY

The following description of the physical geography of the United States deals with conterminous U.S., the 48 contiguous states stretching in a broad band across the North American continent and therefore presenting certain unifying features of geologic history. physiographic structure, climate and natural life. For the physical geography of Alaska and Hawaii, see the separate articles on those states.

A. GEOLOGY AND STRUCTURE

The surface of North America, like that of all continents stands two to three miles above adjacent ocean floors and apparently has so stood during the more than 4,000,000,000 years of its known geologic history. Variations from time to time in ocean-basin capacity. in oceanic volume and in relief of the continent's surface have, however, produced great variations in the amount of continental surface emerging as land above ocean levels. Shallow seas comparable to Hudson bay (average depth 420 ft.) have repeatedly spread over large fractions of the North American continental platform, leaving their record in limestone, shale and sandstone sediments with entombed remains of the marine life of the time. Repeatedly, also, these shallow, marine floodings have been withdrawn and the destructive processes of weathering and erosion from exposure to the atmosphere have attacked the land areas, destroying part of the earlier sedimentary record. Thus marine deposits made during the next time of flooding have come to lie unconformably on the eroded surfaces of older deposits, the unconformity being essentially the land surface at the close of the intervening time of emergence. Elsewhere. large areas remained above sea level and experienced only erosion while the marine transgressions were occurring.

None of the marine submergences exactly duplicated any other, yet the deciphered history shows that the continent possessed certain recurring lineaments, the invading seas early taking possession of linear tracts (geosynclines) subparallel to the eastern, western and southern continental margins and lingering there when marine withdrawals were occurring. Other negative areas (epicontinental, epeiric shelf) were more briefly inundated and certain tracts (shields, geanticlines, positive areas, cratons) repeatedly, although not invariably, escaped even the maximum floodings.

These alternating experiences of the continental surface, largely constructional when beneath epicontinental or geosynclinal seas and largely destructional when exposed to the atmosphere, constitute the framework of its geologic history. The correlation of successive similar events in widely separated regions is possible because of the concomitant progressive evolutionary changes which the embedded fossils, chiefly marine invertebrates, in the sedi-

Table **I.—Area** *and Population of the United States*

State	Area					Population				
	Total *	Land †	Inland water ‡	Territorial waters §	Rank ‖	1960 Census	Rank	Density per sq. mi.¶	% of increase over 1950	Electoral votes
United States	3,615,208	3,548,913	66,295	78,281	—	179,323,175	—	49.6	18.5	538
Alabama	51,609	51,060	549	144	29	3,266,740	19	63.3	6.7	10
Alaska	586,400	571,065	15,335	...	1	226,167	50	0.4	75.8	3
Arizona	113,909	113,575	334	—	6	1,302,161	35	11.4	73.7	5
Arkansas	53,104	52,499	605	—	27	1,786,222	31	33.6	—6.5	6
California	158,693	156,573	2,120	3,638	3	15,717,204	2	99.0	48.5	40
Colorado	104,247	103,884	363	—	8	1,753,947	33	16.8	32.4	6
Connecticut	5,009	4,899	110	18	48	2,535,234	25	506.1	26.3	8
Delaware	2,057	1,978	79	76	49	446,292	46	217.0	40.3	3
District of Columbia	69	61	8	—	—	763,956	—	11,071.8	—4.8	3
Florida	58,560	54,252	4,308	4,124	22	4,951,560	10	84.6	78.7	14
Georgia	58,876	58,274	602	289	21	3,943,116	16	67.0	14.5	12
Hawaii	6,421	6,412	9	...	47	632,772	43	98.5	26.6	4
Idaho	83,557	82,708	849	—	13	667,191	42	8.0	13.3	4
Illinois	56,400	55,930	470	1,526	24	10,081,158	4	178.7	15.7	26
Indiana	36,291	36,185	106	228	38	4,662,498	11	128.5	18.5	13
Iowa	56,290	56,032	258	—	25	2,757,537	24	49.0	5.2	9
Kansas	82,264	82,048	216	—	14	2,178,611	28	26.5	14.3	7
Kentucky	40,395	39,863	532	—	37	3,038,156	22	75.2	3.2	9
Louisiana	48,523	45,106	3,417	1,752	31	3,257,022	20	67.1	21.4	10
Maine	33,215	31,012	2,203	1,016	39	969,265	36	29.2	6.1	4
Maryland	10,577	9,874	703	83	42	3,100,689	21	293.2	32.3	10
Massachusetts	8,257	7,867	390	953	45	5,148,578	9	623.5	9.8	14
Michigan	58,216	57,019	1,197	38,575	23	7,823,194	7	134.4	22.8	21
Minnesota	84,068	80,009	4,059	2,212	12	3,413,864	18	40.6	14.5	10
Mississippi	47,716	47,223	493	122	32	2,178,141	29	45.6	—0.0	7
Missouri	69,686	69,138	548	—	19	4,319,813	13	62.0	9.2	13
Montana	147,138	145,736	1,402	—	4	674,767	41	4.6	14.2	4
Nebraska	77,227	76,612	615	—	15	1,411,330	34	18.3	6.5	5
Nevada	110,540	109,788	752	—	7	285,278	49	2.6	78.2	3
New Hampshire	9,304	9,014	290	—	44	606,921	45	65.2	13.8	4
New Jersey	7,836	7,521	315	362	46	6,066,782	8	774.2	25.5	17
New Mexico	121,666	121,510	156	—	5	951,023	37	7.8	39.6	4
New York	49,576	47,939	1,637	3,969	30	16,782,304	1	338.5	13.2	43
North Carolina	52,712	49,067	3,645	856	28	4,556,155	12	86.4	12.2	13
North Dakota	70,665	69,457	1,208	—	17	632,446	44	8.9	2.1	4
Ohio	41,222	40,972	250	3,457	35	9,706,397	5	235.5	22.1	26
Oklahoma	69,919	68,887	1,032	—	18	2,328,284	27	33.3	4.3	8
Oregon	96,981	96,248	733	945	10	1,768,687	32	18.2	16.3	6
Pennsylvania	45,333	45,007	326	735	33	11,319,366	3	249.7	7.8	29
Rhode Island	1,214	1,058	156	193	50	859,488	39	708.0	8.5	4
South Carolina	31,055	30,272	783	526	40	2,382,594	26	76.7	12.5	8
South Dakota	77,047	76,378	669	—	16	680,514	40	8.8	4.3	4
Tennessee	42,244	41,762	482	—	34	3,567,089	17	84.4	8.4	11
Texas	267,339	262,840	4,499	992	2	9,579,677	6	35.8	24.2	25
Utah	84,916	82,339	2,577	—	11	890,627	38	10.5	29.3	4
Vermont	9,609	9,276	333	—	43	389,881	47	40.6	3.2	3
Virginia	40,815	39,780	1,035	310	36	3,966,949	14	97.2	19.5	12
Washington	68,192	66,709	1,483	530	20	2,853,214	23	41.8	19.9	9
West Virginia	24,181	24,079	102	—	41	1,860,421	30	76.9	—7.2	7
Wisconsin	56,154	54,705	1,449	10,062	26	3,951,777	15	70.4	15.1	12
Wyoming	97,914	97,411	503	—	9	330,066	48	3.4	13.6	3

*Total area does not include boundary water. †Land area includes dry land and land temporarily or partially covered by water, streams less than ⅛ mi. in width, and lakes and ponds less than 40 ac. in area. ‡Inland water includes permanent inland water of over 40 ac. in extent, streams over ⅛ mi. in width, coastal waters near islands separated by less than one nautical mile of open water, and islands of less than 40 ac. §Boundary water consists of deep embayments or sounds and other coastal waters lying outside inland water and protected by islands or headlands separated by less than ten nautical miles of open water; and the Great Lakes; other claimed areas not included. ‖Rank excludes boundary water. ¶Density computed on areas exclusive of boundary water.

mentary rocks record.

Based on the stratified sediments and their fossils, on the interrupting unconformities and on evidence for successive times of mountain making (orogeny) and igneous activity, most geologists have adopted a classification of four great eras of earth history, subdivided into about 15 periods. The terms for these divisions of earth history used herein are those commonly accepted in the United States and Canada.

1. Pre-Cambrian Time.—This slightly awkward term springs from two facts. One is that Cambrian sedimentary rocks, the oldest in the record of the succeeding Paleozoic era, are also the oldest rocks with a good record of abundant and varied organisms. Pre-Cambrian rocks have only very rare showings of organic structures. The other fact is that these Pre-Cambrian rocks have been so tremendously disordered and metamorphosed by orogenic movements and so extensively intruded by igneous invasions from below that the number of years actually involved in making them is unknown. In most geological literature two such eras are specified, Archeozoic, or Archean (Early Pre-Cambrian) and Proterozoic (Late Pre-Cambrian), but the distinctions of dominantly igneous origin of the Archeozoic rocks and dominantly sedimentary origin for the Proterozoic rocks has proved in later studies to be inapplicable and the terms are being abandoned.

Theoretically the rocks made during this earliest era of earth history underlie all younger rocks. Large areas also exist where there is no cover of later deposits, either because one was never made or because erosion destroyed any cover once existing. In the United States all exposed Pre-Cambrian rocks belong to the second group and owe their present position to the occurrence of orogenic deformations in later geological time and the inescapable consequence of such uplifts, destructive erosion. Indeed, the largest of these areas, in northern Minnesota, Wisconsin and Michigan, has virtually lost the mountains themselves, only a few residual hills surviving the reduction of former massive ranges to a peneplained area of low relief. Traced northward into Canada, this tract about the west end of Lake Superior broadens into a great expanse of uncovered Pre-

Cambrian rocks, occupying almost all of the province of Quebec, Labrador and most of Manitoba, Ontario, the Northwest Territories and Baffin Island. This, the Canadian shield. is North America's greatest positive area. Some of it may never have been sub merged in any later time; most of it has certainly had but slight and geologically short-lived sedimentary cover.

The Piedmont plateau and Great Smoky mountains. lying west of the Atlantic coastal plain. are portions of a smaller positive area (Appalachia) composed largely of Pre-Cambrian rocks. The Adirondack mountains of New York, the Green mountains of Vermont and the White mountains of New Hampshire are, despite their magnitude as topographic eminences, only the Pre-Cambrian core rock of former ranges whose folded and faulted structures indicate the way such cores have been forced locally higher than the surrounding "basement" rocks Still covered by perhaps a mile of later formations. Small and isolated outcrops of Pre-Cambrian rocks in the central lowlands and Great Plains are the St. Francis mountains of Missouri, the central part of the Black hills of South Dakota, tracts in southwestern Minnesota and adjacent South Dakota, the Wichita and Arbuckle mountains of Oklahoma and the Llano uplift of central Texas. In the Rocky mountain system many ranges possess exposed Pre-Cambrian core rock, the uplift and erosional uncovering of which is in general of later date than in the eastern occurrences noted. Some basin range mountains, particularly in Arizona and adjacent California, are similar in this respect. The mile-deep Grand canyon of the Colorado was cut down into the Pre-Cambrian basement which there is under a thick plateau cover of flat-lying younger rocks.

Most of these ancient rocks have suffered great metamorphic alteration under repeated high compressions and temperatures during past orogenies. Prevailingly, the high-angle foliation of schists and slates, from growth of platy mineral crystals oriented at right angles to the lateral pressures, largely obliterated original stratification and possible organic records. Little success attended attempts at correlation of formations, orogenies and erosion cycles of widely separated regions. Even unraveling the stratigraphic succession in any one region is difficult. The most nearly satisfactory classification is for the Canadian shield where four systems of sedimentary rocks and contemporaneous lava flows were deposited, each time of deposition being terminated by orogenic deformation and associated granitic intrusions, and each orogeny followed by erosion so long continued that the newly made mountains, were virtually wiped off the face of the earth and a peneplain left truncating the profoundly altered roots of those vanished ranges. 'Unconformably on such peneplained surfaces were deposited the sediments of the next following submergence.

Later Pre-Cambrian rocks in the southern part of the Canadian shield record glaciation by an ice sheet nearly 1,000 mi. across. Elsewhere and at other times, aridity seems recorded. Whatever organisms existed, as they assuredly did, were marine aquatic forms. little affected by climates of the land areas. Seaweed vegetation that secreted calcium carbonate is on record. Animals allied to sponges, worms, corals and crustaceans existed but left very few fossil traces, chiefly because of lack of hard parts. Abundant disseminated graphite in some Pre-Cambrian metasedimentary rocks is accepted as derived from organic carbon.

The pre-eminence of the United States in the manufacture of steel is in part the result of the enormous Pre-Cambrian iron ore deposits (altered ferruginous sediments) of the Lake Superior region. The native copper-mining district of the Keweenaw peninsula, in Michigan, is developed in lavas and conglomerates of Late Pre-Cambrian age, the metal having been deposited in cavities by thermal water rising from deep-seated magma bodies.

Pre-Cambrian time was tremendously long. Perhaps three-fourths of all known earth history occurred before the Cambrian seas with their abundant population of marine invertebrates transgressed the continents. Reckoned from the radioactive disintegration of uranium and thorium minerals of the oldest Pre-Cambrian igneous rock studied, their intrusion, cooling and crystallization occurred 2,500,000,000 years ago. And the Pre-Cambrian rock which received the intrusion was already in existence.

2. The Paleozoic Era.—The pattern for North American positive and negative areas for Pre-Cambrian time is known only in fragments and traces. The Paleozoic record. however, is sufficiently well preserved that generalized maps of the land and water areas of the continent may be made, not only for each of the six periods but for different epochs during the advance, the maximum spread and the retreat of each marine flooding. Four persistently positive areas are known. The Canadian shield. nearly 2,000.000 sq.mi. in area, was the largest. It still exists with only Hudson bay submerging a relatively small part of it. Appalachia lay along the Atlantic seaboard. reaching from the Canadian maritime provinces southwestward to Georgia and Alabama and extending an unknown distance eastward beyond the present continental margin. Llanoria lay to the south and largely subsided during later time into the depths of the present Gulf of Mexico. Cascadia, along the Pacific coast, similarly vanished.

Parallel and close to the inner margins of these positive areas lay three geosynclines or repeatedly subsiding troughs, the Appalachian geosyncline where the Appalachian mountains are now, the nearly east-west Ouachita geosyncline across Oklahoma, Texas and northern Mexico and the Cordilleran geosyncline reaching from the Gulf of California northward across Nevada. Utah, Idaho and British Columbia. The thick and relatively coarse detrital sediments deposited in them (now exposed in eroded mountain structures) are in contrast with the much thinner, finer-textured and largely calcareous deposits made contemporaneously in the broad shallow epeiric seas of the continental interior. Obviously. the thick trough fillings of shallow-water deposits record repeated subsidences in the geosynclines as aggradation continued. The coarseness indicates derivation from closely adjacent positive areas. Repeated risings in those land areas, either as mountainous uplifts or broad warpings, are also required to account for the enormous thicknesses of land waste in the trough sediments. The Appalachian geosyncline received from 30,000 to 50,000 ft. of Paleozoic deposits.

Cambrian Period.—During Early Cambrian time, marine overlap on the continent was limited to the Appalachian and Cordilleran geosynclines. By the middle of the period, the sea had spread across the interior also and aquatic forms could pass from the Atlantic to the Pacific. At least 30% of the continent was then below sea level. The dominant limestone and dolomite formations of the Middle Cambrian Age were derived largely from calcareous tests and shells of inconceivable numbers of Middle Cambrian marine invertebrates. Late Cambrian time witnessed a gradual withdrawal of this epicontinental flooding but, for the first time, the Ouachita geosyncline appeared in the history.

This is a generalized statement of events, the like of which were occurring in other continents as well during the approximately 80,000,000 years of Cambrian time. Minor fluctuations of the sea level and warpings of the continent make a more complicated history than can be outlined here. The period was brought to a close by an almost complete emergence of all continents, perhaps because of a deepening of the ocean basins. The newly exposed Cambrian deposits thereupon suffered some erosion before the return of the sea in the next submergence. Because no mountain folding occurred in North America during this emergent interval and therefore erosion could not bite deeply into the new land, most of the Cambrian sediments survived to become buried later beneath Ordovician and younger deposits.

Cambrian time is noteworthy for the spectacular appearance in the fossil record of almost all invertebrate phyla. Evolutionary changes that occurred during the Cambrian provide index fossils, certain species which lived only during the Early, Middle or Late Cambrian. There were even more extinctions of old and appearances of new forms during the interval following the withdrawal of Cambrian waters and preceding the advance of the Ordovician seas.

Ordovician Period.—The relatively shallow epicontinental seas, returning to inaugurate the Ordovician period, first. entered the geosynclinal troughs, later spread from the arctic to the Gulf of Mexico in the greatest submergence the continent has ever had.

The remaining land areas, scarcely half of North America's total area. were low-lying islands which determined the shifting outlines of embayments and supplied detritus. chiefly fine-grained. to their associated basins. Dominantly the basins received organically derived calcium carbonate, hence the large proportion of limestone and dolomite in the record.

Several low domes (Cincinnati-Nashville, Ozark. etc.) with intervening saucerlike basins (Michigan. Illinois) were prominent in the Ordovician paleogeography. The domes (or arches) were repeatedly submerged and emerged, as numerous discontinuities in their stratigraphic sequences show, while the basins were undergoing more nearly continuous sedimentation.

The fossil record tells of different immigrations at different times into the shiiting epeiric seaways from bordering oceans.

Crustal disturbances in northern Appalachia; chiefly during the Late Ordovician, culminated in close folding, thrust faulting, mountainous uplifts and volcanic activity. Interbedding of lava flows and volcanic ash beds (bentonite) with Ordovician marine deposits are part of this record. So are the coarse nonmarine clastics in the nearby Appalachian geosyncline.

Insofar as the deposits tell of climate, there could not have been a zonation like that of the present earth for some coral species ranged in latitude from the southern United States north into arctic Canada and even Greenland. Only wide and equably distributed mild temperatures of the epicontinental waters can account for this.

Ordovician rocks have yielded immense quantities of petroleum and natural gas, in Ohio for a decade or so before 1900 and in Oklahoma and adjacent Texas beginning about 1920. Most roofing slate quarried in the United States comes from metamorphosed Ordovician shales in the northern part of the Appalachian geosyncline. Most decorative marbles of domestic origin are secured from altered Ordovician limestones in the same great trough oi sedimentation. The Illinois-Wisconsin-lowa lead- and zinc-mining district is developed in mid-continent Ordovician sediments; the sulfide ores, however, postdating the host rock.

Duration of the Ordovician period appears to have nearly equaled that of the Cambrian.

Silurian Period.-.—The stratification of most Silurian rocks in the United States parallels that of the subjacent Ordovician formations. But the differences in fossil fauna below and above the contact indicate a considerable time of emergence (a hiatus or lost interval) when the Ordovician marine forms had been forced to retreat to already populated continental margins and were there crowded into intense competition for living room and food. Evolutionary changes in marine life during all such emergences were maximal, both in extinctions and in appearance of new forms.

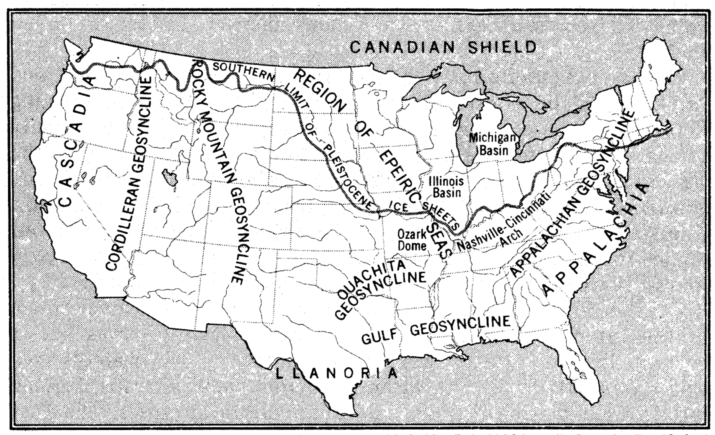
The Silurian record, like the Cambrian and the Ordovician, tells of slow and irregular advance of the sea into the geosynclines and epicontinental areas, interrupted at least twice by emergences suggesting those greater ones which geologists use for delimiting periods. The Early Silurian transgression entered the United States along the Appalachian geosyncline and spread westward across part of the central lowlands and into the Great Plains along the Ouachita trough. By Middle Silurian time, the sea had spread over the Great Lakes region and northward to reach the arctic, actually lapping over on parts of that great positive area, the Canadian shield. In Late Silurian time, restriction and dismemberment of the epicontinental seas left a relict "dead sea" in the Great Lakes region. In it immense quantities of salt were deposited; along with much gypsum and associated marine sediments. This huge evaporation pan must have had a connection with the sea by which it became replenished at intervals with more salt water. By this time, also: the Late Ordovician mountains above noted had been so reduced by erosion that the sea overlapped the disordered strata of their stumps and buried them beneath Late Silurian sediments.

There is scarcely a more striking feature of any Paleozoic period's history than that of the Middle Silurian mid-continent archipelago of coral reefs. Dozens are known in outcrops and quarries of Niagaran (hiid-Silurian) strata in Indiana, Illinois, Iowa, Wisconsin and Canada. Their wide range in latitude indicates the nonzonal character of the Mid-Silurian climate; just as the Late Silurian salt and gypsum record at least a local aridity.

In addition to the great salt reserves, early Middle Silurian rocks along the Appalachian trough contain a sedimentary iron ore, basis of the Birmingham, Ala., iron-mining and steelmaking district.

The 30,000,000 years of Silurian time closed quietly in North America although in high northern iatitudes of all continents, one of the great mountain-making events of earth history occurred. Vulcanism of Late Silurian age occurred in Maine and adjacent Canada.

Devonian Period.—The marine withdrawal and continental emergence, conventionally chosen for subdividing geological time, was incomplete in parts of the Appalachian geosyncline for the Silurian-Devonian interval, sedimentation and a faunal record bridging the gap left elsewhere by the unconformity between the two systems. Indeed. only this trough of sedimentation seems to have gone below sea level during the entire Early Devonian. By



GOODE BASE MAP NO. 209. COPYRIGHT BY THE UNIVERSITY OF CHICAGO. USED BY PERMISSION OF THE UNIVERSITY OF CHICAGO PRESS

FIG. 1.—GEOLOGICAL MAP OF CONTERMINOUS UNITED STATES

the middle of the period, overflow had submerged the Great Lakes region and a much more extensive flooding had advanced southward from the arctic. skirting the Canadian shield and reaching the upper Mississippi valley. It also connected with marine water in the Cordilleran geosyncline and so remained until the end of the period. The eastern and western seas were joined across the continental interior briefly but long enough for mingling oi arctic and low latitude organisms.

By the middle of Devonian time, mountains were again growing in northern Appalachia. the Early Devonian deposits deformed in their making. but the Late Devonian sediments unaffected. The tremendous quantities of coarse waste deposited in the adjacent Appalachian trough testify to the rapid growth of a lofty range.

In the evolution of living forms, the Devonian probably ranks next to the Cambrian in importance for at this time begins the record of life on land and in fresh water. The first known air-breathing vertebrates (Amphibia) and a great variety of primitive fishes appeared. The oldest known land plants, some with trunks 40 ft. long, are buried in Middle Devonian nonmarine deposits of southeastern New York. Favouring climates appear to have prevailed, both on land and on the northern shallow seas.

Mississippian Period.—During the Mississippian, or Lower Carboniferous, Period all the familiar seaways of the continent, excepting the northern part of the Appalachian geosyncline, were occupied, the invasion following the familiar plan of an early possession of the great troughs and a later shallow spreading over the continental interior. The northern Appalachian geosyncline trapped great thicknesses of waste from renewed upbowing of the Middle Devonian mountains but, like most of Late Devonian sedimentation there, the subsiding trough was kept filled above sea level and the deposits were nonmarine. Erosion to the penultimate stage of peneplanation had preceded the Mississippian marine encroachments and the invading seas spread so widely over this lowland that their deposits lie in places on all older systems, even Pre-Cambrian. Apparently Appalachia and Llanoria were one continuous land mass, the sea with its fauna entering from the arctic, Pacific and western Gulf of Mexico. Hundreds of feet of limestones characterized the interior deposits; thousands of feet of more largely clastic rocks were laid down in the troughs adjacent to Llanoria and Appalachia. Either late in Mississippian time or early in the Pennsylvanian period, much crustal unrest occurred in these margining lands and the deformations were extended to sediments in the troughs. Other unrest occurred in the interior. Upper Mississippian formations in Illinois recording eight successive brief withdrawings and returnings of the sea.

Mississippian time, 25.000.000 years long. saw the beginnings of that very extensive swampiness which, for an equal length of time, characterized much of the continent during the following period. Commercial coal of Mississippian age occurs in Virginia. A later mineralization was responsible for the Missouri-Oklahoma-Kansas lead- and zinc-mining district in Mississippian rocks.

Pennsylvanian Period. — Except for mountainous Llanoria and Appalachia, the continent was a great flat lowland in opening Pennsylvanian, or Upper Carboniferous, time. The habitually subsiding geosynclines first went below sea level but only the western one received marine deposits. The other two were filled as rapidly as they sank with waste from their high borderlands. The Appalachian trough also received thick peaty accumulations made in immense swamps and now constituting the Early Pennsylvanian coal beds of West Virginia and Alabama.

By the Middle Pennsylvanian, swamps had spread over much of the interior as well, and the enormous coal reserves of six central lowland states were. being initiated. Repeatedly sea water inundated and was withdrawn from these s amps, leaving interbedded marine deposits and minor unconformities. Farther west Pennsylvanian sediments are chiefly marine.

Orogenic movements occurred in the United States, not only during initial Pennsylvanian stages but at different times and places throughout and at the close of the period. Southern Oklahoma saw a northward thrusting from Llanoria into the Ouachita trough. Southwestern Texas and western Colorado had comparable deformations. These seem to have been forerunners of the enormous lateral squeezings of parts of the continent during the following period. Pronounced orogenies of Late Pennsylvanian and of Permian time occurred in most continents.

The great coal deposits, also made in other continents, bespeak a warm, humid, equable climate for most of the globe. The character of the plants and associated amphibians, insects, spiders and fresh-water clams and snails tells the same story. So do the high-latitude Pennsylvanian corals.

Permian Period. — Despite the orogenies noted, Pennsylvanian time passed into Permian without marked breaks of sedimentation in the geosynclines. It was not for long, however. By Middle Permian time the Appalachian trough had been completely filled and before the Paleozoic era had closed that incredible thickness of sediments (maximum, 50,000 ft.) had been crushed into longitudinal folds and thrust sheets of a great mountain range. As a site of sedimentation, the geosyncline ceased to exist from that time on. Lingering seas in Texas and New Mexico left a great limestone reef (Carlsbad) with adjoining salt-pan lagoons and associated highly oxidized red sands and muds. Obviously the humid Pennsylvanian climate had been altered there to one of marked aridity. A "dead sea" finally came to exist in this region.

The Appalachian orogeny, styled a "revolution," culminated at the close of the period. The 500 mi. of original width of the trough was squeezed into half of that. Restoration of the great folds indicates uplift of three or more miles. The Ouachita geosyncline was also crushed from the south and the dominant folded mountain structures of Arkansas and adjacent Oklahoma were made. Without undergoing such marked orogeny, the Cordilleran geosynclinal region experienced considerable volcanic activity.

The greatest salt deposits of the world are in the Permian system. Associated gypsum and dune sand indicate an aridity exceeding that of today. Not too surprisingly, another climatic consequence of the widespread emergence and uplift was glaciation on four continents, the vicinity of Boston, Mass., yielding a record for the United States.

As might he expected, great changes in the life of the earth resulted from these extreme geographic and climatic changes. The typical coal swamp plants were replaced by conifers and cycads. Reptiles took precedence over amphibians and among their varied forms was a group whose teeth, jaws and skulls foreshadowed the arrival of mammals in the Mesozoic era.

3. The Mesozoic Era. — The widespread mountain making, continental emergence, climatic rigours and biological changes of the Permian mark the close of the Paleozoic era and the opening of succeeding Mesozoic time.

Triassic Period. — The waning importance of Appalachia and Llanoria as positive areas and the elimination of their persistently subsiding bordering geosynclines left only the Cordilleran trough for marint sedimentation on the continent during the Triassic. Interbedded with such marine deposits is much volcanic material. Eastward from this trough are interfingered nonmarine shales and sandstones, part of a great alluvial plain where the Rocky mountains, Colorado plateau and western Great Plains are now. In the eastern United States erosion of the newly made Appalachian mountains took place during much of Triassic time. Late in the period, tensional faulting made a series of elongated basins from North Carolina to Nova Scotia which were filled with nonmarine deposits and intercalated lava flows as rapidly as they were deepened. At the close of the period, tilting and uplift gave this faulted region a mountainous aspect again.

During the Triassic appeared the great conifers of the Arizona petrified forest, nearly 200 ft. high. The small beginnings of the greatest land reptiles, the dinosaurs, date from this time. The sea also had its reptiles, the plesiosaurs and ichthyosaurs. True mammals, however, are not known from Triassic deposits.

Jurassic Period. — The marine Jurassic overlaps on United States territory were from the Pacific, arctic and Gulf, only the former enduring for the entire period. The arctic invasion reached as far south as Colorado and Utah late in Jurassic time; the Gulf invasion (reaching north to Arkansas) did not begin until late in the period. Vigorous vulcanism, some of it submarine, accompanied marine sedimentation in the west. The arctic embayment was long and narrow. During the next period it developed into a new geosyncline which, in the end, suffered the fate of all subsiding troughs with excessively thick sediments; it was crushed into a mountain system, the Rocky mountains. Much Jurassic nonmarine deposition also occurred in the western states, thick dune sand formations dovetailing with marine beds.

Orogeny which deformed and metamorphosed the thick western sediments at about the period's end was accompanied by enormous granitic intrusions, reminiscent of similar Pre-Cambrian events. The California mother lode and the Nevada Comstock lode date from this igneous activity. It was modern stream waste from erosion of the mother lode (placers) which gave California the gold rush of 1849.

Xonmarine Jurassic deposits have yielded skeletons of almost unbelievably huge dinosaurs. A new reptilian venture was the ptcrosaur, a flying saurian. The first birds appeared and, most significant, the first mammals. Small but agile, they lived successfully with the enormous dinosaurs in Wyoming and vicinity.

Cretaceous Period. — The last great submergence of North America marks the last period of the Mesozoic era. The world over. Cretaceous seas probably submerged more continental surface than any previous flood had ever done. In a pulsatory fashion western Gulf water advanced northward to meet arctic water, forming a huge mediterranean sea by the middle of the period. Marginal overlap by Atlantic and Pacific water indicated the final disappearance of Appalachia and Llanoria as borderlands. The eastern Gulf reached north to the southern tip of Illinois.

This North American mediterranean occupied the Rocky mountain geosyncline and its sediments, mostly clastics from the Late Jurassic mountains to the west, eventually obliterated the seaway and made another great alluvial lowland with swamps and sluggish streams. The Late Cretaceous coal beds of this part of the United States are second only to the Pennsylvanian coal reserves.

Major orogeny again followed thick sedimentation in a subsiding trough. Thrusting from the west at the end of Cretaceous time compressed the weak Cretaceous strata and all subjacent rocks into uplifted folds and fault blocks along the entire length of this geosyncline. The making of the Rocky mountain system, coinciding with that of other systems on other continents, is therefore the time marker for closing the Mesozoic era and opening the Cenozoic.

In plant evolution, Cretaceous time saw the appearance of angiosperms (plants with covered seeds), dominant among land plants ever since. The reptilian horde reached its climax and gave place, following the Rocky mountain revolution! to mammals of almost all existing orders. From the variety of land-living organisms and the known paleogeography, Cretaceous climates are judged to have been about as diversified as those of today.

4. **The Cenozoic** Era.—Almost all landscapes of the world, whatever their character, are products of Cenozoic events. In the United States existing mountain ranges are Cenozoic uplifts, most of them along the axes of earlier orogenies. Most of them have even-crested ridges (summit flats, or accordances), surviving from a peneplanation that had destroyed earlier deformative uplifts. Plateaus are broad uplifts with little deformation or are lava-flooded areas. All volcanic cones of the country are Cenozoic growths. The great drainage systems were outlined and developed during this era, as were the coast lines. The monotonous plains are determined by Cenozoic stream and coastal deposits, the debris derived from destruction of the late Mesozoic and early Cenozoic highlands. All lake country in the northern states records a late Cenozoic ice-sheet glaciation. All soils and subsoils are Cenozoic in age. Almost all existing exposures of older rocks are the result of the vigorous erosion of Cenozoic time. Most of these features are consequences of crustal movements which produced at the maximum as emergent a condition and as great a relief as the continent has ever had.

The two Cenozoic periods are differentiated on the basis of climate, the coming of the Ice Age, or Pleistocene Epoch, closing the Tertiary and inaugurating the Quaternary. Marine overlaps were limited to coastal lowlands and the lower Mississippi valley. Cenozoic formations therefore are largely nonmarine deposits occupying intermontane basins and piedmont areas. The life record thus is largely of land animals and plants.

The story of Cenozoic erosion, generalized, is that of the reduction of early highlands to worn-down peneplains which truncated the stumps of the newly made Rockies and the rejuvenated Appalachians and are recognizable even in the landscapes of the Appalachian plateaus and the central lowlands. Several times of renewed uplift interrupted this erosion and complicated the record with successive partial peneplains whose remnants constitute even-crested summits and steplike erosional flats at lower altitudes. Rivers came to flow across such base-leveled surfaces without respect to hard or soft rocks below their valley bottoms. In later uplifts many hard rock crossings have become spectacular water gap canyons in all areas of Pre-Cenozoic folding and faulting. Other canyons are because of physiographic youth alone. Quaternary glaciers aided in the deep sculpturing of many western mountain ranges. The submerged continental shelf is notched by submarine canyons that seem to date from greatly lowered ocean levels at times during the era. Elevated shore lines tell of other times when the ocean level was higher even than now.

Cenozoic deposits made by streams, wind and glacial ice and in lakes of closed basins are limited to favourable places, are very diverse in character and in many cases are difficult to correlate. Particularly difficult has been the correlation of coastal marine sediments with the intermontane, although each class possesses a wealth of paleontologic material.

The Gulf coast Tertiary rocks have been penetrated from below by a large number of cylindrical salt domes or plugs, the salt derived from older rocks and forced upward "like grease in a grease gun" (R. C. Moore) at weaker points. Another noteworthy feature of the Gulf coast is an actively subsiding structural and sedimentational trough across southern Louisiana, known from well logs to contain Tertiary sediments twice as thick as the Gulf is deep. It is pointed out as a modern geosyncline.

Cenozoic vulcanism was most marked in the Pacific border states where a row of towering cones surmounts the Cascade range and where the Columbia plateau of nearly horizontal lava flows covers about 200,000 sq.mi. Yellowstone park plateau is another well-known area of Late Cenozoic vulcanism, its geysers testifying to hot rock at no great depth.

An orogeny which is still continuing began in Middle Tertiary time. Most of the displacements were by faulting and occurred (and still are occurring) along the west coast. A continental uplift throughout the country seems to have been contemporaneous with this.

Of much significance to human occupation was the extensive continental glaciation in Quaternary time. Canada, the source area of the great ice sheet, four times sent its marginal overflow south into the Great Lakes and central lowlands region, which four times was melted back in as yet unexplained climatic oscillations. The interglacial stages had climates as mild as—even milder than—that of the present. The Ohio and Missouri river courses were determined by these encroachments of glacial ice, the Great Lakes basins outlined and the cover of "drift" deposited over the region invaded. Outwash gravel and sand is traceable down the Mississippi to within 150 mi. of the Gulf. Dust blown off these outwash tracts settled on drift-covered and driftless areas alike to constitute the fertile loess soils of Mississippi valley states. The ice-weighted part of the continent sank under its load and is still slowly rising from removal of that load. The entire Cenozoic Era extends over about 60,000,000 to 70,000,000 years.

The present forests of deciduous trees were already outlined at the close of Mesozoic time. Grasses possessed the Cenozoic subhumid plains. Herbivorous mammalian evolution responded to the new food plants and carnivorous mammals swarmed to prey on the herbivores. Migration from other continents brought many kinds to North America, other kinds evolved there and spread to South America and the eastern hemisphere. Land bridges for such migrations, presumably in high latitudes, were essential. Extinctions of earlier mammals went along with appearance and deployment of newer types. The Tertiary record of these faunal changes is wonderfully detailed and diversified. Early human cultures arrived from Eurasia late in the Quaternary period, charcoal and flint implements being far more numerous, however, than skeletal remains.

To the igneous and crustal activity of Cenozoic time are attributed most of the metalliferous veins of the western states. Some of the large oil pools of the United States are found in Cenozoic sediments as are also the Pacific coast coal deposits and the "bench" placers in California. (J. H. Bz.)

B. Physiography

Broadly, conterminous United States consists of a rounded eastern highland trending roughly parallel to the Atlantic coast and bordered south of Plymouth, Mass., by a coastal plain; an interior plain drained mainly by the Mississippi system; and a vast, generally rugged western highland covering a third of the country and dominated by high mountains. the general trend of which is a little west of north. A more accurate analysis divides the country into 8 major physiographic regions which are in turn subdivided into 25 divisions and 86 subdivisions as shown in fig. 2 and 3 and briefly characterized in Table II, to which the maps are keyed.

The larger divisions are described at greater length below, together with the rivers arid harbours of conterminous U.S.

1. Laurentian Upland.— This division, which in the United States comprises the Superior upland, is for the most part rough cutover land of little value to agriculture. Its rocks are igneous and Pre-Cambrian metamorphic; all have been upraised and eroded, first by running water, more recently by continental glaciers.

Although small in size, the area has been of tremendous importance economically because of its rich deposits of iron and copper. The iron mines of the Lake Superior district, although showing some signs of exhaustion, have been probably the most productive in the world.

2. The Atlantic Plain.--The Continental Shelf.—South of New York the continent slopes almost imperceptibly to the shore, beyond which the sea bottom continues the very gentle slope for many miles and then descends less gradually to the oceanic abyss. The line where this relatively rapid descent begins is the real edge of the continent and the margin of shallow sea bottom is the continental shelf. Within this margin is deposited most of the sand and mud carried down from the land. A large part of the ocean's life is concentrated on this shallow bottom where the water is relatively warm and food is abundant. The equivalent Pacific shelf is similar but much narrower.

The Coastal Plain.—Repeatedly in late geologic time this border of the continent has stood either lower or higher than at present, thus alternately broadening and narrowing the continental shelf. The part of the shelf above water at any one time is coastal plain. The present coastal plain has been continental

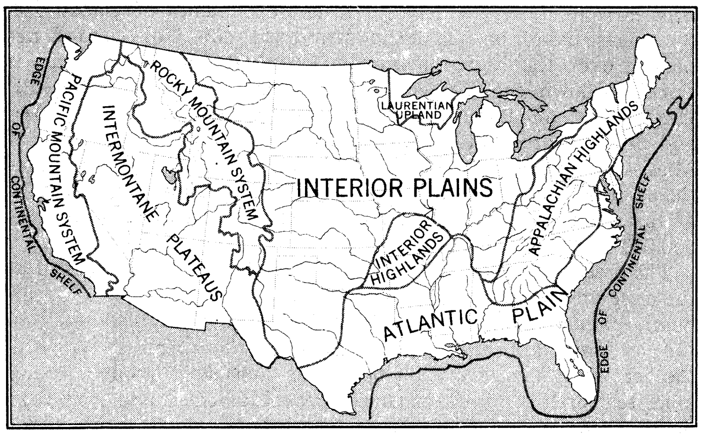


FIG. 2.— THE EIGHT MAJOR PHYSIOGRAPHIC REGIONS OF THE U.S.

shelf at a time so recent that its structure remains unchanged. The materials of its underlying strata are the same as those now accumulating beneath the adjacent shallow sea. Some of the sand, clay and ooze has been poorly consolidated into sandstone, shale or limestone. All beds dip faintly seaward. the older and lower ones passing seaward beneath the younger beds; as the beds offer unequal resistance to erosion and are unlike in their soil-making properties, the several formations appear at the surface in strips parallel to the coast, the lower beds outcropping farthest inland.

As the surface of the continental shelf is extremely flat, so also is the land nearest the coast, which has but recently emerged and lies too near sea level to favour the cutting of valleys. The landward edge of the coastal plain was necessarily first to emerge from the sea. It is also the highest. For both of these reasons it is more deeply eroded and niore completely dissected by small streams than is the seaward edge. In the southern states this inner edge is at places more than 700 ft. above the sea and has a relief of 300 to 400 ft. At places erosion has even made new lowlands or peneplains. Other things being equal, the number and depth of valleys increase inland.

Where the underlying strata resist erosion unequally, a strong stratum may give rise to a cuesta, a ridge with a very gentle slope toward the sea and a steeper slope cutting across the strong stratum and leading down to an "inner lowland" on the underlying weak stratum. The effect on topography is to make the belted coastal plain wherein the stronger beds (usually sandy) make higher. rougher and less fertile belts and the weaker beds (usually clay, marl or chalk) make belts of smooth, fertile lowland Thus central Alabama has its well-known black belt on the outcrop of the Selma chalk (Cretaceous) which erosion has reduced to a lowland with a rich black soil, famous for its cotton. Dipping seaward, the chalk passes under stronger sandy beds which are poor soil makers, hence the rich lowland is paralleled by a broad, now much dissected cuesta of poor upland. Another lowland and another upland follow but are less well known. Northern Texas has a similar belt, the black prairie, along the western boundary of the coastal plain. It is likewise on a chalk outcrop and has an infertile cuesta on its seaward side. New Jersey also has a lowland on the weak Raritan clays which outcrop along the landward edge of the coastal plain. From Trenton southwestward this low strip is followed by the Delaware river. Northeast from Trenton, N J , the railroads from New York city to Philadelphia, Pa., have been built on it.

The coastal plain is broadest at the south and narrows toward the north The opposite is true of the continental shelf. indicating that the continent is now relatively depressed at the north and elevated at the south. One effect of this is seen in the islands from New York to Cape Cod. These islands, Staten. Long, Block, Martha's Vineyard and Nantucket, are disconnected fragments of the coastal plain, parts of one or more cuestas whose corresponding inner lowlands are submerged The low strip across New Jersey is continuous with Long Island sound. The same weak clays underlie both.

Throughout the Atlantic and Gulf coast recent (not necessarily current) sinking is in evidence. From New England to Texas the smaller streams have estuaries, as the larger ones had also uptil filled by sediments. North of southern Virginia all the major streams crossing the coastal plain are drowned across its entire width. The numerous large estuaries from New York to North Carolina make that part of the coast extremely ragged or crenulated. Sand reefs or barrier beaches form a nearly straight "outer coast" and these continue most of the way from Long Island to Mexico. They are especially long and continuous along the coast of Texas where tides are weak.

The peninsula of Florida is the result of an uplift of the sea bottom on an axis almost at right angles to the outline of the continent. Its southern third is so little above sea level that valley cutting is all but impossible. The vast Everglades (*q.v.*), swamps whose water surface is less than 20 ft. above the sea, are located there. The most valuable part of the peninsula is a low limestone ridge on the Atlantic side, bearing Miami and other winter resorts. The northern section has undergone some erosion. Its underlying limestone suffers solution, giving rise to many sinkholes, some of them clogged and making lakes of considerable size. The largest deposits of phosphate rock in the eastern United States are there.

In the vicinity of the Mississippi river the coastal plain is greatly widened, extending north in a pronounced embayment to southern Illinois. The greater part of this area is occupied by the alluvial plains, 40 to 80 mi. wide, of the Mississippi and its tributaries. At the south this plain merges with and includes the great protruding delta, the entire alluvial plain covering an area of nearly 30,000 sq.mi. A large part of it is subject to flooding or would be if not protected by artificial levees. The natural levees are at places 15 to 20 ft. above the back swamps.

3. The Appalachian Highlands— Piedmont and Blue Ridge Provinces.—Inland from the Atlantic coastal plain is a belt underlain mainly by very old rocks, much deformed, generally metamorphosed and resistant to erosion. This belt extends from central Alabama northeastward into Canada, but the part to be described here terminates at the Hudson river. Its greatest width in the south is nearly 200 mi., but north of the Potomac river it averages barely 60 mi. This relic of the early Paleozoic continent is marked by a mountain range on its northwestern side. From southern Pennsylvania, where it is called South mountain, to southern Virginia, where it is called the Blue Ridge, it is rarely more than 10 or 15 mi. wide and from 1,500 to 3,000 ft. high. In North Carolina and adjacent states it broadens to 70 mi. and culminates in Mt. Mitchell (6,684 ft.), the highest point in the eastern United States. The range is interrupted by a short gap in southern Pennsylvania. Northeastward from this gap it is known as the highlands of New Jersey and New York. This part, being detached from the main range (Blue Ridge province) and contiguous with the New England province, which is largely of the same character, is considered as belonging to the latter. From New England to southern Virginia the crest, viewed from a distance, is gently undulating and is considered to be the remains of an uplifted peneplain preserved by the strength of the rocks, while weaker rocks on both sides have been reduced to a new and lower peneplain. In western North Carolina the ancient mountains were not all worn down to the peneplain indicated by the crest farther north. Partly for this reason and partly because of greater recent uplift these mountains are several thousand feet higher.

Between the mountains and the coastal plain is the Piedmont province, most of it a low plateau sloping seaward, consisting in the main of the same rocks found in the mountains. Where the rocks of the Piedmont and mountain belts are similar the existence of a newer and lower peneplain in the former and not in the latter is explained by the fact that the new peneplain developed first along the lower courses of streams flowing from the mountains to the sea. It spread westward, its limit of advancement being the eastward slope of the Blue Ridge. This newer peneplain is itself uplifted and dissected by revived streams. Much of the northern end of the Piedmont province in Pennsylvania and adjacent states is exceptional, consisting of softer Triassic rocks. As these were more readily worn down and, as already pointed out, the continent in this latitude has been less uplifted, this part of the Piedmont province is lowland rather than plateau, though still distinctly higher than the coastal plain.

Ridge and Valley Province.—West of the Piedmont, Blue Ridge and New England provinces is a narrow belt of folded sedimentary rocks stretching from the St. Lawrence valley to the Gulf coastal plain. The length is 1,000 mi. and the width rarely 75 mi., more often half that amount. Between New England and the Adirondacks it is very narrow. In its present state this belt consists of alternating ridges and valleys, the former being parallel, even topped and rarely 3,000 ft. high. For the most part they are nearly straight and in line with the major belt but a zigzag pattern appears in Pennsylvania. The valleys occupy more than half the space. Throughout its length the Paleozoic sandstones, shales and limestones are folded and often faulted by great lateral compression which made mountains of great height.

The ridges now seen are not those made by the folding. Those lay far above the level of the present mountaintops. Even the synclinal trough bottoms were above the present crests. All were eroded away to a peneplain covering this and adjacent provinces. At the time of its making it could not have been, at highest, more than a few hundred feet above the sea. The tilted strata came to the surface of this plain in parallel strips. Later there was a general rise of the whole Appalachian region and the limestones and shales were worn down to a new and lower level (often a peneplain) while the sandstones, being stronger, along with the hard rocks of the Blue Ridge province and the sandstone-capped plateau on the west, retained more nearly their former level.

The greatest breadth of this Ridge and Valley province is in Pennsylvania where it is almost 90 mi. From there to southern Virginia the eastern third or fourth is almost without ridges. Its several parts from the Lebanon valley in Pennsylvania to the Shenandoah valley in Virginia are well known for their agricultural wealth. In this central portion the master streams cross the belt transversely, their longitudinal tributaries being developed on the softer outcrops. In the northern section of the province, the Hudson-Champlain valley, and again in the southern section, the valley of east Tennessee and neighbouring states, the main streams are longitudinal. In the latter case this probably came about by the headward elongation of the Tennessee river capturing the former streams which flowed from the Blue Ridge to the Ohio river.

St. Lawrence Valley.—Only a minute part of this valley is in the United States; essentially it is a young marine plain with low rocky bills projecting above the general level.

Appalachian Plateaus.—West of the Ridge and Valley province is a plateau of almost equal length with a minimum width of about 35 mi. at the south but more than 200 mi. wide farther north. On the side toward the Ridge and Valley province, it is at least as high as the ridges already described, 2,000 to 3,000 ft., but it declines northwestward and is barely 1,000 ft. high where its edge approaches Lake Erie. Its rocks are almost horizontal, generally outcropping on the southeast in an escarpment overlooking the adjoining valley of the folded province. Except at the north end the rocks at the surface are Carboniferous and Permian. Thick beds of strong sandstone are common and generally cap the hills. Soils, therefore, are generally not good. They are least fertile at the south end where the sandstones are most dominant, and best at the north end where Devonian rocks form the plateaus and glaciation has left its heterogeneous drift.

The larger part of the province is almost or quite completely dissected by stream valleys. These may approximate 1,000 ft. in depth on the higher southeast side, but the relief diminishes toward the north and west. Nevertheless the hilltops are about at the same altitude and the horizon is nearly level. The Cumberland plateau at the southern end, mainly in Tennessee, is exceptional in preserving large patches of undissected upland on beds of strong sandstone. In parts of the eastern margin the beds are mildly folded though not enough to develop the topography of the next province to the east. The elevation is less uniform than elsewhere in this province and the horizon less level. As these are also places of greater height these districts are known as mountains, the Allegheny mountains in Pennsylvania and the Cumberland mountains in Kentucky, Tennessee and Virginia, but these names are applied somewhat broadly and without exact boundaries to the deeply dissected eastern margin. The Catskill mountains in southeastern New York are like the adjacent plateau but are covered by an additional thick plate of strong conglomerate now deeply and maturely dissected. The plateau in New York, and to some extent in Pennsylvania and Ohio, was glaciated, leaving the hills and valleys less angular; many lakes and displaced streams were also left, some of which in carving new valleys have made picturesque falls and gorges. The main plateau ends at the north in an escarpment not far south of the 43rd parallel and 600 to 1,000 ft. high. West of Rome, N.Y., this escarpment overlooks the lacustrine plain along Lake Ontario, a part of the central lowland. East of Schenectady, N.Y., the descent from the plateau is to the valley of the Hudson river (Ridge and Valley province). Between these two cities the descent is only to a lower bench of the plateau province. In this bench the Mohawk river has cut its valley, connecting the two lowlands named. As all strata there dip slightly southward, the valley of the Mohawk is a strike valley.

The glaciated northern portion of the Appalachian plateau is favoured agriculturally and is one of the leading dairy districts of the United States. The remainder of the province is almost coextensive with the Appalachian coal fields, 75,000 sq.mi. in extent. As this area was never folded the coal remains bituminous. In the province to the east the folds were so high that the Carboniferous beds, being uppermost, were almost wholly eroded away. Only in a few small spots were the synclines so deep as to leave the coal below the base level of erosion. There the coal was metamorphosed to anthracite. The total original area of the anthracite fields was 484 sq.mi. In the central part of the plateau province are also the Appalachian oil and gas fields.

New England Province.—The New England province is a broadened northeastern extension of the belts already described under the Blue Ridge and Piedmont provinces. It has the same rocks along with some younger Paleozoics, generally deformed, metamorphosed and peneplained. Residual mountains rising above the general level to an altitude of 4,000 to 6,000 ft. are found in the Green mountain section of Vermont and Massachusetts and the White mountain section of New Hampshire and Maine. Between and around these mountains the upland level is generally a little above 1,000 ft., studded here and there with isolated residual mountains or monadnocks, the original Mt. Monadnock being in southwestern New Hampshire. This upland is an uplifted peneplain, dissected by sharp valleys since uplift. The surface declines seaward to the seaboard lowland and it is probable that newer and lower peneplains are represented there. The coastal margin below a level of 500 ft. has a rolling surface with wide open valleys in contrast with the narrow and steeper valleys that incise the plateau. The land below 500 ft. also includes the broad valley of the Connecticut river carved from Triassic rocks and analogous in most ways to the low northern end of the Piedmont province.

Elevation was followed by depression and the valleys are drowned. This is typically shown on the coast of Maine where the style of depressed coast line is quite different from that of the coastal plain because of difference in topography previous to drowning. Outlying islands, formerly hills or mountains of hard rock, are abundant there. Harbours are numerous and fishing is favoured by this as well as by the broad continental shelf.

Unlike the Piedmont and Blue Ridge provinces, New England was severely glaciated: its mountains overridden and scraped by the continental ice sheet and its surface generally covered by ice-laid drift abounding in boulders. Some of its valleys are partly filled with sandy outwash. Both topography and the stony soil are unfavourable to agriculture. The northern part of the province was long the great lumbering district of eastern Cnited States. One of the chief effects of glaciation was the dislocation of streams. Drainage, in beginning anew, was obliged to fill many basins and cross many rocky ledges. Lakes and rapids, therefore, are numerous, the latter being a source of abundant water power.

The Adirondack Province.—In its physical geography the Adirondack area in northern New York is much like northern New England, a combination of subdued mountains and hilly plateaus, all severely glaciated and containing many lakes. Like the White mountains and the New England coast it is a popular summer resort. The state of New York has reserved large areas of forest.

4. **Interior** Plains.—Interior Low *Plateaus*.—West of the southern part of the Appalachian plateaus is a lower plateau province, mainly in the states of Kentucky and Tennessee. At its eastern edge it abuts against the western escarpment of the Cumberland plateau. There the lower plateau is 1,000 to 1,400 ft. high and scored by valleys between which the surface is little eroded. The ragged escarpment of the Cumberland plateau rises 800 ft. higher. Everywhere the level of the interior low plateau declines toward the Ohio river near which, in western Kentucky, the uplands are little more than 500 ft. high. Dissection by streams increases toward the west end where it is complete. The upland level in most of the province, except in the northwest, is approximately that of the Lexington (highland rim) peneplain which covers much of the continental interior. It is developed there on Mississippian rocks. Two low structural domes were thus truncated, the Nashville in Tennessee and the Cincinnati anticline, partly in Kentucky. Ordovician (Lower Silurian) limestones, were exposed in each, affording excellent soils. In Tennessee these soluble rocks were later cut down 500 ft. making the fertile Nashville basin, surrounded by steep slopes rising to the relatively barren highland rim. The bluegrass region in Kentucky preserves, in the main, the general level of the peneplain but is overlooked on the east by the Cumberland plateau and on the south by a narrow monoclinal rim remaining from the former dome. In the central bluegrass district are exposed the oldest rocks and the best soil makers of the Cincinnati anticline. Western Kentucky embraces the south end of a great coal field with its centre in Illinois. There! in a broad, faint syncline, the Pennsylvanian rocks were sufficiently depressed to escape the erosion that stripped them away from neighbouring areas.

Central Lowland.—The term lowland is not capable of exact definition. As applied to north central United States it signifies that most of the area is not obviously much above the level to which streams can cut. down.

Within this great province, roughly one-fourth of the United States, the chief contrasts in topography are determined by glaciation. The entire province may be divided into six sections. Two of them were never covered by the ice; two of them were left after glaciation as relatively smooth till plains without lakes; two others were left with abundant moraines and undrained basins. The Great Lakes section has a topography controlled in detail by its thick glacial deposits, though its large features betray the relief of the underlying rock as carved by preglacial drainage. Terminal and recessional moraines and outwash deposits, with morainic lakes and swamps, cover perhaps half of the area; the other half is till plains (ground moraine) and lacustrine plains.

The beds of all the Great Lakes except Lake Superior follow belts of weak strata which were presumably lowlands in preglacial time and were deepened by glacial erosion. As the ice front retreated northward from the Mississippi-St. Lawrence divide, lakes formed between the divide and the ice. With further retreat of the ice these lakes expanded and merged, changing from time to time in shape, altitude and outlet but generally discharging into the Mississippi system. When the vanishing ice covered only the St. Lawrence the lakes discharged for a time through the Mohawk valley to the Hudson. As each newly discovered outlet lowered the lake levels the water was progressively withdrawn from the farther ends of the basins and the old lake bottoms at the heads of the lakes (south or west ends) were laid bare. An important though minor part of this Great Lakes section consists of these perfectly flat former lake bottoms. The glaciation of this section was in the last, or Wisconsin, ice epoch and the surface has been little altered by erosion. Lakes and swamps are beginning to disappear but stream systems are poorly developed.

The western young drift in Minnesota, northern Iowa and the Dakotas is similar but with a smaller proportion of morainic topography. It has also a smaller rainfall, so that forests are limited to northern Minnesota. An important feature of this section is the great lacustrine plain of former Lake Agassiz in the valley of the Red river. This valley was flooded when the retreating ice cap obstructed the drainage to Hudson bay. The lacustrine plain (most of it in Canada) is the greatest area of spring wheat production in North America.

Southwestern Wisconsin and small parts of adjacent states, the Wisconsin driftless area, were missed by the several ice invasions though surrounded by a glaciated surface that extends 250 mi. farther south. Probably at no one time did the ice close around it. The margin of the ice sheet was divided into lobes following the great valleys. In the different ice epochs they came from different directions, at one time from the northwest, at another from the northeast? the areas covered by these different advances overlapping south of this driftless area. The southern and western parts of this area are limestone uplands rather deeply and at places sharply carved by erosion. The northern part is mainly a lowland underlain by friable Cambrian sandstone covered by glacial outwash. With due allowance for the effects of different kinds of rocks on topography, this driftless area may be regarded as a sample of the topography that was elsewhere overridden by the ice. It is not very different from that which is seen beyond the limit of glaciation in eastern Ohio, western Kentucky or central Missouri.

Most of Illinois, Indiana and western Ohio have a drift cover remarkable for its small relief and distinguished by a total absence of lakes. The flatness is not absolute, for the retreating ice front halted at various stages, building recessional moraines, a few of which have the distinctive topdgraphy of moraines, while others are barely visible, being made apparent only by their effect on drainage. The major streams have cut down moderately into this surface and tributaries are developing, but not much headway has been made except near the Ohio and the Mississippi. A margin near these streams belongs to an older drift sheet (Illinoian) while most of the section was again covered by ice in the last (Wisconsin) glacial epoch. West of this section in Iowa and northern Missouri and parts of eastern Nebraska and Kansas are the dissected till plains, distinguished from the till plains east of the Mississippi by greater erosion. This difference results from the fact that the glacial mantle west of the Mississippi was spread in the Kansan glacial epoch and is the oldest glacial drift widely exposed in the country. Complete drainage is re-established; valleys occupy fully four-fifths of the area. In the type of agriculture that distinguishes the central lowland (grains and livestock) the till plains and dissected till plains are pre-eminent.

South of the latitude of Kansas City (39°) the central lowland (Osage section) was not glaciated. It extends almost to central Texas in a belt nearly 200 mi. wide. The underlying rocks dip gently west beneath the Great Plains syncline and away from the interior highland. As the surface slopes in the opposite direction the formations outcrop in parallel strips trending nearly north and south. The stronger beds form cuestas with east-facing escarpments, some of them so eroded as to make hilly belts a few miles wide.

Great *Plains* Province.—The vast area known as the Great Plains is a north-south belt averaging about 400 mi. in width between the mountains of the western United States and the lowlands of its centre. Its height at the base of the mountains is 5,000 to 6,000 ft. and at its eastern edge 1,500 to 2,000 ft. An eastward slope of ten feet to the mile is common. A part of this great area is literally plain, most of the northern third is peneplain and considerable areas on the borders both in the east and west, are dissected into hills. All of it is semiarid and the only trees are in river bottoms or on certain isolated mountains like the Black hills. Most of it has good soil without the necessary water to take full advantage of the fertility.

The flat portions of the province are best illustrated in the Llano Estacado (staked plains) of Texas and eastern New Mexico. Interrupted by the valleys of transverse streams these flats extend north to southern Nebraska and, in modified form, to the South Dakota boundary forming a belt known as the high plains. These are remnants of a vast alluvial slope made by coalescing alluvial fans from the mountains. When the streams ceased depositing and began again to erode, the eastern edge of the deposit was the first to suffer. In Texas the edge is retreating westward as a well-defined escarpment, there being but a few miles between the flat upland and the lowland on the east. In Kansas and adjacent states the wasting edge of the former upland plain is represented by a broad belt of hills. In Nebraska a thick mantle of loess obscures the transition from high plains to central lowland. Between the belt of preserved high plains and the mountains, erosion was also more favoured, partly by original slopes, partly by the nature of the vegetation. There the fluviatile mantle, where formed, was destroyed and the landscape is one of varied relief. The South Platte, Arkansas and Pecos rivers have broad terraced and well-formed valleys, but northeastern New Mexico and the adjacent part of Colorado is a region of plateaus, trenched by angular valleys and surmounted by various features of volcanic origin. The Edwards plateau at the southern extremity of the province is a limestone tableland almost as flat as the Llano Estacado but without the fluviatile mantle. It is cut off on the south and east sides by the great Balcones fault which for 300 mi. forms the inner boundary of the coastal plain. Streams dissect the plateau at the edges and have in part removed the same limestone from a large area just north of the Edwards plateau. This hilly section in central Texas is in a stage of the erosion cycle intermediate between the youth of the well-preserved plateaus and the old age of the lowlands on the north.

North of latitude 43° the Great Plains province is in large part upraised peneplain, though perhaps not all of the same cycle. Second in areal importance are the extensive gravel plains, some of them perhaps being remnants of a sheet similar in origin to that which covers the high plains. Others are simple stream terraces of Pleistocene age. Some of the streams, especially near the mountains, have valleys hundreds of feet deep and their tributaries have deeply dissected the upland. Isolated mountains are domelike uplifts, the largest of which is the Black hills, about 88 mi. long and 50 mi. wide, crossing the Dakota-Wyoming border. The structural uplift approximates 10,000 ft. but erosion has truncated the dome leaving the actual height less than 4,000 ft. above the plain on the east. The core of granite has thus been exposed at the top, while the strata outcrop in concentric ellipses, the stronger ones making ridges.

The northern part of the Great Plains province and a margin on the east was covered by the Pleistocene icecap leaving a strongly morainic topography in the Dakotas. The course of the Missouri river results from the obstruction of former drainage northeastward to Hudson bay. Its relative youth is shown by the small width of its valley (one to three miles between bluffs) as compared with that of the Yellowstone river and other tributaries.

5. Interior **Highlands.**—*Ozark* Plateaus.—Surrounded by the lowlands of south central United States is the interior highlands. Its northern and larger part consists of the Ozark plateaus on nearly horizontal though slightly domed rocks. The rocks of its southern third are folded along east-west axes. Altitudes in the Ozark plateaus are generally less than 1,600 ft., being highest near the centre, but in northern Arkansas on the southern slope of the dome the strong sandstone beds of the Pennsylvanian are preserved in a plateau that is locally more than 2,000 it. high and ruggedly eroded, making the Boston mountains. In southeastern Missouri in the midst of the plateau stand the Saint Francis mountains, composed of granite, rising no higher than the surrounding horizontal sediments which once covered all. These ancient granite mountains were buried by marine sediments and are being exhumed. They are among the best examples of their class. The Ozark province is one of the leading sources of lead and zinc.

Ouachita Province.—The belt of folded structure in Arkansas and Oklahoma, the Ouachita mountains, is essentially like the Appalachian Ridge and Valley province, the product of two cycles of erosion with ridges on the stronger outcrops and intervening lowlands on the weaker rocks. The rocks of the Arkansas valley are only mildly folded and although the stronger sandstones make either flat or sloping uplands the whole strip is less uplifted than its neighbours. This province has large supplies of coal. The Ouachita mountains have the famous hot springs of Arkansas and produce novaculite (natural whetstone) of the United States. In and near it also are important bauxite deposits.

6. Rocky **Mountain System.**—*Southern* Rocky Mountains.—The southern Rocky mountain province is a group of linear uplifts initiated by east-west compression. The original folds were in large part leveled by erosion which thereby exposed the underlying granite, now revealed in north-south belts with a maximum width of 40 mi. Later uplift raised the general level to mountain heights but without sharp deformation. The old erosion surface mas warped rather than folded, producing intermontane basins. This later uplift enabled erosion to carve valleys in the granite and reduce the weaker rocks to lowlands. Commonly the granite belts are bordered by upturned sedimentary rocks, the several formations being of unlike strength, thus developing monoclinal foothills and valleys. Some large areas of granite 8,000 to 10,000 ft. high are plateaulike with a relief of only several hundred feet. These plainly represent a former lowland made by approximately peneplaining the first mountains. The largest of these tracts is South park, 9,000 to 10,000 ft. high, west of Pikes peak. The same surface farther east and at many other places is carved into mountains whose summits approximate the same level. Looking across these crests, or over the undissected upland, Pikes peak is seen to rise as an isolated eminence 5,000 ft. above the level. It was a monadnock on the South park peneplain. North of the park and extending almost to Wyoming is the main crest of the Front range with many peaks 12,000 to 14,000 ft. high. Along this entire line residual mountains rise clearly above a dissected plateau. Only a minor part of what is called mountains in the southern Rockies consists of these residual eminences. The greater part are carved from the uplifted peneplain. In the entire system, both north and south, most of the residual mountains have "alpine" features caused by former glaciers. These are cirques and U-shaped troughs, often separated by steep and narrow crags. The San Juan mountains in southwestern Colorado consist largely of volcanic rocks which once covered the area in sheets of relatively small relief. Later they were carved by water and ice into their present forms.

Wyoming Basin. — North of the southern Rocky mountains is the Wyoming basin whose floor, about 42,000 sq.mi. in extent, is a plateau 6,500 to 7,500 ft. high and largely without mountains. Beneath its horizontal Tertiary rocks, and rising through them here and there, are the older folded sedimentaries and granite, showing that the Rocky mountain system is structurally continuous. Within and around this plateau the drainage is strikingly out of harmony with the structure and topography. Green, Yampa, Bighorn! North Platte and Laramie rivers all leave the basin by canyons 1,000 to 3,000 ft. deep which might be avoided by going around the mountains. Green river, especially, was once a favourite illustration of an antecedent river. This assumes that the river was in its place before the mountains rose across its course.

It is now believed that these streams are superposed; *i.e.,* they chose their courses when the mountains were buried by weak Tertiary rocks (since eroded away) lying on top of those that now make the basin floor.

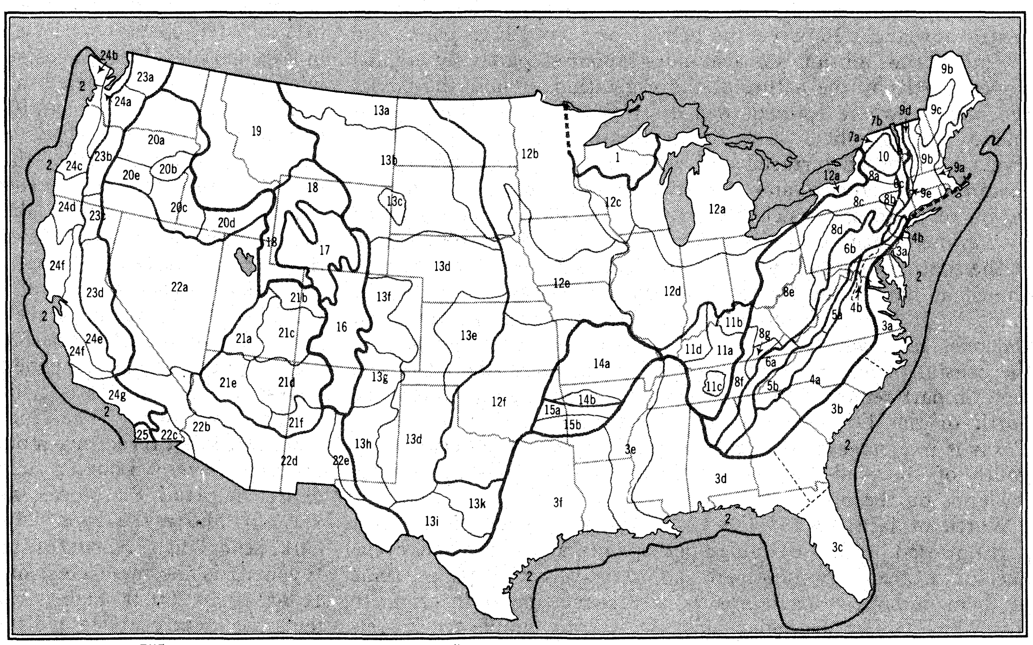
Middle Rocky *Mountains.*—The middle Rocky mountains. between the Wyoming basin and through the Yellowstone National park. consist of definite ranges in which structures and trends are clearly related. The axes radiate from Yellowstone park to the south, southeast and east. A long sickle-shaped arm whose eastern side is the Bighorn range almost surrounds the Bighorn basin. Of the group of ranges trending south, the Wasatch in northern Utah is outlined on the west by a great fault, the range on the upthrown side overlooking Great Salt lake on the downthrow. Meeting this range at right angles is the Uinta range which extends eastward forming the southern rim of the Wyoming basin.

Yellowstone park is a plateau of rhyolitic lava with an average height of about 8,000 ft., enclosed by mountains on three sides but open to the west where a rapid descent leads down to the Snake river (basalt) plateau. A single narrow belt of mountains north and east of the plateau connects those to the north and those to the south. The lava fills a basin probably 2,000 ft. deep and appears to have conserved the heat revealed by geysers and hot springs. The hot springs are among the most extensive in the world and the geysers have no rival.

Northern Rocky *Mountains.*—North and west of Yellowstone park the mountains (with few exceptions) are not in ranges in the usual sense of that word. Linear arrangement in agreement with structure is found to a limited extent, *e.g.,* in the Lewis range of Glacier National park, but in general the present relief does not suggest corrugation. Much the larger part of the area is a vast mountain upland divided only by stream valleys or by Tertiary basins in which the mountain surface has sagged. Generally the dominant ridges within a single view are of nearly equal height so that the horizon is not far from level. Altitudes between 6,000 and 9,000 ft. are prevalent. The Bitterroot mountains on the Montana-Idaho boundary are the upturned edge of a fault block tilted westward. Except for this deformation the surface is as described above. Passes through the northern Rockies are much lower than those in the southern Rockies. The history of the northern Rocky mountains is much like that of those farther south. At similar altitudes glacial features are more pronounced. They are specially marked and picturesque in Glacier National park in the Front range near the Canadian boundary. The Selkirk and Bitterroot ranges are likewise noteworthy in this respect.

7. Intermontane **Plateaus.**—*Columbia* Plateau. — The surface of the Columbia plateau between the northern Rocky mountains and the cascades is made by flows of dark lava. These flows submerged an uneven surface of erosion, locally almost mountainous as may be seen in vertical section in the mile-deep canyon of the Snake river between Idaho and Oregon. The Snake river basin east of the 115th meridian represents the simplest and most youthful phase of lava plains. There the flat surface, 4,000 to 5,000 ft. high, remains as it was when the lava cooled, without erosion and only beginning to weather and to form soil. It is trenched only by the canyon of the Snake river whose depth increases westward to 700 ft. Farther west, in southwestern Idaho and southeastern Oregon, there is more erosion. Near the state boundary the terraced valleys afford valuable irrigable land. The plateau in eastern Washington declines from nearly 3,000 ft. on the east to less than 500 ft. where the Columbia river breaks through the Cascades. This northern section consists of older lavas, subjected to long erosion and having a roiling surface covered (at least in the east) with wind-blown soil. In this area are the famous wheat fields of eastern Washington and western Idaho, cultivated by methods of dry farming by which a crop is raised in alternate years. In eastern Oregon near the middle of the province a group of mountains stood as an island in the floods of lava. Around these a later bulging raised the plateau surface to 7,000 ft., exposing it to greater erosion. This is the Blue mountain section. The rise lay across the course of the Snake river which succeeded in cutting down as fast as the land rose, making a canyon over 7,700 ft. deep.

Colorado Plateaus.—South and west of the Rocky mountains is a region of about 130,000 sq.mi. whose underlying rocks are in the main horizontal and whose surface is tabular. In part it consists of wide-spreading plains at high altitude; elsewhere the plateau consists of tabular remnants between deep and branching canyons. In general the plateau abuts against the mountains



BY COURTESY OF THE GEOLOGICAL SURVEY, U.S DEPT OF INTERIOR

FIG. 3.— DIVISIONSAND SUBDIVISIONS WITHIN THE EIGHT MAJOR PHYSIOGRAPHIC REGIONS (SEE TABLE II)

on the north and east and ends in an escarpment overlooking lowlands on the west and south. The best-known part of the province is the southwestern section traversed by the Grand canyon of the Colorado. This has a maximum depth of 6,000 ft. and a minimum width of less than 5 mi. from rim to rim. The conditions favouring canyons are all present in this province. Great altitude above base level, strong through-flowing streams and geologically recent uplift favour downcutting, while strong rocks and arid climate favour preservation of steepness. In this section the surface is on Permian limestone not deeply eroded. These rocks dip north under younger strata. At the same time the surface rises terracelike over system after system until Eocene beds and lava flows are found capping the high plateaus of Utah, 9,000 to 11,000 ft. high, bounded both east and west by escarpments. Most of the strata underlying the high plateaus iormerly extended southward over the plateau in which the Grand canyon is cut. A mass of rock equal in thickness to the entire depth of the canyon was stripped from this plateau leaving a relatively low surface which was later uplifted. In other words, if the present canyon broadens and similar canyons develop and broaden until the entire plateau has been carried away to the depth of the present canyon bottom, then the streams of the present, newly inaugurated erosion cycle will have accomplished what was done once before. The same Eocene beds which appear in the high plateaus form a wide band on the northern margin, dipping northward until they turn up in the foothills of the Uinta range and ending at the south in an escarpment. The general surface slopes agree with the structure. This is the Uinta basin. South of it, and east of the high plateaus is the area of arid canyon lands deeply trenched by the Colorado river and its tributaries, though its eastern margin in Colorado contains some broad fertile valleys. Farther south is the Navajo section, like the canyon lands but more arid and less canyoned because there are no mountains on the border to supply through-flowing streams. The Datil section on the southeast is largely lava covered as is a considerable area farther west (San Francisco mountain and vicinity) in the Grand canyon section. There also is the Zuni uplift, a dome like the Black hills.

Basin *and* Range Province.—West and south of the Colorado plateau is a region marked by numerous small, roughly parallel mountain ranges separated by nearly flat detrital plains generally 4,000 to 5,000 ft. above the sea, but declining in altitude toward the Gulf of California. The northern half has long been known as the Great Basin and is the largest area of internal drainage in North America. The 100 or more mountain ranges divide it into an almost equal number of undrained basins. The hydrographic centres of some of these are marked by salt lakes; some others have playas, or mud flats covered occasionally by a few inches of water. All are filled or veneered by detritus eroded from the mountains and deposited as alluvial fans. Such sur-

Table 11.—Physiographic Divisions of Conterminous United States

Divisions	Characteristics
A. Laurentian upland	
1. Superior upland	1. Submaturely dissected, recently glaciated peneplain on crystalline rocks of complex structure
B. Atlantic plain	
2. Continental shelf	2. Sloping submarine plain of sedimentation
3. Coastal plain	
a. Embayed section	3a. Submaturely dissected and partially submerged, terraced coastal plain
b. Sea island section	3b. Young to mature terraced coastal plain with submerged border
c. Floridian section	3c. Young marine plain: sand hills, swamps, sinks and lakes
d. East Gulf coastal plain	3d. Young to mature belted coastal plain
e. Mississippi alluvial plain	3e. Flood plain and delta
f. West Gulf coastal plain	3f. Young, grading inland to mature coastal plain
C. Appalachian highlands	
4. Piedmont province	
a. Piedmont upland	4a. Submaturely dissected peneplain on disordered resistant rocks; moderate relief
b. Piedmont lowlands	4b. Less uplifted peneplain on weak strata; residual ridges on igneous rocks
5. Blue Ridge province	
a. Northern section	5a. Maturely dissected mountains of crystalline rocks; accordant altitudes
b. Southern section	5b. Subdued mountains of disordered crystalline rocks
6. Ridge and Valley province	
a. Tennessee section	6a. Second-cycle mountains of folded strong and weak strata: valley belts predominating over even-crested ridges
b. Middle section	6b. The same, but even-crested ridges predominate over valleys except on east side
c. Hudson valley	6c. Glaciated peneplain on weak folded strata
7. St. Lawrence valley	
a. Champlain section	7a. Rolling lowland, glaciated; in part covered by young marine plain
b. Northern section	tb. Young marine plain with local rack hills
8. Appalachian plateaus	
a. Mohawk section	8a. Maturely dissected, glaciated plateau; varied relief
b. Catskill section	8b. Maturely dissected plateau of mountainous relief and coarse texture (glaciated)
c. Glaciated Allegheny plateau	8c. Mature elaciated plateau of moderate relief
d. Allegheny mountain section	8d. Mature plateau of strong relief; some mountains caused by erosion of open folds
e. Unglaciated Allegheny plateau	8e. Mature plateau of fine texture; moderate to strong relief
f. Cumberland plateau section	8f. Submaturely dissected plateau of moderate to strong relief
g. Cumberland mountain section	8g. Higher mature plateaus and mountain ridges on eroded open folds
9. New England province	
a. Seaboard lowland	9a. Peneplains below 500 ft., post maturely eroded and glaciated; few monadnocks
b. New England upland	9b. Dissected and glaciated peneplains on complex structures; monadnocks
c. White mountain section	9c. Subdued and glaciated mountain masses of crystalline rock
d. Green mountain section	9d. Linear ranges of subdued and glaciated mountains and residual plateaus
e. Taconic section	9e. Maturely dissected and glaciated mountains and peneplain on resistant folded strata
10. Adirondack province	10. Subdued mountains and dissected peneplain glaciated
Interior plains	
11. Interior low plateaus	
a. Highland rim section	11a. Young to mature plateau of moderate relief
b. Lexington plain	11b. Peneplain on weak rocks, trenched by main rivers and locally dissected
c. Nashville Basin	11c. Peneplain on weak rocks; slightly uplifted, moderately dissected
d. Shawnee section	11d. Low, maturely dissected plateau with silt-filled valleys
12. Central lowland	
a. Great Lakes section	12a. Maturely dissected and elaciated cuestas and lowlands; moraines, lakes and lacustrine plains
b. Western young drift section	12b. Young glaciated plain; moraines, lakes and lacustrine plains
c. Wisconsin driftless section	12c. Maturely dissected plateau and lowland invaded by glacial outwash (margin of old eroded drift included)
d. Till plains	12d. Young till plains; morainic topography rare; no lakes
e. Dissected till plains	12e. Submaturely to maturely dissected till plains
f. Osage plains	12f. Old scarped plains beveling faintly inclined strata; main streams entrenched
13. Great Plains province	
a. Missouri plateau, glaciated	13a. Glaciated old plateaus; isolated mountains
b. Missouri plateau, unelaciated	13b. Old plateau; terrace lands; local badlands; isolated mountains
c. Black hills	13c. Maturely dissected domed mountains
d. High plains	13d. Broad intervalley remnants of smooth fluviatile plains
e. Plains border	13e. Submaturely to maturely dissected plateau
f. Colorado piedmont	13f. Late mature to old elevated plain
g. Raton section	13g. Trenched peneplain surmounted by dissected, lava-capped plateaus and buttes
h. Pecos valley	13h. Late mature to old plain
i. Edwards plateau	13i. Young plateau mith mature margin of moderate to strong relief
k. Central Texas section	13k. Plateau in maturity and later stages of erosion

TABLE II.—*Physiographic Divisions of Conterminous United States—continued*

Divisions	Characteristics
E. Interior highlands	
14. Ozark plateaus	
a. Springfield-Salem plateaus	14a. Submature to mature plateaus
b. Boston mountains	14b. Submature to mature plateau of strong relief
15. Ouachita province	
a. Arkansas valley	15a. Gently folded strong and weak strata; peneplain with residual ridges
b. Ouachita mountains	15b. Second cycle mountains of folded strong and weak strata
F Rocky mountain system	
16. Southern Rocky mountains	16. Complex mountains of various types: intermontane basins
17. Wyoming basin	17 Elevated plains in various stages of erosion; isolated low mountains
18. Middle Rocky mountains	18 Complex mountains, mainly anticlinal ranges; intermontane basin.
19. Northern Rocky mountains	19. Deeply dissected mountain uplands, not anticlinal ranges; intermontane basins
G. Intermontane plateaus	
20. Columbia plateaus	
a. Walla Walla plateau	20a. Rolling plateau with young incised valleys
b. Blue mountain section	20b. Complex mountains and dissected volcanic plateaus
c. Payette section	20c. Young plateaus of prevailingly weak rocks; broad alluvial terraces (applies to northern part only)
d. Snake river plain	20d. Young lava plateau
e. Harney section	20e. Young lava plateau; features of recent volcanism; ineffective drainage
21. Colorado plateaus	
a. High plateaus of Utah	21a. High block plateaus in part lava-capped; include terraced plateaus on south side
b. Uinta basin	21b. Dissected plateau; strong relief
c. Can,-on lands	21c. Young to mature canyoned plateaus; high relief
d. Navajo section	21d. Young plateaus; smaller relief than 21c. into which it grades
e. Grand canyon section	21e. High block plateaus, trenched by Grand canyon
f. Datil xction	21f. Lava flows entire or in remnants; volcanic necks
22. Basin and range province	
a. Great Basin	22a. Isolated ranges (largely dissected block mountains) separated by aggraded desert plains
b. Sonoran desert	22b. Widely separated short ranges in desert plains
c. Salton trough	22c. Desert alluvial slopes and delta plain; Gulf of California
d. Mexican highland	22d. Isolated ranges (largely dissected block mountains) separated by desert plains
e. Sacramento section	22e. Mature block mountains of gentle dip; block plateaus; playa-drained intermontane desert basins (bolsons)
H. Pacific mountain system	
23. Sierra-Cascade mountains	
a. Northern Cascade mountains	23a. Sharp alpine summits of accordant height; higher volcanic cones
b. Middle Cascade mountains	23b. Generally acrordant summits; higher volcanic cones
c. Southern Cascade mountains	23c. Volcanic mountains variously eroded; no very distinct range
d. Sierra Nevada	23d. Block mountain range tilted westward; accordant crests; alpine peaks near east side
24. Pacific border province	
a. Puget trough	24a. Lowlands of diverse character; in part submerged
b. Olympic mountains	24b. Generally accordant crests; local alpine peaks
c. Oregon Coast range	24c. Uplifted peneplain on weak rocks, dissected; monadnocks of igneous rock
d. Klamath mountains	24d. Uplifted and dissected peneplain on strong rocks; extensive monadnock ranges
e. California trough	24e. Low fluviatile plain
f. California Coast ranges	24f. Parallel ranges and valleys; on folded, faulted and metamorphosed strata; rounded crests of subequal height
g. Los Angeles ranges	24g. Uplifted fault blocks; alluviated lowlands
25. Lower Californian province	25. Dissected west-sloping granite upland (in northtrn part)

faces are nearly level and tend to rise until the basin is full. A few basins along the course of the Humboldt river have been so aggraded with detritus as to establish through drainage which may reach Carson sink or stop at Humboldt lake, according to season and weather. Many of the mountain ranges are 50 to 75 mi. long and 3,000 to 5,000 ft. above the basins and trend approximately north-south. Trees appear only in exceptional spots. Some of the ranges are known to be upraised or uptilted fault blocks. As there is a strong family resemblance among ranges, it is considered probable that faulting is at least the master process in the making of these ranges. The internal structures are complex showing that the rocks were strongly folded and (in the best-known cases) peneplained and lava covered before faulting made the present mountains. In northern Nevada and southern Oregon the mountains were uplifted so recently that their origin by faulting is beyond doubt. Farther south some ranges are so old and eroded that their origin is not obvious.

Some of the ranges bear evidence that the master faults were made before the peneplain, the present mountains consisting of the more resistant fault blocks exhumed by selective erosion.

South of latitude 35° 30′, and extending from California to New Mexico, many of the intermontane basins are connected by through drainage or at least by continuous slopes on which water might flow to the sea if the rainfall were sufficient.

8. **Pacific** Mountain *System.—Sierra-Cascade Mountains.*—From Canada to southern California a continuous barrier of mountains separates the Pacific border from the interrnontane plateaus. The Sierra Nevada south of the 40th parallel presents to the Great Basin one of the highest and steepest mountain fronts on the continent. It is the escarpment of a great fault, or compound fault, west of which an old mountain range, worn down almost to a lowland, rose again with a westward tilt. Streams descending its long western slope have greatly increased its ruggedness by cutting gorges. These were laler occupied by glaciers which deepened the valleys and steepened their sides. Yosemite valley is only an extra fine example of the typical glacial trough with its uneven floor whose basins retained lakes until filled by gravel and its oversteepened walls notched at the top by tributary valleys, the "hanging valleys" which end in falls. These mountains are mainly of granite but in the northern half is a belt of folded and metamorphosed sedimentaries making the gold belt which has yielded a large part of California's output of gold.

North of the Feather river the range changes completely. There is no evidence of uplift, only a piling up of volcanic materials from hundreds of vents. Lava flows, ash beds and cinder cnnes are of all ages, from those that are fresh and shapely to others almost eroded away. Mt. Shasta with its beautiful cone (14,162 ft.) and Mt. Lassen (*see* LASSEN VOLCANIC *NATIONAL* PARK) belong to this southern section of the Cascades. A little north of the Oregon boundary there is evidence that crustal uplift is added to volcanic accumulation. Farther north the range owes its height more and more to uplift and less and less to the piling up of ejecta. The volcanic cover gives out entirely in central Washington, north of which the northern Cascade mountains consist of metamorphosed Paleozoic rocks and granite, intricately dissected into sharp peaks and ridges most of which, in a single view, rise to an almost uniform height. The level thus determined varies from 6,000 to 8,500 ft., being gently arched.

Above this nearly level horizon in both Oregon and Washington rise the isolated cones of extinct volcanoes 3,000 to 7,000 ft. higher. The best known are Mt. Rainier (14,410 ft.) in Washington and Mt. Hood (11,245 it.) in Oregon. Crater lake in southern Oregon is the finest example of its class in North America. It originated by the engulfment of the upper part of a volcano, thus truncating the cone and leaving a pit $4\frac{1}{2}$ to o mi. in diameter at the water level, which is there 6,176 ft. high. Above it the walls of the caldera rise 500 to 2,200 ft. and below it the basin is 2,000 ft. deep.

Pacific *Border Province.*—The Pacific border province embraces a chain of coast ranges with long arid important valleys between these and the Sierra-Cascade mountains. The most northerly range, the Olympic mountains, is not unlike the northern Cascades but lower. The Oregon Coast range is a gentle anticline of Tertiary beds, relatively recent in origin. It is succeeded on the south by the Klamath mountains, a range of long standing, consisting largely of metamorphosed Paleozoic rocks, once eroded down to a peneplain but uplifted again, locally as high as 7.000 ft., then deeply and ruggedly eroded. Most of the California coast is occupied by the California Coast ranges, relatively low mountains (generally between 2,000 and 4.000 ft.) ranged in parallel ridges caused largely by faulting of an earlier, much deformed and much worn-down mountain belt. Some broad valleys south of San Francisco, Calif., are filled with late Tertiary sediments because of depression at that time. Still later the coast seems to have been depressed about 1,500 ft. below its present level. Shore lines etched against the mountainsides are preserved here and there at various levels between the sea and the 1,500-ft. contour. As shown by these old shore lines, the depression that caused San Francisco bay is relatively recent.

Puget sound is the submerged northern end of a trough 350 mi. long between the Cascades and the Coast range. Its southern end is the valley of the Willamette river, a southern tributary of the Columbia. Some of the valleys in this long trough are agriculturally rich. Commercially the region of the sound is favoured by its fine harbours and the transcontinental railroads which these harbours have attracted. The Central valley or Great valley of California between the Coast range and the Sierra Nevada is 400 mi. long and 50 mi. wide. In the upwarp of the adjacent mountain belts, this belt was bent down. As a consequence it was covered with the silt, sand and gravel washed from the mountain slopes. That deposition is still going on in the valley is evident from the habits of the two master streams. the Sacramento from the north and the San Joaquin from the south. These have small gradients and run between high natural levees; sand bars are abundant; at the head of San Francisco bay the two streams unite to build an extensive delta. The filling of the valley is mainly from the higher mountains on the east. Deposition is in the form of alluvial fans which in the southern part have crowded the San Joaquin westward to the foot of the Coast range; the great alluvial fan of Kings river, extending across the valley, has cut off its southern third forming Tulare basin, partly occupied at times by a playa lake. The climate is so arid that all inflow is evaporated and there is no drainage to the San Joaquin. Irrigation is highly developed, especially in the more arid southern half on the great alluvial fans.

Lower *Californian Province.*—The Sierra Nevada and the Great valley extend south to latitude 35" beyond which there are ranges trending nearly east-west from the Mojave desert to the Pacific. The famous fruit-growing lowlands of California lie mainly farther south. The Gulf of California occupies a downwarped trough similar to the Great valley. In recent geologic time the gulf reached 150 mi. farther north. This extension was cut off by the delta of the Colorado river and its waters evaporated. It is now the basin of the Salton sea, still in part below sea level and known, where irrigated, as the rich Imperial valley.

9. Rivers and Harbours.—In a very general way the major divides follow the great highlands, hence the rivers entering the Atlantic between the St. Lawrence and the Gulf of Mexico are of moderate size and of little direct value to navigation. Their indirect value is great, however, because all their valleys were carved when the continent stood at a higher level. Subsidence of the land drowned the lower courses of streams, making estuaries and harbours as at New York city, Baltimore, Md., and all the other Atlantic seaports. The Hudson was drowned to Albany, N.T., and the Delaware to Trenton. S.J., permitting ocean vessels to reach Philadelphia. Chesapeake bay is the largest indentation thus made. One of its branches, the Potomac, is at sea level as far up as Washington, D.C.

The St. Lawrence system embraces the five Great Lakes on the Canadian border. The divide limiting the drainage basin of these lakes on the west and south is not far from their shores, hence all tributary streams are short. But the mouths of these streams have likewise been drowned by the tilting of the basin in such a manner that the southwestern shores of these lakes are being progressively submerged while the northeastern shores are rising. Milwaukee, Wis.. Chicago, Ill.. Toledo, O., and some other ports owed their original harbours to this cause. The extraordinary harbour of Duluth, Minn., lies behind a sand bar which has cut off the western end of Lake Superior.

Nearly 1,250.000 sq.mi. of the United States, mainly in the interior plains, drain to the Mississippi and its branches. These afford thousands of miles of navigable water, chiefly on the main stream and its tributaries from the humid east. The Ohio river is the most navigated stream in North America. New Orleans, La., is a river city 100 mi. from the Gulf; it is a seaport only in the sense that seagoing vessels can reach it. Mobile, Ala., and some other Gulf ports are on drowned valleys altered and supplemented by artificial works. A small estuary at Galveston, Tex., is fronted by a broad sand reef on which the city stands.

The Mississippi river has received much attention on account of navigation and flood prevention. More than three-fourths of its water comes from three main streams: the Missouri, the upper Mississippi (above the mouth of the Missouri) and the Ohio. The hlissouri drains the largest basin but has the least rainfall, hence its volume is least. Each year the Mississippi carries to the sea approximately 340,500,000 tons of solid matter in suspension and 136,400,000 tons in solution. Erosion would thus reduce the level of the entire drainage basin by one foot in 6,000 years.

West of the continental divide on the Rocky mountains are two long rivers. the Snake-Columbia in the north and the Colorado in the south. which traverse the full width of the intermontane plateaus. Other streams are short and the total amount of water reaching the Pacific is small in proportion to the great area drained. In this part of the United States, chiefly in the states of California: Nevada, Utah and Arizona and in the adjacent part of Mexico, is a vast area too arid to drain to the sea. comprising 3.2% of the area of the continent or nearly 250,000 sq.mi. The I'acific shore, like the Atlantic, has suffered submergence, drowning the lower courses of most streams. Thus was made the harbour of Portland, Ore., on the Columbia river, 100 mi. from the sea. The local subsidence that made San Francisco bay came at a point where the chief rivers of California break through the coast ranges to the Pacific. Puget sound, with Seattle, Tacoma and other harbours, is similar to San Francisco bay. San Diego, Calif., near the Mexican border, owes its harbour to the protection of a magnificent sand reef. (Pi. M. F.; O. P. S.)

C. Climate

The climate, or average weather. within conterminous United States exhibits a wide diversity although the country lies almost wholly within the prevailing westerly wind belt. The characteristics of this generally easterly drifting air are changed as the air crosses the continent; these modifications are caused by changes of latitude and altitude, proximity to oceans and their currents, ascent and descent of the air over high mountain barriers and flow across the low smooth interior. Further, surges of polar and tropical air masses and the several types of storms add their effects to increase the variety of climates. The effectiveness of each of these so-called controls differs from one place to another. However, there are wide areas within which the characteristics of temperature, precipitation, etc., are nearly similar, but are distinctly different from the characteristics of adjacent areas.

There are almost as many climate classifications as there are climatologists, but one of the most useful—based solely on moisture characteristics, especially with respect to their effect on either native or cultivated vegetation—divides conterminous United States into five climatic provinces: superhumid, humid, subhumid, semiarid and arid. These provinces are large, in some cases extending through a latitudinal range of 10" or more, and may be subjected to alternating flows of polar *v.* tropical or marine v. continental air masses. Though each province may experience rather wide variations in temperature, except on the highest mountains, at least three months of the year have temperatures conducive to plant growth.

Superhumid Province. — This province lies along the north Pacific coast inland to the crest of the Cascade mountains. Precipitation varies from more than 30 to more than 150 in. annually. Winter is the distinct wet season, the precipitation being caused by frequent cyclonic storms which enter the United States in this latitude and by ascent of the wind up the Olympic, Cascade and Coast ranges. In the mountains much of the precipitation falls as snow which may be 10 to 30 ft. deep by the end of March. Summer is predominantly dry, most weather stations receiving less than one inch in each summer month. So little precipitation falls during the summer that there is a distinct water deficiency despite the enormous surplus in the rest of the year. Temperatures are relatively high during the winter rainy season, averaging about 40° F. at sea level — much higher than to the east at the same latitude. The highest summer temperatures rarely reach 90° and the warmest month is much cooler than it is inland. This is the cloudiest region in the United States; 140 to 200 days are overcast, but there may be more than 80 clear days, mostly in summer, each year. It is foggy along the immediate coast in the summer and inland from the coast in the autumn. There are fewer than ten thunderstorms per year.

Humid Province. — All of the United States east of a line from Lake Superior to the Texas coast and scattered small areas in the western mountains have adequate rainfall, varying from not less than 30 in. to slightly more than 50 in. annually. It is nicely distributed for plant growth because the rainier season is in summer. This seasonal distribution is the result of convectional showers, cyclonic storms and thunderstorms, the latter occurring between 25 (northern part) and 80 (central Florida) times a year. Much of the winter precipitation is snow north of the Ohio river where it may cover the ground from 40 days to nearly 150 days (northern Michigan). Along the Gulf coast snow is rare. The average annual temperature is less than 40° in northern Minnesota but increases to 70° along the Gulf coast and 75° in southern Florida. In January the averages are 5°, 55° and 70° respectively. Arctic and polar air may flow easily and rapidly across this area, bringing cold-wave temperatures in its wake. The coldest observed temperatures are about −50° in Minnesota, −20° in Tennessee, 0° in northwest Florida and 40° in Key West, Fla. In summer there is much less difference from the northern part (July average, 65°) to the southern part (80°). Except for southern Florida and eastern Maine, temperatures of 100° or higher have been observed everywhere in this province. There are about 100 frost-free days in the north and about 300 along the Gulf coast. Killing frosts may occur each year down to central Florida. Frost may penetrate the soil to depths of four to six feet in the north. In general, there are from 100 to 140 clear and 100 to 140 overcast days each year except in Florida. Dense fog is present from 5 to 30 times a year, chiefly in winter. Prolonged drought in summer is rare, but heat waves, caused by flows of warm and very moist air from the Gulf of Mexico, are frequent. During the autumn months devastating hurricanes, with wind speeds up to 125 m.p.h. and torrential rain, may strike Florida and the east coast or, less commonly, the Gulf coast. The southern half and the northwestern segment are frequently visited by tornadic storms between March and September.

Subhumid Province. — This province is a belt 300 to 500 mi. wide to the west of the humid province. The western boundary is a north-south line from mid-North Dakota through Texas. More distant from the moisture-bearing winds from the Gulf of Mexico and the Atlantic ocean than the humid province, it thus receives less precipitation. From east to west the annual totals decrease from about 30 to 18 in. along the Canadian border and from more than 40 to about 25 in. in southern Texas. The higher temperatures and greater evaporation in the south make the precipitation less effective for plant growth than it is to the north. The precipitation is largely concentrated in the late spring and early summer months and thus is especially important for cereal crops. The amount varies considerably; along the east side 1 year in 20 is semiarid whereas along the western boundary the ratio is 10 years in 20. Temperatures are strikingly continental, *i.e.*, cold in winter and hot in summer. and are quite similar to those of the western edge of the humid province. Rapid and large temperature changes are a winter characteristic with blizzards and cold waves in the north and "northers" in the south of frequent occurrence. In North Dakota temperatures of −50" F. have been observed and in central Texas, 0°. Summer temperatures are nearly the same from north to south despite the 25° difference of latitude. The highest temperatures recorded have been between 105° and 115°. The frost-free season is the same as in the western part of the humid province. Tornadoes occur in the southern three-fourths of the area.

Semiarid Province. — West from the subhumid province to the eastern slope of the Rocky mountains is an unbroken belt 300 to 500 mi. wide, extending from Mexico into Canada and including much of the area between the Cascade-Sierra Nevada ranges and Rocky mountains, in which semiarid conditions prevail. Most of it is higher than 3,000 ft. above sea level. Being still farther removed from moist Gulf of Mexico and Atlantic air and with moisture from the Pacific largely removed by passage of the air over the mountains, it receives still less rain and snow than the region to the east. In northern Montana the annual average precipitation is about 12 in.; this increases to about 25 in. in the south of Texas. Over the Great Plains the rainy season in late spring and early summer results from convection and cyclonic storms; much of the rain falls as intense showers with as much as one-third the annual amount falling in a single day. On the other hand, two, three or four months may pass without any rain. Hail is frequent in spring and early summer. In the intermontane area the precipitation is more evenly distributed throughout the year. From 20 to 40 in. of snow may fall during the winter, but ordinarily it does not remain long. Chinooks — warm, dry air descending on the lee (east) slope of the Rockies — are fairly frequent during the winter. The lowest winter temperatures have varied between −66° (Yellowstone park) and 10° (Texas), and the highest summer temperatures have ranged between 105° and 115°.

The Great valley of California, while it receives the same amount of rain as the Great Plains and Rocky mountain areas, is quite different in that almost no rain falls from May to September. Winter rain is caused by cyclonic storms and by the ascent of air over the mountains. Summer drought is so long that nearly all crops must be irrigated. Summer temperatures closely approach those of the arid province. Killing frosts occur regularly each year. Snow, hail and thunderstorms are almost unknown at low altitudes and fog is a frequent winter phenomenon.

Arid Province. — This province is largely restricted to parts of Nevada, Utah, Arizona, New Mexico, southeast California and part of southwest Texas. Precipitation is generally less than 10 in. per year, most of which falls as showers during the summer. The smallest annual average is 1.35 in. per year at Greenland ranch, Calif. Summer temperatures are so high and hence evaporation is so great that no cultivated crops can be raised without irrigation. July averages about 80° and the highest temperatures are well above 110°. On July 10, 1913, 134° F., the second highest temperature ever recorded, was reached at Greenland ranch. Winter averages well above freezing though frost may be expected during at least two months each year. More than 200 clear days and 60 or less overcast days occur annually; Yuma, Ariz., averages more than 280 clear days and more than 90% of the total possible amount of sunshine. because of the clear dry air it is not uncommon for midafternoon temperatures to be 40" to 50° warmer than those at sunrise. (P. E. Ch.; C. C. Mo.)

D. Vegetation

The dominant features of the vegetation are indicated by the terms forest, grassland, desert and alpine tundra. A coniferous forest of white and red pine, hemlock, spruce, jack pine and balsam fir extends interruptedly in a narrow strip near the Canadian border from Maine to Minnesota and southward along the **Ap-**

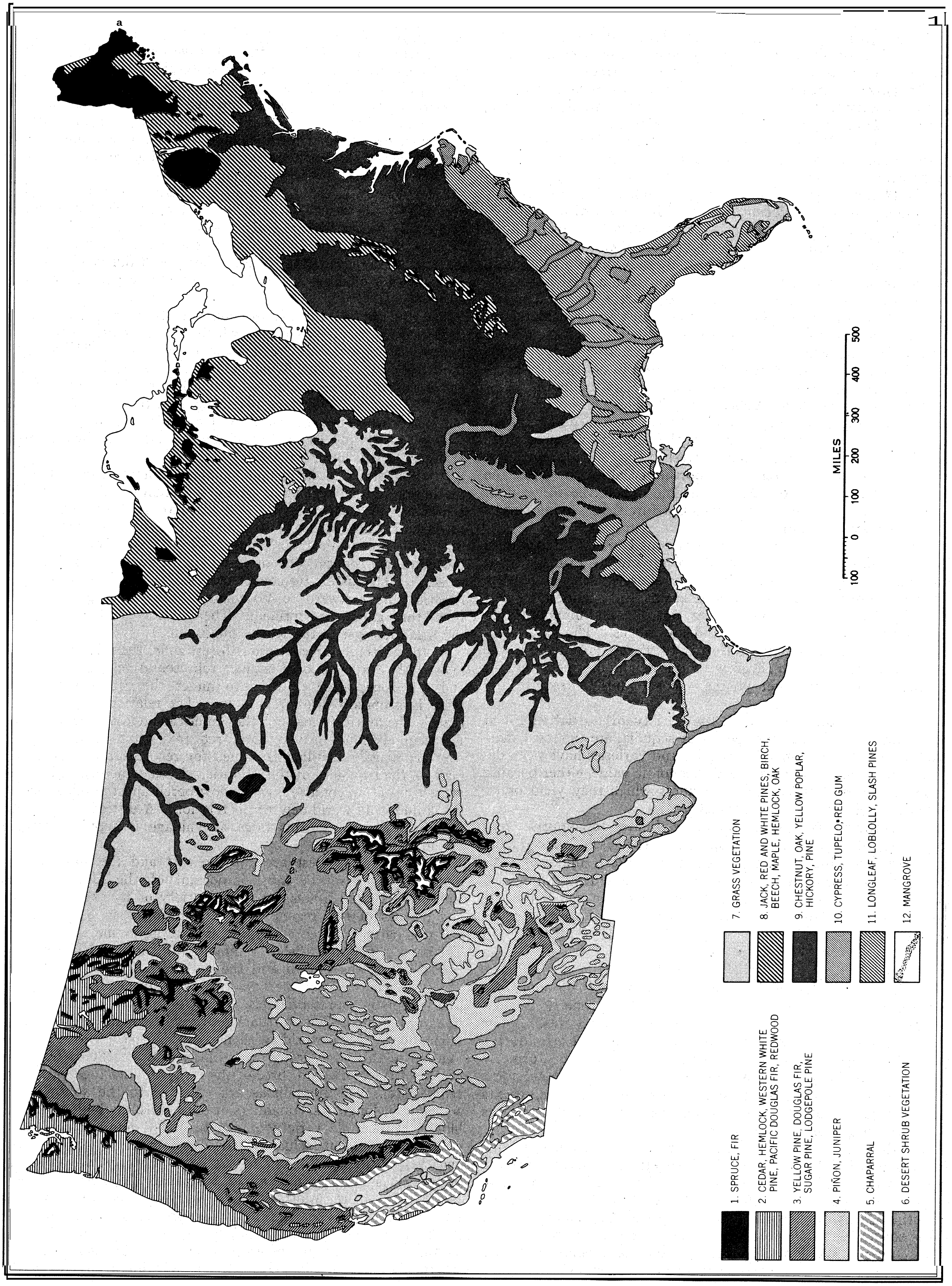


FIG. 4.—DISTRIBUTION OF MAIN TYPES OF NATURAL VEGETATION IN THE U.S.

palachian mountains. There may be found smaller stands of tamarack, spruce, paper birch, willow, alder and aspen or poplar. Southward, a transition zone of mixed conifers and deciduous trees gives way to a hardwood forest of broad-leaved trees. This forest, with varying mixtures of maple, oak, ash, locust: linden, sweet gum, walnut, hickory, sycamore, beech and the more southerly tulip tree, once extended uninterruptedly from New England to Missouri and eastern Texas. Pines are prominent on the Atlantic and Gulf coastal plain and adjacent uplands, often occurring in nearly pure stands called pine barrens. Pitch, longleaf, slash, shortleaf, Virginia and loblolly pines are commonest. Hickory and various oaks combine to form a significant part of this forest, with magnolia, white cedar and ash often seen. In the frequent swamps, bald cypress, tupelo and white cedar predominate. Pines, palmettos and live oaks are replaced at the southern tip of Florida by the more tropical royal and thatch palms, figs, satinwood and mangrove.

The grasslands occur principally in the Great Plains area and extend westward into the intermontane basins and benchlands of the Rocky mountains. Numerous grasses such as buffalo, grama, side oak, bunch, needle and wheat grass, together with many kinds of herbs, make up the plant cover. Coniferous forests cover the lesser mountains and high plateaus of the Rocky mountains, Cascades and Sierra Nevada. Yellow pine, Douglas fir, western larch, white pine, lodgepole pine, several spruces, coast hemlock, grand fir, red fir and the lofty redwood are the principal trees of these forests. The densest growth occurs west of the Cascade and Coast ranges in Washington, Oregon and northern California, where the trees are often 100 ft. or more in height. There the forest floor is so dark that only ferns, mosses and a few shade-loving shrubs and herbs may be found.

The alpine tundra, found in conterminous United States only in the mountains above the limit of trees, consists principally of small plants that bloom brilliantly for a short season. Sagebrush is the commonest plant of the arid basins and semideserts west of the Rocky mountains, but juniper, nut pine and mountain .mahogany are often on the slopes and low ridges. The desert, extending from southeastern California to Texas, is noted for the many cacti, some of which grow to the height of trees, and for the Joshua tree and other yuccas, creosote bush, mesquite and acacias.

The United States is rich in the variety of its native forest trees, some of which, as the species of sequoia, are the most massive known. More than 1,000 species and varieties have been described, of which almost 200 are of economic value, either because of the timber and other useful products which they yield or by reason of their importance in forestry.

Besides the native flowering plants, estimated to comprise from 20,000 to 25,000 species, many hundreds of species introduced from other regions—chiefly Europe, Asia and tropical America—have become naturalized. A large proportion of these are common annual weeds of fields, pastures and roadsides. In some districts these naturalized .'aliens" comprise 50% or more of the total plant population. (P. H. O.; R. C. R.)

E. Animal Life

The fauna includes most of the types of animals of temperate and arctic North America. Only a very few properly tropical forms enter the limits of the conterminous United States. A few tropical frogs and snakes are in extreme southern Texas, and the American alligator is present in southern Florida; the formerly more wide-ranging jaguar and ocelot are scarcely to be found north of the Rio Grande, though the common armadillo, which represents a distinctively South American group, has extended its range as far east as the hlississippi and north into Oklahoma.

Excluding from consideration these tropical and arctic elements, the fauna falls into a well-marked pattern, associated with the more conspicuous botanical formations. The southeastern region of hardwood and pine, a rich mixed forest, extends somewhat beyond the Mississippi, contrasting sharply with the Sonoran desert of the southwest. The great central grasslands from the Dakotas to the Gulf contrast as sharply with the transcontinental coniferous forest at the north; this forest sends great "peninsulas" southward in the Appalachian and Rocky mountains, accompanied by northern types of animals.

The Rocky mountains, with other western ranges, supply a suitable environment for various rock-dwelling types, whose relatives are found in the mountain ranges of Eurasia. The more western ranges, the Cascades and the Sierra Nevada and the Pacific coastal region, have a distinctive fauna with a mixture of unique elements and of forms related to those of the southeastern forest region. The Pacific region has a varied flora, mostly sharply distinct from that of the southeastern forest.

Arrangement of the account of the distribution of the fauna according to these regional provinces has the merit that it can be compared further mith the distribution of insects and of other invertebrates, some of which may be expected to fall into the same patterns as the vertebrates, while others, with different modes or different ages of dispersal, will have geographic patterns of their own.

The transcontinental zone of coniferous forest at the north, the taiga and the tundra zone into which it merges at the northern limit of tree growth are strikingly paralleled by similar zones in the Rockies and on Mt. Washington in the east, where the area above timber line and below snow line is a kind of tundra, often with tundra animals like the ptarmigan and the white *Parnassius* butterflies, while the spruce and other conifers below timber line form a belt sharply set off from the grassland or hardwood forest or desert at still lower altitudes.

A whole series of important types of animals spread beyond the limits of such regions or zones, sometimes over most of the continent. Aquatic animals, in particular, may live equally in forest and plains, in the Gulf states and at the Canadian border. Such widespread animals include the Virginia deer and black bear, the puma and bobcat, the otter and mink, and the beaver and muskrat. The distinctive coyote ranges over all of western North America and eastward to Wisconsin. The larger gray wolf is found throughout the continent. The snapping turtle ranges from the Atlantic coast to the Rocky mountains.

At the north, in the coniferous forest zone, the relations of animals with European or Eurasian representatives are numerous and this zone, often referred to under the Siberian name of taiga, is essentially also circumpolar. The relations are less close than in the arctic forms, but the American moose represents the Eurasian elk, and beaver, hare, red fox, otter, wolverine and wolf are equally familiar as names for recognizably related animals on the two sides of the Atlantic. Even some fishes, like the whitefishes (Coregonidae), the yellow perch and the pike, exhibit this kind of old world-new world relation. A distinctively North American element in this taiga assemblage is supplied by the Canada porcupine.

The hardwood forest area of the east and the southeastern pinelands compose the most important of the faunal regions within the United States. A great variety of fishes, amphibians and reptiles of this region have related forms in eastern Asia, and this pattern of representation is likewise found in the flora. This area is rich in catfishes, minnows and suckers. The curious ganoid fishes, the bowfin and the gar, are ancient types. The "spoon-billed cat," a remarkable type of sturgeon in the lower Mississippi, is represented elsewhere in the world only in the Tangtze in China. The Appalachian region is headquarters for the salamanders of the world, with no less than seven of the eight families of this large group of amphibians represented; no other continent has more than three of the eight families together. The eellike sirens and amphiumas are confined to the southeastern states. The lungless salamanders of the family Plethodontidae exhibit a remarkable variety of genera and a number of species centring in the Appalachians. There is a great variety of frogs, and these include tree frogs of the genus Hyla, whose main development is South American and Australian. The emydid freshwater turtles of the southeast parallel those of eastern Asia to a remarkable degree, though the genus *Clemmys* is the only one represented in both regions. Much the same is true of the water snakes (*Natrix*), the pit vipers (*Ancistrodon*) and various other genera of snakes (*Elaphe, Opheodrys*), though still others are peculiarly American. The familiar alligator is a form with an Asiatic relative, the only other living true alligator being a species in central China.

In its mammals and birds the southeastern fauna is less sharply distinguished from the life to the north and west and is less directly related to that of eastern Asia. The forest is (or was) the home of the Virginia deer, the black bear, the gray fox, the raccoon and the common opossum. The wild turkey and the extinct hosts of the passenger pigeon were characteristic. There is a remarkable variety of woodpeckers. The bird life in general tends to differ from that of Eurasia in the presence of birds, like the tanagers, American orioles and hummingbirds, that belong to South American families. Small mammals abound with types of the world-wide rodent family Cricetidae, and with distinctive moles and shrews.

The western grasslands merge by insensible degrees into semi-desert and desert toward the Great Basin and the Sonoran desert. Most distinctive of the grassland animals proper is the American bison, whose nearly extinct European relative, the wisent, is found in the forest. The most distinctive of the American hoofed animals is the pronghorn, or prongbuck, which represents a family intermediate between the deer and the true antelopes in that it sheds its horns like a deer but retains the bony horn cores. The pronghorn is perhaps primarily a desert mammal, but it formerly ranged widely into the short-grass plains. Everywhere in open country in the west there are conspicuous and distinctive rodents. The burrowing pocket gophers are peculiarly American, rarely to be seen, but making their presence known by their pushed-out mounds of earth. The ground squirrels of the genus *Citellus* are related to those of central Asia, and resemble them in habit; in North America the gregarious prairie dog is a closely related form. The American badger, not especially related to the badger of Europe, has its headquarters in the grasslands. The prairie chicken is a bird distinctive of the plains region, which is invaded everywhere by birds from both the east and the west.

The Sonoran desert of the southwest, which may be regarded as including southeastern California, southern Nevada and Arizona, a corner of Utah, parts of New Mexico and extreme western Texas, is a paradise for reptiles. Distinctive lizards abound, and the rattlesnakes, of which only a few species are found elsewhere in the United States, have their headquarters there. Among lizards the poisonous Gila monster is wholly Sonoran, though with a Mexican relative. Sonoran types range to the Pacific coast and northward in the Great Basin. Noteworthy mammals are the graceful bipedal kangaroo rats (almost exclusively nocturnal), the ring-tailed cat, a relative of the raccoons, and the piglike peccary.

The Rocky mountains and other western ranges afford distinctive habitats for rock- and cliff-dwelling hoofed animals and rodents. The little pikas, related to the rabbits, live in the rock-slides at high altitudes as they do in the mountain ranges of eastern Asia. Marmots live in the Rockies as in the Alps. Every west American range formerly had its own race of mountain sheep. At the north the so-called Rocky mountain goat lives at high altitudes—it is more properly a goat antelope, related to the takin of the mountains of western China. The dipper, remarkable for its habit of feeding in swift-flowing streams, though otherwise a bird without special aquatic adaptations, is a Rocky mountain form with relatives in Asia and Europe.

In the Pacific region, the extremely distinctive frog *Ascaphus*, which inhabits icy mountain brooks, represents a family of frogs by itself, perhaps more nearly related to the frogs of far-off New Zealand than to more familiar types. The Cascades and Sierras form centres for salamanders of the families Ambystomidae and Plethodontidae second only to the Appalachians, and there are also distinctive newts. The burrowing lizards, of the well-defined family Anniellidae, are found only in a limited area in coastal California. The only family of birds distinctive of North America, that of the wren tits, Chamaeidae, is found in the chaparral of California. The mountain beaver, *Aplodontia* (which is not at all beaverlike), is likewise a type peculiar to North America, confined to the Cascades and Sierras,; and there are distinct kinds of moles in the Pacific area.

The mammals of the two coasts are strikingly different, though true seals (the harbour seal and the harp seal) are found on both. The sea lions, with longer necks and with projecting ears, are found only in the Pacific—the California sea lion, the more northern Steller's sea lion and the fur seal. On the east coast the larger rivers of Florida are inhabited by the Florida manatee or sea cow, a close relative of the more widespread and more distinctively marine West Indian species.

See also ALASKA; HAWAII. (K. P. S.)

II. GEOGRAPHIC REGIONS

The division of the earth's surface into regions for descriptive purposes is an attempt to portray the individuality of the various parts of the earth. By this device, thousands of places which have much in common can be grouped together and conveniently discussed as a unit. If a single criterion for regionalization is selected, as in *Physiography,* above, the resulting classification is fairly straightforward. But when geographic regions based on a multiplicity of physical and human factors are laid out, the results tend to be more arbitrary and to reflect, at least in part, the prejudices of their authors. And since the human factors may change rapidly, the regions delimited by them may be valid only for a short time.

The easiest way to delimit regions is to use established political boundaries. The United States government, for example, publishes much of its data by statistical divisions based on state groupings. In addition, a considerable amount of census data are compiled by metropolitan areas and economic areas based on clusters of counties. This method is convenient, but it overlooks the fact that political boundaries are often arbitrary; a given part of a large political unit may have more in common with parts of neighbouring units than with other parts of its own.

The regions presented below, often cutting across political boundaries, are based on areas which for historic, economic or other reasons are commonly thought of as belonging together. The boundaries are somewhat arbitrary and are in almost every case transition zones rather than fixed lines. The zonal nature of these boundaries is suggested by the broad boundary symbols used in fig. 5.

1. New England.—Physically New England is a poor region, a rocky lake-studded upland that ends abruptly in a forbidding coast line. The continental glacier in passing over it carried off much of the topsoil and deposited the rocks which, piled into walls and fences, became a familiar part of the New England landscape. Except in a few valleys the winters are severe and the summers pleasant, but neither climate nor soil favours a fruitful agriculture. Nor are other natural resources superabundant. The early settlers found fish on the adjacent banks, virgin forests—since cut over—marble and granite in Vermont and limited water-power sites. Other than these, nature offered little but challenge.

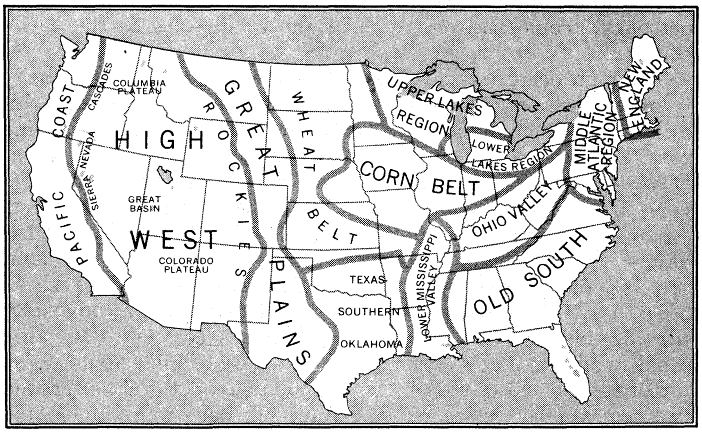


FIG. 5.— GENERALIZED GEOGRAPHIC REGIONS OF CONTERMINOUS UNITED STATES (**see** TEXT)

The history of New England shows that the challenge was met. Lumber was used to build the ships that brought fish: whales and trade to its ports. Imported raw materials, processed first with the aid of water power and muscle, iater with the help of imported coal and intricate machinery devised by Yankee mechanics, gave New England leadership in industry. Yankee thrift, business sagacity and the advantages of an early start put New England in the lead among American regions in education, culture, finance and engineering during the 19th century. Its greatest resource proved to be the ability of its people.

During the 20th century New England has been in retreat. Most of its farms were unable to compete with those of the middle west. The textile mills, long vital to the New England economy, began to move south in search of lower costs and cheaper labour. Trade was challenged by the rise of new ports; the opening of the St. Lawrence seaway enabled ocean-going vessels to travel as far away as the inland cities of Milwaukee, Wis., and Chicago, Ill. It was a retreat, however, and not a rout. New England industry retrenched, diversified, began to place more emphasis on quality, service, prestige and skill and less on quantity and cost.

The population pattern of mid-20th century New England was one of concentration in a few metropolitan areas — Boston, Mass., Providence, R.I., the lower Connecticut valley. The hinterland was used principally to supply the needs of these urban clusters. Dairying, poultry raising and truck gardening, all geared to the urban market, dominated the local agriculture, although in a few favoured spots intensive, specialized farming was practised. Aroostook county, Me., for example, was famous for its potatoes and Cape Cod for its cranberries. Much of the land remained unused or little used: three-fifths of Connecticut mas in forest, two-fifths of New Hampshire and two-thirds of Maine were uninhabited. As tourists discovered many of these areas they became less of a liability, providing recreational facilities not only for urban New Englanders but for visitors from all over the country.

Of the cities, the Boston area specialized in finance, fishing, machine tools, electrical equipment and shoes; Providence in jewelry, lace, metalwares and plastics; the Connecticut valley in hardware, clocks, firearms, motors and office machinery.

Even in the face of agricultural decline and industrial reorganization, New England, with its long tradition of leadership, continued to enjoy national prestige and influence much greater than its 1.8% of the country's area and 5.9% of the population would indicate. (*See* also NEW ENGLAND.)

2. The Middle Atlantic Region.—This region has much in common with New England: a considerable amount of poor land, concentration of population in metropolitan centres and more emphasis on a skilled labour force as a base for industrial prosperity than on raw materials. It also has several advantages over New England: proximity to coal, cement rock and slate, easier access to the interior of the continent and larger areas of good farmland with a somewhat longer growing season. The eastern focus of C.S. business developed there, and at mid-20th century the region accounted for one-iourth of all U.S. personal income. The New York metropolitan area alone accounted for one-eighth of the personal income and one-tenth of the retail sales of the entire country.

The high degree of development of this region arose primarily from its position as a gateway to the mid-continent. Geographically this seems paradoxical, for the Appalachian ridges, running parallel to the coast, cut off the coastal plain from the interior. However, gaps in the mountains mere cut by rivers flowing transverse to the grain of the country, and these rivers terminate in estuaries offering commodious harbours. New York city, with the best of these harbours, is connected inland up the Hudson, navigable by many ocean-going ships as far as Albany. West of Albany the glacier-broadened Mohawk valley provided a convenient site for the New York State Barge canal, successor to the Erie canal, which connects with the Great Lakes. Philadelphia, more fortunate than New York in its immediate agricultural hinterland, had to iay out a more difficult trans-Appalachian route up the Susquehanna tributaries and across the Allegheny front to the navigable headwaters of the Ohio. Baltimore found a similarly difficult route up the Potomac valley.

Agriculturally the middle Atlantic region possesses more level or gently rolling land than New England. The Atlantic coastal plain offers broad areas of sandy soil, suitable. when fertilized, for vegetables. The red soils of the Piedmont lend themselves to dairying and poultry raising and, in the more favoured spots. to corn, wheat and tobacco. The interior valleys specialize in dairying and fruits. Most of these areas are not especially fertile; they are passable farmlands made profitable by their proximity to metropolitan markets.

The chain of cities extending from Boston to Washington, D C., has been called the Atlantic metropolitan belt. With only brief interruptions industrial centre, commercial centre and residential suburbs adjoin each other. The focal point of this metropolitan belt is New York city. One-fourth of all U S. imports enter the port of New York and one-eighth of all U.S. manufactures originate there. The city is a leader in such diverse fields as banking, finance, education, fashion, the theatre, publishing, oil refining and clothing manufacture. to name only a few. Other cities in the middle Atlantic region specialize in somewhat heavier industries; for example. steel manufacturing at Bethlehem and Morrisville, Pa. Baltimore and Philadelphia, while priding themselves on their financial and cultural activities, are more heavily industrialized than New York. Washington, of course, is almost exclusively a governmental centre.

Although the interior contains almost empty lands comparable to the resort areas of New England, there are also scattered small industrial cities. Special note should be made of those along the New Tork State Barge canal: Albany, Schenectady, Utica, Syracuse and Rochester, all of which produce a wide assortment of manufactures. If the region as a whole can be characterized, it is as a closely knit network of towns subdivided by strips of semiwilderness.

3. The Old South. — The Appalachians, the Piedmont and the Atlantic plain, the physical components of the middle Atlantic region. broaden as they continue into the old south, a region which is more and more taking on some of the characteristics of its northern neighbours. The south is hard to define. It has been called the land of the cotton plantation, of the Negro, of the former Confederacy and of the solid Democratic vote, but these criteria no longer suffice. Cotton is no longer grown in many parts of the old south; the Negro is moving north; the plantation is often becoming a ranch or, in winter resort areas, a subdivision. The old south may be delimited on durable physical grounds to include the area with long, warm summers and short, mild winters and with associated red and yellow soils of low fertility. Another unifying factor is the consciousness that its people have of being southern. On the other hand, the old south is a patchwork of diverse soil belts, each with its own specialties, and scattered industrial towns that grew up where convenient rail, road and river junctions offered good transportation.

Along the coast and across most of Florida lies a broad belt of infertile sands interspersed with muddy lagoons and swampy flood plains along the streams. In some places the muds are worth draining for intensive winter-vegetable production and the sands, when fertilized, have supported Florida's orange groves. Elsewhere there are huge pine forests. Many of these are grown for lumber, a profitable venture since trees grow rapidly in the warm climate — twice as fast as in New England. Inland, the coastal plain has bands of well-drained farmlands that can be fertilized to raise local specialties such as cotton, tobacco and peanuts. Farther inland, adjoining the Piedmont, are soils well suited to orchards. The Piedmont itself is a rolling to hilly, often eroded area of clayey soil extending from the Atlantic plain to the Appalachians. Once important for cotton, it supports the most diversified agriculture in the old south including hay and pasturage, soybeans, peanuts, grain sorghums and fruits. In the Piedmont also are many industrial cities, utilizing the coal, stone, lumber and water power of the adjacent mountains.

The rise of manufacturing in the old south has been well advertised. Cheap power, available factory sites, low labour costs and low taxes have attracted many industries which, since they were new, were able to provide themselves with modern plants and machinery. By the early 1960s industrial production in the old south represented about 7% of the U.S total. Although many small factories are widely distributed, the bulk of this industry is concentrated in a few areas. The Piedmont area, around Richmond, Va., Winston-Salem and Charlotte, N.C., specializes in textiles, tobacco and furniture; Atlanta, Ga., in a wide variety of consumer and capital goods; Birmingham, Ala., in iron and steel; and the port cities in chemicals, fertilizers and lumber products.

The old south remains largely a region of subtropical crops, lumber and other ram materials, but is broadening its economic base in agriculture, in industry and in tourism. Once an area of extremely low income, by the early 1960s it had increased its average annual per capita income to about three-quarters of the average for the U.S. as a whole. (See COTTON BELT; SOUTH, THE.)

4. The Lower Mississippi Valley. — Culturally this valley is part of the old south, but the natural wealth provided by about 30,000 sq.mi. of river-deposited soil makes it worth distinguishing as a separate region. A large percentage of this land is too moist for anything but cypress forest, but much has been drained and converted into fertile sugar cane fields (in Louisiana), rice fields (in Louisiana and Arkansas), soybean fields (in Missouri) and cotton fields (throughout the area). Mechanized methods of cultivation and harvesting are widely used. Less intensive agriculture and lumbering are common on the sandy uplands which rise abruptly east and west of the flood plain.

New Orleans, La.. Memphis, Tenn., and St. Louis, Mo., are key centres in the commercial life of the valley. The picturesque steamboats which once gave colour to river life have been replaced by tows of barges able to carry more than the steamboats ever could. Highways and railways add to the freedom of movement through the valley.

River transport together with nearness to oil, salt and natural gas have encouraged the chemical industries. Local raw materials or materials easily brought in by river have given rise to lumber, furniture, vegetable oil. sugar refining and a host of small industries depending on cheap fuel and labour. (See MISSISSIPPI RIVER.)

5. Texas-Southern Oklahoma. — This vast, almost level region is a transition zone where the old south, the wheat belt and the west blend together. Physically, the land consists of north-south strips of prairie and open forest with highly diverse types of soil. The better soils are devoted to farming—especially cotton farming; the poorer areas remain for cattle grazing. This is oil country and oases of prosperity result from local oil booms.

Along the Gulf coast a flourishing industrial region has developed around Houston and the nearby ports of Galveston, Corpus Christi. Port Arthur and Beaumont, Tex. Houston and Galveston first developed as exporters of cotton, grain and oil. Subsequently the wealth of local petroleum, natural gas, salt, sulfur and minerals from the sea made the chemical industries so predominant that the region is sometimes called the petrochemical belt. Other industries include packing, transportation and construction.

Inland, the cities of central Texas are found close to the belt of limey soil known as the black waxy prairie. Cotton is the leading crop there but livestock raising and general farming are also common. Toward the west the country changes from farmland to mediocre grazing land and the threat of drought, prevalent throughout Texas, becomes more serious.

The cities vary widely in character. Dallas, an eastern city in appearance, is the financial capital not only of Texas but of the entire southwest as well. Neighbouring Fort Worth, more western in appearance, is a trade centre for the ranches, dryland farms and oil fields to the west. Austin, nestled against the Balcones escarpment, is the state capital and the site of the University of Texas. San Antonio, most Mexican of large Texas cities, is noted for stockyards and meat packing. All of these cities have some manufacturing but the greatest industrial development has occurred between Dallas and Fort Worth where even aircraft and automobile assembly plants have sprung up.

To the north, in Oklahoma, wheat fields border cotton fields. Oil refining is the outstanding industry but cities such as Tulsa and Oklahoma City add meat packing, flour milling, textiles and other light industries.

6. The Ohio Valley. — The Ohio river (*q.v.*) has cut a narrow winding valley into a low plateau. The dissection of the plateau by the Ohio and its tributaries has formed a broad belt of hill country with soils that are mediocre and much eroded. Except in such rolling areas as the blue grass country of Kentucky and the Nashville basin of Tennessee, farming is on the decline and the rural population is declining with it. Industry rather than farming is the major source of income in the valley.

The Ohio participated with the blississippi in the steamboat boom of the 19th century and both rivers share in the 20th century's bustling barge traffic. A series of dams maintains the Ohio and some of its tributaries at a nine-foot depth. Each dam is easily negotiated by means of locks large enough to accommodate the lengthy, tug-drawn barge convoys. Coal from the hills thus becomes available to the entire valley — an advantage which has caused the region to be nicknamed the American Ruhr. Barges also carry oil, chemicals and even such bulky articles as automobiles. Through connecting streams and canals goods can be taken from the Ohio up the Tennessee to northern Alabama, down the Mississippi and over the Intracoastal waterway to Texas and up the Mississippi and the Illinois to the Great Lakes.

Although new industrial and power developments mere being dispersed along the river in the early 1960s, the major industries were still concentrated in a few areas. The oldest is around Pittsburgh. Pa., where local coking coal and Lake Superior iron ore support a major steel industry. Downstream, another centre noted especially for chemicals has grown up on the lower Kanawha around Charleston, W.Va. A highly diversified industrial complex lies around and north of Cincinnati, O., where the Ohio bends abruptly southward. From it routes fan out toward the rich farmlands to the northwest. The falls of the Ohio, later bypassed by a canal, gave rise to Louisville, Ky., an industrial city noted for horse racing, tobacco, whisky and electrical products. Knoxville, Tenn., and smaller scattered industrial districts have developed in response to the cheap power offered by the Tennessee Valley authority.

7. The Corn Belt. — From the air this flat to rolling region appears in sharp contrast to the partly wooded, much dissected Ohio valley. This lack of major relief features made it possible to lay out fields, farms and roads in close accord with the rectangular land survey used in most pioneer areas after 1800. A lime-rich veneer of glacial deposits, commonly several hundred feet thick, covers almost the entire region. This fertile soil and the hot, humid summers, ideal for growing corn, form the bases for corn belt agriculture.

Corn is usually grown on about half of the land but only in the cash-grain areas near large markets is it sold as grain. The prevailing system is to feed the corn to cattle, hogs and poultry and to obtain cash from the sale of milk, eggs and, especially, meat. Many of the cattle are shipped in lean from western grasslands for fattening. The manure remains on the farm to maintain the fertility of the already rich soil.

Corn is, of course, the mainstay of the corn belt, but it is by no means the only crop. Crop rotation is normally practised and wheat. oats! alfalfa, hay and soybeans are widely cultivated. Most farmers raise vegetables, fruit and fodder for home consumption and frequently have small surpluses for the market.

The typical corn-belt farm is a big, well-operated business. Many are worth well over $100,000, and $1,000,000 farms are not extraordinary. The farm is commonly rectangular in shape, 160 to 400 ac. in size, with a substantialiy built house equipped with all modern conveniences. The outbuildings are spacious and the machinery is elaborate. Probably nowhere in the world is so much land efficiently tilled with so little labour.

The mechanization of the corn belt has caused a decline in the rural population and surplus farm labourers have moved into adjacent towns and cities to find jobs in industry, especially in factories producing farm tools and consumer goods.

The large cities of the region — Chicago (within the lower lakes region). Indianapolis, Ind., and Omaha, Neb., especially—owe their initial development to the packing and marketing of corn-belt produce. They have, however, attracted diverse industrial and commercial activities.

8. The Lower Lakes Region.—North of the corn belt dairying and small grains replace corn. More important than agriculture, however, is the network of transportation routes around the Great Lakes, the greatest fresh-water navigation system in the world. Before the construction of railways water offered the only form of cheap transportation and it remains the best medium for shipping heavy goods. The canal era (1820–50) saw the connection of the lower lakes with the Hudson river via the Erie canal and with the Mississippi-Ohio system via five canals, and the railways, generally, followed the canal routes. This made possible the northward movement of coal, farm produce and other heavy commodities to the lakes and thence to the Atlantic. Lower lakes ports were the obvious places to combine upper lakes ores and lumber with fuels and other materials from the Ohio valley. Before long a continuous industrial section had grown up, roughly in the shape of a triangle with Buffalo, N.Y., Cleveland, and Pittsburgh as its apices. This industry followed the railroads across southern Michigan and northern Indiana to Chicago.

Buffalo, at the eastern end of the region, was and still is important as a transshipment point from lake steamer to canal barge. The focus of many transportation routes and with a nearby source of hydroelectric power at Niagara falls, Buffalo attained world leadership in the flour-milling industry. Other outstanding products of the area include steel, electrical and mechanical machinery, chemicals and foodstuffs.

Cleveland is noted as the financial centre for the Lake Erie area. Its industry is diversified with emphasis on hardware, machine tools, chemicals apd electrical equipment. The many smaller cities along or near the lake shore have local specialties, for example, steel in Lorain and rubber goods in Akron, O.

Detroit, Mich., was a commercial centre long before it became the automobile capital of the world. Its rise to that position was partly an accident of history, but Detroit was not without natural advantages for the automotive industry. In 1900 Michigan had lumber and associated furniture, wagon and carriage industries. As steel bodies became important, Detroit was at first convenient to lower lakes steel centres and later used lake-borne ores and coal to produce its own steel. Finally Detroit could draw on a large number of smaller industrial cities in the lower lakes region to supply batteries, tires and other automobile parts and accessories.

Chicago, located nearly at the southern end of Lake Michigan, became the terminus of the eastern railroads and the starting point of those going to the west. bleats and grains from an arc of farmlands extending at least 1,000 mi. to the west were brought there for processing and shipping, and the city was the logical place for the wholesale and mail-order businesses serving the same area. Because raw materials could be brought in easily by rail and lake steamer, and from the south by canal and pipeline, it was the best place to manufacture many of the goods sold by Chicago merchants. Chicago manufactures goods ranging from bacon to watches to steel girders; it surpasses even the New York area in the variety of its industries although New York holds pre-eminence in finance, commerce and cultural activities.

9. The Upper Lakes Region.—The northern half of the Great Lakes area is a region of rigorous winters and pleasant summers. There the glaciers scraped away much of the soil and blocked the drainage, forming numerous lakes and extensive swamps. The cool, damp climate is conducive neither to the formation of fertile soil nor to the growth of most crops. Only in the southern portion is the land really suitable for fodder crops and dairying; northward it is limited to pine trees, potatoes and rye. Immigrants from northern Europe found conditions on the upper lakes similar to those of their homeland, and the population is largely of Scandinavian origin.

Wisconsin and southern Minnesota are ideal dairying areas. Clover and timothy hay, corn for silage and other fodder crops flourish. Large silos for fodder storage and huge barns for the comfort of the cattle enable the herds to survive the long minters. Milk is marketed in the lower lakes region, but there is also a huge surplus which is converted into butter, cheese and evaporated and powdered milk. Some of the surplus cream is shipped as far as New Tork by tank car.

Farther north, the original pine, birch and maple forests have been cut over and are regrowing slowly into a wilderness pleasing to summer iishermen and winter hunters. Unless they contain minerals, these northern lands are for the most part abandoned. The major mineral, hematite iron ore, is approaching exhaustion and several companies are already using low-grade ore (taconite) which inust be concentrated before it can be used in blast furnaces.

The largest cities. Minneapolis and St. Paul, Minn., have developed in relation to their trade with the dairying area and the wheat belt to the west. Duluth's economy is mainly based on iron ore and on the city's services as a Great Lakes port. (See Great Lakes; The.)

10. The Wheat Belt.—The dark soils of the flattish wheat belt are extremely fertile and in years when the rainfall is good a bumper crop can be produced at low cost. This type of farming is hardly for the poor man, however. To survive, the farmer must have a sufficient reserve to carry him through drought, hail, infestations of locusts, wheat rusts and the many other threats to his crop. He must also have enough capital to buy expensive machinery and the square mile or more of land required to operate it efficiently.

The risk of farming in the wheat belt is so great that throughout its history political groups have arisen to assist the farmer who meets with disaster—disaster which often affects whole counties or even whole states. Besides the natural hazards, the price of wheat is uncertain and even a bumper crop may be unprofitable. In an attempt to level out the ups and downs of wheat-belt agriculture some steps have been taken toward diversification. Cattle, both beef and dairy, are common throughout the region. Oats, barley, rye, flax and potatoes help to vary the crops and, when used in rotation with wheat, assist in maintaining soil fertility.

Throughout the entire region settlement is sparse and towns are small and far apart. The rectangular-field pattern of the corn belt is universal but there is little need for the big cities and prosperous industrial towns which lend variety to the corn belt economy. A possible exception to this is in the Williston basin of North Dakota where oil was discovered.

A distinction should be made between the northern and southern parts of the wheat-belt region. In the south winter wheat is planted in the fall! dies down under the winter snow, grows rapidly in the spring and is ready for harvest in early summer. In the north spring wheat is planted in the spring, grows all summer and is harvested in late summer or early fall. Both wheats are hard and well suited for the manufacture of bread flour. (See Middle West, The.)

11. The Great Plains.—The American west begins with the Great Plains. In the regions considered above settlement is fairly continuous; in the west settlement is scattered. While the more densely populated areas are taking on a resemblance to the older parts of the country and the west of the movies and television is largely a thing of the past, many parts of the west lack water, minerals or any other basis for settlement.

The flat or gently rolling plains of the wheat belt pass without a conspicuous break into the pasture lands of the Great Plains. Water supply on the plains is uncertain. Much of the available water originates in the Rockies towering to the west. Some of it flows from the mountains through long braided streams such as the Arkansas, the Platte and the Yellowstone and is used to irrigate narrow strips of intensively cultivated land yielding sugar beets, melons, grain and fodder crops. In other cases, water from the Rockies flows underground and is brought to the surface through wells.

A relatively small percentage of the Great Plains is cultivated by dry farming—a laborious method of conserving rainfall so that a grain crop can be raised on the dry margin of cultivation. For the most part, however, the land is pasture which supports a few cattle or sheep per square mile and even fewer men. The small towns are widely spaced along the east-west railways and highways and except for agricultural and mineral production there is little business activity.

The rocks underlying the plains are sedimentary and there are few ore deposits. The minerals include low- or middle-grade coal mined for local consumption and some building stone. Petroleum has brought prosperity to a few areas in Texas, the Wyoming basin and western Montana. Some of the ores from the Rockies are smelted on the plains.

Such cities as there are on the plains are generally located close to the Rockies. Denver, Colo., the largest, was originally a supply centre for mining camps. It still manufactures mining machinery and mints coins and, in addition, has the leading stockyard in the west and the leading sheep market in the country. It is also the principal financial and wholesale centre for both the Rockies and the plains.

12. The High West.—This mass of plateaus, mountains, canyons, deserts, salt lakes, forests, scrublands, prairies and irrigated valleys is as varied as would be expected for a region occupying one-third of the country. Yet its development is limited to a few tourist, mining and irrigation centres and the whole huge area supports only 3.8% of the population of the United States.

The eastern edge of the highland consists of the Rockies—high, sharp-edged mountains divided into numerous discontinuous ranges. On the slopes the grasslands of the adjacent plains blend gradually into open pine forest until at the timber line the forest gives way to alpine pastures overshado ed by snow-covered peaks. The Rockies are rich in minerals—gold, silver, lead, tungsten and molybdenum in the Colorado Rockies, copper, silver and gold around Butte, Mont., and silver, lead, zinc and copper in the Coeur d'Alene district of Idaho.

The Cascade-Sierra Nevada ranges make up the western wall of the highlands The fir-covered Cascades are volcanic mountains whose conical, snow-capped peaks rise abruptly from the surrounding plateau. The wooded Sierra Nevada is a huge block of rock tilted up toward the east where its snow-covered crest overlooks the Great Basin. Neither of these ranges is as rich in minerals as the Rockies.

Between the western wall and the Rockies are two huge plateaus and two immense areas of basins and ranges. In the north the volcanic Columbia plateau contains much fertile soil suitable for wheat farming and some arid areas which, when irrigated, support prosperous orchards. In contrast is the almost barren Colorado plateau whose major industry was tourism (Grand canyon) until the discovery of uranium. Between these two plateaus is the vast Great Basin (*q.v.*), an area of inland drainage subdivided into flattish arid basins by abrupt north-south trending ranges. As in the basins and ranges of southern Arizona and New Mexico the land is barren or poor pasture except in the few places where irrigation is possible.

As would be expected in an arid and semiarid area, the outstanding commercial centres are located at oases. Spokane, Wash., is on the Spokane river at the eastern edge of the Columbia plateau; Salt Lake City, Utah, was founded where a river drops onto the eastern edge of the Great Basin; and Phoenix, Ariz., is on the Salt river. Few sections of the high west can support cities and there is little prospect for its intensive development.

13. The Pacific Coast.—In contrast to the high west, the coastal areas are populous, but even they contain sections of wilderness, some lying almost within sight of Seattle, Wash., and San Francisco and Los Angeles, Calif. But the main resource of the Pacific coast is its mild climate.

The climate of the Pacific states is modified by tempering winds blowing eastward from the ocean. Extreme summer heat is rare except in the interior valleys because the coastal currents are cool. There are three varieties of climate. Along the coast north of San Francisco and in the Willamette valley of Oregon the weather resembles that of western Europe with pleasantly warm summers and mild but often foggy or drizzly winters. Along the coast south of San Francisco the weather resembles that of the Levant; the winters are mild with some rain, the summers are hot, sunny and dry. In the interior Great valley of California the winters are mild with some rain, the summers are very hot and irrigation is commonly necessary to supplement the slight annual rainfall.

The coastal regions of Oregon and Washington are green lands of Douglas fir forest, pastures, grain fields and orchards. Seattle, the largest city, with a well-sheltered harbour on Puget sound, is the commercial and financial capital of the area as well as an important centre for lumber and the Alaska trade. At the junction of the Columbia and the Willamette rivers lies Portland, Ore., centre of trade for the agriculturally rich Willamette valley and rival of Seattle for the trade of the Columbia plateau and the northern Rockies—the so-called inland empire. Both cities have developed important industries producing largely for Pacific markets.

Over 100 mi. of sparsely settled, forested mountains separate the Willamette and its sister valleys of western Oregon from the Great valley of California, an alluvium-filled trough over 400 mi. long. The aridity of the Great valley contrasts sharply with the area to the north. Fortunately streams from the rimming mountains enable much of the valley to be irrigated and farmed, the exact crop depending on local soil and temperature conditions. In the north there are pastures and wheat fields; near Sacramento, Calif., rice fields; southward, middle-latitude vegetable gardens and orchards producing for canning or freezing; near Fresno, grapes for wine or raisins and subtropical crops; and in the extreme south, cotton fields. The commercial outlet of this area is the cluster of cities around San Francisco bay, rivaling Los Angeles in an industrial development exceptional in the west.

Southern California, with the mildest climate on the Pacific coast, is tributary to Los Angeles, the most populous city west of Chicago. Once noted for its cattle, then for citrus fruit, then for its motion-picture studios and oil wells, then as a place for retirement, Los Angeles has grown into a mammoth, sprawling industrial, commercial and recreational centre. Its fundamental limitation is water. In succession, the city utilized local well water, the Owen river of the Sierra Nevada slopes and the Colorado river and began to consider the possibility of desalting sea water. This problem, common to all the west, is rendered acute in Los Angeles by the mushrooming population. (See WEST, THE.)

14. Alaska and Hawaii.—Southern Alaska (*q.v.*), because it is bathed by the waters of the Pacific, has a remarkably mild climate. In January Juneau is slightly warmer than Cleveland and July temperatures in Juneau average about the same as Cleveland temperatures in May. Although most of southern Alaska is mountainous, fish and lumber are produced and make up the bulk of its exports.

North of the Alaska range the Yukon valley has severe winters and short, warm summers. This is a huge area of rolling uplands whose resources are largely undeveloped and, for that matter, largely unknown.

The volcanic islands of Hawaii (*q.v.*) are populated by a mixture of peoples, largely oriental in origin. The principal industries of the islands are the raising of sugar cane and pineapples.

(O. P. S.)

III. THE PEOPLE

The Aborigines.—The territory represented by continental United States had, of course, been discovered, perhaps several times, before the voyages of Columbus. When Columbus came he found the new world inhabited by peoples who in all likelihood had originally come from the continent of Asia. Probably these first inhabitants had arrived 10,000 to 30,000 years before in a series of migrations from Asia to North America by way of the Bering strait. By the time the white man appeared the aborigines had spread and occupied all portions of the new world.

Racially speaking, these first human inhabitants of the new world in general, and of what is now continental United States in particular, are believed by physical anthropologists to have emerged largely from Mongoloid (east Asian) physical stock, but precise agreement on racial characteristics is lacking. Indians are not really red men (except when painted so); rather they have brown skin, straight stiff black hair, a minimum of beard and body hair and broad faces.

Language, which has nothing whatever to do with race, presents a highly variegated and interlaced pattern. Languages run into the hundreds, although linguists group them into families. Within the United States the Indian languages are commonly classed into six major groups: Eskimo-Aleut in Alaska; Nadene through much of the Pacific coast area; Penutian in the northwest; Algonkian and Hokan-Siouan in varying parts of the middle west and Atlantic coast; and Aztec-Tanoan in the southwest.

Indian culture patterns are as differentiated as languages. In this area as well as in the linguistic realm anthropologists are continually engaged in research and in the furtherance of knowledge and understanding of the American Indian. The culture patterns, referring to manifestations of human behaviour—to means of subsistence, material accoutrements, economics and tribal social organization—have been at least tentatively classified by areas. Within the United States these culture areas are the arctic and subarctic (Alaska), the northwest coast, California, the southwest, the basin-plateau or intermontane, the plains and the eastern woodland.

The food resources available in each physiographic region largely determined the type of subsistence prevailing there. Fish and sea mammals, for example, contributed the bulk of the food supply of coastal tribes, although the acorn was a staple for California Indians; plant life and wild game (especially the American bison or buffalo) were sources for the plains Indians; small-game hunting and fishing (depending again on local resources) provided for middle-western and eastern tribes. These foods were supplemented by corn and corn in turn was a staple food for the Indians of the southwest. The procurement of these foods called for the employment of fishing, hunting, plant and berry gathering and farming techniques, the application of which depended, in turn, upon the food resources utilized in given areas.

Foods and other raw materials likewise conditioned the material culture of the respective regional groups. All Indians transported goods by human carrier; the use of dogs to pull sleds or travois was widespread; and rafts, boats and canoes were used where water facilities were available. The horse was the white man's importation, but it was quickly adopted by the Indians once it had made its appearance. The horse became widely used by the buffalo-hunting Indians of the plains.

Indian culture groups are distinguished among other things by house types. The dome-shaped ice houses were developed by the Eskimos; rectangular plank houses were produced by the northwest Indians; earth and skin lodges and tepees by plains and prairie tribes; flat-roofed and often multistoried houses by the Indians of the southwest; barrel houses by the natives in the northeast. Clothing, or the lack of it, likewise varied with native groups, as did crafts, weapons and tribal economic, social and religious customs.

At the time of Columbus' discovery there were probably roughly 1,500,000 Indians in what is now continental United States, although estimates vary greatly. In order to assess the role and the impact of the American Indian upon the subsequent history of the United States in any meaningful way, it is imperative that the differentiating factors, such as those mentioned above, be clearly understood. Generally speaking it may be said, however, that the American Indians as a whole exercised an important influence upon the white civilization transplanted from Europe to the new world. Indian foods and herbs, articles of manufacture, methods of raising some crops, war techniques, words, a rich folklore and racial infusions are among the more obvious general contributions of the Indians to their white conquerors. Indian resistance to the white man's advance, taking the form of a protracted brutal conflict on the westward-moving frontier of white settlement, constitutes one of the most tragic chapters in the history of the United States. *(See* INDIAN, NORTH AMERICAN; NORTH AMERICA: *Anthropology;* ARCHAEOLOGY: *Prehistory: The New World Prior to Urban Civilization; Anglo-America.)*

The People of Colonial America.—Not only was Columbus' discovery made under the auspices of the kingdom of Spain, but the first white settlers in the new world were Roman Catholic Spaniards. Their settlement was concentrated in areas south of the present United States, but Spaniards and mestizos (Spanish and Indian mixed blood) nevertheless advanced during and after the 16th century from Cuba into Florida and from present-day Mexico into the American southwest—present-day Texas; New Mexico, Arizona and California. Not until the first half of the 19th century did these Spanish-American provinces become territorial possessions of the United States, but by the close of the colonial period the foundations had been laid for a very significant Spanish contribution to the future U.S. population matrix. It has been calculated that by 1790 (the date of the first United States census) there were approximately 25.000 persons linguistically classified as Spaniards within the future United States. By the time these territories had finally become U.S. possessions (1853), the number of Spanish-speaking peoples had increased roughly fourfold.

Coming later in point of time but constituting the main core of American (U.S.) colonial society were the English. Out of an aggregate white population of more than 3,200,000 in the 1790 census, plus an additional 54,400 living in areas not as yet a part of the United States, the English (and Welsh) represented a range (depending on various statistical analyses made) of 60%–83.5%.

The 13 original colonies were, of course, English governed and the constitutional, institutional and cultural life of American colonial society was therefore predominantly Anglo-Saxon in character. English was the official language and it was spoken in all but isolated "foreign" communities. Either the Church of England or dissenting English Protestant sects dominated colonial religious life) although not to the exclusion of other denominations. In most colonies English customs prevailed but many of these became modified as the frontier of settlement pushed continuously westward.

One distinctive feature of the English colonial system, compared with the colonies of Spain and France in the new world, was its relative tolerance for peoples of non-English nationality. Each and every one of the 13 original colonies was host to such non-English elements. Most numerous of these were the Scots which included descendants of emigrants from Scotland and from northern Ireland, the latter known as Scotch-Irish. According to figures presented by the department of commerce and labour *(A Century of Population Growth,* p. 116, 1909), derived from an analysis of names of heads of families, those of non-English nationality living in the United States in 1790 were as follows: Scots, 188,589; Irish, 44.273; Dutch, 56.623; French, 13.384; Germans. 156,457.

These non-English peoples exerted a profound influence on English colonial society. First to arrive in what eventually was to become New York colony were the Dutch. They came as settlers to New Netherland colony where they founded New Amsterdam (New York city), contributed a distinctive style of architecture, developed a prosperous agriculture (including tobacco raising), engaged in fur trading and general commerce and, as adherents of the Dutch Reformed Church, carried on some missionary work among the Indians. Before succumbing to English conquest the Dutch had absorbed the Swedish colony on the Delaware river. In time they blended with the English as well and so contributed to the making of an American mixed stock. Later, Germans (adhering to assorted Protestant faiths) and Scots-Irish (Presbyterians) helped immeasurably in spearheading settlement in western Pennsylvania and the Shenandoah valley. French immigrants, for the most part relatively prosperous Huguenots, found the emerging American cities to their liking and engaged in business and trade.

Not only did American colonials comprise numerous national groups, as the foregoing figures indicate, but by the close of the colonial period these various stocks had become so extensively mixed through intermarriage that they could properly be called a new people—"American" as distinguished from "British." Moreover, by the time of independence from Great Britain these Americans, representing many faiths and backgrounds, had through several generations of living in the new world developed culture patterns that were also distinctively American.

The New United States (to **1860**).—The winning of independence from Great Britain in 1783 ushered in a multiplicity of

TABLE 111.—*Country of Origin of Foreign-Born Residents in the United States, 1860*

Country of origin	Census of 1860	Proportions in 1860
Ireland	1,611,304	38.93
Germany	1,276,075	30.83
England	433,494	10.48
British America	249,970	6.04
France	109,870	2.66
Scotland	108,518	2.62
Switzerland	53,327	1.29
Wales	45,763	1.11
Norway	43,995	1.06
China	35,565	0.86
Netherlands	28,281	0.68
Mexico	27,466	0.66
Sweden	18,625	0.45
Italy	11,677	0.28
Other countries	84,767	2.05
Total foreign born in the U.S.	4,138,697	100.00

changes, important among them the growth and spread of the American people. A detailed account of population growth is given in Population, below. Suffice it to say here that according to the decennial census figures the total population of the United States in 1790 (white and Negro) was 3,929.214. Seventy years later, on the eve of the American Civil War, this number had increased to 31,443,321. During the first half of this period this increase was largely the result of the multiplication of the native American stock, but during the latter part, especially from 1830 to 1860, the population growth was augmented considerably by immigration, mainly from northern Europe.

These were years of great territorial expansion as well as numerical growth. National boundaries were enlarged to embrace Florida to the south and the huge area lying between the blississippi river and the Pacific ocean to the west. So as the United States suffered from "growing pains," its proliferating population found its major outlet in westward expansion. By 1860 the frontier of settlement had pushed across the Mississippi river well into Minnesota, Kansas, Missouri, Arkansas and eastern Texas. Parts of Colorado were by then experiencing a mining boom; the Great Salt Lake valley was undergoing rapid settlement by a religious sect known as Latter-day Saints; and overland migrations to Oregon in search of free land and to California in search of gold had enabled these two areas to enter the union as states.

The invention of the cotton gin in 1793 had been largely responsible for the surge of migration, especially after 1815, into the rich cotton-producing regions of the trans-Allegheny south. This development in turn was destined to alter the racial complexion of the south and southwest, for as cotton production increased, so too did the encouragement of Negro slave labour. Even though the further importation of Negro slaves was forbidden by law as of 1808, and even though Negro slavery vanished in all northern states, the Negro population multiplied rapidly. In 1860 there were 3,953,760 Negro and mulatto slaves and 476,636 free Negroes and mulattoes (total 4,430,396) in the United States. Free people of colour were to be found in every state and in every territory except Dakota, whereas the slave element was, as indicated, confined to the southern slave states. In some southern states the white-Negro population ratio had, by 1860, attained a rough equality in numbers. And in Mississippi, for example, there were considerably more Negroes than white inhabitants in that year. So regardless of the disposition of the slavery question

TABLE IV.—*Country of Origin of Foreign-Born Residents in the United States, 1900*

Country of origin	1900	1860	Country of origin	1900	1860
Austria	432,798	25,061	Ireland	1,615,459	1,611,304
Bohemia	156,891	..	Italy	484,027	11,677
Canada (English)	784,796	249,970	Mexico	103,393	27,466
Canada (French)	395,126		Norway	336,388	43,995
China	81,534	35,565	Poland	383,407	7,298
Denmark	153,690	9,962	Russia	423,726	3,160
England	840,513	433,494	Scotland	233,524	108,518
France	104,197	109,870	Sweden	582,014	18,625
Germany	2,663,418	1.276.075	Switzerland	115,593	53,327
Netherlands	94,931	28 281	Wales	93,586	45,763
Hungary	145,714	.	Other countries	116,551	39,286
			//Total	0,341,276	4,138,697

in the impending sectional conflict, it is quite clear that the racial complexion of the United States was destined to remain mixed and, to a limited extent, intermixed.

Just as the Negro element was an inheritance of colonial society, so too was the immigration or acquisition of alien European peoples. European immigration, however, was erratic in its pace. Between 1790 and 1820 approximately 120,000 aliens arrived from Europe, to which number should be added another 30,000 Europeans who came under U.S. suzerainty by virtue of new territorial acquisitions. It was, however, the second portion of this period, 1820–60, that witnessed the first really major wave of foreign, or alien, immigration into the United States. A devastating potato famine in Ireland during the late 1840s and serious political upheavals in the Germanies in 1848 and after gave rise to a heavy exodus from the countries involved. England and Scotland, as always, continued to contribute to the American population growth as did, to a lesser degree, the countries of France, the Netherlands and Scandinavia (not including Denmark).

In general, the superintendent of the United States census (1860) attributed this substantial rise in immigration to "the form of our government" and to opportunities within the United States that offered reward for "patient, persevering industry." More specifically the immigrants of this period were attracted to the land, to agriculture rather than to industrial urban areas. And even though the country faced, in 1860, the grim prospect of civil mar. the impending passage of the Homestead bill provided a renewed impetus to prospective immigration during the years ahead. "The gift, substantially, by the government," continued the superintendent, "will induce a large emigration to the new States and Territories."

Table III shows national elements represented in the United States in 1860 and the numbers and proportions involved.

By 1860 certain characteristics of U.S. society stood out boldly. During the first three-quarters of a century of independence, population increases — native and foreign — had kept pace with territorial expansion. The north had emerged as an important industrial as well as an agricultural section of the nation; the south had extended its cotton economy throughout the cotton-growing areas of the old south and into the southwest, including Texas, and with it the "peculiar institution" of Negro slavery; the frontier of settlement continued to move rapidly westward into new agricultural areas. The general complexion of the people was being continually modified, as in colonial times, by the growth of the Negro population. mainly in the south, by the infusion of new blood from northern Europe and by an ever-present frontier element. The outward character of the American people remained essentially that of colonial America: predominantly Anglo-Saxon, industrious, independent, aggressive, Protestant, nationalistic (or independent) and relatively democratic. But in spite of these all-prevailing characteristics the United States was, in 1860. a nation divided. It took the Civil War to establish the principle of federal supremacy over the states' rights principle, and it took this same civil conflict to bring about the abolition of Negro slavery.

A Century of Change. — During the 100 years from 1860 to 1960 the United States experienced a phenomenal population growth; it also underwent significant shifts in the movement and regional distribution of its entire population (see Population, below). The total population increased from 31,443.321 in 1860 to 179,323,175 in 1960. At the same time the population centre of the nation moved relentlessly westward. In 1860 this population centre was located 20 mi. S. of Chillicothe, O. (having moved there from a point 23 mi. E. of Baltimore in 1790); in 1960 it was located at Ferrin, Clinton county, Ill. Until 1920 the direction of movement was slightly north by west but after that time the decennial centres veered slightly south by west.

Apart from the impressive over-all growth of the U.S. population during this 100 years, the most significant discernible trend was the mounting size and shifting source of origin of the immigrant contingents. (See Table IV; cf. Table III.) Immigration from the northern and western countries of Europe dechned, and more and more newcomers arrived from the eastern and southern parts of the continent. Furthermore, beginning in about 1848, a new racial element entered the American stream with the coming. chiefly to the west coast, of oriental peoples. first the Chinese. later the Japanese.

By the turn of the century the nation had become fully aware of this shift in the national origins of its huge immigrant element and with the outbreak of World War I speculation arose regarding the ultimate impact of these changes upon American society and culture (*see* AMERICANIZATION). This awareness had political repercussions which in turn led to the passage of restrictive legislation. The oriental groups were the first to suffer. Welcomed at first because of a shortage of labour following the gold rush. they were eventually resented as depriving native-born workers of jobs. Not only were most orientals prevented from entering the country, but foreign-born orientals already resident in the United States were barred from becoming citizens. Their children. however, became citizens by virtue of being born on U.S. soil. A further series of congressional acts culminated with the passage of the Immigration act of 1924 which limited the immigrant quota to 2% of the nationals of a given country living in the United States in 1890—an arrangement which resulted in a bias in favour of the northern European groups. World War I had seen a marked slowing up of immigration into the United States; the Immigration act of 1923 reduced it to a mere trickle. (*See* also MIGRATION: *Migration* to *the United States.*)

The presence of these "new Americans," many of whom did not assimilate readily. posed new and often serious problems for 20th-century United States. One of these was: how to assess the role and status of minority peoples. Many students of the problem felt that. while economic conditions are factors in this assessment, the problem is largely one of attitudes—the attitudes of older and larger groups toward smaller and in most instances newer ones. Symptomatic of these attitudes were the placing of west coast Japanese—almost all of them citizens—in detention camps during World War II and the difficulties attending desegregation in the public schools in the postwar period.

It must not be assumed that the changes in the composition of the American people that occurred after about 1880 are deleterious. But this changing matrix does bring with it significant alterations in political and social attitudes; it is reflected in the character of America's ever-expanding urban life; it is reflected in turn in the creative arts of the nation. A contemporary observer of the American scene today might validly ask what Michel Crèvecoeur asked in 1780: "What then is the American, this new man?" This question might be answered in part in Crèvecoeur's own words, that an American is still "that strange mixture of blood, which you will find in no other country." He is. however, unlike his colonial progenitor, largely an urban dweller and one possessed of a relatively high standard of living. He is literate, English-speaking. socially conscious, still independent, practical and inventive and, more than ever, he is on the move. (O. O. W.)

IV. HISTORY

COLONIZATION AND EARLY SELF-GOVERNMENT, 1600–1765

The opening of the 17th century found three nations—France, Spain and Great Britain—contending for dominion in North America. Of these Britain. the tardiest on the scene, finally took control of the beginnings of what is now the United States. The French, troubled by foreign wars and internal religious quarrels. long failed to realize the great possibilities of the new continent, and their settlements in the bleak St. Lawrence valley grew feebly. The Spaniards were preoccupied with South America and the lands washed by the Caribbean and Gulf of Mexico. But the British. after initial failures under Humphrey Gilbert and Walter Raleigh, planted firm settlements all the way from Maine to Georgia. nourished them with a steady flow of people and capital and soon absorbed the smaller colonizing venture of the Dutch in the Hudson valley and the tiny Swedish effort on the Delaware river. Within a century and a half the British had 13 flourishing colonies on the Atlantic coast.

These colonies had a number of characteristics that differentiated them from any other communities in the world. For one thing, they possessed a cosmopolitan population. Though English culture set the general political and socioeconomic mold, the people by 1750 included large bodies of Dutch. Germans and Scotch-Irish and smaller groups of Huguenot French, Scotch Highlanders. Swiss and Scandinavians—not to mention the Negroes. The colonists also tended to look to the west. Seeking cheap land. they pushed from the tidewater strip toward the Appalachians. and finally crossed the mountains by the Cumberland gap and Ohio river. Decade by decade they became less European in habit and outlook and more American—the frontier in particular setting its stamp on them (see AMERICAN FRONTIER; AMERICAN COLONIES [U.S.]). Their freedom from most of the feudal inheritances of western Europe, and the self-reliance they necessarily acquired in subduing nature, made them highly individualistic.

How Colonization Took Place.—A variety of motives—political, religious and economic—contributed to the settling of the Atlantic seaboard. Both labour and capital in England had become fairly fluid by 1600, and were seeking more profitable fields. A sharp rise in prices and living costs made many people restless; the increase in sheep grazing and the fencing-in of former common lands drove many from the soil; bold young men, including younger sons of the gentry, losing in peace the occupation which the wars with Spain had given them, looked abroad. Many Englishmen saw that the colonization of the new world might contribute to the power and affluence of the mother country, and that Spain, Portugal and other lands should be given competitors. Finally, the spread of great commercial trading companies assisted in the work.

These companies were chartered by the crown to give Great Britain new outlets abroad. The Muscovy company, for example. founded in 1555, intended to trade with Russia; the Levant company controlled trade with Venice and the near east; and the East India company (1600) covered the Pacific and Indian ocean coasts. Companies were also organized for Newfoundland, the northwest passage and Bermuda: Most important for America. however, were the two companies for which King James I granted a charter in 1606: one to colonize the American coast anywhere between parallels 34° and 41° N. and the other anywhere between 38° and 45° N. As members of the first company lived in London it became known as the London company; since members of the second dwelt in Plymouth, it was called the Plymouth company. Shareholders in the companies were to provide settlers and capital, and were to control production and trade. Government, however, was to remain in the hands of the crown, acting through councils. A guarantee was given the colonists of all the rights and liberties of British subjects, without any definition of their scope. In return. the grantees were forbidden to draft any orders or make any laws contrary to those of England.

The London company lost no time in using its powers. Before Christmas in 1606 three ships sailed for Virginia. carrying among others Capt. John Smith, who was to take an important part in the American story, and Bartholomew Gosnold, who had previously visited the New England coast. In the spring of 1607 the three ships sailed into Hampton Roads. christened the James river! landed 120 men and founded Jamestown. Starvation, disease and Indian warfare ensued, and though more ships with fresh settlers arrived, for a time the colony had but precarious life. In the end Virginia took sturdy root. "We hope to plant a nation, Where none before hath stood," sang a ballad maker among the early adventurers, and they achieved their ambition. (See also VIRGINIA: *History.*)

In these years the London company had achieved a broader legal basis. It obtained two new charters from the crown, one in 1609 and one in 1612. These new grants practically severed it from the Plymouth company and confirmed to it a great belt of territory 400 mi. wide extending through the American continent to the Pacific ocean. The London company thus became proprietor of the colony of Virginia. At the same time it obtained large rights of government. It could appoint the resident governor, his resident council and other officers, and hold full control of them. The old system of joint-stock management of land and trade was abolished, and private property in land and stores took its place. An able soldier. Sir Thomas Dale. went to Virginia in 1611 with three ships, 300 colonists and some livestock, and for five years exercised statesmanlike control. During these years the colony took up the cultivation of tobacco with great profit.

Meanwhile, the Plymouth company had failed in an effort to plant a colony at the mouth of the Kennebec river in Maine. Nothing more was done to colonize what is now New England until a group of Separatists, who believed that the Bible was the only test of faith and revolted against all other creeds, turned to this area. These Pilgrims placed themselves in partnership with a group of merchants and other businessmen, who agreed to finance the venture. In return for advances of ready money, the colonists promised to labour for seven years. throwing all they produced into a common pool; both profits and land were to remain undivided for that period. Of two vessels dispatched, one turned back; but the other, the "Mayflower," set sail on Sept. 6 with about 100 passengers and reached Cape Cod before the year ended. After much suffering and peril courageously met, the colony at Plymouth, Mass. (*q.v.*), took root. Within ten years it was prosperously expanding, had separated itself from the partners in England and had replaced the joint-stock arrangement with private properties and private enterprise.

First Steps in Self-Government.— Both in Virginia and New England the colonists soon began to exercise a certain autonomy. In 1619 Gov. George Yeardley brought out to Jamestown a new plan of government and a momentous step forward was taken. A two-part legislature was created, one part consisting of the governor and his council, named by the company in England, and the other a house made up of two burgesses from each settlement. It was to legislate upon Virginian home affairs, subject to the approval of the governor and the company. During the summer the first true legislature in continental America met in the log church in Jamestown. A little later the Pilgrims, before leaving the "Mayflower," adopted an agreement or compact. It was not a form of government but an agreement that they would live together in orderly fashion under civil officers of their own selection. On board the ship John Carver was chosen governor, soon to be succeeded by William Bradford. As soon as they had begun housing themselves, the Plymouth settlers met and consulted upon laws both for their civil and military government resulting in the first New England town meeting.

But a colony of sturdier individualism, with a bolder degree of self-government, was soon to be established. In the 12 years 1630–42 occurred the "Great Migration" of the Puritans from England to America. These believers in a church purged of old forms and abuses, and a society purified of gross evils, were unhappy under King Charles I, who in 1629 dissolved parliament for 11 years, and under Archbishop William Laud. who declared war upon them. Two men, John Endecott, who led a body of settlers to Salem, Mass., and John Winthrop, a country squire of great energy, showed special leadership. The crown in 1629 gave a charter to the Massachusetts Bay company; the Puritans quickly obtained control of it; and Winthrop as governor persuaded the members to decide in favour of transporting company, charter and a large assemblage of colonists all together to Boston, Mass. New groups at once migrated to this colony of Massachusetts Bay, with Boston as its centre. Careful estimates show that by 1641, 300 ships had carried 20,000 settlers to America. This was an almost purely English migration, which included a few aristocrats and many university graduates. Religious zeal animated most of the migrants. (*See* also MASSACHUSETTS : History.)

The result was the erection of a church state which fell far short of democracy, but cherished a passion for liberty and self-government. Each town of Massachusetts Bay had its own church, minister and town government and was an independent Congregational community. Voting rights were limited to church members, and the ministers exercised a powerful authority in civil affairs. From an early date the voting freemen elected deputies to sit in the general court, or legislature, where they, the governor and a small body of his assistants made laws and levied taxes. Thus a self-sufficient commonwealth of oligarchical type sprang into being. Governor Winthrop and others declared that it had absolute powers of self-government under the crown, and owed no allegiance or deference to the British parliament. The dominance of the clergy, however, and the narrowness and harshness of their government aroused great discontent.

A combination of two impulses, the restlessness of men seeking better land and a desire for greater independence in religion and politics, led various elements in New England to establish other colonies. Thus Roger Williams, a stout adherent of freedom and tolerance, helped bring Rhode Island into existence; Thomas Hooker and others founded settlements on the Connecticut river; and the Rev. John Davenport and others established New Haven colony, which expanded along Long Island sound. The early inhabitants of Maine and New Hampshire were controlled by Massachusetts Bay. All the New Englanders until 1680 practically ruled themselves. They regarded the government in England as sovereign, but passed their own laws, traded under their own regulations and raised their own forces for defense. Their tie with Britain was one of sentiment, not force, and they developed themselves in full freedom.

Particularly during the years of the civil war and Commonwealth in England did the colonies profit from the preoccupation of the mother country with its own affairs. The Massachusetts legislature boldly asserted that the laws of the English parliament did not reach into New England. Under Cromwell and the Commonwealth, Virginia was permitted to elect its own governor and council as well as burgesses. During the period of civil strife in England, the four colonies of Massachusetts Bay, Plymouth, Connecticut and New Haven in 1643 formed a New England confederation which lasted for a full generation. Its primary purpose was defense against the Indians, French and Dutch, but it also dealt with boundary controversies and provided "mutual advice" on various questions.

Land Policy in New England and Virginia.— The New England colonies grew by a process of group settlement. The general courts of the various colonies, most notably that of Massachusetts Bay, would make a grant of land to a migrating group, fixing its boundaries carefully. This group would then establish a new town. Its common lands, fencing, grazing practices and the mode of apportionment of farms were regulated by the general court or legislature; but each town then took control of land allotments and management. The legislature determined who should be admitted to the town as settlers and freeholders. The town meetings, or boards of town proprietors, laid out the land of each settlement as house lots, common fields, meadow and pasture, and ultimately divided it among owners. Inhabitants of each town commonly dwelt together for society and protection and traveled from the town centre to till their acres. The typical town was thus closely akin to an English manor, but with no lord of the manor at its head. The town was, of course, the church centre, and its pastor was the community leader. Militia service, elections and taxation were based on the town.

In Virginia, settlement followed an entirely different pattern. There the colonists spread out widely up the creeks and rivers, soon moving westward as far as the falls of the James river where the city of Richmond now stands. Partly because tobacco rapidly impoverished the soil, they tilled land in much larger units, known as plantations, with almost no village centres; and they made much greater use of servants than did New England. This pattern was unfavourable to social life. co-operation and communal activities, but it created quite as strong a spirit of independence as that existing farther north. Throughout the 17th century the planters preferred white indentured servants to Negroes, and for a time as many as 1,500 arrived every year. They were mainly English, with an admixture of Scotch and Irish, and in general bound themselves, in return for transportation and support, to work without wages for from four to six years. This indenture or redemptioner system became a highly efficient aid to colonization. When they had worked out their terms, the servants moved up the streams, took land, began shipping tobacco from their own wharves, and thus became in turn independent planters or freehold farmers.

The natural political units in Virginia were parishes and counties. Parish institutions were chiefly ecclesiastical, but under the English system they included education; every minister kept a school and the vestry saw to it that all poor children could read and write. Children of prosperous families usually had private tutors. The counties increased in number to keep pace with the steady spread of population. By 1652 Virginia had 13 counties, of which 9 lay on the James river and 2 on the York. The county courts held large powers of local government and tended to come under the control of a few influential families. Until 1636 the house of burgesses was practically elected on manhood suffrage; thereafter the vote was restricted, and when Sir William Berkeley became governor under the Restoration, he kept a compliant house in power for 15 years.

Founding of the Middle Colonies. — Henry Hudson's voyage of 1609 to what is now New York bay was intended to serve trade rather than colonization. The Dutch wished for cargoes of fur, lumber and tobacco. But in 1621 the Netherlands government chartered the Dutch West India company with power to build forts, to establish a government and to colonize the land over wide areas, including the American coast. Two years later the heads of the company sent a vessel with 30 families of Walloons, Protestant refugees from the southern provinces of the Netherlands, to the mouth of the Hudson river, where they established the first permanent settlement on the island of Manhattan. More settlers arrived, and in 1626 Peter Minuit purchasing the island from the Indians, founded New Amsterdam as the seat of government for a colony. Ft. Orange (now Albany) had been planted up the Hudson two years earlier as a fur-trading post. New Amsterdam quickly became a cosmopolitan town, attracting people of various nations and faiths. It had the self-reliant, lawless atmosphere of a seaport, full of privateers, smugglers, tavern keepers and roistering sailors.

For several reasons New Netherland did not grow as vigorously as the British colonies. The Dutch West India company was at first much more interested in preying on Spanish commerce in the Caribbean and Atlantic than in finding permanent settlers. It was also anxious to develop the fur trade and to share in the tobacco trade. When it turned to settlement in earnest, it adopted an unfortunate method. Beginning in 1629 it granted any patroon who brought out 50 families a great estate on which to settle them as tenants, with certain monopolies, as of milling, in the hands of the owner. This kind of feudalism gave a few great families an unhealthy share of wealth and power. Some small farmers did establish independent farms or boweries here and there, as did interloping Puritans from New England who sifted into Westchester and the northern reaches of Long Island; but they were not numerous. Finally, the governors and councils appointed by the Dutch West India company, who ruled without any such popular assemblies as Virginia and New England possessed, were harsh, autocratic and blundering. Far from gaining any popular following, they were generally disliked. The most famous of governors, Peter Stuyvesant was also the most headstrong and shortsighted.

It was impossible for England long to permit a Dutch colony to break the line of its possessions on the Atlantic seaboard. In 1664 a small English naval force obtained the surrender of the New Netherland without firing a shot. The 7,000 inhabitants of the area accepted the new regime without protest. Charles II appointed his brother James, the duke of York, ruler and proprietor of the colony of New York, a domain stretching from the Connecticut river to the Delaware. At once a more liberal regime began. The proprietor sent over a governor with instructions to treat the Dutch inhabitants generously, permit them to keep their lands and to make no interference with their language or religion. Immigration was encouraged and settlements thickened. In 1683 Gov. Thomas Dongan summoned a representative assembly for the province of New York. *(See* NEW YORK *[STATE]*: *History;* NEW *YORK* [CITY] : *History.)*

One of the greatest of all colonial figures presided over the founding of what became Pennsylvania and Delaware. William Penn, son of a prominent English admiral, had been converted to the Society of Friends, or Quakers, in 1667, in his early 20s. He aspired to establish a colony where every race and every sect could find both political and religious freedom. His friendship with the duke of York and the fact that the king owed a large unpaid debt to Admiral Penn, enabled William Penn to gain control of a great part of the imperial domain assigned to the duke. When the crown gave him a proprietary charter in 1681, he immediately began to advertise for settlers. Publishing a description of Pennsylvania in four languages, he offered newcomers land on very liberal terms: 50 ac. free. larger farms at a purely nominal rent, and 5,000 ac. for £100. Penn visited his "Holy experiment" in 1682. And in that year he laid down a charter of government uhich provided for a small elective council, to sit with himself as governor and initiate laws, and a larger elective assembly to pass or reject the proposed laws. Within a few years the assembly gained much larger powers, and itself proposed legislation. In 1701 Penn granted a new charter that lasted until the American Revolution.

It is not strange that Pennsylvania flourished beyond other colonies. Immigrants flocked in large numbers, from England and Germany especially, to enjoy the religious freedom, the humane criminal legislation, the easy terms for gaining fertile land and the opportunities for trade and manufacture. Penn had hoped that Philadelphia, his "city of brotherly love," would always be "a green country town," with gardens surrounding every house; and it did become a beautiful as well as a prosperous city. Quakerism, softened from its originally somen-hat fanatical outlines, gave the colony a special atmosphere. It was in Pennsylvania that a number of institutions on which America later prided itself found their first full-scale trial: complete religious freedom, the distribution of land to actual settlers at very low cost, the encouragement of a melting pot of races and the establishment of excellent schools open to all. Because of the high intellectual and moral standards of the Quakers, the cultural level of Pennsylvania soon became one of unusual elevation. It was noted for its libraries, its refined homes, its interest in science and its architectural taste. When it was only ten years old it had the first printing press to be established outside of New England. *(See* also PENNSYLVANIA: *History.)*

Before Penn died, he bought from the duke of York three counties on the Delaware river which became the province and state of that name. Though they shared their governor with Pennsylvania, from 1702 they had their own elective assembly.

The other middle colonies also began under proprietors. Maryland had a history of special interest because of its initial status as a refuge for Roman Catholics. Charles I granted the district between the Potomac river and the 40th parallel in 1632 to George Calvert, Lord Baltimore, who was much interested in colonization. His son, Cecilius, almost immediately succeeded to the grant, and resolved to establish a colony where his fellow Roman Catholics could find peace. Early in 1634 the first shipload of Roman Catholic settlers chose a site at St. Marys on a tributary of the Potomac near its mouth. Actually, Protestants soon constituted a majority of the settlers, for the Roman Catholics preferred to stay in England. To meet this situation, Cecilius Calvert persuaded the assembly which he called to pass an act of religious toleration in 1649. Unfortunately, this act was repealed before many years.

Though Maryland profited from the proximity of Virginia, which gave it protection and trade, it had a troubled history. The Protestant settlers were irked by Calvert's bestowals of land, offices and favours on his relatives and his Roman Catholic friends. They were also irritated by the very limited authority that he allowed his assembly. Friction over religious and economic questions culminated in hostilities in 1654, the Protestant small farmers finally winning their main objectives. When William and Mary came to the throne in England in 1689, the Calverts lost control of Maryland; but when a new Lord Baltimore embraced Protestantism in 1715 the family regained its rights. *(See* also MARYLAND: *History.)*

Meanwhile the future New Jersey had undergone some confusing and unprofitable changes of name and jurisdiction. The duke of York, the original proprietor, had given the lands between the Hudson and Delaware rivers to two friends, Lord John Berkeley and Sir George Carteret, as the province of Nova Cesaria or New Jersey. To bring in more settlers, they drew up a charter or set of "concessions and agreements" which largely anticipated Penn's liberal ideas. That is, they offered generous terms for acquiring land, complete freedom of conscience and a popular assembly. But Berkeley in 1674 sold his half share to two Quakers, who took the southwestern part of the future state, while the widow of Carteret six years later sold the northeastern half to a new body of proprietors. Ultimately, in 1702 the crown took over both sections. (See also NEW JERSEY: History.)

The Carolinas and Georgia.—The lands south of Virginia were also colonized under royal grants to great proprietors. Under Charles II, a group of eight men obtained a grant of all North America between the 31st and 36th parallels. Two segments of this great domain were developed in very different ways. Sir John Colleton and Anthony Ashley Cooper, who later became Lord Shaftesbury, founded Charleston, S.C., in 1670 with settlers from England and overcrowded Barbados. Groups of French Huguenots and Scots at once migrated to South Carolina, giving it by the year 1700 a population, including Negro slaves, of about 5,000. At first the colony was based on exports of foodstuffs to the West Indies and of turpentine, tar and furs to Europe. Then rice was introduced from Madagascar, and the South Carolinians developed large plantations which grew rice and indigo very profitably. The area to the north, meanwhile, was settled in moderate-sized farms by a variety of immigrants: British, Germans, drifters from Virginia and adventurous New Englanders. A settlement of Swiss at New Bern added one specially prosperous element.

The "Fundamental Constitutions" which John Locke helped Shaftesbury draw up for the Carolinas, providing for a hereditary landed nobility bearing bizarre titles, was totally unsuited to the American scene and never went into real effect. The proprietors gave each colony instead a simple, workable form of government with governor, council and assembly. In the Carolinas, as in Virginia, population spread widely over the land, and though Charleston became an opulent and fashionable little city, other towns were few and small. In social and economic character the two colonies differed sharply. North Carolina found that its tobacco and naval stores, shipped from poor harbours, offered much less revenue than South Carolina's staples. It had no merchants and ship captains to match those of Charleston, and very few great planters. Its populace was poor, ill-educated and restless, and only a few coastal centres had any touch of learning or aristocratic manners. In South Carolina, however, many planters accumulated wealth at their country estates, where they lived most of the year; they had fine town houses in Charleston, where in the hottest summer months they kept up a pleasant social life with rich traders and professional men; and they gave the commons house, as they called the assembly, an English tone.

But North Carolina had two compensations: its white population grew much faster than that of South Carolina, while slaves were fewer; and its people had a much stronger sense of democracy. (See also NORTH CAROLINA: History; SOUTH CAROLINA: History.)

Georgia, the last of the 13 colonies to be founded, was the creation of a group of British philanthropists. These proprietors, obtaining a grant of lands between the Savannah and Altamaha rivers, hoped to give debtors and other deserving poor people a new start in life. In 1733 they sent over Gen. James Oglethorpe with 100 settlers to establish the town of Savannah. Some of the regulations imposed by the trustees were more idealistic than realistic. Slavery was prohibited; the importation of rum, brandy and other strong drink was forbidden; and, to prevent the growth of large estates, every charity colonist was restricted to 50 ac. of land, which he might transmit only to a male heir. This benevolent paternalism retarded the growth of Georgia. The settlers quickly found that they needed larger units of land for economic tillage, and that slave labour would be advantageous. They wanted to exchange their lumber for importations of rum from the West Indies. The trustees gradually liberalized their rules, while in 1751 they allowed the colonists to elect an assembly. The following year, when their tenure of the proprietorship lapsed, they made no effort to renew it, but allowed the crown to take over Georgia.

As a crown colony it still remained so weak that it needed constant subsidies. Its agriculture became more and more like that of South Carolina, and it developed a society of slave-owning planters in the lowlands, merchants in Savannah and small farmers in the uplands. But the philanthropists had accomplished three valuable results: they had saved a considerable number of neglected and abused people; they had maintained a buffer between the other southern colonies and Spanish Florida; and they had laid the foundations for one of the greatest of the southern states. (See also GEORGIA: History.)

New Shapes of Colonial Development.— In the 80 years between 1660 and 1740, three great new forces began to reshape the British colonies in North America. They were the economic regulations embodied in the Acts of Trade and Navigation; the partial systemization of imperial administration; and the contest with the French for dominion over the continent. By the year 1700 the colonists probably numbered about 250,000, and were increasing at a rate that has seldom been equaled in the history of western nations. Immigration, early marriages, the economic value of children in an agricultural society and the relatively high level of health sped this growth.

Under the concept of mercantilism generally accepted by western Europe, English economic policy regarded the colonies as part of an imperial whole which should aim at self-sufficiency and a favourable trade balance. Each part of the empire had something to give and something to receive. This policy was first embodied in three acts of parliament in 1651, 1660 and 1663. The law of 1651 provided that all goods imported into England or the colonies must be carried in ships of which the owner, captain and crew were English (colonials, of course, rated as Englishmen). The exception to this rule was that all goods imported into England and the colonies from Europe might come in ships of the nation which produced the goods. The law of 1660, strengthening the first, required that ships used in carrying goods in and out of Great Britain must be built as well as owned and manned in England or the colonies. It also required that certain "enumerated articles," of which sugar, tobacco and indigo were the chief, be sold only to England or to other colonies. To give the colonists full control of the home market, no one could grow tobacco in England or import it from a foreign land. The law of 1663 was more serious. It stipulated that European goods must be shipped to the colonies through England, and thus made it necessary for many colonial merchants to add an extra leg to their voyages.

Many colonists attempted to evade these acts. They shipped enumerated articles to Europe instead of to England; they imported European goods directly from Europe without stopping in English ports. New laws of 1663 and 1696 were then passed by parliament to end the evasions. Moreover, the list of enumerated articles was lengthened, so that by the year 1721 rice, molasses, naval stores (tar, pitch and turpentine), furs and copper, all important to the colonies, had been placed under control. In 1733 parliament adopted a still more serious measure, the Molasses act, which placed heavy duties on all sugar, molasses, rum and other spirits imported into the colonies from the French, Dutch and Spanish possessions. The object was to restrict trade to the British West Indies. Had it been enforced this law would have been disastrous, for the colonies exchanged large quantities of fish, lumber, meat and foodstuffs with the foreign islands for these commodities. Fortunately, the English government winked at the wholesale violations.

Other irksome restrictions on the colonies concerned manufactures, for the mother country wished to preserve the colonial market for its own industries. The Wool act of 1699 forbade the shipment of woolen fabrics across any colonial boundary. The Hat act of 1732 similarly forbade any colony to export its hats and limited the number of apprentices. Late in the colonial period the Iron act of 1750 stopped the erection in the colonies of rolling and slitting mills, forges and steelmaking plants. Like all new communities, the colonies needed a more abundant currency than they had, and wished to print paper money, but the British authorities feared an inflation which would hurt British creditors and raise the price of colonial exports. In 1751 they therefore forbade the issuance of paper money by New England, and in 1764 applied the ban to the other colonies.

But the mercantilist enactments had many features favourable to the colonies, and in total effect they were far from harsh. The navigation laws fostered shipbuilding in the colonies. A number of important American products were given a monopoly of the British market. Colonial pig iron and bar iron were admitted to Great Britain without duty. British bounties were paid on the production of naval stores. These facts, coupled with the "salutary neglect" of the colonies introduced by Robert Walpole and the nonenforcement of the more onerous laws, permitted a steady development of American economic life. The colonists meanwhile had the protection of the British army and navy. Nevertheless, two facts respecting the acts of trade had their bearing on later events. First, the colonies, like most frontier agricultural communities, were plainly exploited by the older nations both as a source of low-priced raw materials, and as a market for manufactured wares—and like other frontier lands, they resented the fact. Second, widespread law evasion fostered in the colonists a spirit of disobedience and insubordination.

Imperial Organization.— Step by step the list of royal provinces lengthened. On the accession of the duke of York to the throne as James II, this proprietary colony entered the new status and there remained. New Hampshire became a royal province in 1679. The restoration of the Stewarts put an abrupt stop to the wide free autonomy of Massachusetts Bay. A royal commission inquired into charges that the Puritans had violated their charter and disobeyed imperial enactments. Continued contumacy led Charles II to abrogate the charter in 1684 and take special measures for governing the colony. Massachusetts, with Maine, New Hampshire and part of Rhode Island, were first given a single governor; then in 1686 Sir Edmund Andros arrived with instructions to take all New England, New York and New Jersey under his jurisdiction. His arbitrary regime ended, however, with the "glorious Revolution" of 1688 in England, and Massachusetts Bay by adroit effort obtained from William and Mary a new charter which incorporated Plymouth in the colony.

By the time of George I, eight of the colonies were royal provinces. Connecticut and Rhode Island under their old charters were virtually little republics; Pennsylvania and Maryland were still under proprietary regimes; and Georgia, as we have seen, struggled along under its trustees until 1752. Some British leaders wished all the colonies put under uniform royal control, but successive ministries hung back, unwilling to arouse popular resentment or increase the power of the crown. All the colonies had representative assemblies which controlled appropriations and filled many offices and were usually in sharp opposition to the royal governors or proprietors Connecticut and Rhode Island elected their own governors. The colonists had the best of it in these continuous quarrels, for self-interest gave them more persistence and skill. But representative self-government did not mean a true democracy. The franchise in all the colonies was on a property basis, so that the poorest people were unrepresented in the assemblies. Moreover, the oldest settled seaboard communities saw to it that apportionment of seats favoured them as against the newer frontier settlements.

In all the royal and proprietary colonies, the assembly attempted to whittle away the powers of the executive. Using their power of taxation as a lever, they steadily encroached on the authority of the governor and widened that of the legislature. They seized control of fees on which the executive depended, turned appointive positions into elective offices and staged frequent revolts against the governors' councils and other "official cliques." Popular government thus broadened decade by decade. One province, Pennsylvania, after 1701 had no legislative council, the assembly controlling all legislation.

Ultimate authority over British America rested in the crown, acting through the secretary of state and privy council. But it was deputed to a succession of committees or boards: first, in 1660, to the privy council committee for foreign plantations, then in 1673 to the privy council committee called lords of trade and finally in 1696 to the commissioners of trade and plantations, separate from the privy council. It was impossible, however, to keep control highly centralized; it was distributed to various agencies. The treasury board audited whatever revenues came from the colonies, oversaw expenditures for them and scrutinized appointments for the colonial service. The admiralty board dealt with the equipment of the navy in American waters, the protection of commerce and the punishment of smugglers. The war office had control over military affairs within the colonies. The bishop of London supervised the appointment of clergymen of the Anglican Church, watched over their conduct and the parish schools they helped keep. The privy council received letters and petitions on colonial business, arranged hearings and inquiries and issued letters, instructions and orders in council on a wide variety of subjects. It also acted as a colonial court of appeals.

The administration thus required a considerable bureaucracy. But in time a good deal of the business was handled directly by the office of one of the secretaries of state in London, without going before the privy council. That is, the cabinet took control; the secretary of state for the southern department became specially important. Various colonies sent to London agents like Benjamin Franklin, or hired some able British subject, such as Edmund Burke, to make sure their views were effectively presented. In general, imperial administration was loose rather than strict. The very remoteness of the colonies helped ensure this; to send a letter from England to New York and get an answer took at least three months. Distance, a tradition of letting well enough alone and a belief that the Americans could mind their own affairs capably combined to make the crown authorities complaisant. Until 1760 the colonists possessed a greater political freedom than perhaps any other people on earth. They enjoyed many privileges and rights that were totally unknown in French and Spanish lands.

Until 1760 parliament passed only about 100 statutes in all relating to the colonies, and most of these dealt with military and economic matters. Some of the provinces adopted great parts of the statute law of England, and all of them attached high importance to the English guarantees of fundamental rights. The English common law automatically came into force throughout British America. While the crown after 1690 generally required the colonial assemblies to send their acts to England for approval or disapproval by the king in council, this was not a great hardship. As the 18th century advanced the imperial government was concerned primarily with the acquisition of more colonial territory, the fixing of boundaries and the maintenance of commercial interests. It also gave some attention to the Anglican Church and its revenues.

By the end of the colonial period the Puritan or Congregational Church enjoyed establishment in Massachusetts, New Hampshire and Connecticut. Farther south the Anglican (Episcopal) Church was established in the. two Carolinas, Georgia, Virginia and Maryland and in four southern counties of New Tork; but its hold in North Carolina and western Virginia was precarious. In the other colonies, Rhode Island, Pennsylvania, Delaware and New Jersey, church and state were separated. The discrimination involved in the Congregational and Episcopal establishments did not mean that religious tolerance suffered. On the contrary, in the 18th century freedom of faith was much more widely accepted in British America than in most other parts of the world. The crusading Roger Williams and the liberal William Penn had founded model commonwealths whose influence was widely felt. The crown, the various proprietors and important colonial interests, eager to attract settlers, had encouraged a variety of religious sects: Jews to New York and Rhode Island; Huguenots to South Carolina and New York; Mennonites, Dunkards and other German sects to Pennsylvania; Scotch-Irish Presbyterians to lands all the way from New Hampshire to North Carolina; and Roman Catholics to Maryland. This variety of denominations helped keep the religious atmosphere free. In some colonies Jews were barred from the franchise and from office, but Jews were few in number; in most colonies Roman Catholics (partly because of fear of the French) lay under some disabilities, but they had far more freedom than Protestants enjoyed in Roman Catholic lands.

The temper of colonial life was friendly to freedom of thought in every field. Both in New England and the southern provinces the grip of the established churches was gradually loosened as the 18th century wore on; dissenting sects grew rapidly among the common people, and deism among the intellectuals. Taxation for the establishment of churches naturally aroused increasing resentment. The widespread religious revival called the Great Awakening (*q.v.*), which reached full force in the 1730s, perhaps indicated that the older churches had failed to provide the emotional and intellectual nutriment the people needed. It was led in Massachusetts by Jonathan Edwards, an eloquent Yale graduate whose sermons dealt with faith, sin and punishment; in the middle colonies by William Tennent, who came from Scotland to preach with fervour and to establish a log college in Pennsylvania for training other zealous clergymen; and in Georgia by the indefatigable George Whitefield, who soon began touring other colonies, and cast his spell everywhere over immense audiences. The movement continued with vigour throughout the 1740s, converted multitudes and by strengthening a spirit of revolt against older forms of religion gave new strength to the Baptists, to new light Presbyterianism, and in time to the Methodists headed by John Wesley.

The colonists had at least as much freedom of speech, of assembly and of the press as did the British at home. When John Peter Zenger allowed a political leader in New York to criticize the royal governor in his *New York Weekly Journal*, he was arrested for libel. By a spirited appeal to the jury the aged but intrepid Andrew Hamilton, an attorney of Philadelphia, won Zenger's release on the ground that a fundamental English liberty was at stake. As this case suggests. America was soon a land of newspapers. By 1765 every colony but Delaware and New Jersey had at least one. and the whole list numbered 25. Debate in the colonial assemblies had even fewer inhibitions than in Westminster, and was in general fully reported and discussed. Pamphlet publications increased. Intermarriage among peoples of different national stocks produced new generations, with no firsthand knowledge of Europe, who considered themselves purely American. All the conditions of life in the new country. where the abundant natural resources could be seized only by determined efforts. encouraged a spirit of individual enterprise which chafed at restraints.

The Contest With France.— It was inevitable that Great Britain and France should wage a struggle for mastery in North America. Two great powers could not occupy the same land without a desperate battle for supremacy. In its century-long course and its far-reaching consequences, this became one of the epic contests of modern history. It was a protracted war between two peoples, two cultures and two sets of political and religious institutions. Fought out with the deep wilderness as the setting and background, and involving the savage Indian tribes as participants on both sides, its marches. sieges and battles have a picturesqueness seldom found in modern war. It produced leaders of high character and ability: the comte de Frontenac, Antoine de la Mothe Cadillac and the marquis de Montcalm on the French side; James Wolfe, Lord Amherst, John Forbes and George Washington among the Anglo-Americans. w

Led by Samuel de Champlain and by Jesuit, Recollect and Franciscan churchmen, the French strove with little success in the first half of the 17th century to develop Canada as a colony. Seeking fish, furs and converts in a chilly, difficult land, they failed to plant strong agricultural settlements. The despotic if paternal government in Paris kept the colonists under tight rein instead of encouraging self-government and individual initiative based on the British model; it refused to allo any but Roman Catholics to emigrate instead of inviting persons of all faiths. By 1660 only a few thousand French were settled in all of Canada. But when Louis XIV came to the throne he showed an intelligent interest in New France. His government sent out shiploads of emigrants, gave generous subsidies, encouraged exploration and helped fur traders and missionaries carry French influence through the Great Lakes region. In 1659 the first bishop, François Xavier de Laval Montmorency, an able, iron-willed man, arrived in Quebec. determined to make the church dominant in a livelier, more energetic colony.

Then in the last quarter of the century the greatest of the French governors, the comte de Frontenac, made New France a genuine threat to British America. During his regime, which with one short interval lasted from 1672 to 1698, the great explorations of Pere Jacques Marquette, Robert Cavelier, sieur de La Salle and Louis Jolliet opened the way into the west. They mapped much of the upper Mississippi and Ohio valleys; La Salle descended the Mississippi to its mouth and penetrated Texas. Two other explorers. Pierre Esprit, sieur de Radisson and Médart Chouart. sieur de Groseillers, entered the country beyond Lake Superior. Frontenac, with characteristic ability and determination, asserted the authority of the secular arm over the church. The hostile Iroquois had practically wiped out the friendly Huron and Erie tribes among whom the Jesuits had made their best converts: Frontenac chastised the Iroquois and temporarily broke their strength. As New France expanded, the English became alarmed. In Europe the Stewarts, subservient to the French crown, made way in 1688 for William and Mary; and William of Orange, who had defended the Netherlands against the attacks of Louis XIV, was ready to continue hostilities. The conflict at once spread to North America, where it was called King William's War (1689–97).

In this first round of the long conflict neither side accomplished much. Enlisting Indian allies in a warfare of barbaric ruthlessness, the French raided the English colonies from Schenectady, N.Y., to Haverhill. Mass., and along the Maine coast. In return the English organized an expedition which captured Port Royal in Acadia (now Annapolis Royal. Nova Scotia), and sent a fleet of 34 ships under Sir William Phips which disastrously failed to take Quebec. The final treaty of Ryswick left matters just as they had previously stood. After a brief breathing space the War of the Spanish Succession, called in America Queen Anne's War, followed (1701–14). While Marlborough won his brilliant victories in Europe, hostilities ran their former course in America. The French once more conducted horrifying raids with the Indians on exposed settlements; the Anglo-American forces once more retaliated with descents on Canada. While a new expedition against Quebec again failed, this time by shipwreck, New England troops and British marines recaptured Port Royal. But this time the treaty of Utrecht (1713) gave the British empire great gains—in Europe, Gibraltar and Minorca; in America, Acadia. Newfoundland and a great belt of territory surrounding Hudson bay.

The final test of strength lay not far ahead. In preparation the French set up a belt of forts around British America. They had founded Mobile. Ala., in 1702, and established New Orleans, La., in 1718. They connected these Gulf ports with Quebec by nine important posts: Ft. Chartres on the Mississippi opposite St. Louis. Mo.; Vincennes and French Fort on the Wabash river; Ft. Miami on the Maumee river; Ft. St. Joseph near the lower tip of Lake Michigan; Michilimackinac and Ste. Marie on the upper lakes; Detroit, guarding Lake Huron; and Niagara, guarding Lake Erie. Thus New France possessed itself of the heart of the continent, confining British America to the seaboard. When a new conflict broke out, the War of the Austrian Succession, 1740–48 (called in America King George's War), the French maintained their vital positions. They had built a strong fortress at Louisburg on Cape Breton Island to guard the mouth of the St. Lawrence river, and it sheltered privateers who harried New England commerce. Gathering all their energies, the New Englanders under William Pepperrell astonished everyone by capturing it. This was a brilliant feat. When peace was made, houever, Great Britain returned Louisburg to France.

Once more the French took steps to strengthen their position. Laying claim to the whole Ohio valley, they built a new chain of forts from what is now Erie, Pa. (Presque Isle), to the Allegheny river. This was an area in which Anglo-American fur traders and land companies had a strong interest. When the French warned English traders away from the country, Gov. Robert Dinwiddie of Virginia sent George Washington to tell the French in turn to keep off, and to build a fort on the site of present-day Pittsburgh. The sequel was the capture of the site by the French. their erection of Ft. Duquesne and a clash between French troops and Virginia militia under Washington. Thus opened the final conflict of the two empires in North America (1754–63).

The French and Indian War.—The French had certain advantages in this hard-fought struggle, which became known as the French and Indian War in America and the Seven Years' War in Europe. France was more populous than Great Britain, with larger military forces and theoretically could send over greater armies. The highly centralized government of New France could wage hostilities more efficiently than the loosely associated colonies under 13 different governments. The strategically placed French forts were an important asset. But in the end the British colonies were certain of victory. They had a population by 1754 of about 1,500,000, 15 times as great as that of New France. They held a superior strategic position; operating from inside lines, they could strike at almost any point in the long. thinly peopled French crescent extending from Louisburg to New Orleans. The British navy, superior to the French, could better reinforce and supply the armies and could lay siege to the ports of New France. Finally, both Britain and British America excelled in leadership. William Pitt (Lord Chatham) as prime minister of Great Britain proved himself a greater statesman than anyone in France; Wolfe, Amherst and Lord Howe were a trio of generals the French could not equal; and such colonial officers as Washington and Phineas Lyman showed real ability.

At first the war went badly for the Anglo-American effort. Expeditions in 1755 against the French forts at Niagara and at Crown Point on Lake Champlain broke down. An army marching under Gen. Edward Braddock to seize Ft. Duquesne fell into an ambush and was almost destroyed, with the death of its commander. The next year a brilliant French soldier, the marquis de Montcalm, arrived, and gave his forces new energy and organization. He at once captured the British post at Oswego on Lake Ontario. while in 1756 he took Ft. William Henry at the southern tip of Lake George. Later he defeated a British attempt to invade New France by way of Ticonderoga and Lake Champlain.

But after Pitt flung himself into the tasks of war with enthusiasm and vision, the current changed its course. He mobilized the army and navy on a scale never before seen in America. He obtained from the colonial governments, impressed at last with the gravity of the contest, a new degree of co-operation. In 1758 a three-pronged plan of campaign was pushed with adequate resources, able generals and indomitable determination. Forbes cut a road across Pennsylvania and seized Ft. Duquesne, evacuated by the French; Amherst took the fortress of Louisburg for the second and last time; and other troops took possession of outposts on the Ohio. In the summer of 1759 came the decisive stroke of the war in America. Wolfe. after two months of an unsuccessful siege at Quebec, found a path up the cliffs; led 4.500 troops up under cover of night; and at dawn of Sept. 12 confronted Montcalm on the Plains of Abraham commanding the city. Wolfe died in battle. but not before he heard that the French were in flight. Montcalm was borne back mortally wounded during the rout. The capture of Quebec decided the campaign, the war and the fate of New France. The next year Montreal fell to Amherst.

The treaty of Paris (1763) gave Great Britain all the French possessions in America east of the Mississippi save two small fishing islands, and the island of New Orleans. Spain, which had entered the war, ceded Florida to Great Britain. The whole eastern half of the continent, except for New Orleans, which France turned over to Spain, became part of the British empire. It was a matter of great and almost immediate concern to Americans that Louisiana and all French claims west of the Mississippi were ceded to Spain. The British during the war had captured Cuba and the Philippines from the Spaniards; the fact that they were quietly returned to Spain would in time also concern American policy. But the greatest fact of all was that for the moment the colonies seemed free from all threat of aggression. (*See* FRENCH AND INDIAN WAR; SEVEN WEARS' WAR.)

American Social and Cultural Development.—Seven of the colonies made an effort in 1754 to devise a plan of closer association. Their governors met at Albany to agree upon a treaty with the Iroquois. Benjamin Franklin. who was present, offered a scheme of colonial union which. if adopted, might have prevented or delayed the American Revolution. It called for a congress with power to treat with the Indians, control the public lands, maintain military forces and collect taxes for common objects. But though the Albany meeting accepted the scheme, the colonies mere too jealous of their separate powers to approve it, while the British government feared that it might unduly increase the strength and independence of the provinces. The 13 colonies were separated by geographical distance and difficulties of travel, by differences of temper, religious thought and custom and by provincialism of spirit. Even in the crisis of war with the French they co-operated poorly. (See ALBANY CONGRESS.)

Yet they were united by their common English tongue and its rich literature; by their common experience with representative forms of government; by the English common law; and by a basic similarity of outlook. They all believed in democracy in the sense of a rough equality of opportunity, and the possession by every man of the basic human rights of life, liberty and property. During the 18th century barriers between the colonies were steadily reduced. Roads were opened, coastal shipping increased and intercolonial travel became commoner. The newspapers and pamphlets of one province were read widely in others. Restless young men migrated freely, as Franklin moved from Boston to Philadelphia, and Alexander Hamilton from the British West Indies to New York. A post-office service was established for British America, with Franklin as postmaster, 1753–55. Businessmen made frequent journeys from colony to colony to promote trade, and if they were members of a fraternal order such as the Masons, or of a special religious body such as the Quakers, found warm welcomes from fellow members. Mechanic groups were much the same in Charleston, New York or Boston; the lawyers and large landholders of the various colonies held the same views.

Seven different colleges and a large number of private academies were established in the colonies before the Revolution. Harvard was founded in 1636, William and Mary in 1693, Yale in 1701 and King's college (later Columbia) in 1754. The Great Awakening helped bring about the opening of the institutions which grew into Princeton (1746), Brown (1764) and Dartmouth (1769). At first collegiate studies emphasized the classical languages. mathematics, logic, rhetoric and astronomy, but later science gained a strong foothold. Some large private libraries were collected, those of William Byrd in Virginia and Cotton Mather in Massachusetts being especially noteworthy. Not all the books were imported. for American printers began reaching up toward a total of 1.000 titles, chiefly British, a year. Benjamin Franklin was the most versatile American author, publishing essays, satires, scientific papers and collections of aphorisms. Historical works of importance were written in the first 60 years of the 18th century by Robert Beverley for Virginia, John Lawson (an expert on Indian life) for North Carolina and Thomas Prince for New England.

Thirteen colonials obtained the high honour of election to the Royal society in the 60 years preceding the Revolution; among them were Cotton Mather of Massachusetts. Benjamin Franklin of Pennsylvania and Alexander Garden of South Carolina. Mather's greatest work was the mélange of history, biography, religion and science entitled *Magnalia Christi Americana.* Jonathan Edwards made an important contribution to philosophy in his treatise on *Freedom of the Will* (1754). The Pennsylvania botanist John Bartram, the astronomer David Rittenhouse of the same province and the mathematician John Winthrop IV of Harvard all did creditable work. Many specimens of a truly beautiful architecture, mainly English in design and detail, could be found by 1750 in all the colonies from Maine to South Carolina. Skilled cabinetmakers, migrating from Europe, trained excellent colonial artisans. At least four painters attained such distinction that their work has been carefully preserved and highly prized. John Singleton Copley, John Smibert, Robert Feke and Benjamin West—the last-named in time becoming head of the Royal Academy in London Town planning of a high order was to be found in Philadelphia. Williamsburg and Savannah.

Altogether, the colonies by the end of the French and Indian War were becoming mature in some cultural as well as political and economic respects. Their lawyers, doctors, educators and other professional men lookec! to Europe for standards, but hardly felt inferior to their European contemporaries. Their intellectual ties with Great Britain grew closer with the improvement in communications. Newspapers clipped much of their foreign intelligence from English journals; students pursued law at the London Inns of Court and medicine at the university in Edinburgh; Anglican priests had to be trained and ordained in England; and English ideas, notably those of Sir Edward Coke, the Commonwealth thinkers and John Locke, shaped political thought. Loyalty to the crown and affection for the mother country were still strong in 1765—stronger than intercolonial ties. Franklin thought that a union of the colonies was impossible without a course of flagrant oppression by Britain.

But after the French and Indian War the colonists had no intention of accepting a subordinate position in the empire. They were proud of the fighting record of their soldiers. They knew well that Philadelphia was the second largest city under the British flag and that as a seat of learning, scientific inquiry and the arts it compared well with any city outside of London. They knew that American commercial enterprise equaled that of England and that they were making more rapid advances in some respects than any other people in the world. A spirit of self-sufficiency pervaded the land. It was especially strong among the settlers of mixed stocks who had moved out toward the frontiers and among the artisans, mechanics and labourers of the towns. The atmosphere was changing, and John Adams spoke truly when he later declared: "The Revolution was effected before the war commenced. The Revolution was in the minds and hearts of the people."

The Contest for Independence, 1765–83

The addition of Canada and Florida to the British empire, coinciding with the overthrow of French power in India, created a tremendous problem of imperial reorganization. Thus far the colonies had been allowed to grow without much control, with an eye to the development of their potentialities in trade—the supply of raw materials and the purchase of manufactured goods. The mercantilist concept of self-sufficiency had dominated the empire. Now the ruling groups in Great Britain began to value the colonies as sources of world powers; that is, for their strategic position, revenues and contributions to the strength of the imperial army and navy. The new world possessions of Great Britain had been doubled in extent. They were still vulnerable to French and Spanish attack. The steady westward march of population posed difficult problems of land policy and relations with the savage tribes. The Catholic French-Canadians had somehow to be brought into workable accord with the richer and stronger Anglo-Saxon population. Troops, forts and warships had to be maintained for protection. The growing trade had to be regulated.

It was certain that British and American ideas on imperial reorganization would differ. The English government emphasized a careful co-ordination of the different parts of the empire, a strengthening of the central administration and greater efficiency in law enforcement and tax collection. The colonists emphasized their hereditary English liberties and the principle of local autonomy. As all history shows, the problem of adjusting general authority to provincial libertarianism is difficultin any federation or confederation. The imperial problem after the Seven Years' War was rendered specially difficult by the lack of precedents, the great distances involved and the long-established dislike of the mixed body of colonists for any controls whatever. Moreover, Great Britain did not regard the empire as a federation but as a consolidated state. The authorities in London neither planned nor executed any "tyranny," but their new strictness seemed tyrannous, to many Americans.

The West and the Proclamation of 1763.—The first important imperial measure after the war dealt with the lands and Indians of the west. The tribes along the frontier had long been restive under white encroachments on their lands and the fraudulent methods of many fur traders. In 1763 a spasmodic uprising of the northwestern Indians, stimulated by French fur traders, found a leader of talent in the Ottawa chief Pontiac. They battled with desperation, for they saw that their lands north of the Ohio would soon be occupied by English settlers. Every fort in the west except Detroit and Pittsburgh fell, while Indian bands slew and burned all along the border settlements. So weak were the colonial counterattacks that British regulars had to crush the revolt. Clearly it was necessary to adopt some policy for the frontier, and its consideration would take time.

As an emergency step, effective until a full policy could be perfected, the British ministry inspired a royal proclamation in Oct. 1763 to fix temporary boundaries for Quebec, east Florida and west Florida, and to halt settlement beyond the Alleghenies. For the whole area between northern Florida and the 50th parallel, settlers were forbidden to advance beyond the crest of the Alleghenies; and the region stretching thence to the Mississippi was for the time being reserved to the Indians. The crown during the next five years tried to consolidate peace on the border by making treaties with the Iroquois, Cherokee, Choctaw and Chickasaw Indians. Quite naturally, however, settlers paid no attention to the proclamation line. They soon placed permanent settlements on the upper Ohio and its branches, making Pittsburgh and Wheeling, W.Va., busy towns; they pushed into the Watauga, a valley in western North Carolina, and there set up an independent government which endured several years; and on the Virginia frontier they provoked a new outbreak of hostilities, Lord Dunmore's War (1774). A combination of hunters, settlers and the energetic land speculator, Richard Henderson of North Carolina, opened up the rich lands beyond the Cumberland gap, so that before the Revolution Daniel Boone and his associates were in eastern central Kentucky and James Harrod had founded Harrodsburg, Ky., farther west. (See American Frontier, The.)

The garrisoning of the frontier was a special problem. The board of trade in London believed that it would be necessary to establish a line of posts from Florida to Quebec, and from Lake Ontario westward to Mackinac at the junction of Lakes Huron, Michigan and Superior. To man these forts, and maintain the military establishment elsewhere, they estimated that 10,000 men would be needed. This was a grossly exaggerated guess. British field commanders in America would have been satisfied with half as many regulars, and the proposal probably had ulterior motives, including the care of veterans at the expense of the colonies. For a time it stood, however, and efforts had to be made to raise the needed money.

The Sugar and Stamp Acts.—The ministry headed by George Grenville first tried to find revenue by the Sugar act of 1764, replacing the 30-year-old Molasses act, which had never been enforced. The tariff on molasses was cut in half, but the duty on refined sugar imported into the colonies was raised. Duties were placed on wines, coffee and some textiles unless they moved to the colonies by way of England, and measures were taken to give strict effect to the law. This act hurt colonial traders by cutting off the direct flow of wine from the Azores—for Americans drank much Madeira—and largely destroying commerce with the French West Indies. At the same time the new law required that all lumber sold to Europe be transported via British ports. An angry protest came from the northern colonies in particular, Rhode Island even declaring that its existence was threatened. Virginians were simultaneously irritated by the Currency act of 1764, which extended to them and other colonies the prohibition of paper money issues originally limited to New England; for Virginians were heavily in debt to British merchants and wished a cheap legal tender.

Other grievances seemed minor, however, beside those caused by the Stamp act passed in March 1765. In order to raise an estimated £150,000, the Grenville ministry carried a measure requiring that all legal documents, licences, commercial contracts, newspapers, pamphlets and playing cards should carry a tax stamp. The cost of the stamps ranged from a halfpenny to £10, and violations were subject to severe fines. Among the many groups on whom this law laid burdens, some were specially well equipped to arouse discontent and resistance. Newspaper editors, tavern keepers, lawyers and printers had effective ways of reaching the general public and used them. The enactment created more resentment because it was swiftly followed by a Quartering act, which provided that when British garrisons were moved to any place where inadequate barracks existed. they might be put into barns, inns and private residences. Of course, they would pay for their quarters, but few people wanted soldiers in their households.

Parliament quickly learned its mistake in passing the new legislation with practically no debate. The Massachusetts assembly instantly published a vehement protest. If parliament could tax trade. it could tax land, houses and any other property. violating the charter right of Massachusetts to tax and govern itself The law struck at "our British privileges," declared the assembly, and such measures would reduce freeborn subjects "to the miserable state of tributary slaves." The Virginia burgesses, equally angry, were inspired by Patrick Henry's fiery eloquence to pass five resolutions of protest. Two additional resolutions, threatening resistance and coercive treatment of anybody who supported the imperial government, failed but were nevertheless published throughout America. Meanwhile, editors, lawyers and merchants took steps to arouse mass resistance. Angry crowds rioted in New York, Newport, Boston and Philadelphia, hanging crown officials in effigy, forcing stamp collectors to resign and pillaging the houses of even such respected men as Thomas Hutchinson, an able Massachusetts jurist. The opposition organized an intercolonial body called the Sons of Liberty, which kept the flame of protest burning.

At the same time, businessmen in the leading ports tried economic pressure. They signed agreements to stop importing British goods until the Stamp act was repealed and enforced them so well that a general trade paralysis marked the day Nov. 1, the law became effective. Strongly argued pamphlets dealt with the principles at stake. James Otis of Massachusetts had already denounced the writs of assistance (in effect, search warrants to assist in enforcing the acts of trade) as subversive of American liberties. He had also been active with Samuel Adams in organizing the "caucus" which planned measures in the Boston town meetıng, and had attacked the Sugar act in *The Rzghts of the British Colonies Asserted and Proved,* a pamphlet basing these rights on natural law (1764). In 1765 he brought out three more pamphlets, asserting that taxation without representation was tyranny, and pointing out that the imperial economic system involved exploitation of the colonists. As John Adams wrote later, Otis was "a flame of fire." John Dickinson of Pennsylvania took an almost equally advanced stand in his pamphlet "The Late Regulations Respecting the British Colonies . . . Considered" He opposed violent resistance and favoured economic pressure on British merchants, but was as firm as Otis on basic principles.

On a motion of Otis, the Massachusetts assembly sent a circular letter to the other colonies inviting them to meet in a Stamp act congress. This body met in New York on Oct. 7, 1765, with Otis and Dickinson prominent in the proceedings. It passed resolutions embodying Otis' doctrines, though it rejected his proposal of colonial representation in parliament. Nine of the 13 colonies had representatives present, though New York, New Jersey and Delaware sent only men chosen by informal action. Their "Declaration of Rights and Grievances" asserted that all subjects of the king in America had the same rights and liberties as those in Great Britain; that taxation without consent was a violation of these rights; and that as the colonists could not be represented in London, the only taxes that could constitutionally be imposed on them mere those laid by their own legislatures. The congress drew up petitions to the king, the commons and the house of lords.

Meanwhile, the nonimportation movement gained strength. In the last three months of 1765 nearly 1,000 merchants in Boston. New York and Philadelphia signed agreements to stop purchasing European goods until the act was repealed. Refusal to use the stamps on business papers was practically universal; the courts closed rather than to enforce their use on legal documents. British exports to America fell from £2,250,000 in 1764 to £1,944,000 in 1765. Mercantile groups in Great Britain brought forth their own demand for repeal. and many towns sent petitions to parliament. When parliament met in Jan. 1766 it began an immediate debate on the subject. Grenville's ministry had been overthrown on another question, and had been replaced by one under Lord Rockingham. Franklin, as agent for Pennsylvania, appeared before the commons, sitting as committee of the whole, on Feb. 13, with a set of forceful arguments. Emphasizing the heavy colonial expenses during the French and Indian War and the subsequent Indian hostilities, he declared that the colonies did not have enough coin to pay the stamp taxes during a single year. Grenville had told parliament that the army should be used to enforce collections in America. If this were attempted. said Franklin, it might cause rebellion. Agreeing with the pamphleteer Daniel Dulany of Maryland that parliament must distinguish between internal and external taxation and had no right to lay burdens on an unrepresented people. he asserted that repeal was the only solution. William Pitt brought his great prestige behind the same contention. The king also stood for repeal.

On March 4, 1766. complete repeal passed the commons, on March 17 the house of lords and on March 18 gained the royal assent. When late the following month the news reached America, the merchants at once dropped nonimportation. Widespread expressions of gratitude and fealty followed, the New York assembly voting statutes to the king and Pitt. In the general relief most men overlooked the fact that parliament had reached no agreement on the constitutional principles involved. Lord Mansfield asserting the absolute dominion of parliament while Pitt drew the same sharp line between legislation and taxation upon which the colonists insisted Americans also paid scant attention to the fact that repeal was accompanied by a Declaratory act, modeled on previous legislation for Ireland. asserting the right of parliament to pass laws binding the colonies "in all cases whatsoever." Some new trade legislation which followed in 1766 was generally favourable to the colonies. It reduced the molasses duty to one penny a gallon, and abolished export duties on sugar from the British Rest Indies—at the same time, however, requiring all colonial products shipped to northern Europe to pass through British ports.

A Fresh Storm: the Townshend Acts.—Pitt took office as prime minister in Aug. 1766, with his new title of Lord Chatham—"a fall upstairs." as Chesterfield wrote—and in such poor health that his effectiveness nas limited. His chancellor of the exchequer, Charles Townshend, at once took steps to reduce home taxes and raise fresh American revenues for American purposes. The Townshend acts of 1767 placed import duties on glass, lead, paints, paper and tea sufficient to raise an estimated annual revenue of £40,000; this amount was to be used for defense, the administration of justice and the support of civil government in America. As the colonists had controlled governors and judges by use of the purse strings, the idea that their salaries should now be met out of imperial revenues was offensive. Moreover, the ministry passed a set of accompanying measures to facilitate enforcement. It asserted the poaer of the higher judges to issue writs of assistance for bringing smugglers to trial; established new vice-admiralty courts for trying violations of the trade acts; and created in Boston an American board of commissioners of customs, directly controlled by the British treasury. Some trouble had arisen in New York over the Quartering act, and the assembly had refused to comply with requests made by Gen. Thomas Gage for certain unusual barracks supplies. The Tonnshend acts therefore included a suspension of the assembly's powers until it obeyed; but this was unnecessary, for the assembly yielded before the new law reached America.

Once more the colonies turned to various emphatic measures of resistance. Merchants in port towns signed new agreements not to import lists of specified British goods. and a New York mass meeting appointed a committee to make plans for fostering home manufactures. New pamphlets arguing the rights of the colonists as British subjects were published John Dickinson's *Letters From a Farmer in Pennsylvania to the Inhabitants of the British Colonies,* a series of 14 essays printed in the *Pennsylvania Chronicle* (Nov.-Jan 1767–68) and then reissued as a pamphlet. had a wide influence both in America and Great Britain. Moderate in tone, they declared that while parliament had a right to regulate trade it had no just authority to tax Americans for revenue; denounced the suspension of the New York assembly as a blow at the liberties of all the colonies; and, while urging conciliation, hinted at the possible use of force. The Pennsylvania legislature adopted a petition to the king which Dickinson drafted. The Massachusetts assembly sent a circular letter, written by Samuel Adams, to the other 12 colonial legislatures, assailing the Townshend acts, pointing out the danger- in the new move to make governors and judges independent of the people, and calling for united action (Feb. 1768). This so incensed the royal governor, Sir Francis Bernard, that he dissolved the general court. Delegates of Massachusetts towns then met in an irregular convention, the first step toward a revolutionary legislature.

Repeal: the Tea Tax. — Far from abating the storm increased during 1768. The colonial secretary, Lord Hillsborough, wrote to all the colonial governors, attacking the Massachusetts circular and ordering them to dissolve their respective assemblies rather than to let them make favourable responses. But before this order reached America, Virginia, New Jersey, Connecticut and Rhode Island had taken action supporting hiassachusetts. The merchants of New York and Boston united in still more stringent nonimportation measures. In Boston violence broke out. When the customs commissioners tried to enforce the new laws, they met forcible obstruction and asked the ministry (March 1768) for armed assistance. The frigate "Romney," in response to this appeal, arrived in Boston in May. But the Sons of Liberty were not overawed. Early in June they locked up a customs officer while Madeira wine was smuggled ashore, attacked other officers on the wharves and rioted in town. The customs commissioners, taking refuge in Castle William on a harbour island, sent London an urgent plea for troops. On Oct. 1, 1768, two infantry regiments, with some artillery, landed in Boston where they became a centre of irritation, with petty affrays between soldiers and townspeople.

Once more the economic weapon proved potent. By the end of 1769 nonimportation agreements were being observed in every colony but New Hampshire. The action of Virginia was especially influential. The burgesses in May adopted a set of resolutions which were drawn up by George Mason and introduced by George Washington. They criticized the British ministry, asserted that only the governor and legislature of Virginia had the right to tax Virginians and with great vigour attacked a proposal in parliament to enforce the statute of 35 Henry VIII by bringing rebellious subjects across the ocean for trial in England. Patrick Henry and Richard Henry Lee drafted an address to the king. When the governor, Lord Botetourt, dissolved the burgesses, they at once held an informal meeting in the Raleigh tavern in Williamsburg (May 18, 1769). There they adopted the Virginia association, by which they agreed to stop the importation of all dutiable British goods except paper; to cease importing slaves; and to abstain from the use of European luxuries. This association was adopted or copied during the summer by Maryland, South Carolina, North Carolina and the people of Savannah. Other colonies uhich had hung back took parallel action. The imports of the colonies from Great Britain had totaled £2,157,000 in 1768; in 1769 they fell to £1,336,000.

These losses inevitably impressed the ministry. Although English merchants, who largely compensated themselves by a rising continental trade, this time mainly supported the government, many complained. Even in the spring of 1769 the imperial authorities notified the colonial governments that a relaxation of the Townshend duties was being considered. In Jan. 1770 the duke of Grafton, who had become head of the ministry, gave way to Lord Frederick North. who was still more willing to adopt a policy of retreat. North, whom Townshend described as a "great, heavy, booby-looking" man, was amiable, witty and honest, but shortsighted and stubborn. Taking office on the king's entreaties, he was determined to serve George III as completely as possible. He at once showed his lack of vision. Though he believed in repeal, he believed that complete repeal would betray governmental weakness. He moved in the commons (March 5, 1770) a bill to annul the main body of Townshend duties and promised that the ministry would lay no new taxes on the colonists; but he maintained a small duty on tea and with it the principle of parliamentary authority. This decision, in the end, was to lead to war.

The First Armed Clashes. — Repeal of the Townshend acts was hailed with great relief in the colonies. The Quartering act was simultaneously allowed to die without renewal. Not at once. but gradually during 1770. all the colonies except Virginia gave up their nonimportation programs; Virginia finally acquiesced in the summer of 1771. There was a lull in the agitation against the British ministry. This was interrupted early in 1770, however, by two memorable affrays between British troops and Americans. In January the Sons of Liberty in New York, led by Isaac Sears and Alexander McDougall, quarreled with the regulars; and when British soldiers cut down a liberty pole, the Sons of Liberty tore down British banners. These disturbances culminated on Jan. 19 in a riot on Golden hill in Manhattan, the patriots using clubs and swords while 30 or 40 troops wielded bayonets. Several men on both sides were badly hurt, but nobody was killed. More serious was the encounter in Boston early in March which patriots incorrectly dubbed a "massacre." Fist fights and name calling between mechanics and troops had become common, and feeling had mounted. A crowd of unruly civilians on the evening of March 5 began baiting a sentry near the state house. He called for help; a body of the guard, coming to his rescue, was assaulted with stones and lumps of ice; after one soldier fell the others fired upon the colonists, killing three and mortally wounding two more. While the troops mere sent to islands in the harbour, seven of the guard were put on trial for murder. Two able American attorneys, John Adams and Josiah Quincy, consented to defend them. The officer and four men were acquitted, while two others were found guilty of manslaughter, branded on the hand and released. (See also New York [City].)

The "Gaspee": the Colonies Join Hands. — No other incident of note occurred until June 1772, when Rhode Islanders demonstrated their hostility to royal measures. On June 9 a schooner used in customs enforcement, pursuing a smuggling vessel, ran aground below Providence, R.I. Illegal trade had become extensive in Narragansett bay. That night the merchant John Brown headed a party of Providence men who boarded and burned the "Gaspee" as she thus lay helpless. Rewards of £1,000 were offered for proof of the identity of the ringleader, and Brown was put under arrest. But the influence of his powerful family brought about his release, and a commission of inquiry which sat in Newport and Providence failed to amass any real evidence. Such breakdowns of the law irritated the British authorities; indications that if the commission had succeeded the lawbreakers would have been taken to England for trial equally irritated the Americans.

When later in the year Gov. Thomas Hutchinson of Massachusetts announced that the home government would provide the salaries of the governors and superior court justices, many men felt outraged. The legislature was determined to keep such officers under check; it could not do this if their payment came from England. Samuel Adams, James Otis and others, overruling the more conservative John Hancock, appealed to the Massachusetts towns. The Boston town meeting, under their inspiration, created a committee of correspondence to communicate with the smaller towns and with other provinces. Thus a mighty engine was brought into existence. Other provinces one by one formed similar committees, until the continent was knit together by their network*. The Virginia burgesses led the way by appointing a standing body for intercolonial exchanges, with Thomas Jefferson, Patrick Henry and Richard Henry Lee among the members. Early in 1774 all the colonies but two, Pennsylvania and North Carolina, shared in the web.

The Boston Tea Party. — While this was happening the situation was complicated by the troubles of the East India company, important for its control over India. Hard hit by Dutch competition in America and elsewhere. it had piled up both financial losses and a huge surplus stock. The British government was anxious to help it outsell the Dutch. Parliament therefore passed the Tea act in April 1773. The new land maintained the duty of three pence a pound on all tea imported into America, but allowed a remission of the duty on tea shipped by the company to the colonies. This would enable the company to sell at a much lower price in America, undercutting even colonial smugglers who had brought in Dutch tea duty-free. But the threat of a company monopoly of the American market alarmed important interests; it could use its own picked merchants to dominate the market. Meetings of protest were held in Philadelphia, New York and Boston. Some of the merchants chosen as agents gave up their privileges.

When the first tea ship arrived in Boston harbour in Nov. 1773, mass meetings demanded that the cargoes be returned to England. But Governor Hutchinson insisted that the tea duties first be paid, and the people took matters into their own hands. A crowd assembled at Old South church on the evening of Dec. 16; then, at a signal from Samuel Adams, a group rushed to the wharf, boarded the vessel and hurled the whole cargo into the water. At no port did the East India company meet any success in unloading and selling its tea. In Charleston a cargo was seized for nonpayment of duties and was then left to molder in warehouses. A shipment to Annapolis was burned, and the Sons of Liberty tossed a small lot into New York harbour. This amounted to open defiance of the royal government; the decision of the king and the North ministry to resort to coercion brought on the final crisis.

The Coercive Measures of 1774.—The next meeting of parliament, in March 1774, found a majority of members angrily aroused. Edmund Burke, Lord Chatham and others tried without success to allay their feelings. The king and ministry were resolved that punitive action should be taken, and a series of drastic bills was hurried through. One closed the port of Boston to any shipments save those of food and fuel; the port was not to be opened until the East India company and the treasury had received payment for their losses occasioned by the Boston Tea Party. A second law provided that when a crown officer was indicted for a capital offense, committed in the discharge of his duties, and a fair trial seemed unobtainable in Massachusetts, the governor might act to transfer the trial to Great Britain. A third lam so severely curtailed popular government in Massachusetts that it largely nullified the charter. A long list of officers, down to sheriffs and justices of the peace, mas made appointive by the governor; he alone could remove these officers; and he was given power to name the higher judges for confirmation by the king. Town meetings were put under severe restrictions.

At the same time parliament enacted two other measures which increased the resentment of Americans. The Quebec act, passed near the close of the session! was primarily an effort to give Canada the permanent civil administration which it had not received since the end of the French and Indian War. Features of government peculiar to New France, but alien to British America, were wisely retained. The Roman Catholic Church was given a status of special privilege. This inspired colonial criticism; but what chiefly irritated the colonies was the treatment given the west in the law. For lack of adequate American revenue, the imperial government had been compelled to abandon its program for a vigorous, well-planned administration of Indian affairs and western lands. For the time being it seemed wisest and cheapest to handle western matters through the government of Quebec, where authority rested in a governor and legislative council chosen by the crown, without any popular assembly. The boundaries of Canada were therefore extended to the Ohio river, cutting across claims held by Massachusetts, Connecticut and Virginia. (A. N.)

The First Continental Congress.—Patriots at once said that the crisis demanded united colonial action. Gen. Thomas Gage. who had been commander in chief in America, was now appointed governor of hlassachusetts, with authority to maintain the "intolerable acts" by military force. A new Quartering act (June 2, 1774) revived and broadened the old legislation. During the spring of 1774 numerous cities and towns called for the immediate summoning of an intercolonial congress. Massachusetts had at first thought that the best defensive step would be new measures for an economic boycott of Great Britain, but it was clear that a broader program was now needed. Gage had been in Boston hardly a month when the assembly proposed to the other provinces that they send representatives to a congress in Philadelphia in September. During the summer all but Georgia responded favourably.

The 56 delegates who met in Carpenters' hall on Sept. 5, 1774, were a body of real distinction. John and Samuel Xdams attended from Massachusetts; Patrick Henry, Peyton Randolph, Thomas Jefferson and Richard Henry Lee from Virginia; James Wilson, Joseph Gallon-ay and Charles Thomson from Pennsylvania; James Duane from New York; and Christopher Gadsden from South Carolina. The members had been instructed to consult together and to adopt measures calculated to secure the just rights of the colonists; nobody as yet thought of independence. But a sharp difference of temper separated radicals like the Adamses and Patrick Henry from conservatives like Galloway. The Massachusetts men pressed the Suffolk resolves, written by Joseph Warren, adopted by Suffolk county in Massachusetts and brought to Philadelphia by Paul Revere. These resolves declared the coercive measures unconstitutional, null and void; called on the people of Massachusetts to collect their own taxes and impound them until the obnoxious laws were repealed; advised them to arm and drill; and called for drastic measures of economic reprisal.

Voting by colonies, but hearing some speakers who implied that Americans were now thrown into a single mass, the congress sent addresses to the king, and to the people of the colonies, of Quebec and of Great Britain, and prepared a declaration of rights. It is a significant fact that no address was sent to either of the houses of parliament. In its statement of rights the congress (known as the first continental congress) limited itself to those which it believed had been infringed since 1763. These acts they described as innovations, and claimed themselves to be the true conservatives who only desired peace on the basis of the former constitution. The opposition mhich Massachusetts was making to the recent acts of parliament was approved. and the view mas expressed that, if an attempt were made to execute them by force, all America should support Massachusetts. Though the work of this congress was deliberative, it performed one positive act which contained the germ out of which new governments were to develop. That was the issue of the association, or nonimportation and nonexportation agreement, accompanied with resolutions for the encouragement of agriculture and home manufactures and for the organization of committees to carry these measures into effect. Coercion, according to the principle of the boycott, was to be applied by the colonies and other local bodies to all who declined to accept and obey the terms of the association. This policy had been followed at intervals from the time of the Stamp act. It had been revived by many local and provincial bodies for the past few months. The association became the touchstone by which loyalty to the colonies, or to the king, was determined. Those whose loyalty to the king forbade their submission to the new regulations now felt the power of the committees, even to the extent of virtual trial. imprisonment or banishment. From this action the first continental congress derived its chief significance.

Increase of Friction.—The association, with its threats and dependence upon extralegal bodies for enforcement, was a direct blow at the commercial system of the empire and could scarcely help provoking retaliation. When the congress adjourned, some of its members predicted war. In New England the impression that war was inevitable was widespread. In Massachusetts a provincial congress was at once organized, mhich assumed the reins of government and began to prepare for defense. A committee of safety was chosen to carry on the work during recesses of the congress. Thomas Gage, the governor, began fortifying Boston, while he looked about for opportunities to seize military stores which the colonists were accumulating. The raising of voluntary militia companies was soon begun in Virginia In South Carolina. where planters, merchants and attorneys of high repute took charge of the movement, a general committee assumed practical control of the province. From New York city and Philadelphia, as centres, the process of revolutionizing the two most conservative provinces was carried on. When parliament met, at the close of 1774, the king and his ministers declared that a most daring spirit of resistance existed in Massachusetts. which was countenanced by the other colonies, where unlawful combinations against the trade of Great Britain already were widely extended. In these opinions the government had the support of the majority in the two houses. and in a joint address the rebellion in Massachusetts was declared to be a fact. As a conciliatory measure Chatham proposed that parliament agree by resolution not to levy any tax upon the colonies, but that the continental congress be required to make a free grant of a perpetual revenue which should be fully at the disposition of parliament, the congress fixing the quota which should be paid by each province. But the imperialist and mercantilist ideas of Chatham were expressed in the further provisions that the system of trade and navigation should not be changed and that the army might be lawfully kept in any part of the dominions, though it should never be used to violate the just rights of the people. Edmund Burke, in his great speech on conciliation, advocated a return to the system of requisitions and did not consider a representation of the colonists in parliament as a possibility. But these motions were rejected, and a resolution introduced by Lord North was passed. This contained no recognition of extralegal bodies, but provided that when the assembly of any colony should engage to support civil government within the colony and contribute according to its ability to the common defense, the king and parliament would then forbear to levy any more taxes on that province except what were necessary for the regulation of trade. The colonies, with the exception of New York, North Carolina and Georgia, were excluded from the fisheries, as a counterstroke to the association. North's resolution proved futile, and the two parties drifted steadily toward war, though the British government in its military estimates made no adequate provision for meeting the crisis.

Lexington and Concord.—On April 19, 1775, hostilities began in Massachusetts. A force was sent overland to Concord, 20 mi. from Boston, to seize or destroy the military stores which the colonists had brought together at that village. The minutemen were warned to oppose the approaching force, and at Lexington, a village situated on the road to Concord, occurred a skirmish in which the first blood of the American War of Independence was shed. (For this and later military actions, see AMERICAN REVOLUTION, THE.) The troops marched on to Concord and destroyed such of the stores as had not been removed or concealed. On their return march they were pursued by a galling fire from behind fences and buildings, and had it not been for the arrival of a relieving force the command would have been destroyed before it reached the protection of the British vessels of war at Boston. The "Lexington alarm" brought in throngs of militiamen from all parts of New England. Officers were appointed by the provincial congress of Massachusetts and by similar bodies in the other colonies, and immediately the so-called siege of Boston began. Cannon, as well as every other form of military equipment, were now in great demand. In order to secure supplies and at the same time strike a telling blow at British authority in the north, Ticonderoga was surprised and taken on May 10. Men from Connecticut, Massachusetts and the New Hampshire grants (later Vermont) co-operated in this enterprise. It was soon followed by a dash into Canada, by steps which involved New York in the affair, and by the organization of a military force under Gen. Philip Schuyler for permanent service on the northern frontier. Meantime reinforcements reached Boston, led by Howe, Clinton and Burgoyne, and it was resolved to extend the British lines by occupying the heights of Dorchester on the south and those of Charlestown on the north.

Bunker Hill.—The Americans, hearing of this, seized Breed's hill, overlooking Charlestown, where they hastily threw up a redoubt on the night of June 16. The British might easily have entrapped them, but instead on the next day the American position was assaulted on the left and carried, though with much difficulty and after a loss to the assailants of more than 1,000 men. Such was the battle of Bunker hill, one of the most dramatic encounters in the war. In all these events the Americans claimed to be acting on the defensive. But it was not difficult to perceive that, especially in New England, this claim only imperfectly concealed an intensely aggressive spirit.

Second Continental Congress.—The news of the outbreak of hostilities aroused strong feeling throughout the colonies. The second continental congress met under its influence. Its members, however, had been chosen and instructed before the clash of arms, and for that reason the course which had been worked out for them differed only slightly, if at all, from that which had been followed by their predecessors. To a certain extent the new body adhered to the former course of action. But a state of war now existed in New England and on the Canadian border. Troops were expected soon to arrive at New York. Reports of these events were thrust upon the attention of congress at once, and the provinces involved asked for advice as to what course they should pursue. As a result of these events in the colonies generally, the association was being changed from a system of co-operation against British trade into a union for purposes of defense. This new situation the congress was forced to meet. This it did largely by resolutions of advice to the colonies, but also by positive orders. Of the former class were the resolutions about the procuring of military supplies. the assumption of powers of government by the various colonies, and concerning defense at New York city, on the northern frontier and, later, in the highlands of the Hudson. Of a more decisive character was the appointment of officers for the army, George Washington being made commander in chief, the prescribing of their pay, the issue of continental bills of credit, the issue of articles of war, the regulation of trade and of Indian affairs and the establishment of postal communication. As the revolutionary movement progressed through 1775 and the early months of 1776, executive authority in the royal and proprietary provinces collapsed. The assemblies were either dissolved or ceased to meet. The governors, their authority gone, retired on board British vessels of war, returned to England or, perchance, found themselves prisoners. This gradual fall of the old governments, imperial and colonial, was the revolution on its negative side. The rise of the system of congresses, conventions and committees, deriving their authority from the people, was the revolution on its positive side, and foreshadowed the new federal system which was rising on the ruins of the half-federated empire.

Collapse of the Royal Governments.— In Connecticut and Rhode Island the corporate system of government, which they had inherited from the 17th century, necessitated no change. The general assemblies always had been the centres of power, and the leading officials were elective for short terms and were subject to the control of the electorate. So far as the internal organization of the colonies was concerned that was all which the revolution demanded. In the two proprietary provinces—Pennsylvania and Maryland—the executives were not so directly interested nor were they so specifically pledged to support the imperial government as were those of the royal provinces. But Gov. Robert Eden of Maryland was so tactful that, though the last assembly met in 177.4, he was able, with the courts, to keep up some form of government there in the name of the crown and proprietor until the early summer of 1776. In Pennsylvania the proprietors, though in sympathy with the British government, never sought actively to influence events. In the royal provinces the prorogation of the legislatures for indefinite or prolonged periods caused them early to disappear—that of Massachusetts in Oct. 1774. The burgesses of Virginia last met for business in May 1774. They were prorogued to several later dates, but the governor was never again able to meet them. The long and important session of January–March 1775 was the last ever held by the New York assembly. In April 1775, Gov. John Martin of North Carolina met the assembly for the last time, and even then the provincial convention was in session at the same time and place and the membership of the two bodies was the same. The assembly of Georgia disappeared in May 1775; those of New Hampshire and South Carolina met for the last time in June. Gov. William Franklin was able to meet the assembly of New Jersey as late as November, but months before that date the provincial convention had practically assumed the control of affairs.

Widening the Breach.—After Bunker hill the command at Boston had been transferred from Gage to Sir William Howe. In July Washington took command of the colonists and gradually estabiished some degree of order and discipline among them. Though the American troops were raw and ever fluctuating in numbers, the British never seriously attempted to break through their lines. Indeed, it was not the plan of the British to make New England the chief seat of war. As early as Aug. 2, 1775, Lord Dartmouth wrote to General Gage on "the obvious advantages that would attend the taking Possession of New York and the hazard of the Army's continuing at Boston." Rhode Island was considered as a convenient naval station, and steps were soon taken to secure possession of it and its surrounding waters. The British wished to so plan the war as to secure the maximum advantage from their fleet. This would give them an easy command of the entire coast, and enable them to secure a foothold at strategic centres. Hence, though the arrival of a fresh supply of cannon enabled Washington to fortify Dorchester heights, this simply enabled him to hasten a process for which Howe had long been preparing. The evacuation occurred on March 17, 1776, and the British force withdrew temporarily to Halifax. Meantime the bold expeditions of Arnold and Montgomery against Canada had met with only a partial success. Montreal had been occupied, but the assault upon Quebec had failed.

The view, as it was now repeatedly expressed by king and parliament, was that the colonists were in open rebellion. North's offer of conciliation was peremptorily rejected by the continental congress. The acts of parliament were being openly resisted, and the congress in its manifestoes had ignored the two houses. Therefore the British government stood committed to coercion. That was the meaning of the legislation of the winter of 1776—the prohibition of trade with the rebellious colonies, the increase of the estimates for the army and navy, the employment of German auxiliaries for service in America. Preparations were made to send a large military and naval force the folloning season, which should operate in part against the insurgents in New York and the southern colonies and in part through Canada. New England was no longer to be the direct object of attack. The Howes, as commanders of the royal army and navy, uere appointed commissioners to grant assurance of peace and pardon and the repeal of the obnoxious acts, provided submission uas made and some way could be found by parliament in which an imperial revenue for purposes of defense could be secured from the colonies. Military operations, meanwhile, should be directed against points of least resistance, and in that way, if possible, the union of the colonies should be broken. The trend of British policy indicated that an invasion from Canada might be attempted and an effort made to hold Charleston, S.C., Philadelphia and especially New York as strategic points on the coast.

The series of steps in the colonies by which this situation was met was the erection of a system of feeble defenses about New York and the removal there of the army of about 9,000 men in the spring of 1776; the fitting out of privateers to prey on British commerce; the disarming of loyalists; the opening of American ports to the trade of all peoples who were not subject to the British crown; and the tentative opening of relations with France. As the result of a combination of ill luck, bad management and American energy the British suffered a repulse at Charleston in June, which was analogous to the affair of the year before at Bunker hill and which necessitated a postponement of their plans in the south.

The congress and the various revolutionary bodies in the colonies were forced to carry on war upon a constantly increasing scale. They had to assume powers of government and gradually to perfect their organization for the purpose. Committees in congress became more permanent. Conditions approximating to those which existed the year before in New England extended through the colonies generally.

The Declaration of Independence.——On May 15, 1776, as the result of various earlier applications and especially of one from certain Whigs in New York, the congress recommended to the assemblies and conventions of the colonies where no government sufficient to the exigencies of their affairs had been established, "to adopt such government as shall, in the opinion of the representatives of the people, best conduce to the happiness of their constituents in particular and of America in general." The preamble to this resolution set forth as facts the statements that the colonies had been excluded from the protection of the crown, that no answer had been given to their petitions for redress, and tliat the whole force of the kingdom was to be used for their destruction, and therefore that it was no longer reasonable or honest for the colonists to take the oaths or affirmations necessary for the support of government under the crown. Though the preamble was warmly debated. it was adopted. And this act marked a turning point, for the progress of events from that time to the Declaration of Independence was rapid and decisive. The colonies—now becoming states—one after another, in response to letters from Philadelphia, empowered their delegates to concur in declaring independence. On June 7, Richard Henry Lee of Virginia introduced in the congress a resolution "that these United Colonies are and of right ought to be free and independent states," that it was expedient forthwith to take effectual measures for securing foreign allies and that a plan of confederation should be formed. The debate showed that the delegates from the middle colonies and South Carolina could not act, and the decision was postponed for three weeks. In the interval steps were taken to draft a plan of treaties and articles of confederation. A board of war and ordnance, the earliest germ of an executive department, was also created by the congress.

At the end of the three weeks the delegates from all the colonies except Georgia, South Carolina and New York had received instructions favourable to independence. The two former left their delegates free, and under the influence of the British attack on Charleston they voted for independence. News had just come that Howe had landed with a large force at Sandy Hook. Under the impression of these stirring events the Declaration, substantially in the form given to it by Thomas Jefferson, was agreed to (July 4, 1776), only three adverse votes being cast. The delegates from New York took no part, but a few days later the act was approved by the convention of that state. The signing of the document by the members took place at a later time. Thus triumphed the tendencies toward self-government which had been predominant in the continental colonies from the first, and which the system of imperial control had only superficially modified and restrained. But the most significant part of the document for the future was the preamble, in which the democratic aspirations of the new nation mere set forth, the spirit to which Thomas Paine had just made so powerful an appeal in his *Common Sense.* Governments, it was said, derive their just powers from the consent of the governed, and when any system becomes destructive of these ends it is the right of the people to abolish it and to institute a new government, establishing it upon such principles and under such forms as seem most likely to effect their safety and happiness. *(See* DECLARATION OF INDEPENDENCE.)

Weakness of the General Government.—Viewed from one standpoint, the Declaration of Independence was apparently an act of the utmost recklessness. The people were by no means a unit in its support, and in several of the states widespread indifference to it, or active sympathy with the British, prevailed. The Cnited States, as yet, had no international status, and it would seem that that must be secured, if at all, by a series of victories which would ensure independence. But how could these be won against the greatest naval power on the globe, supported by veteran armies of continental and British troops? The colonies had no money; the few vessels which, as a collective body, they did send out, were more like privateers than anything else. Their army was an undisciplined throng of militiamen, serving on short enlistments, without organized commissariat, and for the most part under inexperienced officers. Its numbers, too, were far inferior to those of the British. Taxation by the continental congress for the support of the war was not among the possibilities of the case. A strong tendency toward the provision for immediate needs by the issue of bills of credit had been inherited from the period of the French wars, and that device was again resorted to. The battle of Bunker hill had been immediately followed by an order of the congress for the issue of $2,000,000 in that form of currency. Issues followed in rapidly increasing amounts, until by the close of 1779, $241.000.000 had been authorized. The states put out nearly as much ($209,000,000). The continental paper money depreciated until it became aorthless, as to a large extent did that of the states also. The states decreed it to be legal tender, and dire threats were uttered against those who refused to receive the bills; but all to no purpose. The congress also tried to induce the states to tax themselves for the general cause and was forced to rely on requisitions for the purpose. These measures proved as complete a failure as when resorted to by the crown. The Revolution was therefore never financed. It early became necessary to resort to loans and that chiefly from foreign sources. It was therefore an absolute necessity that the colonies should secure international recognition and status. Then loans were obtained from the governments of France and Spain and from private bankers in the Netherlands to the amount of about $7,830,000.

The collapse of royal government left the colonies in a chaotic state. The old institutions had disappeared and new ones could not be immediately developed to take their place. But the institutions of local government, the town and county systems, were left intact, and upon these as a basis the new fabrics were erected. It was therefore easier to construct the governments of the states than to define and develop the general government. At first little else was intended than that the congress should be the mouthpiece of the patriot party. It proceeded mainly by way of recommendation, and looked to the states, rather than to itself, as the ultimate sources of authority. Upon them it depended for the execution of its measures. As the war proceeded the states grew jealous of the central body and tried to prevent appeals to it from the state courts in prize cases. Under the pressure of war, moreover, the enthusiasm. which had been strong at the outset. declined, and it became increasingly difficult to secure co-operation or sacrifice toward any general enterprise.

Difficulties of the Congress.—At the same time, war devolved upon the congress an enormous burden of work. It was forced to devise general policies and provide for their execution, and also to attend to an infinite number of administrative details. Most of the able members were drawn off into the army, into diplomatic service or official service in the states. Sectional and state jealousies also developed and became intense. As the congress voted by states the smaller commonwealths were often moved by jealousy of their larger rivals to thwart important measures. But, above all, the conduct of the war and foreign relations occasioned infinite jealousies and cabals, while many of the most important measures seemed to meet with downright indifference. Washington's correspondence abounds in evidence of these facts, while it is well known that he was the object against whom one of the cabals of the time was directed. Franklin was the object of somewhat similar jealousies. But, as time passed, rudimentary executive departments, beginning with the board of war and the postmaster general, were developed, and some advance was made toward a working and permanent system. In 1781 the offices of foreign secretary, superintendent of finance, secretary of war and secretary of marine were created.

Military Disasters.—Until almost its very close the campaign of 1776 was a disheartening failure. The battle of Long Island was lost by the Americans and, as at Bunker hill, it would have been quite possible for the British to have captured the entire force which opposed them on Long Island. Howe compelled Washington to evacuate New York city. On Nov. 16 the practical abandonment of the state of New York by the main army was necessitated by the capture of Ft. Washington. Earlier in the year the Americans had been compelled to retire from Canada, while the Tories in northern New York were contributing valuable aid to the British.

The Tide Turns.—But there was another side to the picture, and already certain faint outlines of it were being discerned. The British commander was, at practically every step, failing to seize the advantages that were within his reach, while Washington was learning to play a losing game with consummate patience and tact. After Washington had crossed the Delaware, Howe, instead of seizing Philadelphia and driving the congress and the American army to some remote places of refuge, as he might have done, prepared for winter quarters. Washington seized the opportunity to return across the Delaware and surprise the British outposts at Trenton (Dec. 26, 1776) and Princeton (Jan. 3, 1777), and thus secured a safe post of observation for the winter at Morristown. Confidence was to an extent restored, the larger part of New Jersey was regained, and many loyalists were compelled to take the oath of allegiance. Howe's plan for the next campaign involved the strengthening of his army by large reinforcements. With this force he proposed to capture Philadelphia and thereby to bring the War of Independence to an end in Pennsylvania, New Jersey and New York. New England and the states farther south could then be dealt with in detail. But Howe was overruled by Lord George Germain. the colonial secretary, whose plan included an invasion from Canada, in which Tories and Indians should share, while Howe should advance up the Hudson and meet the northern forces at Albany. If this ambitious scheme should succeed, the British would occupy the valley of the Hudson and New England would be cut off from the rest of the colonies. General Burgoyne was appointed to command the northern expedition. But the failure of the plan was almost ensured from the outset by the neglect on the part of British officials to instruct General Howe as to his part in its execution. Burgoyne was forced to surrender near Saratoga on Oct. 17. Meanwhile, Howe, who had long waited for instructions respecting the northern expedition, was finally informed that he might undertake the Pennsylvania campaign, but with the hope that at its close he would still be able to march up the Hudson. Thereupon, embarking his army, Howe sailed for Chesapeake bay, at the head of which he landed and advanced toward Philadelphia. Washington's army opposed his march at the Brandywine (Chad's Ford), but was defeated (Sept. 11, 1777) and forced to retire beyond Philadelphia. The British then entered the city (Sept. 26) and the congress withdrew to Lancaster, and later to York, in the interior of Pennsylvania. The British fleet had in the meantime arrived in Delaware bay, and, after a prolonged and brave defense, had captured Forts Mercer and Mifflin. When winter began the Delaware, as well as lower New York and Rhode Island, was in the possession of the British. With the fragments of an army Washington retired to Valley Forge.

French Alliance.—But the influence of Burgoyne's surrender in Europe was to prove a turning point in the war. From 1763 a strong sentiment at the French court had been favourable to a resumption of war with Great Britain. An opportunity was now presented by the colonial revolt. In Feb. 1776 Silas Deane was sent to Paris, ostensibly as a business agent, and with the connivance of the French government supplies were sent to America and American vessels were received into French ports. Soon American privateers were bringing their prizes into French harbours, and British commerce began to suffer from these attacks. On the French side Beaumarchais and others actively co-operated in this. In the autumn of 1776 congress appointed three commissioners to France, and resolved that Spain. Prussia, Austria and other European states should be approached with a view to securing recognition and aid. In Dec. 1776 Franklin, who. with Deane and Arthur Lee, had been appointed commissioner to France, arrived at Paris, bringing with him proposals for treaties of commerce and alliance. But, though the attitude of the French court toward the Americans was friendly, and though it continued to send secret aid, and to exert a favourable influence upon Spain, yet it could not be induced to abandon its outward appearance of neutrality until after the news of Burgoyne's surrender arrived. Then the real purpose of the French government was revealed. On Feb. 6, 1778 the treaties were signed, and in the following summer war between France and England began. The influence of France under the family compact brought Spain into the alliance in April 1779. In Oct. 1779 Henry Laurens was elected minister to the Netherlands, and sailed for Europe, taking with him a plan of a commercial treaty. But Laurens and his papers were captured by the British at sea, and partly by that event the Netherlands were forced into war with England. With the other states of northern Europe they undertook to defend the interests of neutrals against the arrogant enforcement by Great Britain of the rights of search at sea. Thus the conflict expanded into a commercial and naval war, Great Britain being confronted by the larger part of Europe.

Philadelphia Recaptured.—The conclusion of the treaty of alliance by France was immediately followed by the equipment of a fleet under Charles Hector, the comte d'Estaing, which sailed from Toulon in April 1778. Sir Henry Clinton had now succeeded Howe in command of the British army. The certainty that a French fleet would soon appear in American waters made it necessary for the British to evacuate Philadelphia and return to a point on the coast where the army could be in easy communication with the fleet. This fact shows how the French alliance had changed the nature of the war. It now became to a large extent a contest between the two navies, the principal evolutions of which occurred in West Indian and European seas. In the north the British now relatively neglected the land war, and refrained from sending such forces to the eastern coast as had supported Howe in 1776. The Americans, on the other hand, had a naval force upon which they relied, in the hope that the blockade of their coasts might be raised and trade routes opened more freely. On the evacuation of Philadelphia in June Washington's army pursued the British as they retired toward New York, and the indecisive battle of Monmouth was fought on June 28. It did not prevent Clinton from reaching New York, and that city continued to be the centre of British power and operations in the north until the close of the war. The congress returned to Philadelphia. Washington's army came gradually to occupy a line of forts, of which West Point in the highlands of the Hudson was the citadel. From there as a centre it was possible to communicate with Newport on the east and with the Delaware region on the south, and at the same time to prevent the British from gaining access to the interior of the country. Though the fleet of D'Estaing carried a heavier equipment of cannon than did that of Admiral Howe, the French commander did not choose to risk an attack on New York, but passed eastward to Newport. Howe followed him, while Washington and his generals planned active co-operation with the new allies by land. But a sudden storm so dispersed and injured the fleets that the French admiral retired to Boston for repairs and later sailed for the West Indies.

State **Constitutions.**—While the war and foreign relations were thus developing, the states were organizing their governments and the congress was beginning to consider articles of confederation between the states. In this way an effort was made to gather up and make permanent the positive results of the Revolution. As under the chartered and royal governments of the colonial period the source of political authority had been the crown. now by a necessary reaction this was sought in the people. This principle had been stated in the Declaration of Independence, and had been implied throughout the earlier controversy. The colonies had insisted on a more precise definition of the powers of government: they had opposed parliament because its powers were undefined and therefore dangerous. Following these ideas. tlie states now described their institutions of government and defined their powers by means of written constitutions. These were formulated by the provincial congresses—which had now become the legislatures—or. as they came to insist upon a more specific expression of the popular will, by conventions chosen for the purpose by the electors. Connecticut and Rhode Island retained their colonial charters. In the earlier days of hasty and temporary devices. the constitutions, like statutes, had been promulgated by the legislatures which formed them and had been put into force by their authority alone. But as time passed and more permanent arrangements became necessary an express popular approval of the instruments was obtained before they were put into force.

The establishment of state governments in this way began before the issue of the Declaration of Independence. It was actively continued during 1776 and the early months of the following year. by which time all of the states had secured at least a temporary constitution. Of the constitutions of the Revolutionary period the two most striking features were the bills of rights and the provisions which restricted most executives and defined their relations to the legislatures. The men of that generation were jealous of government. They insisted upon individual rights, not as acquired and guaranteed by the state, but as original, natural and inhering in time prior to all governments. Governments were instituted for the common benefit, protection and security. Officials were trustees and were accountable to the people. There should be no hereditary title to office or power. There should be no titles of nobility, and in Virginia the system of entails was swept away. Monopolies were declared to be inconsistent with the spirit of a free state. Freedom of the press and of conscience was asserted, and no obstacles to fair and speedy jury trials were to be tolerated. Elections should be free and frequent, and a preference was expressed for short terms of office. The legislature nas universally regarded as the most important department of government. Although the principle of the separation of powers mas recognized. in 8 states provision was made that the executives should be elected by the legislatures. 11 withheld from them the veto, and the states generally provided for a council to advise them. So manifold and important, however, were the restrictions on suffrage that the states were as yet far from being democracies.

The Articles of Confederation.—The first draft of the Articles of Confederation (*q.v.*) between the states was prepared by John Dickinson in the early summer of 1776. Because of the pressure of war it was then laid aside until the autumn of 1777. By that time the feeling in favour of state sovereignty had so increased that the impossibility of securing assent to the articles in any form had begun to be feared. But the document was completed and submitted to the states in Nov. 1777, when all were encouraged by the news of Burgoyne's surrender. The system for which provision was made in this document was a "confederacy," or "firm league of friendship" between the states. The congress was to be continued, and was to consist of delegates annually appointed by the legislature of each state and paid by their states. No attempt was made to create an executive for the confederacy, though authority was given to the congress to appoint a council of state which should manage general affairs, especially during recesses of the congress. To the congress various general powers were entrusted, such as deciding on peace and war and superintending the conduct of the same, building a navy.);: controlling diplomatic relations, coining money and emitting bills of credit, establishing post offices, regulating Indian trade and adjusting boundary disputes between the states. The financial powers entrusted to the congress included those of borrowing money and determining necessary expenditures, but not the power to tax. For supplies the general government had to depend on requisitions from the states. The same system also had to suffice for tlie raising and equipment of troops. The congress could not make its laws or orders effective in any matter of importance. This was simply a continuation of the policy under which the Revolution was being conducted. The control of trade was practically left with the states, the Americans in this matter failing to live up to the requirements of the British system. The predominance of the states was further ensured by the provision that no votes, except those for daily adjournment, could be carried without the assent of a majority of all the states, and no important measure without the consent of nine states. But a common citizenship was declared to exist, and the congress received authority to establish a court of appeal which might pass finally on all disputes between states. Taken as a whole, the Articles of Confederation would bear favourable comparison with other schemes of their kind, and they fairly represented the stage of development to which the American states had then attained.

The West.—It has been seen that, on the whole, the attitude of Great Britain, after the peace of 1763. was not favourable to the colonization of the Mississippi valley. To the colonists the Quebec act gained in offensiveness by seeming to imply that it was intended to exclude them from the west. But all such plans were swept away by the outbreak of the American Revolution. Already. before the beginning of hostilities, emigrants had begun to flock across the mountains. Plans were on foot for the establishment of a number of commonwealths, or proprietary provinces, as the case might be. Daniel Boone and his associates pushed farther west into the Kentucky region, and there it was proposed to establish the commonwealth of Transylvania. Other similar projects were started, all repeating in one form or another the political methods which were used when the seaboard colonies were

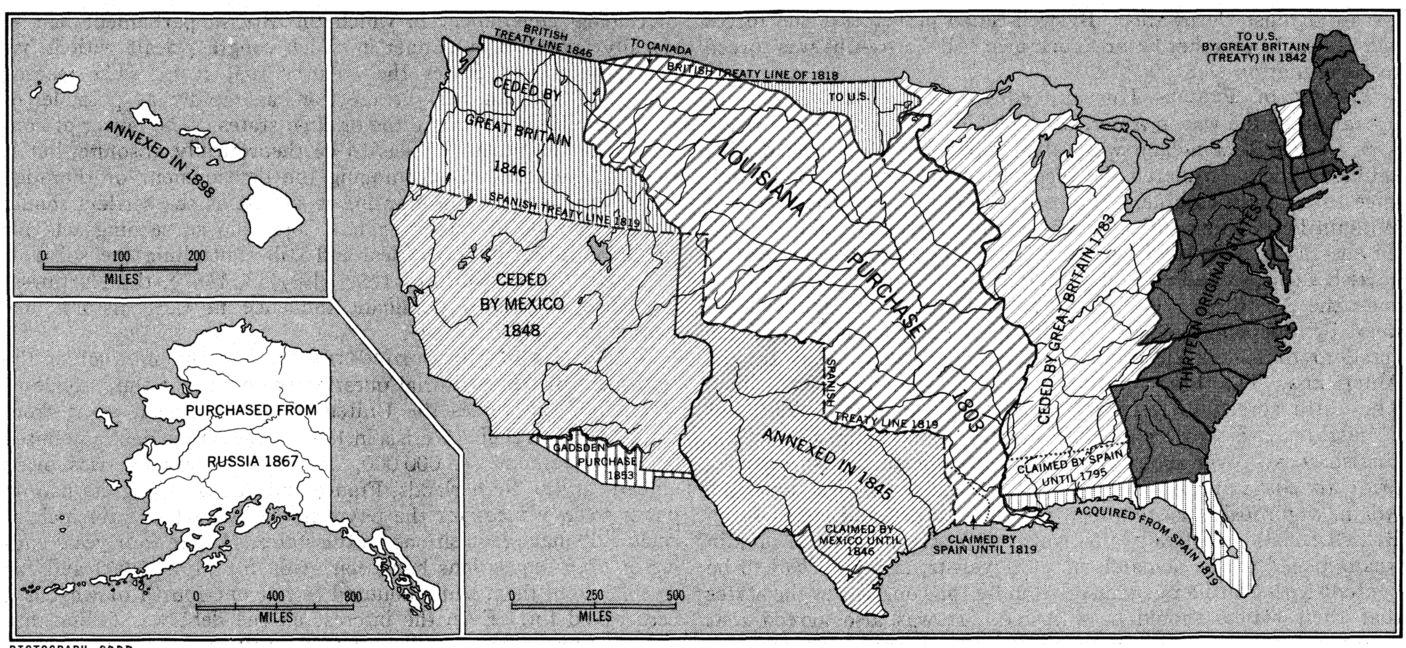


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FIG. 8.— TERRITORIAL EXPANSION OF THE U.S., 1776–1900

first settled. The backwoodsmen who managed these enterprises were extreme individualists, believed in the propriety of resistance to governments, and were in full sympathy with the Revolution. The states which had claims in the west opposed the founding of independent settlements there and, if possible, induced the settlers to be content with the status of counties within some one of the eastern states. After the beginning of the Revolution, the British from Detroit incited Indian raids for the purpose of destroying or driving out the settlers, especially in Kentucky. These raids provoked the important expeditions of George Rogers Clark in 1778 and 1779. With a force of Virginians he seized Kaskaskia and later, after a long march, captured Vincennes and compelled Gen. Henry Hamilton, who had come with a relief force from Detroit, to surrender. This secured to the Americans a permanent hold upon the northwest.

But Spain, after it entered the war, was determined, if possible, to wrest the valley of the Mississippi from the British and to keep all, or the larger part of it, for itself. To that end, operating from New Orleans, its troops took possession of Xatchez, and other posts on the lower Mississippi, and occupied Mobile and Pensacola.

Articles of Confederation **Ratified.**—Within the confederacy a fundamental line of cleavage was that between the large and small states. It was jealousy on the part of the small ones, their fear lest they might be absorbed by their larger neighbours, which had necessitated the adoption of the plan that in the congress the delegates should vote by states. When the articles were referred to the states for ratification, the difficulty reappeared. Massachusetts, Connecticut and New York, with Virginia and the three states to the south of it. had large claims to territory between the Appalachians and the Mississippi. New Hampshire, Rhode Island, Xew Jersey, Delaware and Maryland, which were without hope of westward extension. hesitated to enter the confederacy. if the large states were to be still further increased by additions to their areas of vast stretches of western country. They insisted that before ratification the states which had claims to western lands should surrender these for the common benefit of the United States. Maryland insisted upon this until, in the end, the cause of state equality and of nationality triumphed.

Congress declared that the ceded lands should be formed into states, which should become members of the union with the same rights as other states. When in 1781 the course of action had become possible, Maryland ratified the articles and they came into effect.

War in the South.—So far as the North American continent was concerned, the character of the last stage of the struggle with Great Britain was determined by the fact that the British resolved to transfer the main seat of war to the southern states, in the hope that Georgia and South Carolina might be detached from the union. At the close of 1778 Savannah was captured. In Sept. 1779 D'Estaing returned and assaulted Savannah, but, failing to capture it, sailed for France. In 1780 Clinton sailed from New York, besieged Charleston with a superior force and captured it (May 12). State government in South Carolina ceased. But the chance of detaching those states from the union and of bringing the war in that region to an end was finally lost by the British. This was chiefly because of an order which recalled the paroles of many of those who had surrendered at Charleston and required that they should perform military service under the British. The attempt to enforce this order provoked a bloody partisan conflict in the upper districts, especially of South Carolina, which contributed more than any other cause to run the scale against the British in the remote south. By the winter of 1781 they were forced back to Charleston and Savannah.

Yorktown.—During the summer of 1780 Washington was prevented from accomplishing anything in the north by the demoralized condition of the finances and by the decline of public spirit. It was very difficult to secure recruits or supplies. The pay of the troops had fallen so into arrears that some of them had already begun to mutiny. A second French squadron and military force, under Gen. Jean Baptiste Rochambeau, landed at Newport, but they were at once shut up there by the British. Clinton and Cornwallis were now planning that Cornwallis, having put down resistance in the remote south, should march through North Carolina and Virginia to Baltimore and Philadelphia and that a junction of the two British forces should be effected which, it was believed, would complete the ruin of the American cause. But the turn of the tide in favour of the Americans began with the partisan warfare in South Carolina, which delayed the northward march of Cornwallis, who retired to U'ilmington and then marched north with a small force into Virginia, and in July retired to Yorktown, in the peninsula of Virginia. Washington and Rochambeau had meantime been planning a joint move against the British at New York, or possibly in Virginia, and a letter was sent to the comte de Grasse, the French admiral in the West Indies, suggesting his co-operation. De Grasse replied that he would sail for the Chesapeake. This confirmed Washington and Rochambeau in the opinion that they should march at once for Virginia and, after junction with the force of Lafayette, co-operate with De

Grasse against Cornwallis. By well-timed movements the forces were brought together before Yorktown and Cornwallis was forced to surrender on Oct. 19, 1781.

Treaty of Peace.—This proved to be the last important operation of the war in America. The king was compelled to give way. Lord Rockingham was called into office at the head of a cabinet which considered the recognition of American independence to be indispensable. The negotiations fell into the hands of William Petty Fitzmaurice, earl of Shelburne, the friend of Franklin and disciple of Adam Smith. Richard Oswald was the leading British agent, while Franklin, Jay, John Adams and Henry Laurens were the American negotiators. From the first the acknowledgment of independence, the settlement of the boundaries and the freedom of fishing were insisted on as necessary terms by the Americans. The three points were early conceded by the British. They also agreed to restrict Canada to its ancient limits. But discussions later arose over the right to dry and cure fish on the British coasts, over the payment of debts due to British subjects prior to the war and over the compensation of the loyalists. Adams vigorously insisted upon the right to dry and cure fish on British coasts, and finally this concession was secured. Franklin was opposed to the demands of the loyalists, and they had to be content with a futile recommendation by the congress to the states that their claims should be adjusted. It was also agreed that creditors on either side should meet with no lawful impediment to the collection of their debts. Both France and Spain considered the claims of the Americans to be excessive, and were not inclined to yield to them. But the Americans negotiated directly with the British and the articles were signed without consultation with the French government. Peace was formally ratified on Sept. 3, 1783.

The American army was now disbanded. Since the close of active military operations both officers and men had been striving to secure their pay, which was hopelessly in arrears The congress had voted half pay to the officers for life, and many had agreed to accept a commutation of this in the form of full pay for a certain number of years. Certificates for these amounts were issued. But in this, as in other cases, it was found impossible to procure the money for the purpose from the states. Parts of the army repeatedly mutinied, and it was only the influence of Washington which prevented a general outbreak. When the disbandment was finally effected the officers found their certificates depreciated and the states indisposed to honour them. They received only a small part of their due, and the privates scarcely anything. (H. L. O.)

Struggle for National Government, 1783–1865

The long struggle to secure the ratification of the Articles of Confederation had given time for careful consideration of the new scheme of government. Maryland's persistent criticism had prepared men to find defects in them. Conventions of New England states, pamphlets and private correspondence had found flaws in the new plan; but a public trial of it was a necessary preliminary to getting rid of it. The efforts of the individual states to maintain the war, the disposition of each state to magnify its own share in the result, the popular jealousy of a superior power, transferred now from parliament to the central government, were enough to ensure the articles some lease of life.

Territorial **Cessions.**—Congress and its committees had already begun to declare that it was impossible to carry on a government efficiently under the articles. Its expostulations were to be continued for several years before they were heard. In the meantime it did not neglect the great subject which concerned the essence of nationality—the western territory. Virginia had made a first offer to cede its claims, but it was not accepted. A committee of congress made a report (1782) maintaining the validity of the rights which New York had transferred to congress; and in the next year Virginia made an acceptable offer. Its deed was accepted (March 1, 1784); the other claimant states followed; and congress, which was not authorized by the articles to hold or govern territory, became the sovereign of a tract of about 430,000 sq.mi.

In this territory congress had on its hands the same question of colonial government in which the British parliament had so signally failed. The manner in which congress dealt with it has made the United States the country that it is. The leading feature of its plan was the erection, as rapidly as possible, of states, similar in powers to the original states. The power of congress over the territories was to be theoretically absolute, but it was to be exerted in encouraging the development of thorough self-government, and in granting it as fast as the settlers should become capable of exercising it. Copied in succeeding acts for the organization of territories, and still controlling the spirit of such acts, the ordinance of 1787 (July 13, 1787), the Northwest ordinance, became a dominant influence in U.S. history (see Northwest Territories).

Difficulties of the Confederation.—In the interval of the settlement of the territorial question the affairs of the "league of friendship," known as the United States, had been going from bad to worse, reaching a crisis in 1786. The public debt amounted in 1783 to about $42,000,000, of which $8,000,000 was owed abroad—in the Netherlands, France and Spain. Congress had no power to levy taxes for the payment of interest or principal; it could only make requisitions on the states. In the four years ending in 1786 requisitions had been made for $10,000,000 and the receipts from them had amounted to but one-fourth of what had been called for. Even the interest on the debt was falling into arrears, and the first installment of the principal fell due in 1787. To pay this, and subsequent annual installments of $1,000,000, was quite impossible. Robert Morris, the financier of the war, resigned in 1783 rather than "be the minister of injustice," hoping thus to force upon the states the necessity of granting taxing powers to congress. Washington, on retiring as the command in chief, wrote a circular letter to the governors of all the states. urging the necessity of granting to congress some power to provide a national revenue. Congress (April 18, 1783) appealed to the states for power to levy specific duties on certain enumerated articles, and 5% on others. It was believed that with these duties and the requisitions, which were now to be met by internal taxation, $2,500,000 per annum could be raised. The proposal never received the necessary ratification of all the states. The obedience to the requisitions grew more lax. In 1786 a committee of congress reported that any further reliance on requisitions would be "dishonourable to the understandings of those who entertain such confidence."

The States and Congress.—In the states the case was even worse. Some of them had been seduced into issuing paper currency in such profusion that they were almost bankrupt. Great Britain, in the treaty of peace, had recognized the independence of the individual states, naming them in order; and its government followed the same system in all its dealings with its former Colonies. Its restrictive system was maintained, and the states, competing with each other for more commerce, could adopt no system of counteracting measures. Every possible burden was thus shifted to American commerce; and congress could do nothing, for, though it asked for the power to regulate commerce for 15 years, the states refused it. Several states, toward the end of this period, began to prepare or adopt systems of protection of domestic productions or manufactures, aimed at preventing competition by neighbouring states. The Tennessee settlers were in insurrection against the authority of North Carolina; the Kentucky settlers were disposed to cut loose from Virginia. Poverty, with the rigid execution of process for debt, drove the farmers of western Massachusetts into an insurrection (Shays's rebellion) which the state had much difficulty in suppressing; and congress was so incompetent to aid Massachusetts that it was driven to the expedient of imagining an Indian war in that direction, in order to transfer troops there. Congress itself was in danger of disappearance from the scene. The necessity for the votes of 9 of the 13 states for the passage of important measures made the absence of a state's delegation quite as effective as a negative vote. Congress even had to make repeated appeals to obtain a quorum for the ratification of the treaty of peace with Great Britain. In 1784 congress broke up in disgust, and the French minister reported to his government—"There is now in America no general government — neither Congress, nor president, nor head of any one administrative department."

Congress was evidently incompetent to frame a new plan of national government; its members were too dependent on their states, and would be recalled if they took part in framing anything stronger than the articles. The idea of a convention of the states, independent of congress, was in the minds and mouths of many; Thomas Paine had suggested it as long ago as his Common *Sense* pamphlet: "Let a continental conference be held . . . to frame a continental charter."

Convention of 1786. — The country drifted into a convention by a roundabout way. The navigation of Chesapeake bay and the Potomac needed regulation; and the states of Maryland and Virginia, having plenary power in the matter, appointed delegates to arrange such rules. The delegates met (1785) at Alexandria, Va., and at Washington's house, Mount Vernon, Va., in adopting their report, proposed that Pennsylvania and Delaware be asked to nominate commissioners. Virginia went further and proposed a meeting of commissioners from all the states to frame commercial regulations for the whole. The convention met (1786) at Annapolis, Md., but only five states were represented, and their delegates adjourned, after recommending another convention at Philadelphia in May 1787.

Constitutional Convention. — Congress had failed in its last resort — a proposal that the states should grant it the impost power alone; New York's veto had put an end to this last hope. Confessing its helplessness, congress approved the call for a second convention; 12 of the states (all but Rhode Island) chose delegates; and the convention met at Philadelphia (May 25, 1787) with an abler body of men than had been seen in congress since the first two continental congresses. Among others. Virginia sent Washington, James Madison, Edmund Randolph, George Mason and George Wythe; Pennsylvania: Franklin, Robert, Gouverneur Morris and James Wilson; Xlassachusetts: Rufus King, Elbridge Gerry and Caleb Strong: Connecticut: William S. Johnson, Roger Sherman and Oliver Ellsworth; New York: Alexander Hamilton; New Jersey: William Paterson; and South Carolina the two Pinckneys and John Rutledge. With hardly an exception the 55 delegates were clear-headed, moderate men, uith positive views of their own and firm purpose, but with a willingness to compromise.

The Virginia Plan. — Washington was chosen to preside, and the convention began the formation of a new constitution, instead of proposing changes in the old one. Two parties were formed at once. The Virginia delegates offered a plan proposing a congress, of two houses. having power to legislate on national subjects, and to compel the states to fulfill their obligations. This was a "large-state" plan, proposed by those states which had or hoped for a large population. It meant to base representation in both houses on population, so that the large states could control both of them, and it left the appointment of the president or other executive and the federal judges to congress — so that the whole administration of the new government would fall under large-state control.

The New Jersey **Plan.**—On behalf of the "small states" Paterson of New Jersey brought in another plan. It continued the old confederation, with its single house and equal state vote. but added the power to regulate commerce and raise a revenue, and to compel the states to obey requisitions. The large states had a general majority of six to five, but the constant dropping off of one or more votes, on minor features, from their side to that of the small states prevented the hasty adoption of any radical measures. Nevertheless, the final collision could not be evaded; the basis of the two plans was in the question of one or two houses, of equal or proportionate state votes, of large-state supremacy or of state equality. In July the large states began to show a disposition to force their plan through, and the small states began to threaten a concerted withdrawal from the convention.

The Compromise. — The Connecticut delegates, from their first appearance in the convention, had favoured a compromise. They had been trained under the New England system, in which the assemblies were made up of two houses, one representing the people of the whole state, according to population, and the other giving an equal representation to the towns. They proposed that the new congress should be made up of two houses, one representing the states in proportion to their population, the other giving an equal vote to each state. At a deadlock the convention referred the proposition to a committee, and it reported in favour of the Connecticut compromise. Connecticut had been voting in the large-state list, and the votes of its delegates could not be spared from their slender majority; now another of the large states, North Carolina, came over to Connecticut's proposal, and it was adopted. Thus the first great struggle of the convention resulted in a compromise, which took shape in an important feature of the constitution, the senate.

The small states were still anxious, in every new question, to throw as much power as possible into the hands of their special representative, the senate; and that body thus obtained its power to act as an executive council as a restraint on the president in appointments and treaties. This was the only survival of the first alignment of parties; but new divisions arose on almost every proposal introduced. The election of the president was given at various times to congress and to electors chosen by the state legislatures; and the final mode of choice, by electors chosen by the states, was settled only two weeks before the end of the convention, the office of vice-president coming in with it. The opponents and supporters of the slave trade compromised by agreeing not to prohibit it for 20 years. Another compromise included three-fifths of the slaves in enumerating population for representation. This provision gave the slaveholders abnormal power as the number of slaves increased.

Any explanation of the system introduced by the constitution must start with the historical fact that, while the national government was practically suspended, from 1776 until 1789, the only power to which political privileges had been given by the people was the states. and that the state legislatures were, when the convention met, politically omnipotent, with the exception of the few limitations imposed on them by the early state constitutions. The general rule, then, is that the federal government has only the powers granted to it by the federal constitution, while the state has all governmental powers not forbidden to it by the state or the federal constitution. But the phrase defining the federal government's powers is no longer "expressly granted," as in the Articles of Confederation, but merely "granted." so that powers necessary to the execution of granted powers belong to the federal government, even though not directly named in the constitution. This question of the interpretation or "construction" of the constitution is at the bottom of real national politics in the United States.

The Constitution. — Popular sovereignty, then, is the basis of the American system. But it does not, as does the British system, choose its legislative body and leave unlimited powers to it. It makes its constitution the permanent medium of its orders or prohibitions to all branches of the federal government and to many branches of the state governments: they must do what the constitution directs and leave undone what it forbids. The people, therefore, are continually laying their commands on their governments; and they have instituted a system of federal courts to ensure obedience to their commands. A British court must obey the act of parliament; the American court is bound and sworn to obey the constitution first, and the act of congress or of the state legislature only so far as it is warranted by the constitution. But the American court does not deal directly with the act in question; it deals with individuals who have a suit before it. One of these individuals relies on an act of congress or of a state legislature; the act thus comes before the court for examination; and it supports the act or disregards it as "unconstitutional," or in violation of the constitution. If the court is one of high rank, or one to which a decision may be appealed, as the U.S. supreme court, other courts follow the precedent. and the law falls to the ground.

The preamble states that "we, the people of the United States," establish and ordain the constitution. Events have shown that it was the people of the whole United States that established the constitution, but the people of 1787 seem to have been inclined to the belief that it was the people of each state for itself. This belief was never changed in the south; and in 1861 the people of that section believed that the ordinances of secession were merely a repeal of the enacting clause by the power which had passed it, the people of the state. For an account of the form of government established by the constitution see *Constitution* and *Goverrtment* below.

The constitution's leading difference from the confederation is that it gives the national government power over individuals. The federal courts are the principal agents in securing this essential power; without them, the constitution might easily have been as dismal a failure as the confederation. It has also been a most important agent in securing to the national government its supremacy over the states. From this point of view the most important provision of the constitution is the grant of jurisdiction to federal courts in cases involving the construction of the constitution or of laws or treaties made under it. The 25th section of the Judiciary act of 1789 permitted any supreme court justice to grant a writ of error to a state court in a case in which the constitutionality of a federal law or treaty had been denied, or in which a state law objected to as in violation of the federal constitution had been maintained. In such cases, the defeated party had the right to carry the "federal question" to the federal courts. It was not until 1816 that the federal courts undertook to exercise this power; it raised a storm of opposition, but it was maintained, and has made the constitution what it professed to be—"the supreme law of the land."

Sovereignty.—The system of the United States is almost the only national system, in active and successful operation, as to which the exact location of the sovereignty is still a mooted question. The contention of the Calhoun school—that the separate states were sovereign before and after the adoption of the constitution, that the union was purely voluntary and that the whole people, or the people of all the other states, had no right to maintain or enforce the union against any state—has been ended by the Civil War. But that did not decide the location of the sovereignty. The prevalent opinion is still that first formulated by Madison: that the states were sovereign before 1789; that they then gave up a part of their sovereignty to the federal government; that the union and the constitution were the work of the states, not of the whole people; and that reserved powers are reserved to the people of the states, not to the whole people.

By whatever sovereignty the constitution was framed and imposed, it was meant only as a scheme in outline, to be filled up afterward, and from time to time, by legislation. The idea is most plainly carried out in the federal judiciary: the constitution only directs that there shall be a supreme court, and marks out the general jurisdiction of all the courts, leaving congress, under the restriction of the president's veto power, to build up the system of courts. But the same idea is visible in every department, and it has carried the constitution safely through a period which has radically altered every other civilized government. It has combined elasticity with the limitations necessary to make democratic government successful over a vast territory, having infinitely diverse interests, and needing, more than almost anything else, positive opportunities for sober second thought by the people. A sudden revolution of popular thought or feeling is enough to change the house of representatives from top to bottom; it must continue for several years before it can make a radical change in the senate, and for years longer before it can carry this change through the judiciary, which holds for life; and all these changes must take place before the full effects upon the laws or constitution are accomplished. But minor changes are reached easily and naturally in the course of legislation.

Submission to Congress.—The convention adjourned on Sept. 17, 1787. Its last step was a resolution that the constitution be sent to the congress of the confederation, with the recommendation that it be submitted to conventions elected by the people of each state for ratification or rejection; that, if nine states should ratify it, congress should appoint days for the popular election of electors, and that then the new congress and president should, "without delay, proceed to execute this Constitution." Both congress and the convention were careful not to open the dangerous question, How was a government which was not to be changed but by the legislatures of all the states to be entirely supplanted by a different system through the approval of conventions in three-fourths of them?

Action **of** the States.—Before the end of the year Delaware, Pennsylvania and New Jersey had ratified; and Georgia, Connecticut and Massachusetts followed during the first two months of 1788. Thus far the only strong opposition had been in Massachusetts, a "large state." In it the struggle began between the friends and the opponents of the constitution, with its introduction of a strong federal power; and it raged in the conventions, legislatures, newspapers and pamphlets. In a classic series of papers, the *Federalist,* Alexander Hamilton, with the assistance of Madison and John Jay, explained the new constitution and defended it.

The seventh and eighth states—Maryland and South Carolina—ratified in April and May 1788; and, while the conventions of Virginia and New York were still wrangling over the great question, the ninth state, New Hampshire, ratified, and the constitution passed out of theory into fact. The Anti-Federalists of the Virginia and New York conventions offered conditional ratifications of all sorts; but the Federalists stubbornly refused to consider them, and at last, by very slender majorities, these two states ratified. North Carolina for a time refused to ratify the constitution. In Rhode Island it was referred to the several towns instead of to a convention arid was at first rejected by a majority, the Federalists, who advocated the calling of a convention, refraining from voting. Congress named the first Wednesday of Jan. 1789 as the day for the choice of electors, the first Wednesday in February for the choice of president and vice-president, and the first Wednesday in March for the inauguration of the new government, at New York city. The last date fell on March 4, which continued the limit of each president's term for a century and a half.

When the votes of the electors were counted before congress, it was found that Washington had been unanimously elected president, and that John Adams, standing next on the list, was vice-president. Long before the inauguration the congress of the confederation had expired of mere inanition; its attendance simply ran down until (Oct. 21, 1788) its record ceased and the United States got on without any national government for nearly six months. The struggle for nationality had been successful, and the old order faded out of existence.

Slavery.—The first census (1790) followed so closely upon the inauguration of the constitution that the country may fairly be said to have had a population of nearly 4,000,000 in 1789. Something over 500,000 of these were slaves, of African birth or blood. Slavery of this sort had taken root in almost all the colonies, its original establishment being everywhere by custom. When the custom had been sufficiently established statutes came in effect to regulate a relation already existing. But it is not true, as the Dred Scott decision held long afterward, that the belief that slaves were chattels simply, things, not persons, held good at the time of the adoption of the constitution. Times had changed somewhat. The peculiar language of the constitution itself, describing a slave as a "person held to service or labour," under the laws of any state, puts the general feeling exactly: slaves were persons from whom the laws of some of the states withheld personal rights for the time. In accordance with this feeling most of the northern states were on the high road toward abolition of slavery. Vermont had never allowed it. In Massachusetts it was swept out by a summary court decision that it was irreconcilable with the new state constitution. Other states soon began systems of gradual abolition, which finally extinguished slavery north of Maryland, but so gradually that there were still 18 apprentices for life in New Jersey in 1860, the last remnants of the former slave system. In the new states north of the Ohio slavery was prohibited by the ordinance of 1787 and the prohibition was maintained in spite of many attempts to get rid of it and introduce slavery.

The sentiment of thinking men in the south was exactly the same, or in some cases more bitter from their personal entanglement with the system. Jefferson's language as to slavery is irreconcilable with the chattel notion; no abolitionist agitator ever used warmer language than he. Washington, George Mason and other southern men were almost as warm against slavery as Jefferson, and there were societies for the abolition of slavery in the south. In the Constitutional Convention of 1787 the strongest opposition to an extension of the period of noninterference with the slave trade from 1800 to 1808 came from Virginia, whereas every one of the New England states voted for this extension. Like most slave laws, the laws of the southern states were harsh: rights were almost absolutely withheld from the slave and punishments of the severest kind were legal; but the execution of the system was milder than its legal possibilities might lead one to imagine. The country was as yet so completely agricultural that southern slavery kept all the patriarchal features possible to such a system.

Industries. — Indeed, the whole country was almost exclusively agricultural, and, in spite of every effort to encourage manufactures by state bounties, they formed the meagrest element in the national production. Connecticut, which now teems with manufactures, was just beginning the production of tinware and clocks; Rhode Island and Massachusetts were just beginning to work in cotton from models of jennies and Arkwright machinery surreptitiously obtained from England, and other states, beyond local manufactures of paper, glass and iron, were almost entirely agricultural, or were engaged in industries directly dependent on agriculture.

Population. — There were but five cities in the United States having a population of more than 10.000—New York (33,000), Philadelphia (28,500), Boston (18,000), Charleston (16,000) and Baltimore (13.000). The revenues of the new government in 1790 were only $4,000,000; the expenditures, excluding interest on the public debt, but $1,000,000. It is not easy for the modern American to realize the poverty and weakness of his country at the inauguration of the new government.

Travel. — Outside the cities communication was slow. One stage a week was enough for the connection between the great cities; and communication elsewhere depended on private conveyance. The western settlements were just beginning to make the question more serious. Enterprising land companies were the moving force which had impelled the passage of the ordinance of 1787: and the first column of their settlers was pouring into Ohio and forming connection with their predecessors in Kentucky and Tennessee. Marietta and Cincinnati had been founded. But the intending settlers were obliged to make the journey down the Ohio river from Pittsburgh in bulletproof flatboats, for protection against the Indians. and the return trip depended on the use of oars. For more than 20 years these flatboats were the chief means of river commerce in the west; and in the longer trips. as to New Orleans, the boats were generally broken up at the end and sold for lumber. John Fitch and others were already experimenting on what was soon to be the steamboat; but the statesman of 1789. looking at the task of keeping under one government a country of such distances, with such difficulties of communication, naturally felt anxiety as to the future.

Literature. — The comparative isolation of the people everywhere, the lack of books, the poverty of the schools and newspapers, were all influences which worked strongly against any pronounced literary development. Poems, essays and paintings were feeble imitations of European models; history was annalistic, if anything; and the drama hardly existed. In two points the Americans were strong. and had done good work. Such men as Jonathan Edwards had excelled in various departments of theology, and American preaching had reached a high degree of quality and influence; and, in the line of politics. the American state papers rank among the very best of their kind. Having a very clear perception of their political purposes, and having been restricted in study and reading to the great masters of pure and vigorous English, and particularly to the English translators of the Bible, the American leaders came to their work with an English style which could hardly have been improved. The writings of Franklin, Washington, the Adamses, Hamilton, Jefferson, Madison, Jay and others show the secret of their strength in every page. Much the same reasons, with the influences of democracy, brought oratory, as represented by Patrick Henry, Fisher Ames, John Randolph and others, to a point not very far below the mark afterward reached by Daniel Webster. The effect of these facts on the subsequent development of the country is not often estimated at its full value.

Limits of Settlement. — The cession of the Northwest Territory by Virginia and New York had been followed by similar cessions by Massachusetts (1785), Connecticut (1786) and South Carolina (1787). North Carolina did not cede Tennessee until early in 1790, nor Georgia its western claims until 1802. Settlement in all these regions was still very sparse. The centres of western settlement, in Tennessee and Kentucky, had become more firmly established, and a new one, in Ohio, had just been begun. The whole western limits of settlement of the old 13 states had moved much nearer their present boundaries; and the acquisition of the western title, with the liberal policy of organization and government which had been begun, was to have its first clear effects during the first decade of the new government. Almost the only obstacle to its earlier success had been the doubts as to the attitude which the Spanish authorities, at New Orleans and Madrid, would take toward the new settlements. They had already asserted a claim that the Mississippi was an exclusively Spanish stream from its mouth up to the Yazoo, and that no American boat should be allowed to sail on this part of it. To the western settler the Alleghenies and bad roads were enough to cut him off from any other way to a market than down the Mississippi; and it was not easy to restrain him from a forcible defiance of the Spanish claim. The northern states were willing to allow the Spanish claim for a period of years in return for a commercial treaty; the southern states and the western settlers protested angrily; and once more the spectre of dissolution appeared, not to be laid again until the new government had made a treaty with Spain in 1795 securing common navigation of the Mississippi.

The Development of Democracy. — All the tendencies of political institutions in the United States had been toward democracy; but the leading men were not unanimous in their agreement with this tendency. Not a few of them were pronounced republicans even before 1775, but the mass of them had no great objections to a monarchical form of government until the war spirit had converted them. The Declaration of Independence had been directed rather against the king than against a king. Even after popular sovereignty had pronounced against a king, class spirit was for some time a fair substitute for aristocracy. As often happens, democracy at least thought of a Caesar when it apprehended class control. Certain discontented officers of the continental army proposed to Washington that he become king, but he promptly and indignantly put the offer by.

The state constitutions were democratic, except for property or other restrictions on the right of suffrage, or provisions carefully designed to keep the control of at least one house of the state legislature "in the hands of property." The federal constitution was so draan that it would have lent itself kindly either to class control or to democracy. The electoral system of choosing the president and vice-president was altogether antidemocratic, though democracy has conquered it: rarely has an elector disobeyed the purely moral claim of his party to control his choice. Since the senate was to be chosen by the state legislatures, "property," if it could retain its influence in those bodies, could control at least one house of congress. Whether the constitution was to have a democratic or an antidemocratic interpretation was to be settled in the next 12 years.

The states were a strong factor in the final settlement, from the fact that the constitution had left to them the control of the elective franchise: they were to make its conditions what each of them saw fit. Religious tests for the right of suffrage had been quite common in the colonies; property tests were almost universal. The religious tests disappeared shortly after the Revolution; the property tests survived in some of the states far into the constitutional period. But the desire to attract immigration was always a strong impelling force to induce states, especially frontier states, to make the acquisition of full citizenship and political rights as easy and rapid as possible. This force was not so strong at first as it was after the great stream of immigration began about 1848, but it was enough to tend constantly to the development of democracy.

Organization of the New Government. — The Anti-Federalists had been a political party, but a party with but one principle, The absolute failure of that principle deprived the party of all cohesion; and the Federalists controlled the first two congresses almost entirely. Their pronounced ability was shown in their organizing measures, which still govern the American system very largely. The departments of state, of the treasury, of mar, of justice and of the post office were rapidly and successfully organized; acts were passed for the regulation of seamen, commerce, tonnage duties, lighthouses, dealing with the Indians, territories and the militia; a national capital was selected; a national bank was chartered; the national debt was funded, and the state debts were assumed as part of it. The first four years of the new system showed that the states had now to deal with a very different power from the impotent congress of the confederation. The new power was even able to exert pressure upon the two states which had not ratified the constitution. As a first step, the higher duties imposed on imports from foreign countries were expressly directed to apply to imports from North Carolina and Rhode Island. North Carolina having called a second convention, its case was left to the course of nature; the second convention ratified the constitution (Nov. 21, 1789). The Rhode Island legislature asked that their state might not be considered altogether foreigners, made their duties agree with those of the new government, and reserved the proceeds for "continental" purposes. Still no further steps were taken. A bill was therefore introduced, directing the president to suspend commercial dealings with Rhode Island, and to demand from it its share of the continental debt. This was passed by the senate, and needed but two steps further to become law. Newspaper proposals to divide the little state between its two nearest neighbours were stopped by its ratification of the constitution (May 29, 1790). The "old 13" were thus united under the constitution; and yet, so strong is the American prejudice for the autonomy of the states that these last two were allowed to enter in the full conviction that they did so in the exercise of sovereign freedom of choice.

Protection. — Protection was begun in the first tariff act, whose object. said its preamble, was the protection of domestic manufactures. The duties, however, ranged only from $7\frac{1}{2}\%$ to 10%, averaging about $8\frac{1}{2}\%$. The system. too, had rather a political than an economic basis. Until 1789 the states had controlled the imposition of duties. The separate state feeling was a factor so strong that secession was a possibility which every statesman had to take into account. Hamilton's object. in introducing the system. seems to have been to create a class of manufacturers, running through all the states, but dependent for prosperity on the new federal government and its tariff. This would be a force which would make strongly against any attempt at secession. The same feeling seems to have been at the bottom of his establishment of a national bank, his assumption of state debts and most of the general scheme which his influence forced upon the Federalist party.

Development of Parties. — In forming his cabinet Washington had paid attention to the opposing elements which had united for the temporary purpose of ratifying the constitution. The national element was represented by Hamilton, secretary of the treasury, and Henry Knox, secretary of war; the particularist element (using the term to indicate support of the states, not of a state) by Jefferson, secretary of state, and Edmund Randolph. attorney general. At the end of 1792 matters were in train for the general recognition of the existence of two parties, whose struggles were to decide the course of the constitution's development. The occasion came in the beginning of 1793, when the new nation was first brought into contact with the French Revolution.

The controlling tendency of Jefferson and his school was to the maintenance of individual rights at the highest possible point, as the Hamilton school was always ready to assert the national power to restrict individual rights for the general good. The Jefferson school supported the states, in the belief that they were the best bulwarks for individual rights. When the French Revolution began its course in America by agitation for the "rights of man," it met a sympathetic audience in the Jefferson party and a cold and unsympathetic hearing from the Hamilton school of Federalists, who were far more interested in securing the full recognition of the power and rights of the nation than in securing the individual against imaginary dangers, as they thought them. For ten years the surface marks of distinction between the two parties were to be connected with the course of events in Europe.

The new government was not yet four years old; it was not familiar, nor of assured permanency. The only national governments of which Americans had had previous experience were the British government and the confederation: in the British they had had no share. and in the confederation had had no power. The only places in which they had had long-continued, full and familiar experience of self-government were their state governments. The governing principle of the Hamilton school, that the construction or interpretation of the terms of the constitution was to be such as to broaden the powers of the federal government, necessarily involved a corresponding trenching on the powers of the states. It was natural, then, that the Jefferson school should look on every feature of the Hamilton program as "antirepublican." The disposition of the Jefferson school to claim for themselves a certain peculiar title to the position of "republicans" developed into the appearance of the first Republican, or the Democratic-Republican, party. about 1793.

Many of the Federalists were shrewd and active businessmen, who naturally took prompt advantage of the opportunities which the new system offered. The Republicans therefore believed and asserted that the whole Hamilton program was dictated by selfish or class interest; and they added this to the accusation of monarchical tendencies. These charges, with the fundamental differences of mental constitution, exasperated by the passion which differences as to the French Revolution seemed to carry with them everywhere, made the political history of this decade a very unpleasant record. The provision for establishing the national capital on the Potomac (1790) was declared to have been carried by a corrupt bargain; and accusations of corruption were renewed at every opportunity. In 1793 a French agent, Edmond Genet, appeared to claim the assistance of the United States for the French republic, and went to the length of commissioning privateers, and endeavouring to secure recruits. Washington decided to issue a proclamation of neutrality, the first act of its kind in American history. It was the first indication, also. of the policy which has made the course of every president, with the exception of Polk. a determined leaning to peace, even when the other branches of the government have been intent on war. Genet, however, continued his activities, and made outrageous demands upon the government, so that finally Washington demanded and secured (1794) his recall. The proclamation of 1793 brought about the first distinctly party feeling; and it was intensified by Washington's charge that popular opposition in western Pennsylvania (1794) to the new excise law (see WHISKY INSURRECTION, THE) had been fomented by the extreme French party. Their name, Democrat, was applied by the Federalists to the whole Republican party as a term of contempt, but it was not accepted by the party for about 20 years; then the compound title Democratic-Republican became, as it long remained, the official title of the party. There was no party opposition, however, to the re-election of Washington in 1792, or to the admission of Vermont (1791), Kentucky (1792) and Tennessee (1796) as new states.

Jay's Treaty. — The British government had accredited no minister to the United States, and it refused to make any commercial treaty or to give up the forts in the western territory of the United States, through which its agents still exercised a commanding influence over the Indians. In the course of its war with France, the neutral American vessels, without the protection of a national navy, fared badly. A treaty negotiated in

1794 by Chief Justice John Jay settled these difficulties for the following 12 years. But, as it engaged the United States against any intervention in the war on behalf of France, was silent on the subject of the right of search, and agreed to irksome limitations on the commercial privileges of the United States, the Republicans made it very unpopular, and the bitter personal attacks on Washington grew out of it. In spite of occasional Republican successes, the Federalists retained a general control of national affairs; they elected John Adams president in 1796, though Jetierson was chosen vice-president with him; and the national policy of the Federalists kept the country out of entangling alliances with any of the European belligerents. To the Republicans, and to the French republic, this last point of policy was only a practical intervention against France and against the rights of man.

At the end of Washington's administration the French Directory broke off relations with the United States, demanding the abrogation of Jay's treaty and a more pronounced sympathy nith France. Adams sent three envoys, Charles C. Pinckney, John Marshall and Elbridge Gerry, to endeavour to re-establish the former relations; they mere met by demands for "money, a great deal of money," as a prerequisite of peace. They refused; their letters home were published, and the Federalists at last had the opportunity of riding the whirlwind of an intense popular desire for war with France. Relations nith France were suspended by congress (1798); the treaties with France were declared at an end; American frigates were authorized to capture French vessels guilty of depredations on American commerce and the president was authorized to issue letters of marque and reprisal; and an American Army was formed, Washington being called from his retirement at Mount Vernon to command it. The war never went beyond a few sea fights. in which the little American navy did itself credit, and Napoleon, seizing power the next year, renewed the peace which should never have been broken.

The Alien and Sedition Laws. — The reaction in Great Britain against the indefinite "rights of man" had led parliament to pass an alien law, a sedition law suspending the writ of habeas corpus and an act giving wide and loosely defined powers to magistrates for the dispersion of meetings to petition for redress of grievances. The Federalists were in control of a congress of limited powers; but they were strongly tempted by sympathies and antipathies of every sort to form their program on the model furnished from England. The measures which they actually passed were based only on that construction of the constitution which is at the bottom of all American politics; they only tended to force the constitution into an antidemocratic direction. But it was the fixed belief of their opponents that they meant to go farther, and to secure control by some wholesale measure of political persecution.

Three alien laws were passed in June and July 1798. The first (repealed in April 1802) raised the number of years necessary for naturalization from 5 to 14. The third permitted the arrest or removal of subjects of any foreign power with which the United States should be at war. The second, which is usually known as the Alien law, was limited to a term of two years; it permitted the president to arrest or order out of the country any alien whom he should consider dangerous to the country. As many of the Republican editors and local leaders were aliens, this law really put a large part of the Republican organization in the power of the president. The Sedition law (to be in force until March 1801, and not rene ed) made it a crime, punishable by fine and imprisonment, to publish or print any false, scandalous and malicious writings against the government of the United States, either house of congress, or the president, or to stir up sedition or opposition to any lawful act of congress or of the president, or to aid the designs of any foreign power against the United States. In its first form the bill was even more sweeping than this and alarmed the opposition.

Most of the ability of the country was in the Federalist ranks; the Republicans had but two first-rate men — Jefferson and Madison. In the sudden issue thus forced between individual rights and national power, Jefferson and Madison could find but one bulwark for the individual — the power of the states; and their use of it gave their party a pronounced list to state sovereignty from nhich it did not recover for years. They objected to the Alien law on the grounds that aliens were under the jurisdiction of the state, not of the federal government; that the jurisdiction over them had not been transferred to the federal government by the constitution, and that the assumption of it by congress nas a violation of the constitution's reservation of powers to the states; and, further, because the constitution reserved to every "person." not to every citizen, the right to a jury trial. They objected to the Sedition law on the grounds that the constitution had specified exactly the four crimes for whose punishment congress was to provide; that criminal libel was not one of them; and that the 1st amendment forbade congress to pass any law restricting freedom of speech or of the press.

The Republican objections might have been made in court, on the first trial. But the Republican leaders had strong doubts of the impartiality of the federal judges. who were Federalists. They resolved to entrench the party in the state legislatures. The Virginia legislature in 1798 passed a series of resolutions prepared by Madison, and the Kentucky legislature in the same year passed a series prepared by Jefferson. Neglected or rejected by the other states, they were passed again by their legislatures in 1799. The leading idea expressed in both was that the constitution was a "compact" between the states, and that the powers (the states) which had made the compact had reserved the power to restrain the creature of the compact, the federal government, whenever it undertook to assume powers not granted to it. Madison's idea seems to have been that the restraint was to be imposed by a second convention of the states. Jefferson's idea is more doubtful; if it meant that the restraint should be imposed by any state which should feel aggrieved, his scheme was merely Calhoun's idea of nullification; but there are some indications that he agreed with Madison.

The first congress of Adams' term of office ended in 1799. Its successor, elected in the heat of the French war excitement, kept the Federalist policy up to its first pitch. Out of congress the execution of the objectionable laws had taken the shape of political persecution. Men were arrested, tried and punished for writings which the people had been accustomed to consider within legitimate political methods. The Republican leaders made every trial as public as possible, and gained votes constantly, so that the Federalists began to be shy of the very powers which they had sought. Every new election was a storm signal for the Federalist party; and the danger was increased by schism in their own ranks.

Election of 1800. — Hamilton was now a private citizen of New York; but he had the confidence of his party more largely than its nominal head, the president, and he maintained close and confidential relations with the cabinet which Adams had taken unchanged from Washington. The Hamilton faction saw no way of preserving and consolidating the newly acquired powers of the federal government but by keeping up and increasing the war feeling against France; Adams had the instinctive leaning of an American president toward peace. Amid cries of wrath and despair from his party he accepted the first overtures of the new Napoleonic government, sent envoys to negotiate a peace and ordered them to depart for France when they delayed. Then, discovering flat treachery in his cabinet, he dismissed it and blurted out a public expression of his feeling that Hamilton and his adherents were "a British faction." Hamilton retorted with a circular letter to his party friends, denouncing the president; the Republicans intercepted it and gave it a wider circulation than its author had intended. The result depended on the electoral vote of New York; and Aaron Burr, who had introduced the drill and machinery of a modern American political party there, had made the state Republican and secured a majority for the Republican candidates. These (Jefferson and Burr) received the same number of electoral votes (73) and the house of representatives (controlled by the Federalists) was thus called upon to decide which should be president. There was an effort by the Federalists to disappoint the Republicans by making Burr president; but Jefferson obtained that office, Burr becoming vice-president for four years. This disputed election. however. led to the adoption in 1804 of the 12th amendment to the constitution, which prescribed that each elector should vote separately for president and vice-president, and thus prevent another tie vote of this kind.

The "revolution of 1800" decided the future development of the United States. The new dominant party entered upon its career weighted with the theory of state sovereignty; and a civil war was necessary before this dogma. put to use again in the service of slavery. could be banished But the democratic development never was checked. As the Republicans obtained control of the states they altered the state constitutions so as to cut out all the arrangements that favoured property or class interests, and reduced political power to the dead level of manhood suffrage. In most of the states outside of New England this process was completed before 1815; but New England tenacity was proof against the advancing revolution until about 1820. For 20 years after its downfall of 1800 the Federalist party maintained its hopeless struggle, and then it faded away into nothing, leaving as its permanent memorial the excellent organization of the federal government, which its successful rival hardly changed. Its two successors — the Whig and the second Republican party — have also been broad constructionist parties, but they have admitted democracy as well.

The New Capital. — The disputed election of 1800 was decided in the new capital city of Washington, to which the government had just been moved, after having been for ten years at Philadelphia. Its streets and parks existed only on paper. The Capitol had been begun; the executive mansion was unfinished. and its audience room was used by Mrs. Adams as a drying room for clothes; the congressmen could hardly find lodgings. The inconveniences were only an exaggeration of the condition of other American cities. Their sanitary conditions were bad, and yellow fever and cholera from time to time reduced several of them almost to depopulation. More than once during this decade the fever visited Philadelphia and New York city, drove out most of the people and left grass growing in the streets. The communication between the cities was still wretched. The traveler was subject to every danger that bad roads, bad carriages, bad horses, bad inns and bad police protection could combine to inflict upon him.

The **West.**—About this time the term the west appears. It meant then the western part of New York, the new territory north of the Ohio, and Kentucky and Tennessee. In settling land boundaries New York had transferred (1786) to Massachusetts, whose claims crossed its territory, the right to (but not jurisdiction over) a large tract of land in central New York and to another large tract in the Erie basin. The sale of this land had carried population considerably west of the Hudson. Between 1790 and 1800 the population of Ohio had risen from almost nothing to 45,000, that of Tennessee from 36.000 to 106.000 and that of Kentucky from 74,000 to 221,000 — the last-named state now exceeding 6 of the "old 13" in population. The difficulties of the western emigrant, however, were still enormous. He obtained. land of his own, fertile land and plenty of it, but little else. The produce of the soil had to be consumed at home, or near it; ready money was scarce and distant products scarcer; and comforts, except the very rudest substitutes of home manufacture, were unobtainable. The number of post offices rose during these ten years from 75 to 903; the miles of post routes from 1,900 to 21.000 and the revenue from $38.000 to $231.000.

Cotton. — The power of congress to regulate patents was already bearing fruit. Until 1789 this power was in the hands of the states, and the privileges of the inventor were restricted to the territory of the patenting state. Now he had a vast and growing territory within which all the profits were his own. Twenty patents were issued in 1793. and 23,471, 100 years later. One of the inventions of 1793 was Eli Whitney's cotton gin.

When the constitution was adopted it was not known that the cultivation of cotton could be made profitable in the southern states. The roller gin could clean only six pounds a day by slave labour. In 1784 eight bags of cotton, landed in Liverpool from an American ship, had been seized on the ground that so much cotton could not be the produce of the United States. Eli Whitney invented the saw gin, by which the cotton was dragged through parallel wires with openings too narrow to allow the seeds to pass; and one slave could now clean 1,000 lb. a day. The exports of cotton leaped from 189,000 lb. in 1791 to 21,000,000 lb. in 1801, and doubled in three years more. The influence of this one invention, combined with a series of British inventions which had paved the way for it, can hardly be estimated in its commercial aspects. Its political influences were even wider, but more unhappy. The introduction of the commercial element into the slave system of the south robbed it at once of the patriarchal features which had made it tolerable; while it developed in slaveholders a new disposition to defend a system of slave labour as a "positive good."

Democracy and Nationality. — When Jefferson took office in 1801 his party, ignoring the natural forces which tied the states together even against their wills, insisted that the legal basis of the bond was in the power of any state to withdraw at will. This was no nationality; and foreign nations naturally refused to take the American national coin at any higher valuation than that at which it was current in its own country. The urgent necessity was for a reconciliation between democracy and nationality; and this was the work of this period. An underlying sense of all this has led Democratic leaders to call the war of 1812–15 the "Second War of Independence"; the result was independence of past ideas as the first had been of Great Britain.

Louisiana and Oregon. — The first force in the new direction was the acquisition oi Louisiana in 1803. Napoleon had acquired it from Spain, and, fearing an attack upon it by Great Britain, offered it to the United States for $15,000.000. The constitution gave the federal government no power to buy and hold territory, and the party was based on a strict construction of the constitution. Possession of power forced the strict-construction party to broaden its ideas, and Louisiana was bought, though Jefferson quieted his conscience by talking for a time of a futile proposal to amend the constitution so as to grant the necessary power. The acquisition of the western Mississippi basin more than doubled the area of the United States, and gave it control of all the great river systems of central North America. The difficulties of using these rivers were removed almost immediately by Robert Fulton's utilization of steam in navigation (1807). Within four years steamboats were at work on western waters; and thereafter the increase of steam navigation and that of population stimulated one another. The centre of population during this period advanced from about the middle of Maryland to its earlier extreme western limit; that is, the centre of population was in 1830 nearly at the place which had been the western limit of population in 1770. (See AMERICAN FRONTIER, THE.)

Jefferson also laid the basis for a further acquisition in the future by sending an expedition under Meriwether Lewis and William Clark to explore the territory north of the then Spanish territory of California and west of the Rocky mountains — the Oregon country as it was afterward called. The explorations of this party (1804–06), with Capt. Robert Gray's discovery of the Columbia river (1792), made the best part of the claims of the United States to the country 40 years later.

Election **of** 1804. — Jefferson was re-elected in 1804. His great success as president was the acquisition of Louisiana, which was a violation of his party principles; but all his minor successes were, like this, recognitions of the national sovereignty which he disliked so much. After a short and brilliant naval war the Barbary pirates were reduced to submission (1805). The long continued control of New Orleans by Spain, and the persistent intrigues of the Spanish authorities, looking toward a separation of the whole western country from the United States, had been ended by the acquisition of Louisiana. There still existed a dangerous ignorance of federal power and control, of which Aaron Burr took advantage (1806–07). Organizing an expedition in Kentucky and Tennessee, probably for the conquest of the Spanish colony of Mexico, he was arrested on the lower Mississippi and brought back to Virginia. He was acquitted; but the incident opened up a vaster view of the national authority than democracy had yet been able to take.

Jefferson and his party persistently refused to recognize the inherent power of the nation in international affairs. The Jay treaty expired in 1806 and American commerce was left to the course of events, Jefferson refusing to accept the only treaty which the British government was willing to make. All the difficulties which followed may be summed up in a few words: the British government was then the representative of the ancient system of restriction of commerce, and had a powerful navy to enforce its ideas; the American government was endeavouring to force into international recognition the system of neutral rights and unrestricted commerce, but its suspicious democracy refused to give it a navy sufficient to command respect.

Neutral Commerce.—Great Britain was now at war, from time to time, with almost every other nation of Europe. In time of peace European nations followed generally the old restrictive principle of allowing another nation. like the United States, no commercial access to their colonies; but, when they were at war with Great Britain, whose navy controlled the ocean. they were very willing to allow the neutral American merchantmen to carry away their surplus colonial produce. Great Britain had insisted for 50 years that the neutral nation, in such cases, was really intervening in the war as an ally of its enemy; but it had so far modified its claim as to admit that transshipment, or breaking bulk, in the United States was enough to qualify the commerce for recognition. The neutral nation thus gained a double freight, and grew rich in the traffic; the belligerent nations no longer had commerce afloat for British vessels to capture; and the "frauds of the neutral flags" became a standing subject of complaint among British merchants and naval officers. About 1805 British prize courts began to disregard transshipment and to condemn American vessels which made the voyage from a European colony to the mother country by way of the United States.

Impressment.— The question of expatriation, too, furnished a good many burning grievances. Great Britain maintained the old German rule of perpetual allegiance, modified by the right of emigration. The United States, founded by immigration, was anxious to establish the right of the subject to divest himself of allegiance by naturalization under a foreign jurisdiction. Four facts thus tended to break off friendly relations: (1) Great Britain's claim to allegiance over American naturalized subjects; (2) its claim to the belligerent right of search of neutral vessels; (3) its claim of right to impress for its vessels of war its subjects who were seamen wherever found; and (4) the difficulty of distinguishing native-born American from British subjects, even if the right to impress naturalized American subjects were granted. British naval officers even undertook to consider all who spoke the English language as British subjects, unless they could produce proof that they were native-born Americans. The American sailor uho lost his papers was thus open to impressment. A particularly flagrant case of seizure of Americans occurred in 1807. On June 27 the British ship "Leopard" fired upon the American frigate "Chesapeake," which, after having lost 3 men killed and 18 wounded, hauled down its flag; the British commander then seized four of the "Chesapeake's" crew. This action aroused intense anger throughout the country, and but for the impotence of the government would undoubtedly have led to immediate war. The American government in 1810 published the cases of such impressments since 1803 as numbering over 4,000, about one-third of the cases resulting in the discharge of the impressed man.

In May 1806, the British government, by orders in council, declared a blockade of the whole continent of Europe from Brest to the Elbe, about 800 mi. In November, after the battle of Jena, Napoleon answered by the "Berlin decree," in which he assumed to blockade the British Isles. thus beginning his "continental system." A year later the British government answered by further orders in council, forbidding American trade with any country from which the British flag was excluded, allowing direct trade from the United States to Sweden only, in American products. and permitting American trade with other parts of Europe only on condition of touching in England and paying duties. Napoleon retorted with the "Milan decree," declaring good prize any vessel which should submit to search by a British ship; but this was evidently a vain fulmination.

The Navy.—The Democratic party of the United States was almost exclusively agricultural and had little sympathy with commercial interests; it was pledged to the reduction of national expenses and the debt, and did not wish to take up the responsibility for a navy; and, as the section of country most affected by the orders in council. New England, was Federalist, a tinge of political feeling could not but colour the decisions of the dominant party Various ridiculous proposals were considered as substitutes for a necessarily naval war; and perhaps the most ridiculous was adopted. Since the use of nonintercourse agreements as revolutionary weapons against Great Britain, an overweening confidence in such measures had sprung up, and one of them was now resorted to—the embargo of Dec. 22, 1807. forbidding foreign commerce altogether. It was expected to starve Great Britain into a change of policy; and its effects may be seen by comparing the $20,000.000 exports of 1790, $49,000,000 of 1807 and $9,000,000 of 1808. It does not seem to have struck those who passed the measure that the agricultural districts also might find the change unpleasant; but that was the result. and their complaints reinforced those of New England. The pressure had been slightly relieved by the substitution of the Non-Intercourse law of March 1, 1809; it prohibited commercial intercourse with Great Britain and France and their dependencies. leaving other foreign commerce open, prohibited the importation from any quarter of British and French goods, and forbade the entrance of British or French vessels, public or private, into any port of the United States. Madison, Jefferson's secretary of state, who succeeded Jefferson in 1809, assumed in the presidency a burden which was not enviable. New England was in a ferment, and was suspected of designs to resist the restrictive system by force; and the administration did not face the future with confidence.

The **War of 1812.**—The Non-Intercourse law was to be in force only "until the end of the next session of Congress" and was to be abandoned as to either belligerent which should abandon its attacks on neutral commerce, and maintained against the other. In 1810 the American government was led to believe that France had abandoned its system. Napoleon continued to enforce it in fact; but his official fiction served its purpose of limiting the nonintercourse for the future to Great Britain, and thus straining relations between that country and the United States still further. The elections of 1811–12 resulted everywhere in the defeat of "submission men" and in the choice of ne members who were determined to resort to war against Great Britain. Henry Clay, John C. Calhoun, William H. Crawford and other new men seized the lead in the two houses of congress, and forced Madison. it is said, to agree to a declaration of war as a condition of his renomination in 1812. Madison sent to congress a confidential "war message" on June 1 and on the 18th war was declared. The national democracy meant to attack Great Britain in Canada. partly to gratify its western constituency, who had been harassed by Indian attacks, asserted to have been instigated from Canada. Premonitions of success were drawn from the battle of Tippecanoe, in which William Henry Harrison had defeated in 1811 the northwestern league of Indians formed by Tecumseh. Between the solidly settled Atlantic states and the Canadian frontier was a wide stretch of unsettled or thinly settled country, which was itself a formidable obstacle to war. Ohio had been admitted as a state in 1802, and Louisiana was admitted in 1812; but their admission had been because of the desire to grant them self-government rather than to their full development in population and resources. Cincinnati was a little settlement of 2,500 inhabitants; the fringe of settled country ran not very far north of it; all beyond was a wilderness. The case was much the same with western New York. It would have been far less costly, as events proved. to have entered at once upon a naval war; but the crusade against Canada had been proclaimed all through Kentucky and the west, and their people were determined to wipe out their old scores before the conclusion of the war. (For the military and naval events of the war see WAR OF 1812.)

The home dislike of the war had increased steadily with the evidence of incompetent management by the administration. The

Federalists, who had always desired a navy, pointed to the naval successes as the best proof of folly with which the war had been undertaken. New England Federalists complained that the federal government utterly neglected the defense of their coast. and that southern influence was far too strong in national affairs. They showed at every opportunity a disposition to adopt the furthest stretch of state sovereignty, as stated in the Kentucky resolutions; and every such development urged the national democracy unconsciously further on the road to nationality. When the New England states sent delegates to meet at Hartford, Conn.. and consider their grievances and the best remedies, treason was suspected, and a readiness to suppress it by force was plainly shown. The recommendations of the convention came to nothing; but the attitude of the dominant party toward it is one of the symptoms of the manner in which the trials of actual war were steadily reconciling democracy and nationality. The object which Hamilton had sought by high tariffs and the development of national classes had been attained by more natural and healthy means.

In April 1814 the first abdication of Napoleon took place, and Great Britain was able to give more attention to its American antagonist. The main attack mas to be made on Louisiana, the weakest and most distant portion of the union. A fleet and army were sent there, but the British assault was completely repulsed (Jan. 8, 1815) by the Americans under Andrew Jackson. Peace had been made at Ghent 15 days before the battle was fought. but the news of the battle and the peace reached Washington almost together.

The United States secured a fairly good treaty. It is true that it said not a word about the questions of impressment, search and neutral rights, the grounds of the war; Great Britain did not abandon its position on any of them. But everybody knew that circumstances had changed. The new naval power whose frigates alone in the past 20 years had shown their ability to fight English frigates on equal terms was not likely to be troubled in future with the question of impressment; and in fact, while not renouncing the right, the British government no longer attempted to enforce it.

Postwar Political and Economic Trends.—The remainder of this period is one of the barrenest in American history. The opposition of the Federalist party to the war completed the measure of its unpopularity. and it had only a perfunctory existence for a few years longer. Scandal, intrigue and personal criticism became the most marked characteristics of American politics until the dominant party broke at the end of the period, and real party conflict was renewed. But the seeds of the final disruption are visible from the peace of 1814. The old-fashioned Republicans looked with intense suspicion on the new form of Republicanism generated by the war, a type which instinctively bent its energies toward the further development of national power. Clay was the natural leader of the new Democracy; but John Quincy Adams and others of Federalist antecedents or leanings took to the new doctrines kindly; and even Calhoun, Crawford and others of the southern interest were at first strongly inclined to support them. One of the first effects was the revival of protection and of a national bank.

The charter of the national bank had expired in 1811, and the dominant party had refused to recharter it. The attempt to carry on the war by loans resulted in almost a bankruptcy and in a complete inability to act efficiently. As soon as peace gave time for consideration, a second bank mas chartered (April 10, 1816) for 20 years with a capital of $35,000,000, one-fifth of mhich was to be subscribed for by the national government. It was to have the custody of the government revenues, but the secretary of the treasury could divert the revenues to other custodians, giving his reasons for such action to congress.

Protection was advocated again on national grounds. but not quite on those which had moved Hamilton. The additional receipts were now to be expended for fortifications and other national defenses, and for national roads and canals. The war and blockade had been an active form of protection, under which American manufactures had sprung up. As soon as peace was made English manufacturers drove their American rivals out of business or reduced them to desperate straits. Their cries for relief had a double effect. They gave the spur to the nationalizing advocates of protection, and, as most of the manufacturers were in New England or New York, they developed in the citadel of Federalism a class nhich looked for help to a Republican congress. This was the main force nhich brought New England into the Republican fold before 1825 An increase in the number of spindles from 80.000 in 1811 to 500.000 in 1815. and in cotton consumption from 500 bales in 1800 to 90 000 in 1815. the rise of manufacturing towns, and the rapid development of the mechanical tendencies of a people nho had been hitherto almost exclusively agricultural were influences which were to be reckoned with in the politics of a democratic country.

The tariff of 1816 imposed a duty of about 25% on imports of cotton and woolen goods, and specific duties on iron imports except pig iron. on which there nas an ad valorem duty of 20%. In 1818 this duty also was made specific (50 cents a hundredweight). The ad valorem duties carried most of the manufacturers through the financial crisis of 1818–19, but the iron duties nere less satisfactory. In English manufacture the substitution of coke for charcoal in iron production led to continual decrease in price. 4s the price went down the specific duties were continually increasing the absolute amount of protection. Thus spared the necessity for improvements in production, the American manufacturers felt English competition more keenly as the years went by, and called for more protection.

James Monroe succeeded Madison as president in 1817, and, re-elected nith hardly any opposition in 1820. he served until 1825 So complete was the supremacy of the Republican party that this is often called the era of good feeling It came to an end when a successor to Monroe was to be elected; the two sections of the dominant party then had their first opportunity for open struggle. During Monroe's two terms of office the nationalizing party developed the policy on which it proposed to manage national affairs This was largely the product of the continually swelling western movement of population The influence of the steamboat was felt more and more every year, and the nant of a similar improvement in land transport was correspondingly evident The attention drann to western New York by the war had filled that part of the state with a new population The southern Indians had been completely overthrown by Andrew Jackson during the War of 1812. and forced to cede their lands The admission of the new states of Indiana (1816), Mississippi (1817) Illinois (1818), Alabama (1819) Maine (1820) and Missouri (1821)—all but Maine the product and evidence of western growth—were the immediate results of the development consequent upon the war. All the territory east of the Mississippi, except the northern part of the North-west Territory. was now formed into self-governing states: the state system had crossed the Mississippi; all that was needed for further development was the locomotive engine. The 4,000,000 inhabitants of 1790 had gronn to nearly 13 000.000 in 1830

The "American System."—The urgent demand of western settlers for some road to a market led to a variety of schemes to facilitate dealings between the east and the west—the most successful being that completed in New York in 1525. the Erie canal The Hudson river forms the great natural breach in the barrier range which runs parallel to the Atlantic coast. When the traveler has passed up the Hudson through that range he sees before him a vast flat, open country extending westward to the Great Lakes, and perfectly adapted by nature for a canal Such a canal. to turn western traffic into the lake rivers and through the lakes. the canal and the Hudson to New York city. was begun by the state through the influence of De Witt Clinton It nas derisively called Clinton's big ditch until its completion laid the foundations for the great commercial prosperity of New York state and city Long before it was finished the evident certainty of its success had enticed other states into far less successful enterprises of the kind and had established as a nationalizing policy the combination of high tariffs and expenditures for internal improvements which was long known as the "American system"

The tariffs or duties on imports were to be carried as high as revenue results would justify; the superabundant revenues were to be expended on enterprises which mould tend to aid the people to subdue the continent. Protection was now to be for national benefit, not for the benefit of classes. Western farmers were to have manufacturing towns at their doors, as markets for the surplus which had hitherto been rotting on their farms; competition among manufacturers was to keep down prices; and Henry Clay's eloquence was to commend the whole policy to the people. The old democracy, particularly in the south. insisted that the whole scheme really had its basis in benefits to classes, that its communistic features mere not such as the constitution meant to cover by its grant of power to congress to levy taxation for the general welfare. The dissatisfaction in the south rose higher when the tariffs were increased in 1824 and 1828. The proportion of customs revenue to dutiable imports rose to 37% in 1825 and to 44% in 1829; and the ratio to aggregate imports to 33% in 1825 and 37% in 1829.

The Monroe Doctrine.—In international relations the action of the government was strong, quiet and self-respecting. Its first weighty action took place in 1823 It had become pretty evident that the Holy alliance meant to aid Spain in bringing its rebellious South American colonies to obedience. Great Britain had been drifting steadily away from the alliance, and George Canning. the new secretary, determined to call in the weight of the transatlantic power as a check upon it. A hint to the American minister was followed by a few pregnant passages in Monroe's annual message in December. "We could not view," he said, "any interposition for the purpose of oppressing them [the South American states]. or controlling in any other manner their destiny by any European power, in any other light than as the manifestation of an unfriendly disposition towards the United States." If both the United States and Great Britain were to take this ground the fate of a fleet sent by the alliance across the Atlantic was not in much doubt, and the project was at once given up.

It was supposed at the time that Spain might transfer its colonial claims to some stronger power; and Monroe therefore said that "the American continents, by the free and independent condition which they have assumed and maintained, are henceforth not to be considered as subjects for future colonization by any European powers." This declaration and that quoted above constitute together the Monroe Doctrine as originally proclaimed. The doctrine has remained the rule of foreign policy for all American parties. (See MONROE DOCTRINE. THE.)

By a treaty with Russia (1825) that power gave up all claims on the Pacific coast south of the present limits of Alaska. The northern boundary of the United States had been defined by the treaty of 1783; and, after the acquisition of Louisiana, a convention with Great Britain (1818) settled the boundary on the line of latitude 49° N. as far west as the Rocky mountains. West of these mountains the so-called Oregon country, on whose limits the two powers could not agree, was to be held in common possession for ten years. This common possession was prolonged by another convention (1827) indefinitely, with the privilege to either power to terminate it, on giving 12 months' notice. This arrangement lasted until 1846.

Elections of 1824 and 1828.—Monroe's term of office came to an end in March 1825. He had originally been an extreme Democrat, who could hardly speak of Washington with patience; he had slowly modified his views, and his tendencies were now eagerly claimed by the few remaining Federalists as identical with their own. All the candidates for the presidency in 1824—Andrew Jackson, a private citizen of Tennessee; William H. Crawford, Monroe's secretary of the treasury; John Quincy Adams, his secretary of state; and Henry Clay, the speaker of the house of representatives—claimed to be Republicans alike; but the personal nature of the struggle was shown by the tendency of their supporters to call themselves "Adams men" or "Jackson men," rather than by any real party title. Calhoun was supported by all groups for the vice-presidency, and was elected without difficulty. The choice of a president was more doubtful.

None of the four candidates had anything like a party organization behind him. Adams and Clay represented the nationalizing element. as Crawford and Jackson did not; but there the likeness among them stopped. The strongest forces behind Adams were the new manufacturing and commercial interests of the east; behind Clay were the desires of the west for internal improvements: and the two elements were soon to be united into the National Republican or Whig party. Crawford was the representative of the old Democratic party, with all its southern influences and leanings. Jackson was the personification of the new democracy—not very cultured, perhaps, but honest, and hating every shade of class control instinctively. As he became better known the whole force of the new drift of things turned in his direction. Crawford was taken out of the race, just after the electors had cast their votes. because of ill-health, and Adams. later, by the revival of ancient quarrels uith the Federalists of New England; and the future was to be with Clay or with Jackson. But in 1824 the electors gave no one a majority; and the house of representatives, voting by states, gave the presidency to Adams.

Adams' election in 1825 was attributed to the fact that Clay's friends in the house—unable to vote for him, as he mas the lowest in the electoral vote, and only three names were open to choice in the house—very naturally gave their votes to Adams. As Adams appointed Clay to the leading position in his cabinet. the defeated party at once raised the cry of "bargain and intrigue." one of the most effective in a democracy, and it was kept up throughout Adams' four years of office. Jackson had received the largest number of electoral votes, though not a majority and the hazy notion that he had been injured because of his devotion to the people increased his popularity. Though demagogues made use of it for selfish purposes, this feeling was an honest one, and Adams had nothing to oppose to it. He tried vigorously to uphold the American system, and succeeded in passing the tariff of 1828; he tried to maintain the influence of the United States on both the American continents; but he remained as unpopular as his rival grew popular. In 1828 Adams was easily displaced by Jackson. the electoral vote being 178 to 83. Calhoun was reelected vice-president.

Jackson's inauguration in 1829 closes this period, as it ends the time during which a disruption of the union by the peaceable withdrawal of any state was even possible. The party which had made state sovereignty its bulwark in 1798 was non in control of the government again; but Jackson's proclamation in his first term, in which he warned South Carolina that "disunion by armed force is treason," and that blood must flow if the laws were resisted, speaks a very different tone from the speculations of Jefferson on possible future divisions of the United States. Even the sudden attempt of South Carolina to exercise independent action shows that some interest dependent upon state sovereignty had taken alarm at the drift of events. and was anxious to lodge a claim to the right before it should slip from its fingers forever.

Slavery and the Westward **Movement.**—When the vast territory of Louisiana was acquired in 1803 the new owner found slavery already established there. Congress tacitly ratified existing law by taking no action; slavery continued legal, and spread further through the territory: and the state of Louisiana entered as a slave state in 1812. The next state to be carved out of the territory was Missouri, admitted in 1821. A territory. on applying for admission as a state, brings a constitution for inspection by congress; and when it was found that the new state of Missouri proposed to recognize and continue slavery, a vigorous opposition spread through the north and west, and carried most of the senators and representatives from those sections with it. In the house of representatives these two sections had a greatly superior number of members; but. as the number of northern and southern states had been kept about equal. the compact southern vote, with one or two northern allies, generally retained control of the senate. Admitted by the senate and rejected by the house, Missouri's application hung suspended for two years until it was successful by the admission of Maine, a balancing northern state, and by the following arrangement, known as the Missouri Compromise of 1820: Missouri mas to enter as a slave state; slavery was forever prohibited throughout the rest of the Louisiana

Purchase north of latitude 36° 36'. the main southern boundary of Missouri; and, though nothing was said of the territory south of the compromise line, it was understood that any state formed out of it was to be a slave state, if it so wished. Arkansas entered under this provision in 1836.

The question of slavery was thus set at rest for the present, though a few agitators were roused to more zealous opposition to the essence of slavery itself. In the next decade these agitators succeeded only in the conversion of a few recruits, but these recruits were the ones who took up the work at the opening of the next period. It is plain now, however, that north and south had already drifted so far apart as to form two sections, and it became evident during the next 40 years that the wants and desires of these two sections were so divergent that it was impossible for one government to make satisfactory laws for both.

The vast flood of settlers which had been pouring westward for years had now pretty well occupied the territory east of the Mississippi, while, on the west side of that stream, it still showed a disposition to hold to the river valleys. The settled area had increased from 240,000 sq.mi. in 1790 to 633,000 sq.mi. in 1830, with an average of 20.3 persons to the square mile. There was still a great deal of Indian territory in the southern states of Georgia, Alabama, Mississippi and Florida, for the southern Indians were among the finest of their race; they had become semicivilized, and were formidable antagonists to the encroaching settlers. The states interested had begun preparations for their forcible removal, in public defiance of the attempts of the federal government to protect the Indians (1827); but the removal was not completed until 1835. In the north, Wisconsin and Michigan, with the northern halves of Illinois and Indiana, were still very thinly settled, but everything indicated an early increase of population. The first lake steamboat, the "Walk-in-the-Water," had appeared at Detroit in 1818, and the opening of the Erie canal in 1825 added more vessels.

The land system of the United States had much to do with the early development of the west. From the first settlement, the universally recognized rule had been that of absolute individual property in land, with its corollary of unrestricted competitive or "rack" rents; and this rule was accepted fully in the national land system. The public lands were to be divided into hundreds each 10 miles square and containing 100 mile-square plots The hundred was called a township. and was afterward reduced to 6 miles square, of 36 mile-square plots of 640 ac. each. From time to time principal meridians and east and west base lines have been run, and townships have been determined by their relations to these lines. The price fixed in 1790 as a minimum was $2 per acre; in 1820 it was reduced to $1.25 per acre; it has tended to decrease, and no effort has ever been made to gain a revenue from it. When the nation acquired its western territory it secured its title to the soil, and always made it a fundamental condition of the admission of a nen state that it should not tax United States lands. To compensate the new states for the freedom of unsold public lands from taxation, one township in each 36 was reserved to them for educational purposes; and the excellent public-school systems of the western states have been founded on this provision. The cost of obtaining a quarter section (160 ac.), under the still later homestead system of granting lands to actual settlers, came to be only about $26 to cover fees for filing claim and granting title; the interest on this, at 6%, represents an annual rent of 1 cent per acre—making this. says F. A. Walker, as nearly as possible the "no-rent land" of the economists

The bulk of the early westward migration was of home production; the great immigration from Europe did not begin until about 1847. The west as well as the east thus had its institutions fixed before being called upon to absorb an enormous foreign element

Industrial Development and Sectional Divergence, 1829–50.—The years 1829–37 have been called the reign of Andrew Jackson; his popularity, long struggle for the presidency and his feeling of his official ownership of the subordinate offices gave to his administration at least an appearance of Caesarism. But it was a strictly constitutional Caesarism; the restraints of written law were never violated, though the methods adopted within the law were new to national politics. From about 1800 state politics in New York and Pennsylvania had been noted for the systematic political use of the offices. The presence of New York and Pennsylvania politicians in Jackson's cabinet taught him to use the same system. Removals, except for cause, had been relatively rare before; but under Jackson men were removed almost exclusively for party purposes and a clean sweep was made in the civil service. Other parties adopted the system, and it remained the rule at a change of administration until near the end of the century.

Parties.—The system brought with it a semimilitary reorganization of parties. Hitherto nominations for the more important offices had been made mainly by legislative caucuses; candidates for president and vice-president were nominated by caucuses of congressmen, and candidates for the higher state offices by caucuses of the state legislatures. Late in the preceding period conventions of delegates from the members of the party in the state were held in New York and Pennsylvania; and in 1831–32 this became the rule for presidential nominations. It rapidly developed into systematic state, county and city conventions; and the result was the appearance of that complete political machinery, the American political party. The Democratic machinery was the first to appear, in Jackson's second term (1833–37). Its workers were paid in offices, or hopes of office, so that it was said to he built on the "cohesive power of public plunder"; but its success was immediate and brilliant. The opposing party, the Whig party, had no chance of victory in 1836; and its complete overthrow drove its leaders into the organization of a similar machinery of their own, which scored its first success in 1840.

Bank of the U.S.—The Bank of the United States had hardly been heard of in politics until the new Democratic organization came into hostile contact with it. A semiofficial demand upon it for a political appointment was met by a refusal; and the party managers called Jackson's attention to an institution which he could not but dislike the more he considered it. His first message spoke of it in unfriendly terms, and every succeeding message brought a more open attack. The old party of Adams and Clay had by this time taken the name of Whigs, probably from the notion that they were struggling against the reign of Andrew Jackson, and they adopted the cause of the bank with eagerness. The bank charter did not expire until 1836, but in 1832 Clay brought up a bill for a new charter. It was passed and vetoed; and the Whigs made the veto an important issue of the presidential election of that year. They were beaten; Jackson was re-elected, receiving 219 electoral votes, and Clay, his Whig opponent, only 49, and the bank party could never again get a majority in the house of representatives. But the president could not obtain a majority in the senate. He determined to take a step which would give him an initiative, and which his opponents could not induce both houses to unite in overriding or punishing. Taking advantage of the provision that the secretary of the treasury might order the public funds to be deposited elsewhere than in the bank or its branches, he directed the secretary to deposit all the public funds elsewhere. Thus deprived of its great source of dividends, the bank fell into difficulties, became a state bank after 1836 and then went into bankruptcy.

All the political conflicts of Jackson's terms of office were close and bitter. Loose in his ideas before 1829, Jackson showed a steady tendency to adopt the strictest construction of the powers of the federal government, except in such official perquisites as the offices. He grew into strong opposition to all traces of the American system, and vetoed bills for internal improvements unsparingly; his feeling of dislike to all forms of protection is as evident, though he took more care not to make it too public.

Nullification. Calhoun and **Jackson.**—Calhoun and Jackson were of the same stock—Scotch-Irish—much alike in appearance and characteristics, Calhoun representing the trained and educated logic of the race, Jackson its instincts and passions. Jackson was led to break off his friendly relations with Calhoun in 1830. and he had been led to do so more easily because of the appearance of the doctrine of nullification which was generally attributed, correctly enough, to Calhoun. Asserting, as the Republican party of 1798 had done, the sovereign powers of each state, Calhoun held that. as a means of avoiding secession and violent struggle upon every occasion of the passage of an act of congress which should seem unconstitutional to any state, the state might properly suspend or "nullify" the operation of the law within its jurisdiction. The passage of the tariff act of 1832, which organized and systematized the protective system, forced his party into action. A state convention in South Carolina on Nov. 24, 1832, declared the tariff act null, and made ready to enforce the declaration.

But the time was past when the power of a single state could withdraw it from the union. The president issued a proclamation. warning the people of South Carolina against any attempt to carry out the ordinance of nullification; he ordered a naval force to take possession of Charleston harbour to collect the duties under the act; he called upon congress for additional executive powers, and congress passed what nullifiers called the "bloody bill," putting the land and naval forces at the disposal of the president: and he is said to have announced, privately and profanely, his intention of making Calhoun the first victim of any open conflict. Affairs looked so threatening that an unofficial meeting of "leading nullifiers" agreed to suspend the operation of the ordinance until congress should adjourn: whence it derived the right to suspend has never been stated.

Tariff of 1833.—The president had already asked congress to reduce the duties; and many Democratic members of congress, who had yielded to the popular clamour for protection, were very glad to use the crisis as an excuse for now voting against it. A compromise tariff act, scaling down all duties over 20% by one-tenth of the excess every two years until 1842. when the remaining excess over 20% should be dropped, was introduced by Clay and became law. Calhoun and his followers claimed this as all that the nullification ordinance had aimed at; and the ordinance was formally repealed. But nullification had received its deathblow, even those southern leaders who maintained the right of secession refused to recognize the right of a state to remain in the union while nullifying its laws.

Railways.—All the internal conditions of the United States were completely altered by the introduction of railways. For 20 years past the Americans had been pushing in every direction which offered a hope of the means of reconciling vast territory with enormous population. George Stephenson's invention of the locomotive came just in time, and Jackson's two terms of office marked the outburst of modern American life. The miles of railway were 23 in 1830, 1,098 in 1835, about 2.800 in 1840, and thereafter they about doubled every five years until 1860.

A railway map of 1840 shows a fragmentary system, designed mainly to fill the gaps left by the means of communication in use in 1830. One or two short lines run back into the country from Savannah and Charleston; another runs north along the coast from Wilmington to Baltimore; several lines connect New York city with Washington and other points; and short lines elsewhere mark the openings which needed to be filled at once—a number in Nen England and the middle states, three in Ohio and Michigan and three in Louisiana. Year after year new inventions were made to increase and aid this development. The anthracite coal of the middle states was now successfully applied to railways (1836), and to the manufacture of iron (1837). Steam navigation across the Atlantic was established in 1838. The telegraph came next, Samuel F. B. Morse's line being erected in 1844. No similar period in American history of the 19th century is so extraordinary for material development as the decade 1830–40. At its beginning the country was an overgrown type of colonial life; at its end American life had been shifted to entirely new lines, which it has since followed.

The steamboat had aided western development, but the railway aided it far more. The steamboat influenced the railway, and the railway gave the steamboat new powers. Vacant places in the states east of the Mississippi were filling up; the long lines of emigrant wagons gave way to the new and better methods of transport. Chicago was but a frontier fort in 1832; within six years it was a flourishing town, with eight steamers connecting it with Buffalo, N.Y., and dawning ideas of its future development of railway connections. Two new states, Arkansas and Michigan, were admitted (1836 and 1837). The population of Ohio grew from 938,000 to 1,519,000, that of Michigan from 32.000 to 212,000, and that of the country from 12,866,000 to 17,069.000, betneen 1830 and 1840.

Social Conditions.—With the change of material surroundings and possibilities came a steady amelioration of social conditions and a development of social ideals. Such features of the past as imprisonment for debt and the cruel indifference of old methods of dealing with crime began to disappear; the time was past when a state could use an abandoned copper mine as its state prison, as Connecticut had formerly done The domestic use of gas and anthracite coal. the introduction of expensive aqueducts for pure water and the changing life of the people forced changes in the interior and exterior of American dwellings. Wood was still the common building material; imitations of Greek architecture still retained their vogue; but the interiors were models of comfort in comparison with the houses even of 1810. In the "new" regions this was not yet the case. and there social restraints were still so few that society seemed to be reduced almost to its primitive elements. Western steamers reeked with gambling, snindling, dueling and every variety of vice. Public law was almost suspended in some regions; and organized associations of counterfeiters and horse thieves terrorized whole sections of the country. But this state of affairs was altogether temporary, as well as limited in its area; the older and more densely settled states had been well prepared for the change and had never lost command of the social forces. and the process of settling down went on, even in the newer states, with far more rapidity than could have been expected

Literature.—A distinct American literature dates from this period. Most of the publications in the United States nere still cheap reprints of foreign works; but native productions no longer followed foreign models nith servility. Between 1830 and 1840 Whittier, Longfellow, Holmes, Poe, Hanthorne, Emerson, Bancroft and Prescott joined the advance guard of American writers—Bryant. Dana. Halleck. Drake, Irving and Cooper; and even those ariters who had already made their place in literature showed the influence of new conditions by their growing tendency to look less to foreign models and methods. Popular education was improved. The new states had from the first endeavoured to secure the best possible system of common schools. The attempt came naturally from the political instincts of the class from which the migration came; but the system which resulted was to be of incalculable service during the years to come. Their absolute democracy and their universal use of the English language made the common schools most successful machines for converting the raw material of immigration into American citizens. This supreme benefit is the basis of the system and the reason for its existence and development, but its incidental advantage of educating the people has been beyond calculation. It mas an odd symptom of the general change that American newspapers took a new form during these ten years. The old blanket sheet nenspaper, cumbrous to handle and slow in all its ways, met its first rival in the type of newspaper which appeared first as the *New York Sun*, the *New York Herald* and the *New York Tribune* (1833, 1835 and 1841). Swift and energetic in gathering news. and fearless, sometimes reckless, in stating it, they brought into American life, with very much that is evil, a great preponderance of good.

Speculation.—The chaos into which a part of American society had been thronn had a marked effect on the financial institutions of the country which went to pieces before it for a time It had not been meant to make the public lands of the United States a source of revenue so much as a source of development. The sales had touched their high-water mark during the speculative year 1819, when receipts from them had amounted to $3,274,000; in other years they seldom went above $2,000,000. When the railway set the stream of migration moving faster than ever, and cities began to grow like mushrooms, it was natural that speculation in land should feel the effects. Sales rose to $3,200,000 in 1831. and to $25,000,000 in 1836. In 1835 the president announced to congress that the public debt was extinguished, and that some way of dealing with the surplus should be found. Calhoun's proposal, that after the year *1836* any surplus in excess of $5,000,000 should be divided among the states as a loan. was adopted. as regards the surplus (almost $37,000,000) of that year; and about *$28.000.000* was actually distributed before the crisis of *1837* put an end to the surplus and to the policy. The states had already taken a hand in the general speculation by beginning works of public improvement. Foreign, particularly English, capital was abundant; and states which had been accustomed to think a dozen times over a tax of *$100.000* now began to negotiate loans of millions of dollars and to appropriate the proceeds to the digging of canals and the construction of railways. Their enterprises were badly conceived and badly managed. The imaginations of individuals ran riot. Everyone wanted to buy; prices rose and everyone was growing richer on paper. The assessed value of real estate in New York city in *1832* was $104,000,000; in *1836* it had grown to *$253.000.000.* In Mobile the assessed value rose from *$1.000.000* to *$27.000.000.*

When Jackson in *1833* ordered the government revenues to be deposited elsewhere than in the Bank of the United States, there was no government agent to receive them. The secretary of the treasury selected banks at various points in which the revenue should be deposited by the collecting officers; but these banks were organized under charters from their states. The Democratic feeling was that the privilege of forming banking corporations should be open to all citizens, and it soon became so. Moreover. it was not until after the crash that New York began the system of compelling such deposits as would really secure circulation. In most of the states banks could be freely organized with or without tangible capital. and their notes could be sent to the west for the purchase of government lands, which needed to be held but a month or tno to gain a handsome profit. "Wildcat banks" sprang up all over the country; and the "pet banks," as those chosen for the deposit of government revenues were called, nent into speculation as eagerly as the banks which hardly pretended to have capital.

Panic of 1837.—The Democratic theory denied the power of congress to make anything but gold or silver coin legal tender. There have been "paper-money heresies" in the party; but there was none such among the new school of Democratic leaders which came in in *1829;* they were "hard-money men." In July *1836* Jackson's secretary of the treasury ordered land agents to take nothing in payment for lands except gold or silver. In the following spring the full effects of the order became evident; they fell on the administration of Martin Van Buren, Jackson's successor. Van Buren had been Jackson's secretary of state, the representative man of the new Democratic school, and it seemed to the Whigs poetic justice that he should bear the neight of his predecessor's errors. The "specie circular" turned the tide of paper back to the east, and when it was presented for payment most of the banks suspended specie payment. There was no longer a thought of buying; everyone wanted to sell; and prices ran down with a rapidity even more startling than that with which they had risen. Failures on a scale unprecedented in the United States made up the panic of *1837.* Many of the states had left their bonds in the hands of their agents, and. on the failure of the agents, found that the bonds had been hypothecated or disposed of, so that the states got no return from them except a debt nhich was to them enormous. Saddled suddenly nith such a burden, and unable even to pay interest, some of the states repudiated their obligations; and repudiation was made successful by the fact that a state could not be sued except by its own consent. Even the U.S. government felt the strain, for its revenues were locked up in suspended banks. A little more than a year after congress had authorized the distribution of its surplus revenues among the states, Van Buren was forced to call congress into special session to provide some relief for the government itself.

The Subtreasury.— Van Buren held manfully to the strictest construction of the powers of the federal government. He insisted that the panic would best right itself nithout government interference, and, after a four years' struggle, he succeeded in making the "subtreasury scheme" law *(1840).* It cut off all connection of the government with banks, putting collecting and disbursing officers under bonds to hold money safely and to transfer it under orders from the treasury, and restricting payments to or by the United States to gold and silver coin. Its passage had been preceded by another commercial crisis (1839), more limited in its field. but more discouraging to the people.

Election of 1840.—Van Buren's firmness was unpopular. and the Whig party now adopted methods which were popular if somewhat demagogical. It nominated William Henry Harrison in *1840;* it contrasted his homely frontier virtues with Van Buren's "ostentatious indifference to the misfortunes of the people" and after the first of the modern campaigns of mass meetings and processions Harrison was elected, receiving *234* electoral votes and Van Buren only *60.* Harrison died only a month after his inauguration, and the vice-president. John Tyler, became president.

Tyler was of the extreme Calhoun school, which had shown some disposition to grant to Van Buren a support which it had refused to Jackson; and the Whigs had nominated Tyler to retain his faction with them Now he was the nominal leader of the party, while his politics were opposite to theirs, and the real leader of the party, Clay, was ready to force a quarrel upon him. The quarrel took place; the Whig majority in congress was not large enough to pass any measures over Tyler's veto; and the first two years of his administration were passed in barren conflict with his party. The subtreasury law was repealed *(1841)*; the tariff of *1842* introduced a modified protection; and there the Whigs were forced to stop. Their dissensions made Democratic success comparatively easy. The success of the Democratic machinery, and the reflex of its temporary check in *1840,* with the influences brought to bear on it by the returning Calhoun faction, were such as to take the control of the party out of the hands of the leaders who had formed it. They had had high regard for political principle, even though they were willing to use doubtful methods for its propagation; these methods had now brought out new men, who looked mainly to success, and to close connection with the controlling political element of the south as the easiest means of attaining success. When the Democratic convention of *1844* met it was expected to renominate Van Buren, but James K. Polk nas nominated. The Whigs nominated Clay.

Abolitionist Movement.— The beginning of the abolitionist movement in the United States, the establishment of the Liberator (1831), and of the American Antislavery society (1833), and the subsequent divisions in it, are dealt with elsewhere *(see* GARRISON, *WILLIAM* LLOYD). Up to that time abolition had meant gradual abolition; Garrison called for immediate abolition. The basis of the American system mas in the reserved rights of the states, and slavery rested on their will. The mission of the abolitionists was to force the people to think of the question; and, in spite of riots, assaults and persecution of every kind, they fulfilled it manfully. In truth, slavery was more and more out of harmony with the new economic conditions which were taking complete control of the north and west, but had hardly been felt in the south. Thus the two sections, north and south, were more and more disposed to take opposite views of everything in which slavery was involved, and it had a faculty of involving itself in almost everything. The status of slavery in the territories had been settled in *1820;* that of slavery in the states had been settled by the constitution; but even in minor questions the intrusive element had to be reckoned with. The abolitionists sent their documents through the mails, and the south wished the federal government to stop this practice. The abolitionists persisted in petitioning congress for the passage of various measures which congress regarded as utterly unconstitutional; and the disposition of congress to deny or regulate the right of petition in such matters excited the indignation of northern men nho had no sympathy with abolition. But the first occasion on which the views of the two sections came into flat contrast was on the question of the annexation of Texas.

Texas and Oregon.—The United States had had a vague claim to Texas until *1819,* when the claim was surrendered to Spain in part compensation for Florida. On the revolt of Mexico, Texas became a part of that republic. It was colonized by Americans, mainly southerners and slaveholders, seceded from Mexico in 1835 and defeated the Mexican armies and established its independence in the following year. Southern politicians desired its annexation to the United States. People in the north were either indifferent or hostile to the proposal; Van Buren had declared against it. and his action was a reason for his defeat in the Democratic convention.

On the other hand, there were indications that the joint occupation of the Oregon country could not last much longer. American immigration into it had begun, while the Hudson's Bay company. the British tenant of the soil was the natural enemy of immigration. The two points were coupled; and the Democratic convention declared for the reannexation of Texas and the reoccupation of Oregon.

Election of 1844.—One of the cardinal methods of the political abolitionists was to nominate candidates of their own against a doubtful friend, even though this secured the election of an open enemy. Clay's efforts to guard his condemnation of the Texas annexation project were just enough to push the Liberty party, the political abolitionists, into voting for candidates of their own in New York; on a close vote their loss was enough to throw the electoral votes of that state to Polk. and its votes decided the result. Polk was elected (Nov. 1844); and Texas was annexed to the United States in the following spring. At the next meeting of congress (1845) Texas was admitted as a state.

West of Texas the northern prolongation of Mexico ran right athwart the westward movement of American population; and though the movement had not yet reached the barrier the Polk administration desired further acquisitions from Mexico. The western boundary of Texas was undefined; a strip of territory claimed by Texas was settled exclusively by Mexicans; but the Polk administration directed Gen: Zachary Taylor, the American commander in Texas. to cross the Nueces river and seize the disputed territory. Collisions with Mexican troops followed; they were beaten in the battles of Palo Alto and Resara de la Palma, and were chased across the Rio Grande. Taylor followed and took the city of Monterrey.

War With Mexico.—On the news of the first bloodshed, congress declared war against Mexico. over the opposition of the Whigs. A land and naval force took possession of California and a land expedition occupied New Mexico, so that the authority of Mexico over all the soil north of its present boundaries was abruptly terminated (1846). At the beginning of 1847 Taylor fought the last battle in northern Mexico (Buena Vista). defeating the Mexicans. and Gen. Winfield Scott. with a new army. landed at Vera Cruz for a march upon the city of Mexico. Scott's march was marked by one successful battle after another, usually against heavy odds: and in September he took the capital city and held it until peace was made (1848) by the treaty of Guadalupe Hidalgo. Among the terms of peace was the cession of the present California. Utah. Arizona and New Mexico. the consideration being a payment of $15.000.000 by the United States and the assumption of about $3.000.000 of debts owed by Mexico to American citizens. With a subsequent rectification of frontier (1853) by the Gadsden treaty (*see* GADSDEN. JAMES). this cession added about 500.000 sq.mi. to the area of the United States: Texas itself made up a large additional area. The settlement of the northeast and northwest boundaries by the Webster-Ashburton and Buchanan-Pakenham treaties (1842. 1846) with the Texas and Mexican cessions. gave the United States the complete territorial form retained until the annexation of Alaska in 1867.

Slavery in the New Territory.— In the new territory slavery had been forbidden under Mexican law: and its annexation brought up the question of its status under American law. If slavery was to he excluded from the new territory. the states which should ultimately be formed out of it would enter as free states. and the influence of the south in the senate would be decreased. For the first time the south appears as a distinct *imperium* in *imperio*.

The first appearance of these difficulties brought out in the Democratic party a solution which was so closely in line with the prejudices of the party that it bade fair to carry the party through the crisis without the loss of its southern vote. This was squatter sovereignty. the notion that it would be best for congress to leave the people of each territory to settle the question of the existence of slavery for themselves. The broader and democratic ground for the party would have been that which it at first seerned

TABLE V.—*The States of the Union*

State	Date of admission	Order of admission	Capital
United States	—	—	Washington, D.C.
Alahama	Dec. 14, 1819	22	Montgomery
Alaska	Jan. 3, 1959	49	Juneau
Arizona	Feb. 14, 1912	48	Phoenix
Arkansas	June 16, 1836	25	Little Rock
California	Sept. 9, 1850	31	Sacramento
Colorado	Aug. 1, 1876	38	Denver
Connecticut	Jan. 9, 1788 ♁	5	Hartford
Delaware	Dec. 7, 1787 ♁	1	Dover
District of Columbia	—	—	—
Florida	Mar. 3, 1845	27	Tallahassee
Georgia	Jan. 2, 1788 ♁	4	Atlanta
Hawaii	Aug. 21, 1959	50	Honolulu
Idaho	July 3, 1890	43	Boise
Illinois	Dec. 3, 1818	21	Springfield
Indiana	Dec. 11, 1816	19	Indianapolis
Iowa	Dec. 28, 1846	29	Des Moines
Kansas	Jan. 29, 1861	34	Topeka
Kentucky	June 1, 1792	15	Frankfort
Louisiana	Apr. 30, 1812	18	Baton Rouge
Maine	Mar. 15, 1820	23	Augusta
Maryland	Apr. 28, 1788 ♁	7	Annapolis
Massachusetts	Feb. 6, 1788 ♁	6	Boston
Michigan	Jan. 26, 1837	26	Lansing
Minnesota	May 11, 1858	32	St. Paul
Mississippi	Dec. 10, 1817	20	Jackson
Missouri	Aug. 10, 1821	24	Jefferson City
Montana	Nov. 8, 1889	41	Helena
Nebraska	Mar. 1, 1867	37	Lincoln
Nevada	Oct. 31, 1864	36	Carson City
New Hampshire	June 21, 1788 ♁	9	Concord
New Jersey	Dec. 18, 1787 ♁	3	Trenton
New Mexico	Jan. 6, 1912	47	Santa Fe
New York	July 26, 1788 ♁	11	Albany
North Carolina	Nov. 21, 1789 ♁	12	Raleigh
North Dakota	Nov. 2, 1889	39	Bismarck
Ohio	Mar. 1, 1803	17	Columbus
Oklahoma	Nov. 16, 1907	46	Oklahoma City
Oregon	Feb. 14, 1859	33	Salem
Pennsylvania	Dec. 12, 1787 ♁	2	Harrisburg
Rhode Island	May 29, 1790 ♁	13	Providence
South Carolina	May 23, 1788 ♁	8	Columbia
South Dakota	Nov. 2, 1889	40	Pierre
Tennessee	June 1, 1796	16	Nashville
Texas	Dec. 29, 1845	28	Austin
Utah	Jan. 4, 1896	45	Salt Lake City
Vermont	Mar. 4, 1791	14	Montpelier
Virginia	June 26, 1788 ♁	10	Richmond
Washington	Nov. 11, 1889	42	Olympia
West Virginia	June 20, 1863	35	Charleston
Wisconsin	May 29, 1848	30	Madison
Wyoming	July 10, 1890	44	Cheyenne

♁Original state; date shown is that of ratification of constitution.

likely to take—the Wilmot proviso, a condition proposed to be added to the act authorizing acquisitions of territory, providing that slavery should be forbidden in all territory to be acquired under the act. In the end apparent expediency carried the dominant party off to squatter sovereignty, and the Democratic adherents of the Wilmot proviso, with the Liberty party and the antislavery Whigs. united in 1848 under the name of the Free-Soil party. The Whigs had no solution to offer; their entire program consisted in a persistent effort to evade or ignore all difficulties connected with slavery.

Election of 1848.—Taylor. after the battle of Buena Vista. resigned and came home. considering himself ill-used by the administration. He refused to commit himself to any party; and the Whigs were forced to accept him as their candidate in 1848. The Democrats nominated Lewis Cass; the Free-Soilers nominated Van Buren. Taylor was elected president, receiving 163 electoral votes. while Cass received 127. Taking office in March 1849. he had the whole burden of the territorial difficulties, aggravated by the discovery of gold in California and the sudden rise of population there. Congress was so split into factions that it could for a long time agree upon nothing; and the Californians. with the approval of the president, proceeded to form a constitution and apply for admission as a state. They had so framed their constitution as to forbid slavery; and this was really the application of the Wilmot proviso to the richest part of the new territory. and the south felt that it had been robbed of the cream of what it alone had fought cheerfully to obtain.

Compromise of 1850.—The admission of Califorria was not secured until Sept. 1850, soon after Taylor's sudden death (July 9). and then only by the addition of a bonus to Texas, the division of the rest of the Mexican cession into the territories of Utah and New Mexico without prohibition of slavery. and the passage of a fugitive slave law. The slave trade, but not slavery. was forbidden in the District of Columbia. The whole was generally known as the Compromise Measures of 1850. Two of its features need notice. As has been said, slavery was not mentioned in the act; and the status of slavery in the territories was thus left uncertain. Congress can veto any legislation of a territorial legislature but, in fact, the two houses of congress were hardly ever able to unite on anything after 1850. and both these territories did establish slavery before 1860, without a congressional veto. The advantage there was with the south. The other point. the fugitive slave law was a special demand of the south. The constitution contained clauses directing that fugitive criminals and slaves should be delivered up, on requisition, by the state to which they had fled. In the case of criminals the delivery was directed to be made by the executive of the state to which they had fled; in the case of slaves no delivering authority was specified. and an act of congress in 1793 had imposed the duty on federal judges or on local state magistrates. Some of the states had passed personal liberty laws. iorbidding or limiting the action of their magistrates in such cases; and the act of 1850 transferred the decision of such cases to United States commissioners, with the assistance of United States marshals.

New States.—Five states were admitted during the last ten years of this period: Florida (1845), Texas (1845), Iowa (1846), Wisconsin (1538) and California (1850). The early entrance of Iowa. Wisconsin and Florida had been largely attributed to Indian wars. after each of which the defeated Indians were compelled to cede lands. The extinction of Indian titles in northern Michigan brought about the discovery of the great copper fields of that region. Elsewhere settlement followed the lines already marked out. except in the new possessions on the Pacific coast, whose full possibilities were not yet known. Railways in the eastern states were beginning to show something of a connected system; in the south they had hardly changed after 1840; in the west they had been prolonged only on their original lines. The telegraph was brought into use in 1844; but it was not until the census of 1860 that its effects were seen in the fuliy connected network of railways which then covered the whole north and west.

Inventions.—The sudden development of wealth in the country gave an impetus to the spirit of invention. Charles Goodyear's method of vulcanizing rubber (1839) had come into use. Cyrus Hall McCormick had made an invention the results of which have been hardly less than that of the locomotive in their importance to the United States. He had patented a reaping machine in 1834, and this, further improved and supplemented by other inventions, had brought into play the whole system of agricultural machinery. A successful sewing machine came in 1846; the power loom and the surgical use of anesthetics in the same year; and the rotary press for printing in 1847.

The **Mormons.**—All the conditions of life were changing so rapidly it was natural that the minds of men should change with them. This was the era of new sects, of communities. of transcendentalism in literature. religion and politics. The most successful of these was the sect of Mormons (see LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF). They settled in Utah in 1847, calling their capital Salt Lake City. and spread through the neighbouring territories. Their numbers were so great that it was against American instincts to deprive them of self-government. while their polygamy and total submission to their hierarchy made the rest of the country unwilling to erect them into a state having complete control of marriage and divorce. The difficulty was lessened by their renunciation of polygamy in 1890.

The South.—The material development of the United States from 1830 had been extraordinary, but every year made it more evident that the south was not sharing in it. It is plain now that the fault was in its labour system: its own labourers were slaves, and a slave who was fit for anything better than field labour was prima iacie a dangerous man. The divergence had as yet gone only far enough to awaken intelligent men in the south to its existence, and to stir them to efforts as hopeless as they were earnest, to find some artificial stimulus for southern industries. In the next ten years the process was to show its effects on the national field.

Slavery had put the south out of harmony with its surroundings. Even in 1850, though they hardly yet were aware of it, the two sections had drifted so far apart that they were practically two different countries.

The south remained much the same as in 1790; while other parts of the country had developed, it had stood still. The remnants of colonial feeling, of class influence, which advancing democracy had wiped out elsewhere, retained their force there. The ruling class had to maintain a military control over the labouring class, and a class influence over the poorer whites. It had even secured in the constitution provision for its political power in the representation given to three-fifths of the slaves. The 20 additional members of the house of representatives were not simply a gain to the south; they were still more a gain to those districts in which whites were few, and the slaveholder controlled the district. Slaveowners and slaveholders together, there were but 350.000 of them; but they had common interests. the intelligence to see them and the courage to contend for them. The first step of a rising man was to buy slaves; and this was enough to enroll him in the dominant class. From it were drawn the representatives and senators in congress, the governors and all the holders of offices over which the slave power, as it came to be called, had control.

Immigration into the United States was not an important factor in its development until about 1847. The immigrants, as late as 1820, numbered but 8,000 per annum; their number did not reach 100.000 until 1842; and then it fell for a year or two almost to half that number. In 1847 it rose again to 239,000, in 1849 to 300,000, and in 1850 to 380.000; all told. more than 2,814,000 persons from abroad settled in the United States between 1837 and 1853. Leaving out the dregs of the immigration, which settled down in the seaboard cities. its best part was a powerful nationalizing force. It had not come to any particular state. but to the United States, yet all the influences of this enormous immigration were confined to the north and west; the immigration avoided slave soil as if by instinct. And as the sections began to differ further in aims and policy the north began to gain heavily in ability to ensure its success.

Texas nas the last slave state ever admitted: and, as it re fused to be divided, the south had no further increase of numbers in the senate. Until 1850 the admission of a free state had been so promptly balanced by the admission of a slave state that the senators of the two sections had remained about equal in number: in 1860 the free states had 36 senators and the slave states only 30. As the representation in the house had changed from 35 free state and 30 slave state members in 1790 to 147 free state and 90 slave state in 1860, and as the number of presidential electors is the sum of the numbers of senators and representatives, political power had passed away from the south in 1850. If at any time the free states should unite they would be supreme.

Tendencies to Disunion.— In circumstances so critical a cautious quiescence and avoidance of public attention was the only safe course for the slave power, but that course had become impossible. The numbers interested had become too large to be subject to complete discipline; not all could be held in cautious reserve; and when an advanced proposal came from any quarter of the slaveholding lines the whole army was shortly forced up to the advanced position. If collision came it must be on some question of the rights of the states; and on such a question the whole south would move as one man.

The Protestant churches of the United States had reflected in their organization the spirit of the political institutions under which they lived. Acting as purely voluntary associations, they had been organized into governments by delegates. much like the "conventions" which had been evolved in the political parties. The omnipresent slavery question intruded into these bodies, and split them. Only the Episcopal and Roman Catholic Churches retained their national character.

The political parties showed the same tendency. Each began to shrivel up in one section or the other. The notion of squatter sovereignty, attractive at first to the western democracy, and not repudiated by the south, enabled the Democratic party to pass the crisis of 1850 nithout losing much of its northern vote, while southern Whigs began to drift in, making the party continually more proslavery. This could not continue long nithout beginning to decrease its northern vote but this effect did not become plainly visible until after 1852. The efforts of the Whig party to ignore the great question alienated its antislavery members in the north. while they did not satisfy its southern members The Whig losses were not at first heavy, but. as the electoral vote of each state is determined by the barest plurality they were enough to defeat the party almost everywhere in the presidential election of 1852. The Whigs nominated Gen. Winfield Scott and the Democrats Franklin Pierce; Pierce carried all but four of the 31 states, and was elected, receiving 254 out of the 296 electoral votes. This revelation of hopeless weakness was the downfall of the Whig party; it maintained its organization for iour years longer, but the life had gone out of it. The future mas with the Free-Soil party, though it had polled but few votes in 1852.

Party leadership had been changing. During the administration of Taylor (and Vice-president Millard Fillmore, who succeeded him) Clay. Webster, Calhoun and Polk had died, and there was a steady drift of other political leaders out of public life. New leaders were appearing everywhere, and in both sections they showed the prevailing tendency to disunion. The best of them nere unprecedentedly radical. Charles Sumner, William H. Seward and Salmon P. Chase came into the senate, bringing force and ability to the antislavery feeling in that body. The new southern men. such as Jefferson Davis. and the Democratic recruits from the southern Whig party, such as Alexander H Stephens, were ready to defend the position on which Calhoun had always insisted—that congress was bound not merely to the negative duty of not attacking slavery in the territories. but to the positive duty of protecting it. This, if it should become the general southern position, was certain to destroy the notion of squatter sovereignty, and thus to split the Democratic party, which was almost the last national ligament that now held the two fragments of the union together.

The social disintegration mas as rapid. Northern men traveling in the south were naturally looked upon with increasing suspicion, and were made to feel that they were on a soil alien in sympathies. Some of the worst phases of democracy were called into play in the south; and, in some sections, law openly yicldcd supremacy to popular passion in the cases of suspected abolitionists. Southern conventions, on all sorts of subjects, became common; and, permeated by a dawning sense of southern nationality, hardly any proposition looking to southern independence of the north was met with disfavour.

Calhoun in his last and greatest speech, called attention to the manner in which one tie after another was snapping. But he ignored the real peril of the situation—its dangerous facts: that the south was steadily growing weaker in comparison with the north, and more unable to secure a wider area for the slave system; that it was therefore being steadily forced into demanding active congressional protection for slavery in the territories; that the north would never submit to this; and that the south must submit or bring about a collision by attempting to secede.

Kansas-Nebraska Act.—Antislavery feeling in the north was stimulated by the manner in which the fugitive slave law was enforced immediately after 1850. The chase after fugitive slaves was prosecuted in many cases with circumstances of revolting brutality. The added feeling showed its force when the Kansas-Nebraska act mas passed by congress (1854). It organized the two new territories of Kansas and Nebraska. Both of them were forever free soil by the terms of the Missouri Compromise. But the success of the notion of squatter sovereignty in holding the Democratic party together while destroying the Whig party had intoxicated Stephen A. Douglas and other northern Democrats; and they now applied the doctrine to these territories. They did not desire "to vote slavery up or down," but left the decision to the people of the two territories.

The Republican Party.— The Kansas-Nebraska act was one of the grossest political blunders in American history. The status of slavery had been settled, by the constitution or by the compromises of 1820 and 1850, on every square foot of American soil; right or wrong the settlement was made. The new act took a great mass of territory out of the settlement and flung it down as a prize for nhich the sections mere to struggle The first result of the act was to throw parties into chaos. An American or Know-Nothing party. a secret oath-bound organization. pledged to oppose the influence or power of foreign-born citizens, had been formed to take the place of the defunct Whig party. It had been quite successful in state elections for a time. and was now beginning to have larger aspirations. It, like the Whig party. intended to ignore slavery. but, after a few years of existence. the questions complicated with slavery divided it also. Even in 1854 many of its leaders in the north were forced to take a position against the Kansas-Nebraska act, while hosts of others joined in the opposition without any party organization. No American party ever rose so swiftly as this; nith no other party name than the awkward title of anti-Nebraska men, it carried the congressional elections of 1854 in the north, forced many of the former Know-Nothing leaders into union with it. and controlled the house of representatives of the congress which met in 1855. The Democratic party, which had been practically the only party from 1852, had now to face the latest and strongest of its broad-constructionist opponents. It acknowledged, at first, no purpose aimed at slavery, only an intention to exclude slavery from the territories; but, under such principles, it was the only party which was potentially an antislavery party The new party had grasped the function nhich belonged of right to its great opponent, and it seized nith it its opponent's original title. The name Democrat had quite taken the place of that first used—Republican—but Republican had never passed out of popular remembrance and liking in the north. The new party took quick and skillful advantage of this by assuming the old name and early in 1856 the two great parties of the present—Democratic and Republican—were drawn up against one another.

Foreign Relations.—The foreign relations during Pierce's term of office were overshadowed by the domestic difficulties, but were of importance. In the Koszta case (1853) national protection had been afforded on foreign soil to a person nho had taken only the preliminary steps to naturalization. Japan had been opened to American commerce (1854). But the question of slavery was more and more thrusting itself even into foreign relations. A great southern republic. to be founded at first by the slave states, but to take in gradually the whole territory around the Gulf of Mexico and include the West Indies, was soon to be a not uncommon ambition among slaveholders, and its first phases appeared during Pierce's administration. Efforts mere begun to obtain Cuba from Spain; and the three leading American ministers abroad. meeting at Ostend, Belg., united in declaring the possession of Cuba to be essential to the well-being of the United States (1854). "Filibustering" expeditions against Cuba or the smaller South American states. intended to revolutionize them so as to lay a basis for application for annexation to the United States. became common. But these yielded in importance to the affairs in Kansas.

Kansas. — Nebraska was then supposed to be a desert, and attention was directed almost exclusively to Kansas. No sooner had its organization left the matter of slavery to be decided by its people than the antislavery faction of the north and west felt it to be their duty to see that the people of the territory should be antislavery in sympathy. Emigrant associations were formed, and these shipped men and families to Kansas, arming them for their protection in the new country. Southern newspapers called for similar measures in the south, but the call was less effective. Southern men without slaves. settling a new state. were uncomfortably apt to prohibit slavery. as in California. Only slaveholders were trusty proslavery men; and such were not likely to take slaves to Kansas and risk their ownership. But for the people of Missouri. Kansas would have been free soil at once. Lying across the direct road to Kansas, the Missouri settlers blockaded the way of free-state settlers, crossed into Kansas and voted profusely at the first territorial election. The struggle passed into a real civil war, the two powers fighting battles, capturing towns and paroling prisoners. The struggle was really over in 1857, and the south was beaten. There were. horn-ever. many obstacles yet to be overcome before the new state of Kansas was recognized by congress, after the withdrawal of the senators of the seceding states (1861).

Election of 1856. — In the heat of the Kansas struggle came the presidential election of 1856. The Democrats nominated James Buchanan, declaring. as usual, for the strictest limitations of the powers of the federal government and reaffirming the principle of the Kansas-Nebraska act — the settlement of slavery by the people of a territory. The remnant of the Whig party, including the Know-Nothings of the north and those southern men who wished no further discussion of slavery. nominated Millard Fillmore. The Republican party nominated John C. Frémont: the bulk of its manifesto was taken up with protests against attempts to introduce slavery into the territories; but it showed its broad construction tendencies by declaring for appropriations of federal money for internal improvements. The Democrats were successful in electing Buchanan; but the position of the party was quite different from the triumph with which it had come out of the election of 1852. It was no longer master of 27 of the 31 states; all the free states but 5 had gone against it; its candidate no longer had a majority of the popular vote. For the first time in the history of the country a distinctly antislavery candidate had obtained an electoral vote, and had even come near obtaining the presidency. Fillmore had carried but one state, Maryland; Buchanan had carried the rest of the south, with a few states in the north and Frémont the rest of the north and none of the south.

Dred Scott. — Oddly enough the constitutionality of the Compromise of 1820 had never happened to come before the U.S. supreme court for consideration. In 1856–57 it came up for the first time. One Dred Scott, a Missouri slave who had been taken in 1834 to Illinois, a free state, and in 1836 to Minnesota, within the territory covered by the compromise, and had some years after being taken back to Missouri in 1838 sued for his freedom. was sold (1852) to a citizen of New York. Scott then transferred his suit from the state to the federal courts, under the power given them to try suits between citizens of different states, and the case came by appeal to the supreme court. Its decision, announced on March 6 1857. put Scott out of court on the ground that a slave. or the descendant of slaves could not be a citizen of the United States or have any standing in federal courts The opinion of Chief Justice Roger Taney went on to attack the validity of the Missouri Compromise, for the reasons that one of the constitutional functions of congress mas the protection of property, that slaves had been recognized as propeity by the constitution, and that congress was bound to protect, not to prohibit, slavery in the territories Most of the northern people held that slaves were looked upon by the constitution not as property but as "persons held to service or labour" by state laws A large part of the north flouted the decision of the supreme court and the storm of angry dissent nhich it aroused did the disunionists good service in the south. From this time the leading nenspapers in the south maintained that the radical southern view first advanced by Calhoun, and but slowly accepted by other southern leaders. as to the duty of congress to protect slavery in the territories had been confirmed by the supreme court; that the northern Republicans had rejected it; even the squatter sovereignty of northern Democrats could no longer be submitted to by the south.

John Brown. — The population of the United States in 1860 was over 31 000 000 an increase of more than 8 000 000 in ten years As the decennial increases of population became larger, so did the divergence of the sections in population. and still more in nealth and resources Two more free states came in during this period — Minnesota (1858) and Oregon (1859) — and Kansas was clamouring loudly for the same privilege The free and slave states, which had been almost equal in population in 1790 stood non as 19 to 12. And of the 12.000 000 in slave states, the 4.000 000 slaves and the 250,000 free Negroes were not so much a factor of strength as a possible source of weakness and danger No serious slave rising had ever taken place in the south; but John Broun's attack (1859) on Harpers Ferry, as the first move in a project to rouse the slaves and the alarm uhich it carried through the south. were tokens of a danger which added a new horror to the chances of civil war

Democratic Party Split. — Northern Democrats, under the lead of Douglas, had been forced already almost to the point of revolt by the determination of southern senators to prevent the admission of Kansas as a free state, if not to secure its admission as a slave state When the Democratic convention of 1860 met at Charleston. the last strand of the last national political organization parted; the Democratic party itself was split by the slavery question The southern delegates demanded a declaration in favour of the duty of congress to protect slavery in the territories It was all that the Douglas Democrats could then do to maintain themselves in a fen northern states, such a declaration meant political suicide everywhere and they voted it donn The convention divided into two bodies The southern body adjourned to Richmond and the northern and border state convention to Baltimore There the northern delegates. by seating some delegates friendly to Douglas, provoked a further secession of border state delegates, nho. in company with the Richmond body, nominated John C. Breckinridge and Joseph Lane for president and vice-president. The remainder of the original convention nominated Douglas and H V. Johnson.

The remnant of the old Whig and Know-Nothing parties, now calling itself the Constitutional Union party, met at Baltimore and nominated John Bell and Edward Everett The Republican convention met at Chicago Its platform of 1856 had been somenhat broad constructionist but a strong Democratic element in the party had prevented it from going too far The election of 1856 had shown that, nith the votes of Pennsylvania and Illinois, the party would have then been successful, and the Democratic element was nou ready to take almost anything which would secure the votes of these states. This state of affairs will go to explain the nomination of Abraham Lincoln, of Illinois for president, with Hannibal Hamlin, a former Democrat, for vice-president. and the declaration of the platform in favour of a protective tariff. The mass of the platform was still devoted to the necessity of excluding slavery from the territories.

Election of 1860.—No candidate received a majority of the popular vote, Lincoln standing first and Douglas second. But Lincoln and Hamlin had a clear majority of the electoral vote, and so were elected, Breckinridge and Lane coming next. It is worthy of mention that, up to the last hours of Lincoln's first term of office. congress would always have contained a majority opposed to him but for the absence of the members from the seceding states. The interests of the south and even of slavery were thus safe enough under an antislavery president. But the drift of events was too plain. Nullification had come and gone, and the nation feared it no longer. Even secession by a single state was now almost out of the question: the letters of southern governors in 1860, in consultation on the state of affairs, agree that no state would secede without assurances of support by others. If this crisis were allowed to slip by without action, even a sectional secession would soon be impossible.

Secession.—In Oct. 1860 Gov. W. H. Gist of South Carolina sent a letter to the governor of each of the other cotton states except Texas, asking co-operation in case South Carolina should resolve upon secession: and the replies were favourable. The democratic revolution which, since 1829, had compelled the legislature to give the choice of presidential electors to the people of the states had not affected South Carolina; its electors were still chosen by the legislature. That body, after having chosen the state's electors on Nov. 6, remained in session until the telegraph had brought assurances that Lincoln had been elected; it then (on the 10th) summoned a state convention and adjourned. The state convention on Dec. 20 unanimously passed an "ordinance of secession," repealing the acts by which the state had ratified the constitution and its amendments, and dissolving "the union now subsisting between South Carolina and other states, under the name of the 'United States of America.'" The convention took all steps necessary to prepare for war, and adjourned. Similar ordinances were passed by conventions in Mississippi !Jan. 9, 1861). Florida (Jan. 10), Alabama (Jan. 11), Georgia (Jan. 19), Louisiana (Jan. 26) and Texas (Feb. 1).

The Confederate States.—The opposition in the south did not deny the right to secede, but the expediency of its exercise. Their effort was to elect delegates to the state conventions who would vote not to secede. They were beaten, says A. H. Stephens, by the cry. originally uttered by T. R. R. Cobb before his state legislature (Nov. 12, 1860), "We can make better terms out of the Union than in it." That is. the states were to withdraw individually. suspend the functions of the federal government within their jurisdiction for the time, consider maturely any proposals for guarantees for their rights in the union, and return as soon as satisfactory guarantees should be given. When the conventions of the seceding states had adopted the ordinances of secession, they proceeded to other business. They appointed delegates, who met at Montgomery, the capital of Alabama. formed a provisional constitution (Feb. 8) for the "Confederate states," chose a provisional president and vice-president (Jefferson Davis and A. H. Stephens), and established an army, treasury and other executive departments. The president and vice-president were inaugurated on Feb. 18. The permanent constitution, adopted on March 11, was copied from that of the United States, with variations meant to maintain state sovereignty, to give the cabinet seats in congress and to prevent the grant of bounties or any protective features in the tariff or the maintenance of internal improvements at general expense; and it expressly provided that in all the territory belonging to the Confederacy but lying without the limits of the several states "the institution of negro slavery, as it now exists in the Confederate States, shall be recognized and protected by Congress and by the Territorial Government."

Under nhat claim of constitutional right all this was done passes cornprehension. That a state convention should'have the final poner of decision on the question which it was summoned to consider is quite as radical doctrine as has yet been heard of; that a state convention, summoned to consider the one question of secession, should go on. with no appeal to any further popular authority or mandate, to send delegates to meet those of other states and form a new national government, which could only exist by warring on the United States, is a novel feature in American constitutional law. It was revolution or nothing. Only in Texas, where the call of the state convention was so irregular that a popular vote could hardly be escaped, was any popular vote allowed. Elsewhere the functions of the voter ceased when he voted for delegates to the state convention.

The Border States.—The border states mere in two tiers—North Carolina, Tennessee and Arkansas next to the seccding states, and Delaware, Maryland, Virginia, Kentucky and Missouri next to the free states. None of these was willing to secede. There was, however, one force which might draw them into secession. A state which did not wish to secede, but believed in state sovereignty and the abstract right of secession, would be inclined to take up arms to resist any attempt by the federal government to coerce a seceding state. In the following spring, the original seven seceding states were reinforced by four border states.

In the north and west surprisingly little attention was given to the systematic course of procedure along the Gulf. The people of those sections were very busy; they had heard much of this talk before, and looked upon it as a kind of stage thunder. Republican politicians, with the exception of a few. were inclined to refrain from public declarations of intention. Some of them such as Seward, showed a disposition to let the "erring sisters" depart in peace, expecting to make the loss good by accessions from Canada. A few, like Sen. Zachariah Chandler, believed that there would be "bloodletting," but most of them were still doubtful as to the future. In the north the leaders and the people generally shrank from the prospect of war. Among the various proposals to this end, that offered in the senate by John J. Crittenden, of Kentucky, and known as the Crittenden compromise, was perhaps received with most favour. This took the form of six proposed amendments to the constitution, of which two were virtually a rephrasing of the essential feature of the Missouri Compromise and of the principle of squatter sovereignty, and others provided that the national government should pay to the owner of any fugitive slave, whose return was prevented by opposition in the north, the full value of such slave, and prohibited the abolition of slavery in the District of Columbia "so long as it exists in the adjoining states of Virginia and Maryland or either." This proposed compromise mas rejected by the senate by a close vote on March 2, 1861. A peace congress. called by Virginia. met in Washington from Feb. 4 to 27, 1861, 21 states being represented, and proposed a constitutional amendment embodying changes very similar to those of the Crittenden compromise, but its proposal was not acted upon by congress. Congress did nothing, except to admit Kansas as a free state and adopt the protective Morrill tariff; even after its members from the seceding states had withdrawn, those who remained made no preparations for conflict, and, at their adjournment in March 1861, left the federal government naked and helpless.

The War Governors.—The only sign of life in the body politic, the half-awakened word of warning from the democracy of the north and west, was its choice of governors of states. A remarkable group of men, soon to be known as the "war governors"—Israel Washburn of Maine, Erastus Fairbanks of Vermont. Ichabod Goodwin of New Hampshire, John Albion Andrew of Massachusetts. William Sprague of Rhode Island, William Alfred Buckingham of Connecticut. Edwin Dennison Morgan of New York. Charles Smith Olden of New Jersey, Andrew Gregg Curtin of Pennsylvania, William Dennison of Ohio, Oliver Perry Morton of Indiana, Richard Yates of Illinois, Austin Blair of Michigan, Alexander Williams Randall of Wisconsin, Samuel Jordan Kirkwood of Iowa: and Alexander Ramsey of Minnesota—held the executive powers of the northern states in 1861–62. Some of these governors, such as Andrew and Buckingham, as they saw the struggle come nearer, went so far as to order the purchase of warlike material for their states on their private responsibility, and their action saved days of time.

U.S. Property Seized.—The little army of the United States had been almost put out of consideration; wherever its detachments could be found in the south they were surrounded and forced to surrender and were transferred to the north. After secession, and in some of the states even before it, the forts, arsenals. mints. customhouses, shipyards and public property of the United States had been seized by authority of the state. and these were held until transferred to the new Confederate States organization.

Only a few forts, of all the magnificent structures with which. the nation had dotted the southern coast, remained to it—the forts near Key West, Fortress Monroe at the mouth of Chesapeake bay, Ft. Pickens at Pensacola and Ft. Sumter in Charleston harbour. Both of the last-named were beleaguered by hostile batteries, but the administration of President Buchanan, intent on maintaining the peace until the new administration should come in. instructed their commanding officers to refrain from any acts tending to open conflict. The federal officers, therefore, were obliged to look idly on while every preparation was made for their destruction, and even while a vessel bearing supplies for Ft. Sumter was driven back by the batteries between it and the sea.

The divergence between the two sections of the country had thus passed into disunion, and was soon to pass into open hostility. The legal recognition of the custom of slavery, acting upon and reacted upon by every step in their economic development and every difference in their natural characteristics and institutions, had carried north and south farther and faster apart, until the elements of a distinct nationality had appeared in the south.

Secession had taken away many of the men who had for years managed the federal government, and who understood its workings. Lincoln's party was in power for the first time; his officers were new to the routine of federal administration; and the circumstances with which they were called upon to deal were such as to daunt any spirit. The government had become so nearly bankrupt in the closing days of Buchanan's administration that it had .escaped only by paying double interest. The army had been almost broken up by captures of men and matériel and by resignations of competent and trusted officers. The navy had come to such a pass that, in Feb. 1861, a house committee reported that only two vessels, one of 20, the other of two guns. were available for the defense of the entire Atlantic coast. And, to complicate all difficulties, a horde of clamorous office seekers crowded Washington.

Civil War, 1861–65.—Soon after Lincoln's administration began. the starting of an expedition to provision Ft. Sumter brought on an attack by the batteries around the fort, and after a bombardment of 36 hours the fort surrendered (April 14, 1861). It is not necessary to rehearse the familiar story of the outburst of feeling which followed this event and the proclamation of President Lincoln calling for volunteers. The 75,000 volunteers called for were supplied three or four times over.

There had been some belief in the south that the northwest would take no part in the impending conflict, and that its people could be persuaded to keep up friendly relations with the new nationality. In the spring months of 1861 Douglas, who had long been denounced as the tool of the southern slaveholders, was spending the closing days of life in expressing the determination of the northwest that it would never submit to have "a line of customhouses" between it and the ocean. The batteries which Confederate authority was erecting on the banks of the Mississippi were fuel to the flame. California, considered neutral by all parties, pronounced as unequivocally for the national authority.

The shock of arms put an end to opposition in the south as well. The peculiar isolation of life in the south precluded the more ignorant voter from any comparisons of the power of his state with any other; to him it was almost inconceivable that his state should own or have a superior. The better educated men, of wider experience. had been trained to think state sovereignty the foundation of civil liberty, and, when their state spoke, they felt bound to follow their state. The president of the Confederate states issued his call for men, and it also was more than met.

Lincoln's call for troops met with an angry reception wherever the doctrine of state sovereignty had a foothold. The governors of the border states generally returned it with a refusal to furnish any troops. Two states: North Carolina and Arkansas, seceded and joined the Confederate states. In two others, Virginia and Tennessee. the state politicians formed military leagues with the Confederacy. allowing Confederate troops to take possession of the states and then submitted the question of secession to popular vote. The secession of these states was thus accomplished, and Richmond became the Confederate capital. The same process was attempted in Missouri, but failed, and the state remained loyal. The politician class in Maryland and Kentucky took the extraordinary course of attempting to maintain neutrality; but the growing power of the federal government soon enabled the people of the two states to resume control of their governments and give consistent support to the union. Kentucky. however, had troops in the Confederate armies; and one of its citizens. the former vice-president, John C. Breckinridge. left the senate and became an officer in the Confederate service. Delaware cast its lot from the first with the union.

The first blood of the mar mas shed in the streets of Baltimore, when a mob attempted to stop Massachusetts troops on their way to Washington (April 19). For a time there was difficulty in getting troops through Maryland because of the active hostility of some of its citizens, but this was overcome, and the national capital was made secure. The Confederate lines had been pushed up to Manassas Junction, about 30 mi. from Washington. When congress, called into special session by the president for July 4, came together, the outline of the Confederate states had been fixed. The length of the line. including also the Atlantic and Gulf coasts, has been estimated at 11,000 mi. The territory within it comprised about 800,000 sq.mi., with a population of over 9,000,000 and great natural resources. Its cotton was almost essential to the manufacturers of the world; in exchange for it every munition of war could be procured; and it was hardly possible to blockade a coast over 3,000 mi. in length, on which the blockading force had but one port of refuge, and that at about the middle of the line. Nevertheless, President Lincoln issued his first call for troops on April 15. President Davis then issued a proclamation (on the 17th) offering letters of marque and reprisal against the commerce of the United States to private vessels, and on the 19th Lincoln answered with a proclamation announcing the blockade of the southern coast. The news brought out proclamations of neutrality from Great Britain and France.

The president found himself compelled to assume powers never granted to the executive authority, trusting to the subsequent action of congress to validate his action. He had to raise and support armies and navies; he even had to authorize seizures of necessary property, of railroad and telegraph lines, arrests of suspected persons, and the suspension of the writ of habeas corpus in certain districts. Congress supported him, and proceeded in 1863 to give the president power to suspend the writ anywhere in the United States; this power he promptly exercised. The supreme court, after the war. in the Milligan case (4 Wallace 133) decided that no branch of the government had power to suspend the writ in districts where the courts were open—that the privilege of the writ might be suspended as to persons properly involved in the war, but that the writ was still to issue, the court deciding whether the person came within the classes to whom the suspension applied.

When congress met (July 4, 1861) the absence of southern members had made it heavily Republican. It decided to consider no business but that connected with the war, authorized a loan and the raising of 500,000 volunteers, and made confiscation of property a penalty of rebellion. While it was in session the first serious battle of the war—Bull Run, or Manassas—took place (July 21), and resulted in the defeat of the federal army.

The **"Trent"** Case.—The overzealous action of a naval officer in taking the Confederate envoys James M. Mason and John Slidell out of the British steamer "Trent" sailing between two neutral ports almost brought about a collision between the United States and Great Britain in November. But the American precedents were all against the United States, and the envoys were given up.

The broad construction tendencies of the Republican party showed themselves more plainly as the war grew more serious; there was an increasing disposition to cut every knot by legislation, with less regard to the constitutionality of the legislation. A paper currency commonly known as greenbacks, was adopted and made legal tender (Feb. 25, 1862). Slavery was prohibited (April 16) in the District of Columbia and the territories (June 19); the army was forbidden to surrender escaped slaves to their owners; and slaves of insurgents were ordered to be confiscated. In addition to a homestead act giving public lands to actual settlers at reduced rates. congress began a further development of the system of granting public lands to railways Another important act (1862) granted public lands for the establishment of agricultural and mechanical colleges.

Railways. — The railway system of the United States was but 20 years old in 1850, but it had begun to assume some consistency. The day of short and disconnected lines had passed, and the connections which were to develop into railway systems had appeared. Consolidation of smaller companies had begun; the all-rail route across the state of New York was made up of more than 12 original companies at its consolidation in 1853. The Erie railway, chartered in 1832, was completed from Piermont to Dunkirk, N.Y., in 183'1; and another line—the Pennsylvania—was completed from Harrisburg to Pittston, Pa., in 1854. These were at least the germs of great trunk lines. The cost of American railways has been only from one-half to one-fourth of the cost of European railways: but an investment in a far western railway in 1850–60 was an extrahazardous risk. Not only did social conditions make any form of business hazardous: the new railway often had to enter an uninhabited territory. and there create its own towns, farms and traffic. Whether it could do so was so doubtful as to make additional inducements to capital necessary. The means attempted by congress in 1850, in the case of the Illinois Central railroad, was to grant public lands to the corporation, reserving to the United States the alternate sections. At first grants were made to the states for the benefit of the corporations; the act of 1862 made the grant directly to the corporation.

The vital military and political necessity of an immediate railway connection with the Pacific coast was hardly open to doubt in 1862; but the necessity scarcely justified the terms uhich were offered and taken. The Union Pacific railroad was incorporated; the United States government was to issue to it bonds, on the completion of each 40 mi., to the amount of $16,000 per mile, to be a first mortgage; through Utah and Nevada the aid mas to be doubled. and for about 300 mi. of mountain building to be trebled; and, in addition to this, alternate sections of land were granted. The land-grant system, thus begun. was carried on extensively. the largest single grants being those of 47,000,000 ac. to the Northern Pacific (1864) and of 42,000,000 ac. to the Atlantic and Pacific line (1866).

Economic Patterns. — Specie payments had been suspended almost everyahere toward the end of 1861; but the price of gold was only 102.5 at the beginning of 1862. About May its price in paper currency began to rise. It touched 170 during the next year. and 285 in 1864; but the real price probably never went much above 250. Other articles felt the influence in currency prices.

The duties on imports were driven higher than the original Morrill tariff had ever contemplated. The average rates, which had been 18% on dutiable articles and 12% on the aggregate in 1860–61, rose, before the end of the war, to nearly 50% on dutiable articles and 35% on the aggregate. Domestic manufactures sprang into new life under such encouragement; everyone who had spare wealth converted it into manufacturing capital. The probability of such a result had been the means of getting votes for an increased tariff; free traders had voted for it as well as protectionists. For the tariff was only a means of getting capital into positions in which taxation could be applied to it, and the internal revenue taxation was merciless beyond precedent. The annual increase of wealth from capital was then about $550,000,000; the internal revenue taxation on it rose in 1866 to $310,000,000 or nearly 60%.

The stress of all this upon the poor must have been great, but it was relieved in part by the bond system on which the war was conducted. While the armies and navies were expending future income that would be realized from the crops of 1880 or 1890, work and wages were abundant for all who nere qualified and able. It is true, then, that the poor paid most of the cost of the war; it is also true that the poor had shared in that anticipation of the future which had been forced on the country. and that. when the drafts on the future came to be redeemed, it was done mainly by taxation on luxuries. The destruction of a northern railway meant more work for northern iron mills and their workmen. The destruction of a southern road was an unmitigated injury; it had to be made good at once. by paper issues; the south could make no drafts on the future, by bond issues, for the blockade had put cotton out of the game, and southern bonds were hardly salable. Every expense had to be met by paper issues; each issue forced prices higher. *A Rebel War-Clerk's Diary* gives the following as the prices in the Richmond market for May 1864: "Boot. $200; coats, $350; pantaloons, $100; shoes. $125; flour. $275 per barrel; meal, $60 to $80 per bushel; bacon, $9 per pound; no beef in market; chickens. $30 per pair; shad, $20; potatoes, $25 per bushel; turnip greens. $4 per peck; white beans, $4 per quart or $120 per bushel; butter, $15 per pound; wood, $50 per cord."

The complete lack of manufactures told heavily against the south from the beginning. As men were drawn from agriculture in the north and west, the increased demand for labour was shaded off into an increased demand for agricultural machinery; every increased percentage of power in reaping machines liberated so many men for service at the front. The reaping machines of the south—the slaves—were incapable of any such improvement and, besides, required the presence of a portion of the possible fighting men at home to watch them. But no insurrection took place

The pressing need for men in the army made the Confederate congress utterly unable to withstand the growth of executive poner. Its bills were prepared by the cabinet, and the action of congress was quite perfunctory. The suspension of the writ of habeas corpus, and the vast powers granted to President Davis, or assumed by him, made the Confederate government almost a despotism. It was not until the closing months of the war that the expiring Confederate congress mustered up courage enough to oppose the president's will.

The Emancipation Proclamation. — At the beginning of the war the people and leaders of the north had not desired to interfere uith slavery, but circumstances had been too strong for them. Lincoln had declared that he meant to save the union as best he could—by preserving slavery, by destroying it or by destroying part and preserving part. Just after the battle of Antietam (Sept. 17, 1862) he issued his proclamation calling on the rebellious states to return to their allegiance before the next year, othernise their slaves would be declared free men. No state returned and the threatened declaration was issued on Jan. 1. 1863. As president. Lincoln could issue no such declaration; as commander in chief of the armies and navies of the Cnited States he could issue directions only as to the territory within his lines; but the Emancipation Proclamation applied only to territory outside of his lines. It has therefore been debated whether the proclamation was in reality of any force. It may fairly be taken as an announcement of the policy which was to guide the army and as a declaration of freedom taking effect as the lines advanced. At all events, this was its exact effect. Its international importance was far greater. The locking up of the world's source of cotton supply had been a general calamity, and the Confederate government and people had steadily expected that the British and French governments would intervene in the war. The conversion of the struggle into a crusade against slavery made intervention impossible.

The Victory of the North. — The turning point of the war was evidently in the early days of July 1863, when the victories of Vicksburg and Gettysburg came together. The national government had at the beginning cut the Confederate states down to a much smaller area than might well have been expected; its armies had pushed the besieging lines far into the hostile territory; and the war itself had developed a class of generals who cared less for the conquest of territory than for destroying the opposing armies. The great drafts on the future which the credit of the federal government enabled the north to make gave it also a startling appearance of prosperity; so far from feeling the nar. it was driving production of every kind to a higher pitch than ever before.

The war had not merely developed improved weapons and munitions of war; it had also spurred the people on to a more careful attention to the welfare of the soldiers, the fighting men drann from their own number. The sanitary commission, the Christian commission and other voluntary associations for the physical and moral care of soldiers, received and disbursed very large sums. The national government was paying an average amount of $2,000,000 per day for the prosecution of the mar and. in spite of the severest taxation, the debt grew to $500,000,000 in June 1862, to twice that amount a year later, to $1,700,000,000 in June 1864 and reached its maximum on Aug. 31, 1863' —$2,845,907,626. But this lavish expenditure nas directed with energy and judgment. The blockading fleets were kept in perfect order and with every condition of success. The railway and telegraph were brought into systematic use for the first time in modern warfare. Late in 1863 Edwin M. Stanton, the secretary of war, moved two corps of 23 000 men from Washington to Chattanooga. 1,200 mi., in seven days.

Conscription. — On the other hand. the federal armies now held almost all the great southern through lines of railway, except the Georgia lines and those which supplied Lee from the south. The want of the southern people was merely growing in degree, not in kind. The conscription, sweeping from the first, had become omnivorous; toward the end of the war every man between 17 and 55 was legally liable to service, and in practice the only limit was physical incapacity. In 1863 the federal government also mas driven to conscription. The first attempts to carry it out resulted in forcible resistance in several places. the worst being the "draft riots" in New York (July), when the city was in the hands of the mob for several days. All the resistance was put down; but exemptions and substitute purchases were so freely permitted that the draft in the north had little effect except as a stimulus to the states in filling their quotas of volunteers by voting bounties.

Election of 1864. — In 1864 Lincoln was re-elected with Andrew Johnson as vice-president. The Democratic convention had declared that, after four years of failure to restore the union by war, during which the constitution had been violated in all its parts under the plea of military necessity, a cessation of hostilities ought to be obtained, and had nominated Gen. George B. McClellan and G. H. Pendleton. Farragut's victory in Mobile bay (Aug. 5), by which he sealed up the last port, except Wilmington, of the blockade-runners, and the evidently staggering condition of the confederate resistance in the east and the west, were the sharpest commentaries on the Democratic platform; its candidates carried only 3 of the 25 states taking part in the election. The 36th state — Nevada — had been admitted in 1864.

Surrender of Lee. — The actual fighting of the war ended with the surrender of Gen. Robert E. Lee to Gen. U. S. Grant at Appomattox, Va., April 9, 1865. All the terms of surrender named by Grant were generous: no private property was to be surrendered; both officers and men were to be dismissed on parole, not to be disturbed by the Gnited States government so long as they preserved their parole and did not violate the laws; and he instructed the officers appointed to receive the paroles "to let all the men who claim to own a horse or mule take the animals home with them to work their little farms." Gen. Joseph E. Johnston, with the only other considerable army in the field, surrendered on much the same terms at Durham Station, N.C. (April 26), after an unsuccessful effort at a broader settlement. All organized resistance had now ceased; union cavalry were ranging the south, picking up government property or arresting leadtrs; but it was not until May that the last detached parties of Confederates gave up the contest. (For the military events oi the war, *see* AMERICAN CIVIL WAR.)

Death of Lincoln. — Just after Lee's surrender President Lincoln was assassinated on April 15. Even this event did not impel the U.S. people to any vindictive use of their success for the punishment of individuals. In the heat of the war, in 1862. congress had so changed the criminal law that the punishment of treason and rebellion should no longer be death alone, but death or fine and imprisonment. Even this modified punishment was not inflicted. There was no hanging; some of the leaders were imprisoned for a time, but never brought to trial.

The Armies. — The armies of the Confederacy are supposed to have been at their strongest (700,000) at the beginning of 1863; and it is doubtful whether they contained 200.000 men in March 1865. The dissatisfaction of the southern people at the manner in which Davis had managed the war seems to have been profound; and it was converted into hero worship only by the ill-advised action of the federal government in arresting and imprisoning him. Desertion had become so common in 1861, and the attempts of the Confederate government to force the people into the ranks had become so arbitrary, that the bottom of the Confederacy had dropped out of it before Gen. William T. Sherman moved northward from Savannah) Ga. On the contrary, the numbers of the federal armies increased steadily until March 1865, when they were a few hundreds more than 1,000,000. As soon as organized resistance ceased, the disbanding of the men began; they were sent home at the rate of about 300,000 a month, about 50,000 being retained in service as a standing army.

Cost of the War. — The direct cost of the Civil War has been variously estimated. the best estimate including the first three years of Reconstruction being $5,000,000,000 to the north and $3,000,000,000 to the south. But if pensions. interest and other such items up to 1910 are included, the result is a total of between $11,000,000,000 and $12,000,000,000 for the north alone. But the cost to the south also was enormous; $4,000,000,000 cannot be an exaggeration. (A. J.; X.)

FROM 1865 TO 1910

The capitulation of Lee, followed by the assassination of Lincoln and the surrender of the last important Confederate army, under J. E. Johnston, marked the end of the era of war and the beginning of that of Reconstruction, which involved a revolution in the social and political structure of the south, in the relation of state and nation in the American federal union and in the economic life of the whole country.

Condition of the South. — Economically the condition of the south was desperate. The means of transport were destroyed; railways and bridges were ruined; southern securities were valueless; the Confederate currency system was completely disorganized. Emancipated Negroes wandered idly from place to place, trusting the union armies for sustenance, while their former masters toiled in the fields to restore their plantations.

The social organization of the south had been based on Negro slavery. Speaking generally, the large planters had constituted the dominant class, especially in the cotton states; and in the areas of heaviest Negro population these planters had belonged for the most part to the old Whig party. Outside of the larger plantation areas, especially in the hill regions and the pine barrens, there was a population of small planters and poor whites who belonged in general to the Democratic party. In the mountain regions: where slavery had hardly existed, there were union areas, and from the poor whites of this section had come Andrew Johnson, senator and war governor of Tennessee, who was chosen vice-president on the union ticket with Lincoln in 1864 as a recognition of the union men of the South.

The North. — The importance of personality in history was clearly illustrated when the wise and sympathetic Lincoln, who had the confidence of the masses of the victorious north, was replaced by Johnson, opinionated and intemperate, whose antecedents as a Tennessean and Democrat, and whose state rights principles and indifference to norihern ideals of the future of the Negro made him distrusted by large numbers of the Union Republican party.

The composition of this party was certain to endanger its stability when peace came. It had carried on the war by a coalescence of Republicans, War Democrats, Whigs, Constitutional Unionists and Native Americans, who had rallied to the cause of national unity. At the outset it had asserted that its purpose was not to interfere with the established institutions in slave states, but to defend the constitution and to preserve the union. But the war had destroyed slavery, as well as preserved the union, and the civil status of the Negro and the position of the former Confederate states now became burning questions. To the extremists of the radical wing it seemed in accordance with the principles of human liberty that the Negro should not only be released from slavery but should also receive full civil rights. including the right to vote. This group was also ready to revolutionize southern society by destroying the old ascendancy of the great planter class.

For many years before the war, parties had differed on such important questions as the tariff, internal improvements and foreign policy; and the south had used its alliance with the northern Democrats to resist the economic demands of the industrial interests of the north. A return of southern congressmen might mean a revival of the old political situation, with the south and the northern Democrats once more in the saddle.

Attitude of the Two Sections.—Any attempt to restore the south to full rights, therefore, without further provision for securing for the freedmen the reality of their freedom, and without some means of establishing the political control of the victorious party, mould create party dissension. Even Lincoln had aroused the bitter opposition of the radical leaders by his generous plan of reconstruction. Johnson could have secured party support only by important concessions to the powerful leaders in congress; and these concessions he was temperamentally unable to make. The masses of the north, especially in the first rejoicings over the peace, were not ungenerous in their attitude; and the south as a whole, accepted the results of defeat in so far as to acquiesce in the permanence of the union and the emancipation of the slaves, the original issues of the war.

Reconstruction.—In the settlement of the details of reconstruction. however, there were abundant opportunities for the hatred engendered by the war to flame up once more. As it became clear that the northern majority was determined to exclude the leaders of the south from political rights in the reconstruction of the union, and especially as the radicals disclosed their purpose to ensure Republican ascendancy by subjecting the section to the rule of the loyalist whites and, later to that of the emancipated Negroes, good will disappeared, and the south entered upon a fight for its social system. The natural leaders of the people. men of intelligence and property, had been the leaders of the section in the war. Whatever their views had been at first as to secession, the great majority of the southern people had followed the fortunes of their states. To disfranchise their leaders was to throw the control into the hands of a less able and small minority of whites; to enfranchise the Negroes while disfranchising the white leaders was to undertake the task of subordinating the former political people of a section to a different race, just released from slavery, ignorant, untrained and without property.

These underlying forces were in reality more influential than the constitutional theories which engaged so much of the discussion in congress. theories which, while they afford evidence of the characteristic desire to proceed constitutionally were really urged in support of, or opposition to, the interests just named.

The most extreme northern Democrats. and their southern sympathizers, starting from the premise that constitutionally the southern states had never been out of the union, contended that the termination of hostilities restored them to their former rights in the federal union unimpaired and without further action. This theory derived support from President Lincoln's view that not states, but assemblages of individuals, had waged war against the government. The theory of the extreme Republican radicals was formulated by Sumner and Stevens. Sumner contended that, while the states could not secede. they had by naging war reduced themselves to mere territories, entitled only to the rights of territories. Stevens, appealing to the facts of secession, declared the southern states conquered provinces, subject to be disposed of at the will of the conqueror. In the end congress adopted a middle ground, holding that while the states could not leave the union, they were, in fact, out of normal relations, and that the constitutional right of the federal government to guarantee republican governments to the various states gave to congress the power to impose conditions precedent to their rehabilitation.

It is necessary to recall the initiation of reconstruction measures by President Lincoln rightly to understand the position which was taken by President Johnson. Impatient of theoretical discussion, Lincoln laid down practical conditions of restoration in his proclamation of Dec. 8, 1863. In this he offered amnesty to those who would take an oath of loyalty for the future and accept the acts of congress and the proclamation of the president with reference to slaves. From the amnesty he excepted the higher military, civil and diplomatic officers of the Confederacy as well as those who had relinquished judicial stations, seats in congress, or commissions in the army or navy and those who had treated persons in the federal service otherwise than lawfully as prisoners of war. The proclamation provided, further, that when in any of the seceding states (except Virginia, where the president had already recognized the loyal government under Gov. Francis H. Pierpont) a number of peisons not less than one-tenth of the voters in 1860 should have taken the above described oath, and, being qualified voters under the laws of the state in 1860, should have established a state government, republican in form, it should be recognized.

The First Reconstruction Bill.—Although Lincoln expressly pointed out that the admission of the restored states to representation in congress rested exclusively with the respective houses, and announced his readiness to consider other plans for reconstruction, heated opposition by the radicals in congress was called out by this proclamation. They feared that it did not sufficiently guarantee the abolition of slavery, which up to this time rested on the war powers of the president, and they asserted that it was the right of congress, rather than of the president, to determine the conditions and the process of reconstruction. In a bill which passed the house by a vote of 73 to 59 and was concurred in by the senate, congress provided that reconstruction was to be begun only when a majority of the white male citizens of any one of the Confederate states should take oath to support the constitution of the United States. The president should then invite them to call a Constitutional Convention. The electors of this convention would be required to take an oath of allegiance which excluded a much larger class than those deprived of the benefit of the amnesty proclamation, for it eliminated all who had voluntarily borne arms against the United States, or encouraged hostility to it or voluntarily yielded support to any of the Confederate governments. The bill also required that the state constitution should exclude a large proportion of the civil and military officers of a Confederate government from the right of voting, and that it should provide that slavery be forever abolished and that state and Confederate debts of the war period should never be paid. In July I864 Lincoln gave a "pocket veto" to the bill and issued a proclamation explaining his reasons for refusing to sign. The triumph of Lincoln in the election of 1864 did not clearly signify the will of the people upon the conditions of reconstruction, for the declaration of the Democratic convention that the war was a failure overshadowed the issue, and the Union party which supported Lincoln was composed of men of all parties.

The 13th Amendment.—On Jan. 31, 1865 the house concurred in the vote of the senate in favour of the 13th amendment to the constitution abolishing slavery throughout the union. Four years earlier congress had submitted to the states another 13th amendment by the terms of which no amendment should ever authorize congress to interfere with slavery within the states. But because of the war this amendment had remained unratified, and now congress proposed to place beyond constitutional doubt, or the power of states to change it, the emancipation of slaves. By Dec. 18, 1865 the amendment had been ratified and was proclaimed in force.

In the meantime. Louisiana, in accordance with Lincoln's proclamation. had adopted a constitution and abolished slavery within the state. As a result of the obstructive tactics of Sumner. aided by Democrats in the senate, congress adjourned on March 4. 1865. without having recognized this new state government as legitimate. "If we are wise and discreet." said Lincoln. "we shall reanimate the states and get their governments in successful operation with order prevailing and the Union re-established before Congress comes together in December."

President Johnson. — Such was the situation when Johnson became president upon Lincoln's death. After an interval of uncertainty in which he threatened vengeance against various southern leaders. President Johnson accepted the main features of Lincoln's policy. Congress not being in session, he was able to work out an executive reconstruction on the lines of Lincoln's policy during the summer and autumn of 1865. On May 29 he issued a proclamation of amnesty, requiring of those who desired to accept its provisions an oath to support the constitution and union, and the laws and proclamations respecting the emancipation of slaves. Certain specified classes of persons were excepted. including certain additions to those excluded by Lincoln, especially "all persons who have voluntarily participated in said rebellion and the estimated value of whose taxable property is over twenty thousand dollars.!' This provision was characteristic of Johnson. who disliked the southern planters aristocracy, and aimed at placing the preponderant power in the hands of the Democratic small farmers. As part of his system he issued another proclamation in which he appointed a governor for North Carolina and laid down a plan for reconstruction. By this proclamation it was made the duty of the governor to call a convention chosen by the loyal people of the state, for the purpose of altering the state constitution and establishing a state government. The right to vote for delegates to this convention was limited to those who had taken the oath of amnesty and who had been qualified to vote prior to the secession of the state.

Already Virginia. Tennessee. Louisiana and Arkansas had governments which had been recognized by Lincoln. Between June 13 and July 13. 1565 Johnson applied the same process which he had outlined for North Carolina to the remaining states of the confederacy. Before congress met in December all the Confederate states, except Texas (which delayed until the spring of 1866). had formed constitutions and elected governments in accordance with the presidential plan. All of their legislatures, except that of Mississippi, ratified the 13th amendment.

Gradually, however, the south turned to its former leaders to shape its policy. and the radical Republicans of the north were .alarmed at the rapidity of the process of restoration on these principles. The disorganized and idle condition of the former slaves constituted a serious element in the southern situation. as Lincoln had foreseen. The Negroes expected a grant of land from confiscated southern estates, and it was difficult to preserve order and to secure a proper labour supply.

Under these conditions the efforts of the south to provide security for their communities by bodies of white militia were looked upon with apprehension by the north, and there was sufficient conflict between the two races to give colour to charges that the south was not accepting in good faith the emancipation of the slaves. Especially irritating to northern sentiment were the so-called "black codes" or "peonage laws," passed by the newly elected southern legislatures. They rested on the belief that it was necessary that the former slaves should be treated as a separate and dependent class. Some of these imposed special disabilities upon the Negro in the matter of carrying weapons and serving as witnesses. Vagrancy laws and provisions regarding labour contracts which had precedents in colonial and British legislation. but were specifically framed to restrain the Negroes only, were common. Mississippi denied them the right to own land, or even to rent it outside of incorporated towns; South Carolina restricted them to husbandry and to farm or domestic service, unless ipecially licensed.

The Freedmen's Bureau. — The problem of succouring and protecting the Negroes had forced itself upon the attention of the north from the beginning of the war. and on March 3, 1865 congress had created the Freedmen's bureau with the power to assign abandoned lands. in the states where the war had existed. to the use of the freedmen; to supervise charitable and educational activities among them; to exercise jurisdiction over controversies in which a freedman was a party; and to regulate their labour contracts. The local agents of the bureau were usually northern men: some of them gave the worst interpretation to southern conditions and aroused vain hopes in the Negroes that the lands of the former masters would be divided among them; and later many became active in the political organization of the Negro.

Although the national government itself had thus recognized that special treatment of the freedmen was necessary, congress. on assembling in Dec. 1865. was disposed to regard the course of the south in this respect with deep suspicion. Moreover. as the 13th amendment was now ratified, it was seen that the south, if restored according to the presidential policy. would return to congress with added representatives for the freed Kegroes. Only three-fifths of the Kegro slaves had been counted in apportioning representatives in congress; though now free they were not allowed to vote. Under the leadership of the radicals, congress refused, therefore, to receive the representatives of the states which had met the conditions of the president's proclamations. A joint committee of 15 took the whole subject of reconstruction under advisement. and a bill was passed continuing the Freedmen's bureau indefinitely. When this was vetoed by President Johnson (Feb. 19, 1866) congress retaliated by a concurrent resolution (March 2) against admitting any reconstructed state until congress declared it entitled to recognition. thus asserting for the legislative body the direction of reconstruction.

While the measure was under consideration the president in an intemperate public address stigmatized the leaders of the radicals by name as labouring to destroy the principles of the government and even intimated that the assassination of the president was intended. It was hardly possible to close the breach after this, and the schism between the president and the leaders of the Union Republican party was completed when congress passed (April 9. 1866) the Civil Rights bill over Johnson's veto. The act declared the freedmen to be citizens of the United States with the same civil rights as white persons and entitled to the protection of the federal government.

The 14th Amendment. — To place this measure beyond the danger of overthrow by courts or by a change of party majority, on June 13. 1866. congress provided for submitting to the states a 14th amendment to the constitution. This gave constitutional guarantee of citizenship and equal civil rights to freedmen. and in effect provided that when in any state the right to vote should be denied to any of the male inhabitants 21 years of age and citizens of the United States, except for participation in rebellion or other crime, the basis of representation in the state should he reduced in the proportion which the number of such citizens bore to the whole number of male citizens 21 years of age in the state. This section of the amendment, therefore, left the states the option between granting the suffrage to the Negro or suffering a proportionate reduction in the number of representatives in congress. It was a fair compromise which might have saved the south from a long period of misrule and the north from the ultimate breakdown of its policy of revolutionizing southern political control by enfranchisement of the Negroes and disfranchisement of the natural leaders of the whites.

In order to ensure the passage of this amendment the radical leaders proposed bills which declared that. after its adoption. any of the seceding states which ratified it should be readmitted to representation. But it also provided that the higher classes of officials of the Confederacy should be ineligible to office in the federal government. These bills were allowed to await the issue of the next election.

For further protection of the rights of the Negro. congress succeeded in passing. over President Johnson's veto. an act continuing the Freedmen's bureau for two years. Tennessee, having ratified the 14th amendment, was (July 24, 1866) restored to representation and congress adjourned, leaving the issue between the president and the legislative body to the people in the congressional elections.

Party Changes.—The campaign brought with it some realignment of party. President Johnson. having broken with the leaders of the Union Republican party, was more and more forced to rely upon Democratic support. although his executive appointments were still made from the ranks of the Republicans. The so-called National Union convention, which met in Philadelphia in midsummer in an effort to abate sectionalism, and to endorse the president's policy, included a large number of war Democrats who had joined the Union party after the secession of the south, many moderate southerners, a fragment of the Republican party, and a few Whigs, especially from the border states. They claimed that the southern states had a right to be represented in congress. Other meetings friendly to the radicals were called, and under the designation of Union-Republican party they declared for the congressional policy. While the campaign for elections to congress was in progress the president made a journey to Chicago, speaking at various cities en route and still further alienating the Republicans by abuse of his opponents. As a result of the autumn elections two-thirds of the members of the house of representatives were opposed to him. Almost contemporaneously every seceding state except Tennessee rejected the 14th amendment, paving the way for the entire triumph of the northern extremists.

Tenure of Office Act.—In the ensuing minter and spring congress completed the conquest of the president. awed the supreme court. and provided a drastic body of legislation to impose Negro suffrage on the south. By the Tenure of Office act (March 2, 1867) congress forbade the president to remove civil officers without the consent of the senate, and at the same time by another act required him to issue military orders only through the general of the army (Grant), whom the president was forbidden to remove from command or to assign to duty at another place than Washington. unless at the request of the officer or by the prior assent of the senate. These extraordinary invasions of the presidential authority were deemed necessary to prevent Johnson from securing control of the military arm of the government, and to protect Edwin Stanton, the secretary of war, and General Grant. Fearing the president might take advantage of the interim when congress would not be in session, the 40th congress was required to meet on March 4. immediately following the expiration of the 39th.

Other Legislative Acts.—The Reconstruction act of March 2, 1867, provided for the military government of the southern states while the drastic policy of congress was being carried out. It was passed over the veto of the president and declared that no legal governments or adequate protection for life or property existed in the seceding states, except Tennessee. These states it divided into five military districts) each to be placed under the command of a general of the army. whose duty it was to preserve law and order. But the existing civil governments were declared provisional only and subject to the paramount authority of the United States to abolish, modify, control or supersede them. The act further provided that a constitutional convention might be elected by the adult male citizens of the state, of whatever race, colour or previous condition, resident in the state for a year, except such as might be disfranchised for rebellion or felony.

When the convention, thus chosen under Negro suffrage, and with the exclusion of Confederate leaders, should have framed a state constitution conforming to the federal constitution and allowing the franchise to those entitled to vote for the members of the convention. the constitution was to be submitted for the approval of congress. If this were obtained and if the state adopted the 13th amendment. and this amendment became a part of the federal constitution: then the state should be entitled to representation in congress; but the senators and representatives sent to congress were required to take the "iron-clad oath," which excluded those who had fought in the confederate service? or held officeunder any government hostile to the United States, or given support to any such authority.

By the pressure of military control congress thus aimed at forcing the adoption of the 14th amendment, as well as the acceptance of Negro suffrage in the state constitutions of the south. A supplementary act of March 23, 1867, and an act of interpretation passed on July 19 completed this policy of "thorough." In the registration of voters the district commanders were required to administer an oath which excluded those disfranchised for rebellion and those who after holding state or federal office had given aid and comfort to the enemies of the United States.

Supreme Court Decisions.—Against this use of military power to govern states in time of peace the supreme court interposed no effective obstacle. Like the executive it was subordinated to congress. It is true that in the case *ex parte Milligan,* decided in Dec. 1866, the court held military commissions unlawful where the ordinary civil tribunals were open. In the case of *Cummings* v. *Missouri* (Jan. 14, 1867) it decided also that a state test oath excluding Confederate sympathizers from professions was a violation of the prohibition of ex post facto laws; and the court (ex *parte Garland*) applied the same rule to the federal test oath so far as the right of attorneys to practise in federal courts mas concerned.

But threats were made by the radicals in congress to take away the appellate jurisdiction of the court, and even to abolish the tribunal by constitutional amendment. The judges had been closely divided in these cases and, when the real test came. the court refused to set itself in opposition to congress. When Mississippi attempted to secure an injunction to prevent the president from carrying out the reconstruction acts, and when Georgia asked the court to enjoin the military officers from enforcing these acts in that state, the supreme court refused (April and May 1867), pleading want of jurisdiction. Chief Justice Salmon P. Chase argued that if the president refused to obey, the court could not enforce its decree, while if he complied with the order of the court, and if the house of representatives impeached him for refusing to enforce the law, the supreme court would he iorced to the vain attempt to enjoin the senate from sitting as a court of impeachment.

In one instance it seemed inevitable that the court would clash with congress; the McCardle case involved an editor's arrest by military authority for criticizing that authority and the reconstruction policy. But congress, apprehending that the majority of the court would declare the reconstruction acts unconstitutional, promptly repealed that portion of the act which gave the court jurisdiction in the case, and thus enabled the judges to dismiss the appeal. Afterward, when the reconstruction policy had been accomplished, the court, in the case of *Texas* v. *White* (1869), held that the constitution looked to "an indestructible Cnion composed of indestructible states"; and that although the secession acts were null, and the federal obligations of the seceding states remained unimpaired, yet their rights were suspended during the war.

Impeachment of President Johnson.—The powerful leaders of the Republicans in congress had been awaiting their opportunity to rid themselves of President Johnson by impeachment. For full details of these efforts *see* JOHNSON, ANDREW. His trial in the spring of 1868, however, by the senate resulted in a verdict of acquittal.

"Carpetbaggers."—Meanwhile the military reconstruction of the south and the organization of the Negro vote progressed effectively. The party management of the Negroes was conducted by "carpetbaggers,!' as the northern men who came south to try their fortunes were nicknamed, and by the white loyalists of the south, to whom was given the name "scalawags." In the work of marshaling the freedmen's vote for the Republican party secret societies like the Loyal league, or Union league played an important part. As the newly enfranchised mass of politically untrained Negroes passed under northern influence politically, the southern whites drew more and more together and although they were unable under the existing conditions to take control, they awaited their opportunity. A solid south was forming in which old party divisions gave way to the one dominant antagonism to Republican ascendancy by Negro sufirage. Politically the important fact was that the Republicans had rejected the possibility of reviving the old party lines in the south, and had gambled upon the expectation of wielding the united Negro vote with such leadership and support as might be gained from former Northerners and loyal ahites. In the end Negro rule failed. as was inevitable when legal disabilities and military force were removed; but the masses of the southern whites emerged with a power which they had not possessed under the old rule of the planters aristocracy. For the time being, however, Segro votes gave control to the Republicans. In South Carolina, Florida, Alabama, Mississippi and Louisiana the Segroes were in a majority; in Virginia, North Carolina. Arkansas and Texas they were in the minority; while in Georgia the two races were nearly evenly balanced.

Ku-Klux Klan.—The white leaders of the south were divided as to the best means of meeting the problem. Some advocated that those entitled to vote should register, and then refrain from the polls, in order to defeat the constitutions made under Negro suffrage, for the law required them to be ratified by a majority of the qualified voters. Others would have the white race bear no part in the process. Societies such as the Ku-Klux Klan and the Knights of the White Camelia were organized to intimidate or restrain the freedmen. But for the present the Republicans carried all before them in the south. Some of the new state constitutions imposed severe disfranchisement upon the former dominant class, and before the end of July 1868 all of the former Confederate states, except Virginia, Mississippi and Texas, had ratified the 14th amendment, which was proclaimed in effect. By the beginning of 1870 these three states had also ratified the amendment, as had Georgia a second time, because of its doubtful status at the time of its first ratification.

The Southern States Restored to the **Union.**—By the summer of 1868 Arkansas, South Carolina, North Carolina, Georgia, Alabama, Louisiana and Florida, having satisfied the requirements of the reconstruction acts, were entitled to representation in congress. But Georgia did not choose its senators until after the adjournment of congress, and, inasmuch as the state excluded the Negro members of the legislature in September, congress on reassembling returned the state to military rule until its submission. Alabama was restored in spite of the fact that its white voters had remained away from the polls in sufficient numbers to prevent a majority of all the voters registered from having ratified the constitution. The nominating conventions and the campaign of 1865 gave interesting evidence of the trend of political and economic events. Party lines, which had broken down in the north when all united in saving the union, were once more reasserting themselves. President Johnson, who had been elected by the Union Republican party, had found his most effective support among the Democrats. The Republicans turned to General Grant, a Democrat before the outbreak of the war.

Grant Nominated.— The Republican nominating convention met on May 20, 1868, a few days after the failure of the impeachment proceedings, and it chose Grant as the candidate for the presidency. The platform supported the congressional reconstruction measures. Upon the vital question whether universal Negro suffrage should be placed beyond the power of states to repeal it by a new constitutional amendment, the platform declared: "The guarantee by Congress of equal suffrage to all loyal men at the South was demanded by every consideration of public safety, of gratitude and of justice, and must be maintained; while the question of suffrage in all the loyal states properly belongs to the people of those states." Nowhere in the north was the Negro an important element in the population, but the north had shown an unwillingness to apply to itself the doctrines of Negro rights which had been imposed upon the south. Between 1865 and 1868 Connecticut, Wisconsin, Minnesota, Kansas, Ohio and Michigan had refused to give the Negro the right to vote within their own bounds, and this plank was evidence of the unwillingness of the party to make a direct issue of universal Negro suffrage. The platform pronounced in favour of payment of the public debt, not only according to the letter hut the spirit of the laws under which it was contracted. The significance of this lay in its challenge to the Democratic agitation on the currency question.

It was this question which gave the tone to the proceedings of the Democrats at their convention in July 1868. The situation can best be presented by a brief review of the financial history just preceding the convention. Together with the discussion over political reconstruction in the south. congress and the administration had been obliged to deal with the reconstruction of debt, taxation and currency in the nation at the close of four years of expensive war. The problems of funding, readjustment of taxation and resumption of specie payments proved to be so complicated with the industrial growth of the nation that they led to issues destined to exert a long-continued influence.

Finance.— The various war tariffs, passed primarily for the sake of increased revenue, had been shaped for protection under the influence of the manufacturing interests, and they had been framed also with reference to the need of compensating the hea y internal taxes which were imposed upon the manufacturers. When the war ended, public sentitnent demanded relief from these heavy burdens, especially from the irksome internal taxes. The rapidly growing grain-raising districts of the middle west exhibited a lively discontent with the protective tariff. but this did not prevent the passage in 1867 of the Wóol and Woolens act, which discriminated in favour of the woolen manufacturers and raised the ad valorem duty on wool. In spite of several large reductions of internal revenue, the national debt was being rapidly extinguished.

The currency question, however. furnished the economic issue which was most debated. One set of interests aimed at rapidly reducing the volume of the currency by retiring the legal tender notes, or greenbacks. The secretary of the treasury, Hugh McCulloch, pressed this policy to the foreground, and desired authority to issue bonds to retire these notes. Another set of interests demanded the retention of the greenbacks, supporting their views by arguments varying according to the degree of radicalism of the speakers. The more moderate, like Sen. John Sherman, of Ohio, who reflected the views of parts of the west, argued that the recuperation of the nation and the rapid increase of business would absorb the existing currency, while gold would cease to go abroad. Thus, by the increasing credit of the government, specie payment would be automatically resumed. The most extreme, so far from contracting the currency by retiring the greenbacks, wished to increase this form of money, while diminishing the circulation of the notes of the national banks. The discussion tended to produce a sectional issue with the west against the east, and a social issue with bondholders and the creditor class in general arrayed against the less well-to-do. Congress agreed with Secretary McCulloch, and in the Funding act of 1866 not only provided for converting short-time securities into long-term bonds, but also for retiring $10,000~000 of greenbacks in six months and thereaiter not more than $4,000,000 monthly. But the agricultural depression of 1866 produced a reaction. Loud demands were made that bonds should be paid in greenbacks instead of coin and the national banknotes suppressed. In 1868, on the eve of the presidential campaign! congress! alarmed by the extent of these popular demands, suspended the process of contraction after $40,000,000 in greenbacks had been retired. Ohio was the storm centre of the agitation. The "Ohio idea" that greenbacks should become the accepted currency of the country was championed by George H. Pendleton, of that state, and his friends now brought him forward for the Democratic nomination for president on this issue. In the national convention of that party they succeeded in incorporating into the platform their demands that there should he one currency for the government and the people, the bondholder and the producer, arid that where the obligations of the government did not expressly provide for payment in coin, they should be paid in lawful money (*i.e.,* greenbacks) of the United States.

But another wing of the Democratic party desired to make prominent the issue against the reconstruction measures of the Republicans. This wing added to the platform and declaration that these acts were unconstitutional and void. and the demand that the southern states should be restored to their former rights and given control over their own elective franchise.

Democrats Nominate Seymour.— Although the followers of

Pendleton had shaped the financial plank of the platform, they could not nominate their leader. The opposition was at first divided between the various candidates. New York, mhich feared the effect upon the conservative financial interests of the east if Pendleton were nominated, attempted to break the deadlock by proposing an Ohio man, Chief Justice Chase. But eager as Chase was for the presidency he had flatly refused to abandon the views which he held in favour of Negro suffrage. Ohio was, therefore, able to retaliate by stampeding the convention in favour of Horatio Seymour, of New Uork. As the war governor of his state he had been a consistent critic of the extremes to which the federal administration had carried its interpretation of the war power. For vice-president the convention nominated Francis P. Blair of Missouri.

Grant Elected. — But the popularity of Grant' in the north, together with the Republican strength in the states of the south mhich had been reconstructed under Negro suffrage. gave an easy victory to the Republicans in the election of 1868. Seymour carried only Delaware, New Jersey, New York and Oregon, of the north; and Maryland, Kentucky, Georgia and Louisiana of the south. Tennessee. and five of the former Confederate states, upon which Negro suffrage had been imposed (North Carolina, South Carolina. Florida, Alabama and Arkansas) voted for Grant. Virginia, Mississippi and Texas had not yet been restored.

The 15th Amendment. — This decisive victory and the knowledge that it had been won by the advantage of the Negro vote in the restored states led the Republican leaders 'to ignore their recent platform declaration in regard to Negro suffrage. Shortly after congress assembled propositions were made to place the freedman's right to vote beyond the power of the states to change. To do this by constitutional enactment it was necessary to make the provision universal, and congress, therefore, submitted for ratification the 15th amendment declaring that "the right of citizens of the United States to vote shall not be denied or abridged by the United States or by any state on account of race: color or previous condition of servitude." Congress was given power to enforce the amendment by appropriate legislation. By March 30, 1870 the amendment had been ratified; but it is doubtful whether this could have been accomplished by legislatures chosen on the issue. As it was, the states of Virginia, Mississippi, Texas and Georgia were required to ratify it as a condition of their readmittance to representation in congress, and the three former states. having been permitted to vote separately on the obnoxious provisions of their constitutions in regard to the disfranchisement of former Confederates, rejected those clauses: adopted the 15th amendment and were restored in 1870. Georgia, after a new experience of military rule, likewise ratified the amendment, and its representatives were likewise admitted to congress.

As soon as the 15th amendment was proclaimed in effect, and the military governments of the south were superseded, the dominant party proceeded to enact measures of enforcement. These seemed especially necessary in view of the fact that, partly by intimidation of the Negro vote, Louisiana (1868) and Tennessee (1869) broke away from the Republican column; while in the election of 1870 Tennessee, North Carolina, Georgia, Virginia and Alabama went Democratic. The enforcement legislation of 1870 provided penalties for violating the 14th and 15th amendments and re-enacted the Civil Rights act of 1866. In the years 1871 and 1872 acts were passed providing for effective federal supervision of congressional elections, and the Ku-Klux acts (1871 and 1872) still further increased the power of the federal courts to enforce the amendments and authorized the president to suspend the writ of habeas corpus and use military force to suppress public disorders. But these stern measures were accompanied by some efforts to restore harmony, such as the repeal' of the "iron-clad oath" for former Confederates! in 1871, and the passage of the General Amnesty act of 1872. The north was becoming restive under the long-continued use of the federal military arm within state borders in time of peace.

Reconstruction Governments. — In any case the cost of rehabilitating the public works and providing education and the political and judicial institutions which should apply equally to the hitherto nonpolitical class of the Negroes: would have been a heavy one. But the legislatures, especially of Louisiana. South Carolina, Tennessee, Arkansas and Alabama, plunged into an extravagance made possible by the fact that the legislatures contained but few representatives who paid considerable taxes. In 1872 it was estimated that the public debts of the 11 reconstructed states amounted to nearly $132,000,000, two-thirds of which was composed of guarantees to corporations. Legislative expenses were grotesquely extravagant. the Negro members in some states engaging in a saturnalia of corrupt expenditure. This alienated from the so-called Radical party the support of southern whites, because they resented the concessions of the carpetbag leaders to the Negro vote, because they suffered from the burden of taxation. and above all because race friction increased.

By 1872 a coalition had been formed under the name of Conservatives. But the control of electoral machinery in the strongly centralized state executives chosen by Negro votes, and coercion by the federal authority, still upheld Republican rule in various southern states. Virginia and North Carolina were practically bankrupt. the capitals of Louisiana. Arkansas and Alabama, where rival state officers claimed possession, were occupied by federal troops, and many of the governments were so corrupt that only the comparable practices in New Uork city and in certain branches of the federal government afford a parallel.

Southern Changes.——An important economic reorganization was in progress in the south. White districts were recovering from the war and were becoming the productive cotton areas by the use of fertilizers and by more intelligent management. Cities were rising, and the mines and manufactures of the southern Appalachians were developing. In the "black belt." or region of denser Negro settlement the Negroes became tenant farmers, or workers on shares. The effective and just direction of Negro labour was a difficult problem and was aggravated by the political agitation which intensified race friction. It became evident that there was a Negro problem as well as a slavery question, and that the north was unable to solve it.

Foreign Relations. — In the meantime important foreign relations had been dealt with by Secretary William H. Seward. under Johnson, and by Secretary Hamilton Fish: under Grant. Not only were many treaties of commerce and extradition, including one with China, negotiated by Seward, but he also brought about a solution of more important diplomatic problems. The relations of the United States with France and Great Britain had been strained in the course of the war. Not only had Napoleon III been inclined to recognize the Confederacy, but he had also taken advantage of the war to send into Mexico a French army in support of the emperor Maximilian. The temptation to use force while American military prestige was high appealed even to General Grant; but Seward by firm and cautious diplomatic pressure induced France to withdraw its troops in 1867, and the power of Maximilian collapsed. Russia's friendly attitude throughout the war was signalized by its offer to sell Alaska to the United States in 1867. Seward promptly accepted it and the treaty was ratified by the senate and the purchase money ($7,200,000) was voted by the reluctant house, which saw little in the acquisition to commend it.

With Great Britain, affairs were even more threatening than with France. Confederate cruisers (notably the "Alabama"), built in England and permitted by the negligence of the British government to go to sea; had nearly swept the American merchant marine from the ocean. Unsettled questions of boundary and the fisheries aggravated the ill feeling, and Britain's refusal in 1865 to arbitrate made a serious situation. Prolonged negotiations followed a change of attitude of Great Britain with regard to arbitration. and in 1870 President Grant recommended to congress that the Cnited States should pay the claims for damages of the Confederate cruisers? and thus assume them against Great Britain. However, in 1871, the treaty of Washington was negotiated under Secretary Fish, by the terms of which Great Britain expressed regret for the escape of the cruisers and provided for arbitration of the fisheries, the northwestern boundary and the "Alabama" claims. The case of the Cnited States was victorious, the tribunal awarding damages against Great Britain to the amount of $15 500,000 Two months later the German emperor gave to the Cnited States the disputed northweit boundary, including San Juan Island in Puget sound.

In the West Indies also important question? were presented Senard had negotiated a treaty of purchase of the Danish West Indies, but the senate refused to ratify it, nor did Grant's attempt to acquire Santo Domingo meet with a different fate at the hands of that body (1870) In Cuba another insurrection was in progress. Secretary Fish "pigeon-holed" a proclamation of President Grant recognizing the Cubans as belligerents, and secured a policy of neutrality which endured even the shock of the "Virginius" affair in 1873, when 50 of the men of the filibustering steamer flying the American flag were shot by the Spanish authorities It was shonn that the vessel had no right to the flag Negotiations for an isthmian canal resulted only in a treaty with Nicaragua in 1868 giving to the United States a right of way across the irthmus and providing for a government survey of the Panamá route

It was in the field of domestic concerns, in economic and social development, that the most significant tendencies appeared The old issues were already diminishing in importance before the other aspect of reconstruction which came from the revived expansion of the nation toward the west and the new forms taken by the development of American industrial society.

Finance. — The Republican party, following the traditions of the Whigs, was especially responsive to the demands of the creditor class. who demanded legislation to conserve their interests. Its victory in 1868 was signalized by the passage in the spring of the following year of an act pledging the faith of the United States to pay in coin or its equivalent all the obligations of the United States. except in cases where the law authorizing the issue had expressly provided otherwise. In 1870 and 1871 refunding acts were passed. providing for the issue of bonds to the total amount of S1.800.000.000. $1,000,000,000 of which was to run for 30 years at 4%. This abandonment of the doctrine of early convertibility was made in order to render the bonds acceptable to capitalists, but in fact they soon went to a premium of more than 25%.

While the legislature was thus scrupulous of the credit of the nation and responsive to the views of capital, the supreme court was engaged in deciding the question of whether the legal tender notes (greenbacks) were constitutional. Successive decisions in 1868 determined that they were not legal in certain cases. In these decisions the judges had divided, four to three. Within a year the court was changed by the appointment of one new judge to fill a vacancy. and the addition of another in accordance with a law enlarging the court. In 1871 the former decision was reversed and the constitutionality of the Legal Tender acts sustained on loose construction reasoning. In 1884 the court went to the extent of affirming the right of congress to pass legal tender acts in time of peace. In 1871 and 1872 Secretary George S. Boutwell illustrated the power of the administration to change the volume of the currency, by issuing in all over $6,000,000 of legal tender notes; and, following the practice of his predecessors. he sold gold from the treasury to check speculations in that part of the currency.

Economic Changes. — Speculation and the rapid growth of great fortunes were characteristic of the period. The war itself had furnished means for acquiring sudden riches; the reorganization of taxation: currency and banking increased the opportunities; and the opening of new fields of speculative enterprise in the oil fields of Pennsylvania and Ohio and the gold and silver mines of the mountains of the far west tended in the same direction. An enormous development of manufactures resulted from the diminished commerce and increased demand for manufactured goods, the protection afforded by the tariff, the stimulus because of rising prices and the consumption of the rapidly growing west. It was officially reported in 1869 that "within five years more cotton spindles had been put in motion, more iron furnaces erected, more iron smelted, more bars rolled, more steel made, more coal and copper mined, more lumber sawn and hewn. more houses and shops constructed. more manufactories of different kinds started. and more petroleum collected, refined and exported, than during any equal period in the history of the country."

Pacific Railways. — Between the Civil War and 1872, the extension of the nation's activity to the industrial conquest of the great west, as well as the economic reorganization of the east, had a profound effect upon the development of the United States. Between 1862 and 1872 grants were made to the Union Pacific and Central Pacific companies, and to other connecting corporations. for railways from the Missouri to the Pacific, amounting to nearly 33,000,000 ac., and in the same period large loans of funds were made by the general government for this enterprise. Construction advanced rapidly after 1866, and by 1869 an all rail connection had been established on the line of the Union Pacific and Central Pacific railways between the east and San Francisco, Calif. Various grants were made in these years to other roads, both transcontinental and middle western. Between 1850 and 1871 congress granted about 155,000,000 ac. for railway construction. but not all these grants were perfected. It is estimated that about $500.000.000 were invested in the construction of western railways between 1868 and the panic of 1873, and about 30,000 mi. of railway had been added.

The effects of this extraordinary extension of railway transportation were immediately apparent. In the far west the railway lines rapidly made possible the extinction of the bison herds. This opened the way for the great extension of the cattle country. following the retreat of the Indians. Upon the plains Indians the effect was revolutionary. Their domain had been penetrated by the railways at the same time that their means of subsistence had been withdrawn. During the Civil War most of these western tribes had engaged in hostilities against the federal government. By the Peace Commission act of July 20. 1867, commissioners, including General Sherman, were sent to negotiate treaties. As a result the tribes of the Indian Territory were so concentrated as to permit the transfer of other western tribes to the same region. while the Sioux of the northern plains were given a reservation embracing the western portions of the Dakotas. Discontent with these treaties resulted, however, in hostilities following 1867. Between the close of the war and 1880 about $22,000,000 were expended in Indian wars; although the act of 1871 inaugurated the change of policy whereby the Indians were no longer dealt with by treaty, but were regarded as wards of the nation. to be concentrated on reservations and fed at the expense of the nation under the supervision of Indian agents.

Mining. — Part of these Indian difficulties were the result of the opening up of new mining areas in the Rocky mountains, some of them within the Indians' choicest hunting grounds. At the beginning of the Civil War a preliminary mining boom struck Colorado; the rich Cornstock lode was opened in Nevada; Arizona was the scene of mining rushes; the Idaho mines mere entered; and the Montana ores were discovered; so that in the period of the Civil War itself the territories of Nevada, Idaho and Montana had been organized. The discovery of gold in the Black hills in 1874 continued the same movement. In 1860 the nation produced $156,000 worth of silver, in 1361 over $2,000,000 and in 1873 nearly $36.000.000. Capital in mines and quarries of the United States was over $65,000,000 in 1860, over $245,000,000 in 1870, and nearly $1,500,000,000 in 1880.

The Middle West. — This revolution in the life of the Great Plains and the Rocky mountains, opening the way to agriculture and to cattle raising, and preparing for the exploitation of the precious metals of that great area, was contemporaneous with the important development of the farming regions of the middle west. Even during the Civil War the agricultural development of the northern half of the Mississippi valley had continued. This was aided by the demand for food products to supply the armies and was made possible by the extension of railways, the taking up of the prairie lands through the operation of the homestead law of 1862, the marketing of the railway land grants and the increased use of agricultural machinery in those years. Between 1860 and 1870 the population of the north central group of states increased over 42%, and in the next decade by 34%, a total addition to the population in those two decades of 8,000,000. Between 1870 and 1880 about 200.000 sq.mi. were added to the farmlands of the Cnited States: an area almost equal in extent to that of

France. In the same decade the north central states increased their improved farms from near 78,500,000 ac. to over 136,800.000 ac. The production of corn about doubled between 1860 and 1880, and that of wheat and oats more than doubled. The addition came chiefly from the middle west.

Railway Scandals. — The pressing need of increased transportation facilities had led, as we have seen, to lavish land grants and to subsidies by nation states and municipalities to the railways. The railways themselves, tempted by these opportunities, had extended their lines in some cases beyond the immediate needs of the regions Extravagances in construction and operation, aggravated by "construction rings" of railway officials and by rolling stock companies who received extravagant prices by favouritism, brought about a condition where the roads were no longer able to meet the demands of their stockholders for returns on the investment without imposing rates that the western farmer deemed extortionate. In the competitive development of these roads and in the struggle of business corporations and localities with each other, the roads also discriminated between persons and places. This condition chiefly accounted for the political unrest which manifested itself in the west in the so-called Granger movements of the 1870s.

Granger Movement. — The farmers felt the pressure of the unsettled currency. taxes were very heavy. the protective tariff seemed to them to bear unduly upon the producers of crops which exceeded the home consumption and had to seek the foreign markets. The price of corn, wheat and cotton in the early 1870s tended to fall as production rose, so that the gold value of the total crop was not greatly increased during the decade after the war, in spite of increase of production Dissatisfaction with their share in the prosperity of the country, and especially nith the charges of middlemen and transportation companies, discontent nith the backwardness of rural social conditions and a desire for larger political influence, all aided in fostering the growth of organizations designed to promote the farmers' interests. The most influential of these organizations mas the Patrons of Husbandry, which was founded in 1867 and spread chiefly after 1872 by local clubs or granges. especially in the west and south.

The height of the movement was reached in the autumn of 1874. It threatened the disruption of the old political parties in most of the middle western states. By holding the balance of power the Grangers secured legislation in many of these states. fixed maximum railway rates and provided for regulation through commissions. In the reaction after the panic of 1873 (when nearly one-fifth of the railway mileage of the United States had passed into the hands of receivers) many of the Granger laws were repealed, the regulation was rendered nominal and the railways more than regained their political power; yet the agitation had established the important principle, sanctioned by decisions of the supreme court, that the railways were common carriers subject fully to public regulation so far as it was not confiscatory. The movement for regulation of interstate commerce by congressional legislation was begun at this time under the leadership of congressmen from the Granger states. Later efforts were more wisely considered and more effective; but the rural democracy showed its opposition to the increasing political influence of capital. to special privileges and to the attempts of corporations to avoid public control periodically thereafter.

The presidential election of 1872 took place in the midst of this western upheaval At the same time in the south the reform Republicans and Democrats were uniting under the name oi Conservatives against the carpetbag rule, and control was passing into their hands A reform movement was active against the evident corruption in national and municipal administrations, for Grant's trust in his appointees was grossly violated. The Tweed ring nas systematically looting New York city, and prior to Tneed's indictment in 1871 it was acquiring large power in state legislation. Civil service reformers, men of moderate views with respect to reconstruction. many war Democrats who had adhered to the Union party, and tariff reformers began to break away

Grant Re-elected. — The Liberal-Republican movement started in Missouri. and a national convention was called to meet at Cincinnati, O., on May 1. 1872. Their platform attacked the corruption of civil service by the administration, supported the results of the war as embodied in the last three amendments and demanded amnesty and local civil government for the south. It opposed further land grants to railways, but denounced repudiation and demanded specie payments in terms which excluded from its support the advocates of inflation of the currency. This effort to combine the opponents of Grant's administration was wrecked by the nomination of Horace Greeley, a strong protectionist, who did not command the confidence of the masses of the disaffected. Although endorsed by the Democrats, Greeley was defeated by Grant, who ran on the record of the Republican party. which now dropped the word Union from its name. Greeley died before the electoral count; the Democrats won only the states of Maryland, Kentucky. Missouri. Tennessee, Georgia and Texas, the votes of Louisiana and Arkansas being thrown out.

Panic of 1873. —The enormous cost of the war. the excessive railway building, overtrading, and inflated credit and fluctuating currency, the sinking of capital in opening new farming lands and in readjusting manufactures to new conditions brought their results in the panic of 1873, precipitated by the failure (Sept. 18) of Jay Cooke. the financier of the Northern Pacific railway. For over five years the nation underwent a drastic purgation; railway building almost ceased and as late as 1877 over 18% of the railway mileage of the nation was in the hands of receivers. The iron industry mas prostrated and mercantile failures for four years amounted to $775,000,000 At the close of the period there was a replacement of partnerships and individual businesses by corporations. but in the interval political unrest was in the foreground

Crédit **Mobilier.**—The charges that congressmen had been bribed by stock in the Crédit Mobilier, a construction company controlled by Union Pacific stockholders, led to a congressional investigation which damaged the reputations of prominent Republicans, including Vice-President Schuyler Colfax; but the same congress which investigated this scandal voted itself retroactive increases of salary. and this back-pay grab created popular indignation. Evidences of fraud and corruption in revenue collection under the moiety system, and the general demoralization of the civil service continued. The demand for relief from the stringency of the crisis of 1873 expressed itself in the so-called Inflation bill (passed April 1874) providing a maximum of $400,000.000 for greenback issues. This was vetoed by Grant, but he later signed a bill accepting as a maximum the existing greenback circulation of $382,000,000. This compromise was satisfactory neither to contractionists nor greenbackers.

Republicans Lose Congress. — The tidal wave in the congressional elections of 1874 was the result of these conditions. It marked a political revolution. The house of representatives, which exhibited a two-thirds Republican majority in 1872, showed an opposition majority of about 70, and the senate was soon to be close. Such Republican strongholds as Pennsylvania. Ohio and Massachusetts went over to the Democrats in the state elections. while in the grain-raising states of the middle west the Grangers were holding the balance of power, and in the south the Republican radicals remained in force in few states and only by the use of federal troops. President Grant in his message of Dec. 1874 acknowledged that public opinion was opposed to this use of force, but declared that without it Negro suffrage would be worse than a mockery. Thus by the year 1874 the era of triumphant Republicanism and Reconstruction was closing. The leaders perceiving power about to pass from them rapidly enacted a series of party measures before the meeting of the newly elected congress. Under the leadership of Sen. John Sherman an act was passed (Jan. 14, 1573') providing for resumption of specie payments on Jan 1, 1879, gradually contracting greenbacks to $300,000,000 and compensating this by expanding the circulation of the national banks.

In the field of the tariff a similar policy was followed. The act of 1870 had somewhat reduced duties on tea, coffee. sugar and iron; but under western pressure in 1872 the Republican congress had consented to a 10% reduction on most classes of goods in order to save the general system of protection. On the eve of their relinquishment of full power the Republicans (March 3. 1875) repealed the Tariff act of 1872, increased the duties on molasses and sugar and increased the revenue tax on tobacco and spirits. Thus the tariff was restored to the war basis, before the incoming Democratic house could block the advance. Similarly on March 1 congress passed a Civil Rights act. milder than the measure for which Sumner had fought so long, guaranteeing equal rights to the Negroes in hotels, public conveyances and places of amusement and forbidding the exclusion of them from juries. An effort to pass a new force bill leveled against the intimidation of Negro voters failed. By these measures the Republicans placed the important features of their policy where they could be overturned only by a Democratic capture of presidency and senate

Supreme Court Decisions.—In the midst of these changes the supreme court handed down decisions undoing important portions of the reconstruction system by restraining the tendency of the nation to encroach on the sphere of the state; and restricting the scope of the recent constitutional amendments. On April 14, 1873, in the Slaughterhouse cases, the courts held that the amendments were primarily restrictions upon the states for the protection of the freedom of the Negro, rather than extensions of the power of the federal government under the definition of Cnited States citizenship, and that general fundamental civil rights remained under state protection In the case of the *United States* v *Reese,* decided March 27, 1876, the court declared parts of the act of 1870 (nhich provided for the use of federal force to protect the Negro in his right to vote) unconstitutional, on the ground that they did not specify that the denial of suffrage must be on the sole ground of race or colour. A reasonable prerequisite, such as a poll tax. for voting was permissible. The south later took advantage of this decision to restrain Negro suffrage indirectly. In *United States* v. *Cruikshank* (1876) the court held that the amendments to the constitution left it still the duty of the state rather than of the United States, to protect its citizens. even when whites had mobbed the Negroes. In 1883 the court declared the conspiracy clause of the Ku-Klux act unconstitutional and reitricted the application of the law to acts of a state through its officers and not to private citizens. In the same year it declared the Civil Rights act of 1875 invalid.

In 1875 President Grant refused the appeal of the carpetbagger Gov. Adelbert Ames of Mississippi to be supported by troops, whereupon Ames resigned his office to the conservatives. The Mississippi plan of general intimidation of Negroes to keep them from the polls was followed in Louisiana, South Carolina and Florida uhich alone remained Republican. Thus steadily the radical reconstruction policy and Republican control of the south were being reversed. It was made clear that Negro suffrage could be enforced upon the south only by military rule which could no longer command northern sympathy or the sanction of the federal court Northern interest increasingly turned to other issues, and especially to discontent over administrative corruption.

Corruption.—The spoils system had triumphed over the advocates of civil service reform to such an extent that Grant abandoned the competitive system in 1875 on the ground that congress did not support him in the policy. Enormous frauds in the collection of the internal revenue by the whisky ring with the connivance of federal officials were revealed in 1875, and at about the same time. Secretary of War William W. Belknap resigned to avoid impeachment for corruption in the conduct of Indian affairs. The enforced resignation in 1876 of Secretary of the Treasury Benjamin H. Bristow, after he had successfully exposed the whisky ring, and of Postmaster General Marshall Jewell, who had resisted the spoils system in his department, tended to discredit the administration. Blaine, the leader of the Republicans in the house of representatives, fell under suspicion on account of his earlier relations with the Little Rock and Fort Smith and Northern I'acific railways, which left it doubtful, in spite of his aggressive defense, whether he had not used his influence as speaker in previous congresses to secure pecuniary advantages from land grant railways.

Campaign of 1876.—Thus the campaign of 1876 approached, with the Republicans divided into (1) steadfast supporters of the Grant administration; (2) a discontented reform wing (which favoured former Secretary Bristow); and (3) an intermediate group which followed Blaine. This statesman made a bold stroke to shift the fighting which the Democrats planned to make against the scandals of the administration, to the old-time war issues. By proposing to exclude Jefferson Davis from amnesty, he goaded southern congressmen into indiscreet utterances which fanned anew the fires of sectional animosity. A compromise candidate was selected in the person of Gov. Rutherford B. Hayes. of Ohio, who had vigorously opposed the greenback movement in his state, and whose life and character, though little known to the general public. made him acceptable to the reform leaders of the party. The Democrats, demanding reform, economy, a revenue tariff and the repeal of the resumption clause of the act of 1875, chose the reform governor of New York, Samuel J. Tilden, as their candidate. The Independent National. or Greenback, party. which was to develop rapidly in the next two years, nominated Peter Cooper, a New York philanthropist, and demanded the repeal of the Resumption act, and the enactment of a law providing a paper currency.

Hayes Elected.—The election proved to be a very close contest. Tilden, according to the count of both parties, had a plurality of over 250,000 votes, and at first the leading Republican journals conceded his election. He had carried New York, Indiana, New Jersey and Connecticut and, by the Democratic count, the solid south. But the Republican headquarters claimed the election of Hayes by one electoral vote, based on the belief that the states of South Carolina, Florida and Louisiana had gone Republican. Since these states were in the midst of the transition from Negro to white government and elections were notorious for fraudulent practices, a serious question was raised. first as to the proper authority to count the electoral vote, and second, how far it was permissible to go behind the returns of the state authorities to ascertain the validity of the canvass of the votes in the state. The political capacity and moderation of the nation were severely tested; but in the end a characteristic American solution was found by the creation of an electoral commission in which five associate justices of the supreme court were joined with an equal number of representatives from each of the two houses of congress. The result was that this commission refused to "go behind the returns," and Hayes was declared elected by one vote. To prevent the threatened danger of a filibuster by Democrats of the house of representatives against the completion of the count until after the legal date for the inauguration of the president, Hayes's friends agreed with leading Democrats that he would withdraw the federal troops from Louisiana.

Thus a new era began under a moderate and reforming Republican president, a close Republican senate and a Democratic house of representatives. The southern question was not settled. but other issues of an economic and social nature increasingly forced themselves to the front. During the 12 years that followed Hayes's inauguration neither party held complete possession of both the executive and the two houses of congress. His own moderate character, the conditions of his election and the check imposed during the first two years by a Democratic house of representatives (and during the second two years by an opposition in both houses) made the period of Hayes's administration a transition from the era of Reconstruction to the era of dominant economic and reform agitation.

When he withdrew the troops which sustained the Republican governments in Louisiana and South Carolina. those states returned to the rule of the white Democrats. In the congress elected in 1878 the former slave states chose 101 Democrats to the house of representatives and only four Republicans. Leading Republicans like Blaine protested vigorously against the policy, declaring that the men who saved the union should govern it; and on the other hand the Democrats in congress added "riders" to appropriation bills designed to starve the administration into complete cessation of the use of troops and federal deputy marshals at southern elections. As a result of this policy extra sessions had to be iummoned in 1877 and 1879 to provide supplies for the government Hayes assisted his party by vetoing these coercive attempts of the Democrats and it was not until later that federal attempts to supervise southern elections entirely ceased.

Civil Service Reform.—As his early policy toward the south had dissatisfied many of the leaders of his party, his opposition to the spoils system alienated others. In 1877 a Civil Service Reform association was formed in New York and extended to other states. In June 1877 President Hayes issued an executive order against the participation of federal officers in political management, and he furnished evidence of his sincerity by removing Alonzo B. Cornell, the naval officer of New York, who was also chairman of both state and national Republican committees, and Chester A. Arthur, collector of the port of New York. As both were friends of Sen. Roscoe Conkling of that state, the leader of the Grant men, this was a bold challenge. The "Stalwarts" answered it by securing the nomination of Cornell as governor of New York and Arthur as vice-president of the United States.

Finances.—The monetary question rose to primary importance at this time. Hayes himself had campaigned in Ohio successfully against the greenback movement, and he chose as his secretary of the treasury, John Sherman, whose long service as chairman of the finance committee had made him familiar with conditions and influential with moderate men. The per capita circulation of the nation had fallen from $20.57 in 1865 to $15.58 in 1877 and was still declining. The remarkable increase in the production of silver, as the new mining regions were opened, was accompanied by a fall in its ratio to gold from 15 to 1 in 1860 to 17 to 1 in 1877. Congress had, in 1873. passed an act dropping the standard silver dollar from the list of coins; but though the significance of this omission of a coin not widely circulated passed almost unnoticed at the moment, the demonetization of silver was afterward stigmatized as a conspiracy, "the crime of 1873." As the date (Jan. 1, 1879) for the redemption of the greenbacks in specie approached, demands were renewed for the replacement of national bank notes by greenbacks, for the postponement, or abandonment of resumption, for the free coinage of silver, and for the use of silver as well as gold in payment of bonds redeemable in coin. Sectional grouping of debtor against creditor regions, rather than party alignment, showed itself in the votes, for each party had its "soft money" as well as "hard money" followers.

A monetary commission, appointed in 1876, reported in 1877, but without agreement or real influence upon the country. The president took strong ground against free coinage and against the payment of bonds in silver; but the house of representatives passed the measure, known as the Bland bill, for the free coinage of silver. by a vote of 163 to 34. In the senate this was amended and as it finally passed both houses it was known as the Bland-Allison act after the two leaders, the Democratic representative from Missouri and the Republican senator from Iowa. This compromise was carried over the veto of President Hayes and became a law Feb. 28, 1878. In the vote of Feb. 15, all but one of the senators from New England, New York and New Jersey opposed it, while the states west of the Alleghenies furnished only four opposing votes. The law restored the legal tender character of the silver dollar and authorized the secretary of the treasury to buy silver bullion at the market price, to an amount of not less than $2,000,000 nor more than $4,000,000 per month, and to coin the bullion into silver dollars.

Hardly had the Bland-Allison compromise been effected on the silver issue when an act was passed (May 31, 1878) forbidding the further retirement of greenbacks, which remained at $346,681,000. Substantially the same sectional alignment was followed in the vote on this bill as in the silver votes. Not satisfied with this legislation, nearly 1,000,000 voters cast their ballots for Greenback party candidates at the congressional elections in the autumn of 1878. The preparations of Secretary Sherman had been so carefully made, and the turning tide of trade brought coin so freely to the United States, that before the date of resumption of specie payments a gold reserve had been accumulated to the amount of $133,000,000 in excess of matured liabilities and the greenbacks rose to par before the date of redemption.

Election of 1880.—In the campaign of 1880 Hayes and Tilden both declined to stand for renomination. Thus the issue of the "fraud of 1876," which the Democratic platform called the paramount issue, was subordinated. Nor was it possible for the Republicans to force the tariff question into a commanding position, for although the Democratic platform declared for a tariff for revenue only, a considerable wing of that party led by Samuel J. Randall, of Pennsylvania, favoured protection. Gen. Winfield S. Hancock, a distinguished soldier in the Civil War, whose nomination for the presidency by the Democrats was designed to allay northern distrust, refused to make the tariff a national issue. The recent adjustment of the monetary question and return of prosperity relegated the discussion of the currency also to a subordinate place.

The Republicans, after a heated convention in which the followers of Grant, Blaine and Sherman fought each other to a deadlock, selected Gen. James A. Garfield of Ohio, who was political manager for Sherman in the convention. This was a blow to the Grant or Stalwart wing, which was, however, partly placated by the nomination of Arthur for the vice-presidency. Garfield's popular plurality was only a little over 9,000 out of a total vote of over 9,000,000; but his electoral vote was 214 to Hancock's 155. The area of the former slave states marked the boundaries between the Republican and the Democratic states, except that Hancock also carried New Jersey, Nevada and California. The Republicans won the elections for the house of representatives which would meet in 1881, and the senate was at first nearly evenly divided, two independents holding the balance. In the ensuing four years party lines were badly broken, factions made bitter war upon each other, and the independent reformers or Mugwumps grew in numbers. The selection of Blaine as secretary of state committed Garfield to the anti-Grant wing, and the breach was widened by his appointment of the collector of the port of New York against the protests of Roscoe Conkling and Thomas C. Platt, the Stalwart senators from New York. They resigned, then sought re-election in order to vindicate the right of senatorial recommendation, but were defeated.

Garfield Assassinated.—In the midst of this excitement the president was assassinated by a disappointed office seeker. Vice-President Arthur, who succeeded Garfield in Sept. 1881, by his tact and moderation won the admiration of former opponents; but the poor crops in 1881 and the dissatisfaction with boss rule among independent voters caused a Democratic victory in the congressional campaign of 1882.

Legislative Acts.—Garfield's assassination had given new impetus to the movement against the spoils system, a National Civil Service Reform league had been organized in 1881, President Arthur presented the question in his message of December of that year, and in 1882 George H. Pendleton, a Democratic senator from Ohio, urged the subject upon the attention of congress. Stimulated by the elections of 1882 congress passed an act (Jan. 16. 1883) authorizing the president to appoint a commission to classify certain of the federal employees, and providing for appointment and promotion within this classified list by competitive examination. Congressional recommendacions for these offices were not to be received, and political assessments for campaign purposes were forbidden. This was an effective beginning in the purification of the civil service; but the evil of assessment of employees was succeeded by the evil of soliciting campaign contributions from corporations interested in legislation. The extension of the competitive list proceeded gradually through succeeding administrations. The Edmunds Anti-Polygamy act (1882) was leveled at the Mormons and the Chinese Exclusion act was passed at the demand of labour, after a long agitation in 1882. the way having been prepared by the treaty of Peking in 1880. Bills to this effect had been vetoed by Hayes and Arthur as violative of international agreement, but the desire of the politicians to win the California vote, and the compromise by which the exclusion was limited to ten years finally carried the measure, and the supreme court (1889) held it constitutional.

Surplus Revenues.—From 1879 to 1890 the treasury showed a surplus of revenue over expenditure. This furnishes the explanation of much of the legislation of that period. It led to extravagant appropriations, such as the Arrears of Pensions act of 1879, and the River and Harbor act of 1882 providing for the expenditure of more than $18,000,000 which was passed over the veto of Arthur. Appropriation bills were merely constructed in various committees of congress under a system of bargaining between interests and sections with primary reference to the political fortunes of the congressmen.

The surplus also strengthened the demand for a reduction of the tariff. A tariff commission, composed of men friendly to protection. appointed in 1882, proposed an average reduction of 20% to 25%. Nevertheless, in the act as passed in 1883 duties were increased in general on those protected articles which continued to be imported in large volume, especially on certain woolen goods and about two-thirds of the imported cotton goods, and on iron ore and some steel products. while they were lowered on finer grades of wool and cheaper grades of woolen and cotton fabrics. etc. It was unsatisfactory to large portions of both parties and did not materially lower the revenue; but the act of 1883 made extensive reductions in internal taxes. As the senate had just fallen into the hands of the Republicans, and the house would not become Democratic until the new congress met, this protective law gave the Republicans the advantage of position. Moreover, the Deinocrats were themselves divided, 19 representatives voting with the Republicans on the act of 1883. In the next congress (1884), when the leaders made an attempt to rally the Democrats to show their position by passing a bill for a horizontal reduction of 20% in general, 41 Democrats voted against the bill and prevented its passage through the house.

Election of **1884.**—Thus the campaign of 1884 found both parties still lacking unity of policy although it seemed possible that the tariff might become the touchstone of the contest. The Republicans challenged the independents by nominating Blaine. whose record was objectionable to many reformers, and who had been chiefly identified with the Reconstruction politics. The Democrats, taking advantage of the situation, nominated Grover Cleveland of New York. He had won approval by his reform administration as mayor of Buffalo and as governor of New York during the past two years, when he had shown an independence of party "bosses" and had convinced the public of his sincerity and strength of character. He represented conceptions and interests which had grown up since the war, and which appealed to a new generation of voters. The platform emphasized the idea that "new issues are born of time and progress." and made the leading question that of reform and change in administration, lest the continued rule of one party should corrupt the government. On the question of tariff the Democrats took a conservative attitude, emphasizing their desire to promote healthy growth, rather than to injure any domestic industries, and recognizing that capital had been invested and manufactures developed in reliance upon the protective system. Subject to these limitations, they demanded correction of abuses. The Greenbackers nominated Gen. Benjamin F. Butler of Massachusetts, recently chosen governor of that state on the Democratic ticket, but he polled only 175,000 votes. John P. St. John, the candidate of those who would prohibit the liquor traffic, secured 150.000 votes, an unprecedented gain.

Cleveland President.— The campaign abounded in bitter personalities, and the popular vote was close, Cleveland's plurality being only about 23,000. The state of Kew York, with electoral votes enough to have turned the scale. was carried by the Democrats by only a few more than 1.000 votes out of a total of over 1,000,000. Cleveland's electoral majority was 37. The election was nevertheless recognized as marking an epoch. For the first time since victory came to Lincoln and the Republicans on the eve of the Civil War, nearly a quarter of a century earlier, the country had entrusted power to the Democrats, although over two-thirds of their electoral vote came from the former slave states. Kew York, Connecticut, New Jersey and Indiana constituted their northern territory. Perhaps the most significant thing about the result was the evidence that in the north political and sectional habits and prejudices were giving way among a sufficient number of independent voters, responsive to strong personal leadership on reform issues, to turn the political scale. The transition from war issues which began in 1872, and became marked in 1876, was completed by the election of Cleveland in 1884.

During the first half of his term President Cleveland had the opposition of a strongly Republican senate. In the second half the senate remained Republican by a majority of two, and the house continued Democratic. His civil service policy naturally met severe criticism not only from his party foes, but also from the spoilsmen among his Democratic followers, who desired a clean sweep of Republican officeholders, and from those of his independent supporters who looked to him to establish the service on a strictly nonpartisan basis. The outcome of the first two years of his administration was that. of the entire body of federal officeholders. two-thirds were changed and the Tenure of Office act was repealed. thus leaving the president the right of removal without presenting his reasons. Nevertheless there was a gain, for the criticism by the Republicans placed them on record against the former spoils system; Cleveland somewhat checked the political activity of officeholders; and before leaving the presidency he transferred the railway mail service to the classified list requiring competitive examination.

The transition of executive power for the time to the Democratic party, however much it impressed the imaginations of the public, as the end of an era, was not so significant as the national growth and expansion in the decade between 1880 and 1890 whereby forces were set loose which determined the characteristics of the succeeding period. Between these years the nation grew from about 50,000,000 to nearly 63,000,000. The middle west, or north central group of states, gained over 5,000,000 and the western division over 1,250,000. West of the Alleghenies altogether more than 8,000,000 persons had been added. while the old eastern states gained but 4,000,000. In 1890 the north central division alone had achieved a population more than 5,000,000 greater than that of the north Atlantic, while the trans-Allegheny region surpassed the whole east by about 10,000,000, and the numbers of its representatives in house and senate placed the political destiny of the nation in its hands.

The West.—One of the most important reasons for the wholesale taking up of western resources in these and the following years was the burst of railway building subsequent to the interruption of the panic of 1873. The eager pioneers pushed into western Kansas and Nebraska as they had into the northern Ohio valley a half-century before. Nebraska grew from a population of 123.000 in 1870 to 450,000 in 1880 and to over 1,000,000 in 1890. From about 365.000 in 1870, Kansas rose to almost 1,000,-000 in 1880, and to nearly 1,500,000 in 1890. The railway had "boomed" the "golden west" and a cycle of abundant rains seemed to justify the belief that the Great American desert mas a myth. Thus settlers borrowed money to secure farms beyond the region of safe annual rainfall under the agricultural methods of traditional pioneering. Swift disappointment overtook them after 1886, when droughts and grasshoppers ruined the crops and turned back the tide of middle western colonists until the western parts of these states were almost depopulated, Kansas alone losing one-seventh of its population; nor did prosperity return for a decade.

As the column of settlement along the Ohio valley had extended its flanks into the old northwest between the Ohio and the Great Lakes, and into the old southwest of the lower Mississippi after the War of 1812, so the later pioneers by railway trains began to take possession of the remoter and vaster northwest and southwest. The granger roads, centring in Chicago, thrust their lines out to develop wheat farms in interior Iowa, Minnesota and the Dakotas, where the virgin soil of the prairie farms brought returns that transferred'the wheat belt to this new land of promise, and by competition forced the older wheat areas to develop varied agriculture. The introduction into the Minneapolis mills of the recently invented steel-roller system of making flour not only built up a great flour industry there but created a demand for the hard wheat suited to the northwestern prairies. The pine forests of Michigan, Wisconsin and Minnesota were exploited in the same era.

A more impressive movement was in progress as additional transcontinental railways were extended from the frontier to the Pacific. In 1870 for 1,000 mi. W. of Duluth. Minn., at the head of Lake Superior, along the line of the projected Sorthern

Pacific railway there a-ere no cities or little towns. Relying upon its land grant and upon the undeveloped resources of the vast tributary region, the railway, after halting for a few years subsequent to the panic of 1873 at Bismarck, N. Dak., on the Missouri rushed its construction to Seattle. Wash.. and was opened in 1883. The Great Northern, a product of the vision and sound judgment of James J. Hill, started from St. Paul, Minn., without a land grant and reached Puget sound in 1893. Thus a new industrial zone had been brought into existence. Colorado had become a state in 1876; in 1889 North Dakota, South Dakota, Washington and Montana were admitted as states and the next year Idaho and Wyoming were added. The western political forces. especially the friends of silver, were thus given the balance of power in the senate.

As a new northwest was opened by the completion of the Canadian Pacific (1883). the Northern Pacific (1883) and the Great Northern (1893), so the new southwest was entered by the completion of the Southern Pacific from New Orleans, La.. across Texas, New Mexico, Arizona and southern California to San Francisco by 1883. In 1883 also the lines which became the Atchison, Topeka and Santa Fe, extending from the lower Missouri valley, with St. Louis and Kansas City. Mo., as important terminals, through southeastern Colorado, northern Arizona and New Mexico. reached the same goal. The Denver and Rio Grande opened new mining areas between Denver, Colo., and Ogden. Utah.

Not only additional mines were reached by these lines: but a great cattle country, recently the habitat of the bison and the Indian, was opened. All the large cities commanding the approaches to this country developed packing industries. but Chicago especially profited. Southeastern Texas was the original home of these cattle ranches, but the driving of herds to supply the miners of the Rocky mountains revealed the fact that the whole bison country was capable of supporting range cattle. and the practice grew of driving the stock to the feeding ground of the north and returning. The height of the movement along the cattle trail, which in its largest extent ran through the public lands of the Great Plains from Texas to the Dakotas and Montana. was reached in 1884. In that period cattlemen fought over the possession of the range, controlled vast tracts by seizing the approaches to the water supplies under perversion of the land laws, fenced in the public domain! either defiantly or by leases from land-grant roads, and called out proclamations of presidents from Hayes to Cleveland. The steady advance of the farmer, and protective measures against the spread of the cattle disease known as Texas fever, gradually prevented the continuance of the trail and ultimately broke down the system of great ranches. About 1870 shipment of livestock from Chicago had become significant,and within a decade the refrigerator car revolutionized the packing industry by making possible the shipment of dressed beef not only to the markets of the eastern United States but even to Europe. The value of slaughtering and packing industries in the United States increased from less than $30,000.000 in 1870, to $564,000,000 in 1890.

Another important revolution in American economic life was effected by the opening of new iron mines, the growth of the steel and coal industry and the rise of an extraordinary internal commerce along the whole length of the Great Lakes. By 1890 the output of pig iron in the United States surpassed that of Great Britain! having doubled after 1880. The full meaning of the revolution is seen in the fact that by 1907 the United States produced more pig iron and steel than Great Britain. Germany and France combined. As a result of the growth of the wheat, lumber and iron-ore production of the northwest, the traffic along the 1,000 mi. of the Great Lakes grew (chiefly after 1890) by leaps, and changed from wooden sailing vessels to steel ships driven by steam. The traffic through the Sault Ste. Marie canal came greatly to exceed that through the Suez canal.

The New South. — The south shared in these industrial transformations. Not only did white labour produce an increasing proportion of the cotton crop, but cheap white labour came from the uplands to cotton mills situated at water-power sites. This, with the abundant supply of raw material, enabled the south to develop cotton manufacture between 1880 and 1890 on a scale that threatened New England's dominance. The southern Appalachians began to yield their treasures of coal and iron; northern Alabama became one of the great centres of the iron industry and the south produced nearly 400,000 tons of pig iron in 1880 and 2,500,000, 20 years later. By 1890 the production of coal, iron ore and pig iron in this section was as great as that of the United States in 1870. The value of the products of manufacture in the south rose from $338,000,000 in 1880 to $1,184,000,000 in 1900. The exploitation of the longleaf pine forests also attracted northern capital. Fruit and truck gardening grew rapidly, and the south began to exhibit traits of industrial development familiar in the north and west. The Negro problem continued to hold the south as a whole to the Democratic party.

Industrial Changes. — The opportunities opened to capital by these forces of growth in the west and south, as well as the general influence of an age of machine production, led to transformations in the east which brought new difficulties for political solution. The east began to exhibit characteristics of other long-settled countries where increasing density of population and highly developed industry were accompanied by labour troubles. To capital the opening resources of the west, and the general national prosperity after 1879, offered such inducements that large-scale production by corporations became the order of the day. The forces which had exhibited themselves in increased manufacture and railway development between the Civil War and the panic of 1873 now found expression in a general concentration of industries into fewer plants with vastly greater capital and output, in the combination of partnerships into corporations, and of corporations into agreements and trusts to avoid competition and to secure the needed capital and economies for dealing with the new problems of industrial magnitude. Western farming competition led to the actual abandonment of much inferior land in New England and to agricultural disadvantages in the middle states. As agriculture became less attractive and as industrial demands grew, the urban population of the east increased at the expense of the rural. The number of cities of the United States with a population of more than 8,000 nearly doubled between 1880 and 1890; by 1900, the urban population constituted more than one-third of the total; this phenomenon was especially marked in the north Atlantic division, where, by 1900, more than one-half the population was in cities of more than 8,000 inhabitants.

In similar fashion concentration of industry in large establishments was in progress. In 1880 nearly 2,000 mills were engaged in the woolen industry; in 1890 not many more than 1,300. Even more marked was the change in iron and steel, where large-scale production and concentration of mills began to revolutionize this fundamental industry, and other lines of production showed the same tendency. The anthracite mines of Pennsylvania fell into the possession of seven coal-carrying railways which became closely allied in interest. In most of the important industries the tendency of large organizations to subject or drive out the small undertakings became significant. Already the railways, to avoid cut-throat competition, had begun to consolidate, to form rate agreements and to pool their earnings.

Interstate Commerce Act. — The Cullom bill as enacted into the Interstate Commerce law of Feb. 4. 1887, was framed to prevent unjust discriminations by the railroads between persons, places and commodities, the tendency of which was to foster monopoly. The law forbade discriminations and pooling, made a higher charge for a short haul than for a long haul over the same road illegal, required publicity of rates. and provided for a commission to investigate and fine offenders. But the decisions of the commission were reviewable by the federal courts and the offender could be coerced. if he refused to obey the commission, only by judicial proceedings. The commission was empowered to provide uniform accounting and to exact annual reports. The principle settled by the lam was an important one, and marked the growing reliance of the former individualistic nation upon federal regulation. But the difficulties by no means disappeared; the federal judiciary, refusing to accept the findings of the commission on questions of fact, retried the cases; and the supreme court overruled the commission on fundamental questions, and narrowed the scope of the act by interpretation.

Social Unrest.—Labour exhibited the tendency to combination shown by capital. The Knights of Labor, founded in 1869, on the basis of "the individual masses" instead of the trades unions, and professing the principle that "the injury of one is the concern of all." grew from a membership of about 100,000 in 1885 to 730.000 in 1886. The number of strikes in 1886 was more than twice as many as in any previous year. In one of the strikes on the Gould railway system 6,000 mi. of railway were held up. In New York, Henry George, author of books proposing the single tax on land, ran for mayor of the city and received 68,000 out of 219,000 votes. At the same time socialistic doctrines spread. even among western farmers. But sympathetic strikes, anarchistic outbreaks and drastic plans for social change did not appeal to the people as a whole. The Knights of Labor began to split, and the unions, organized as the American Federation of Labor, began to take their place with a less radical membership. President Cleveland broke with precedents in 1886 by sending in the first message on labour, in which he advocated. without success, a labour commission to settle controversies. A national bureau of labour to collect statistics had been established in 1884; state legislation increasingly provided for arbitration of labour disputes and regulation of factories and child labour.

Early in 1885 a law had been enacted forbidding the importation of labour under contract, and in 1888 the Chinese Exclusion act was continued. Immigration was exceptionally large in the decade from 1880 to 1890, amounting to about 5,250,000 as compared with 2,800,000 for the previous decade. But a large number of these newcomers settled on the newly opened lands of the middle west. By 1890 persons of German parentage in the middle west numbered more than 4,000,000. Minnesota held 373.-000 persons of Scandinavian parentage. The Irish constituted the largest element among the English-speaking immigrants. The population of foreign parentage amounted to one-third of the whole population of the United States in 1890.

In the midst of this national development and turmoil President Cleveland struggled to unite his party on a definite issue. The silver question continued to divide each party, the continued fall of silver leading to renewed agitation for free coinage. The surplus led to extravagant appropriation bills, such as special pension bills, which Cleveland vetoed altogether, thereby incurring criticism by veterans of the Civil War, and river and harbour improvement measures, particularly the act of 1886, to which the president gave reluctant assent, and the bill of 1887, to which he gave a pocket veto by refusing his signature. But the retention of the surplus in the treasury would create a monetary stringency, its deposit in banks aroused opposition and its use to buy bonds was unpopular with the Democrats.

The Tariff.—Cleveland boldly met the issue and gave purpose to his party by his annual message of Dec. 1887, which he entirely devoted to an exposition of the situation arising from the surplus, and to a demand for a revision of the tariff in order to reduce revenue. He did not profess free-trade doctrines: "It is a condition which confronts us, not a theory,'! he declared. The election of 1386 had reduced the Democratic majority in the house, but the president was able to induce his party to pass the Mills hill (1888) through that body as a concrete presentation of policy. The hill put many important raw materials (including wool) on the iree list. substituted ad valorem for specific duties to a large extent. and generally reduced the protective duties. It was believed that the measure would remit more than $50,500.000 of duties, nearly $20,000,000 of which would result from additions to the free list. The Republican senate also found party unity on the tariff issue and its committee on finance, under the leadership of Sen. Nelson W. Aldrich of Rhode Island, drafted a counter-proposal. They would reduce revenue by repealing the taxes on tobacco, and the taxes on spirits used in the arts and for mechanical purposes, and by revising the tariff so as to check imports of articles produced at home.

Harrison Elected.—On the tariff issue the two parties contested the election of 1888, the Republicans denouncing the Mills bill and the Democrats supporting it. Blaine having withdrawn from the contest, and John Sherman having secured but little more than half the votes necessary to nominate, the Republicans picked from a multitude of candidates Gen. Benjamin Harrison of Indiana, grandson of Pres. William Henry Harrison, to run against Cleveland. The popular vote was exceedingly close, but Harrison had an electoral majority of 65, having carried all of the states except the solid south. Connecticut and New Jersey. The increasing use of money to influence the election, and particularly the association of great business interests with such political bosses as Matthew S. Quay of Pennsylvania and Thomas C. Platt of New York, were features of the campaign. The congressional elections ensured to the Republicans the undisputed control of all branches of the government when the 51st congress should convene, and it was generally agreed that the party had a mandate to sustain the protective tariff.

Lacking a large majority in either house the Republicans were exposed not only to the danger of free silver defections in the senate, but also to filibustering by the Democratic minority in the house as the means of blocking the victorious party's program. These obstructive tactics were made possible chiefly by the use of privileged motions and roll calls to delay business, and the refusal to respond on the roll call for a vote, thus preventing a quorum. Speaker Thomas B. Reed of Maine, a virile and keen-witted leader, greatly strengthened the power of the speaker, as well as expediting the business of the house, by ruling that the constitution required a present, not a voting: quorum; and in spite of disorderly protests he "counted a quorum" of those actually present. By securing rules sanctioning this action and empowering the speaker to refuse to entertain dilatory motions, that officer became the effective agent for carrying on the business of the party majority. As his power through the committee on rules, which he appointed, grew, he came, in the course of time, also to dominate the action of the house, refusing to recognize members except for motions which he approved. This efficiency of action was secured at a loss to the house as a representative and debating body, responsive to minority proposals.

Sherman Anti-Trust Act.—But the discipline of party caucus and house rules enabled the Republican leaders to put through with rapidity a number of important laws. One of these was the measure known as the Sherman Anti-Trust act of July 2, 1890, which declared combinations affecting commerce between the several states, or with foreign nations, illegal and punishable by fine or imprisonment or both. This act, the full power of which was not exhibited until later, was a response to the growing unrest of the nation as other corporations emulated the success of the Standard Oil trust (formed in 1882). The members of a trust combined in an organization managed by boards of trustees whose certificates the former owners accepted instead of their shares of stock in the component companies. Competition was thus eliminated within the combination and the greatly increased capital and economies enabled it not only to deal with the increasing magnitude of business operation! but also to master the smaller concerns which opposed it. State legislation had proved unable to check the process. partly because the trust was an interstate affair. By putting into operation its power to regulate interstate commerce: congress responded to the popular demand for federal restraint of these great combinations which threatened the old American ideals of individualism and freedom of competition. The trusts, although embarrassed, soon showed their ability to find other devices to maintain their unified control. Nor was the act used, in this period, to prevent the railways from agreements and combinations which in large measure neutralized the anti-pooling clause of the Interstate Commerce act of 1887.

Silver **Purchases.**—Another important law was the so-called Sherman Silver Purchase act of July 14, 1890. By 1885 the ratio of silver to gold had fallen to 1 to 22. In the 12 years of the Bland-Allison act of 1878 over 378,000,000 silver dollars had been coined from bullion purchased at the market price. This bullion value was falling: it was 89 cents in 1877 and 72 cents in 1889. The production of gold in the United States in 1878 was about 2.500.000 fine ounces, and of silver about 35,000,000: in 1890 the gold production was 1,588,000 and the silver j1.500.000. The Silver Purchase act authorized the secretary of the treasury to purchase each month 4,500,000 oz. of silver at its market price and to pay for it in treasury notes redeemable at his discretion, in silver or gold.

McKinley Tariff. — The customs duties upon which the fighting of the campaign of 1888 had turned was promptly taken up, and in the McKinley Tariif act of Oct. 1, 1890 the Republicans embodied their conceptions of protection to American industry. Some of the main features of this law were: the addition of agricultural products to the protected articles; the extension of the free list. particularly the inclusion therein of raw sugar, which had been bringing in a revenue of $50.000.000 annually; the granting of compensating bounties to sugar planters to an amount of about $10,000,000 a year; and the raising of duties to the prohibitory point on many articles of general consumption which could be produced at home. Blaine, then secretary of state, had just been active in promoting closer relations with South America wherein he hoped for an extension of American trade and he severely criticized the bill as it passed the house, because the free list opened wide the doors of American trade, particularly to sugar-producing countries, without first exacting compensating advantages for U.S. products in those markets. To meet this criticism a provision was finally added authorizing the president to impose discriminating duties where it was necessary to obtain the advantages of reciprocity.

This tariff. which passed on the eve of the congressional elections of 1890. was immediately followed by such increases in prices and the cost of living that it was potent in bringing about the political revolution. or landslide. which swept the Republicans from power in the house of representatives. The Republicans returned but 88 members as compared with nearly twice that number in the congress which passed the McKinley bill. Looked at broadly, the movement was a rural uprising, strongest in the south and middle west, the old Granger areas. against forces which seemed to them to threaten their ideals of American democracy. But the movement was recruited by the silver-mining states and discontented labour interests.

Farm products had not proportionately shared the general increase in prosperity. This convinced large portions of the agricultural west that the currency system had too narrow a basis in gold, which was appreciating ,in value. Much of the middle western agricultural development had been made on borrowed eastern capital, and it seemed to the farmer that the principal of his mortgage was in effect increasing with the rise in the price of gold, at the same time that his crops brought a smaller net profit. He did not give due attention to the effect of greatly increased production; as the new wheat lands mere opened on such a grand scale; but he was keenly sensitive to increased freight rates and to the influence of eastern capitalists, banks, bondholders. trusts and railways upon federal and state legislatures arid judiciary. After the evidence of the power of this tide of western discontent in the elections of 1890, those portions of it which were ripest for revolt combined in 1892 as the People's party or Populists. soon to prove an important political factor.

'The Republicans meanwhile had been actively reducing the surplus. In 1892 the excess of revenue over expenditures was $10,000,000; in 1893 only $2,000,000. This was effected not only by the Tariff act but by such measures as the Dependent Pension act of 1890 (resulting in a list of pensioners of the Civil War which cost the nation $68,000,000 by 1893, over one-half of these pensioners having been added during Harrison's administration ι; the rapid construction of the new navy, raising the United States from 12th to 5th in the list of naval powers; the repayment of the direct war tax to the states (1891) to the amount or' $51,000,000; and other appropriations such as those provided by river and harbour bills. The Democrats stigmatized this congress as a "billion-dollar congress" from its expenditures: to which Speaker Reed replied that the Cnited States was a billion-dollar nation. In fact the Democrats when they regained power were not able greatly to diminish the cost of government.

Homestead Strike. — The Democratic house in the 52nd congress repressed obstructive Republican tactics by methods like those adopted by Speaker Reed. and contented itself with passing a series of bills through that body proposing reductions of the tariff in special schedules, including free wool and a reduction of the duty on woolens, free ram material for the cotton planters of the south, free binding twine for the farmers of the north and a reduced duty on tin plate for the fruit raisers Of course these bills failed in the Republican senate. A bloody strike on the eve of the election of 1892 in the great steel norks at Homestead, Pa , where armed guards engaged by the company fired upon the mob which sought higher wages, was not nithout its adverse effect upon public sentiment in regard to the Republican tariff for the protection of labour.

During the campaign of 1892 the Democrats rejected a conservative tariff plank, dcnounccd the McKinley tariff in violcnt language, and denied the constitutional power to impose tariff duties except for the purpose of revenue only. But Cleveland, who was renominated in spite of vigorous opposition from leading politicians of his own state, toned down the platform utterances on the tariff in his letter of acceptance. In their declarations upon the currency the Democrats furnished a common standing ground for the different factions by attacking the Silver Purchase act of 1890 as a cowardly makeshift.

Cleveland Re-elected. — The People's party, in its national convention at Omaha, Neb. (July 1892), drew a gloomy picture of government corrupted in all of its branches, business prostrated, farms covered with mortgages, labour oppressed, lands concentrating in the hands of capitalists. Demanding the restoration of government to the plain people, they proposed an expansion of its powers, to afford an adequate volume of currency and to check the tendency to "breed tramps and millionaires." Among their positive proposals were: the free and unlimited coinage of silver at the legal ratio of 16 to 1; the expansion of a national currency issued directly to the people; the establishment of postal savings banks; government ownership of the railways, telegraph and telephone; restoration to the government of the lands held by railways and other corporations in excess of thei needs; and a graduated income tax. Combining with the Democratic party in various states beyond the Mississippi, and with Republicans in some of the southern states, they won large masses of voters in the west, and exerted an influence upon public opinion in that section beyond what was indicated in the returns, although Gen. James B. Weaver of Iowa, their candidate for the presidency, received over 1,000,000 popular votes and 22 votes in the electoral college. The Republicans renominated President Harrison, though he lacked an enthusiastic personal following. They supported the McKinley Tariff act in spite of the wave of opposition shown in the elections of 1890. But, fearing party divisions, they, like the Democrats, made an ambiguous declaration on the currency. The result of the election of 1892 was to return the Democrats under Cleveland to power by a plurality of over 380,000 and an electoral plurality of 132. Congress in both branches was to be Democratic in 1893, and the way was open for the first time in a generation for that party to carry out a policy unchecked by any legislative or executive branch of government.

Panic of 1893. — But before Cleveland was fairly started in his second administration the disastrous panic of 1893 swept the nation, nor did prosperity return during the four years that followed. The panic is not, directly at least. to be traced to the silver purchases; but was the result of various causes, including the agricultural depression, farm mortgages, reckless railway financing and unsound banking in the Cnited States. The panic began in the spring with the failure of the Reading railway and the collapse of the National Cordage company: one of the numerous examples of reckless trust financiering into which large banks had also been drawn. Clearinghouse certificates were resorted to by the New Tork banks in June, followed in August by partial suspension of specie payments. Currency remained at a premium for a month; deposits in national banks shrank enormously; national bank loans contracted more than 14.7%; failures were conimon; 22,000 mi. of railways were under receiverships and construction almost ceased.

The panic of 1893 was in many ways a turning point in American history. It focused attention upon monetary questions. prostrated the silver-mining states, embittered the already discontented farming regions of the west, produced an industrial chaos out of which the stronger economic interests emerged with increased power by the absorption of embarrassed companies, and was accompanied by renewed labour troubles. Most noteworthy of these was the Pullman Car company strike near Chicago in 1894, which led to sympathetic strikes by the American Railway union, extending over 27 states and territories from Cincinnati to San Francisco, Mobs in Chicago burned and looted cars The refusal of Gov John P. Altgeld of Illinois to call out the militia, and interference with the United States mails, led President Cleveland to order federal troops to the scene, on the constitutional ground that they were necessary to prevent interference with interstate commerce and the postal service and to enforce the processes of the federal courts. The courts issued a sweeping injunction requiring that the members of the American Railway union or other persons to desist from interference with the business of the railways concerned. The president of the striking organization. Eugene V. Debs, was imprisoned for contempt of court and conspiracy.

Silver Issue.—The most immediate political effect of the panic was upon the silver issue. Soon after the outbreak of the financial crisis, the gold reserve, which protected the greenbacks and the treasury notes issued under the Silver Purchase act, shrank ominously, while foreigners returned their American securities instead of sending gold. To sell bonds in order to replenish the gold reserve, and to repeal the Silver Purchase act without substituting free coinage, would aggravate western discontent and turn away the promise of recruits to the Democratic party from the Populists of the prairie and silver-mining states; to carry out the Democratic platform by a tariff for revenue only while mills were shutting down would be hazardous in the east The fruits of victory were turning to ashes; but Cleveland summoned a special session of congress for August, while the panic was acute, and asked his party to repeal the Silver Purchase act without accompanying the repeal with provisions for silver. Not until the last of Oct. 1893 was repeal carried, by a vote in which the friends of repeal in the house were about equally divided between Democrats and Republicans, and nearly two-thirds of its opponents Democrats.

By this time the surplus had disappeared and the gold reserve was drawn upon for ordinary expenses. Early in 1894 the administration, failing to secure legislation from congress to authorize the sale of gold bonds on favourable terms to protect the reserve, sold under the Resumption act of 1875 $50,000,000 5% bonds, redeemable in ten years. Part of this very gold, however. was withdratvn from the reserve by the presentation of legal tender notes for redemption. and the endless chain continued this operation to the verge of extinguishing the reserve, so that another loan of $50,000,000 in 1854 was followed in 1855 by a dramatic meeting between Cleveland and some of his cabinet with the Wall street banker, J. Pierpont Morgan, who agreed on behalf of his syndicate to sell the government $65,166,000 of gold for $62,315,000 of bonds, equivalent to 4% bonds for 30 years at a price of 104. In return the syndicate agreed to use its influence to protect the withdrawals of gold from the treasury. These securities were oversubscribed when offered to the public at 1124. President Cleveland had protected the treasury and sustained the parity of gold and silver, but at the cost of disrupting his party. Again, in the beginning of 1896, the treasury was forced to sell bonds, but this time it dealt directly with the public and easily placed $100,000,030 in bonds at about 111, affording a rate of interest about equal to 3.4%.

Tariff Reform.—Before the political harvest of the monetary issue was reaped, the Democrats had also found party ties too weak to bear the strain of an effective redemption of the party pledges on the tariff. The Wilson bill prepared as the administrative measure was reported late in 1893, while the panic was still exerting a baneful influence. Its leading features were the substitution of ad valorem for specific duties in general, the extension of the free list to include such materials of manufacture as iron ore wool coal, sugar and lumber and the reduction of many prohibitory rates. The loss in revenue was partly provided for by an income tax significant of the new forces affecting American society, and an increase in the duty on distilled liquors. Although the bill passed the house by an overwhelming majority, it met the opposition in the senate of the representatives. Democratic as nell as Republican, of those states ahose interests were adversely affected. Led by Senators Arthur P. Gorman of Maryland, Calvin S. Brice of Ohio, and David B. Hill of New Tork, the bill was transformed by an alliance between Democratic and Republican senators on the plea that it would otherwise result in a deficit of $100,000 000 Coal, iron ore and sugar were withdrawn from the free raw materials and specific duties replaced ad valorem in many cases. while many other individual schedules were amended in the direction of protection. The house, given the alternative of allowing the McKinley act to remain or to accept the senate's bill, yielded, and the Wilson-Gorman Tariff act became a law without the president's signature, Aug 27, 1854. Even the income tax was soon (1895) held by the supreme court to be unconstitutional.

Venezuela Message.—Tonard the close of his administration Cleveland s brusque message on the Venezuelan boundary question aroused such excitement and so rallied the general public (though not the more conservative) that the war spirit, shown soon afterward against Spain, might have been a potent factor in the election of 1896 had not Great Britain exhibited exceptional moderation and self-restraint in its attitude. The silver question, therefore, became the important issue. The Republicans nominated McKinley and declared for the gold standard in opposition to free coinage, losing thereby an influential following in the silver-mining and prairie states, but gaining the support of multitudes of businessmen among the Democrats in the east and middle west.

William J. Bryan.—The Democratic convention marked a revolution in the party. The old school leaders were deposed by decisive majorities, and a radical platform was constructed which made "the free and unlimited coinage of both silver and gold at the present legal ratio of 16 to one, without waiting for the aid or consent of any other nation," the paramount issue. Objecting also to the decision against the income tax, and to "government by injunction as a new and highly dangerous form of oppression," they incurred the charge of hostility to the federal judiciary. William Jennings Bryan made a brilliant speech in behalf of free coinage. and so voiced the passion and thought of the captivated convention that he was nominated by it for the presidency over the veteran free-silver leader. Richard P. Bland of Missouri. The Cleveland men, or "gold Democrats," broke with their party after it became committed to free silver, and holding a convention of their own, nominated Gen. John McA. Palmer, of Illinois, for the presidency on a platform which extolled Cleveland. attacked free coinage and favoured the gold standard. Its main influence was to permit many Cleveland men to vote against Bryan without renouncing the name of Democrats. On the other hand the Populist convention also nominated Bryan on a platform more radical than that of the Democrats.

The contest was marked by great excitement as Bryan traveled across the country addressing great audiences. The endangered business interests found an efficient manager in Marcus A. Hanna of Ohio: McKinley's adviser, and expended large sums in a campaign of education. In the event, the older states of the middle west, holding the balance between the manufacturing and capitalistic east and the prairie and mining states of the west. gave their decision against free silver. But class appeals and class voting were a marked feature of the campaign, the regions of agricultural depression and farm mortgages favouring Bryan, and those of urban life favouring McKinley. Labour was not convinced that its interests lay in expanding the currency. and Hanna had conducted McKinley's campaign successfully on the plea that he was the advance agent of prosperity under the gold standard and a restoration of confidence. McKinley carried all the northern states east of the Missouri, and North Dakota, Oregon and California of the far west. as well as Maryland, Delaware, West Virginia and Kentucky. His plurality over Bryan in the popular vote was less than 600,000, and his electoral majority 95. All the departments of government were transferred by the election to the Republicans.

Dingley Tariff.—Having secured power, the administration called a special session of congress, and enacted the Dingley protective tariff (July 24, 1897), under which the deficit in the treasury was turned into a surplus. The act raised duties to their highest point, and as the protective schedules included some important articles produced by trusts which had a practical monopoly, such as sugar and petroleum, this was seized upon by the Democrats to stigmatize the tariff as the "mother of trusts." Many articles which had been placed on the free list in the Tariff act of 1894, including lumber and wool were made dutiable.

Gold Standard. — The Republicans also wrote their triumph into the Gold Standard act of March 4, 1900, which ensured the maintenance of this standard by reserving $150,000,000 of gold coin and bullion to redeem the United States notes and the treasury notes of 1890, and by authorizing the sale of bonds when necessary to maintain the reserve. National banks were authorized in the smaller towns (3,000 or less) with a capital of $25.000, half of that formerly required, and increased circulation was further provided for by permitting the national banks to issue notes on United States bonds up to their par value.

Economic Changes. — The economic policy of the Republicans was facilitated by the prosperity which set in about 1898. The downfal! of silver-mining turned the prospectors to seek new gold fields, and they found them, especially in Alaska; and contemporaneously the chemists discovered cheaper and more efficient methods of extracting the gold from low-grade ores. Within five years after the crisis of 1893 the gold production of the United States nearly doubled. The United States coined $437,500,000 in gold in the five-year period 1897–1902, while the average for five-year periods from 1873 had been only $224,000,000. Thus gold instead oi silver began to inundate the market, and to diminish the demand for expansion of the currency. Agriculture, prostrated in the years immediately preceding and following the panic of 1893, turned to the scientific study of its problems, developed dry farming, rotation and variety of crops, introduced forage crops like alfalfa, fed its corn to cattle and hogs, and thus converted it into a profitable and condensed form for shipment. Range cattle were brought to the corn belt and fattened, while packing industries moved closer to these western centres of supply. Dairy farming replaced the unprofitable attempts of older sections of the middle west and the east to compete with the wheat fields of the far west. Truck and fruit farming increased in the south, and the canning industry added utility to the fruits and vegetables of the west. Following the trend of combination the farmers formed growers' associations and studied the demand of the market to guide their sales. The mortgaged farms were gradually freed from debt. The wheat crop increased from less than 400,000,000 bu. valued at $213,000,000 in 1593 to 675,000,000 bu. valued at $392,000,000 in 1898. Prosperity and contentment replaced agitation in the west. and the Republican party gained the advantage of these changed conditions.

In the south also there was greater contentment as the new industries of iron, textiles and forestry grew, and as the cotton crops increased. Unrest was diminished by the new state constitutions: which aiter 1890 disqualified Negro voters by educational and tax requirements so contrived as not to disfranchise the poor whites.

In the decade which followed the crisis of 1893 a new industrial structure was made out of the chaos of the panic. High financing was undertaken on a scale hitherto unknown. Combinations absorbed their weaker rivals; Standard Oil especially gained large interests in New York banks and in the iron mines and transportation lines about the Great Lakes, while it extended its power over new fields or' oil in the southwest. In general, a small group of powerful financial interests acquired holdings in other lines of business, and by absorptions and "community of interest" exerted great influence upon the whole business world. The group of financiers, headed by Morgan, came to dominate various southern transportation lines and the anthracite coal roads and mines, and extended their influence to the Northern Pacific railway: while a new genius in railway financing, Edward H. Harriman, began an avowed plan of controlling the entire railway system of the nation. Backed by an important banking syndicate he rescued the Union Pacific from bankruptcy, and with its profits as a working basis he began to acquire connecting and competing lines. Labour also shared in the general prosperity after 1898. Relative real wages increased, even allowing for the higher cost of living and the length of the working day in general decreased except in special industries.

General Prosperity. — By 1900 the continental United States had a population of 76,000,000; an aggregate real and personal wealth of $88,500,000,000; a per capita public debt of $14.52, and per capita money circulation of $26.94 against $21.41 in 1896. In 1901 bank clearings amounted to nearly $115,000,000,000 against $45,000,000,000 in 1894. Imports of merchandise had fallen in this period, while exports rose from about $847,000,000 in 1893 to $1,394,000,000 in 1900. Of these exports foodstuffs and food animals, crude and partly manufactured, aggregated nearly 40% of the total. The production of pig iron, which was about 7,000,000 long tons in 1893, mas nearly twice that in 1900. This economic prosperity and these far-reaching processes of social change by which the remaining natural resources of the nation were rapidly appropriated, went on contemporaneously with the extension of the activity of the nation overseas. The first rough conquest of the wilderness accomplished, the long period of internal colonization drawing to a close, the United States turned to consider its position as a world power.

To understand this position it is necessary to return to an earlier period and briefly survey the foreign relations since the close of the Reconstruction era. The most significant and persistent influence came from the growing interest of the United States in the Pacific, as its population and economic power extended to that ocean. The problem of an overflow of Chinese migration to the Pacific coast, and the jeopardizing of the American standard of labour by this flood, had been settled by various treaties and laws after 1880. The question of the relation of the United States to an interoceanic canal was not so easily settled. In 1878 Colombia granted a concession to a French company, promoted by Ferdinand de Lesseps, the engineer of the Suez canal, to dig a tide-level canal through the Isthmus of Panamá. President Hayes voiced the antagonism of the United States to this project of European capital in his message of 1880 in which he declared that such a canal should be under the control of this nation, and that it would be "virtually a part of the coast-line of the United States." Although an American company was organized to construct a canal under a concession from Nicaragua in 1884, no real progress was made, and the French company, defeated by engineering and sanitary difficulties. failed at the close of 1888.

Pan-American **Congress.**—Meantime, for a few months, Blaine, as secretary of state under President Garfield, began a vigorous foreign policy with especial reference to the Pacific. He attempted to get the consent of Great Britain to abrogate the Clayton-Bulwer treaty of 1850, which contemplated the construction of an isthmian canal by private enterprise under joint control and neutralization of the United States and Great Britain, together with such other powers as should join them. In South America he actively pressed the influence of the United States to settle the war between Chile and Peru. Again, in the years from 1889 to 1892, Blaine held the portfoiio of state, and attempted to increase the influence of his country in Spanish America by the Pan-American congress of 1890, which proposed a great international railway system and bank, commercial reciprocity and arbitration, without immediate results. Indeed: the bad feeling aroused by his earlier policy toward Chile found expression in 1891 in a mob at Yalparaíso, when some of the men from the United States ship "Baltimore" on shore leave were killed and wounded. An apology averted the war which President Harrison threatened. Blaine also asserted, against Canada particularly, the right of the Cnited

States to the seals of the Bering sea; but in 1893 arbitrators decided against the claim.

Foreign Affairs.—As the navy grew and American policy increasingly turned to the Pacific, the need of coaling stations and positions advantageous to its sea power was appreciated. By a tripartite treaty in 1889 the Samoan islands were placed under the joint control of the United States, Great Britain and Germany, and, a decade later, they were divided among these powers, Tutuila and the harbour of Pago-Pago falling to the United States. The Hawaiian Islands, which had been brought under the influence of civilization by American missionaries, were connected by commercial ties with the United States. Upon the attempt of the ruler to overturn the constitution, the American party, aided by the moral support of the United States, which landed marines, revolted, set up a republic and asked annexation to the union. A treaty, negotiated under President Harrison to this end, was withdrawn by President Cleveland, after investigation, on the ground that the part of the United States in the revolution was improper. He attempted, without success, to restore the original state of affairs, and on July 7, 1898, the islands were annexed.

President Cleveland's conservatism in this and other matters of foreign policy had not prepared the people for the sudden exhibition of firmness in foreign policy with which he startled the nation in his message of Dec. 1895 upon the question of the boundary of Venezuela. Venezuela and Great Britain had a long-standing dispute over the line which separated British Guiana from Venezuela. Great Britain declined to arbitrate, at the suggestion of the United States, and gave an interpretation to the Monroe Doctrine which the administration declined to accept. President Cleveland thereupon brusquely announced to congress his belief that Great Britain's attitude was in effect an attempt to control Venezuela, and proposed that a commission on the part of the United States should report upon the disputed boundary, and support Venezuela in the possession of what should be ascertained to be its rightful territory. Secretary of State Richard Olney declared: "To-day the United States is practically sovereign on this continent, and its fiat is law upon the subjects to which it confines its interposition." Great Britain tactfully accepted arbitration, however, and in the end (1899) was awarded most of the territory regarding which she had been unwilling to arbitrate.

Spanish-American War.—The growing activity of the United States in foreign relations next manifested itself against Spain. Cuba in its commanding position with reference to the Gulf of Mexico and the approaches to the proposed isthmian canal, as well as in its commercial relations, and its menace as a breeding spot for yellow fever, had long been regarded by the United States as an important factor in its foreign policy. Between 1868 and 1878 a harsh war had been in progress between the island and the mother country, and American intervention was imminent. But Spain promised reforms and peace followed; again in 1895 revolt broke out, accompanied by severe repressive measures, involving grave commercial injury to the United States. (For the military events of the conflict see SPANISH-AMERICAN WAR OF 1898.)

By the treaty of Paris, signed Dec. 10, 1898, Spain lost the remaining fragments of its ancient American empire. It relinquished Cuba, which the United States continued temporarily to occupy without holding the sovereignty pending the orderly establishment of an independent government for the island. Puerto Rico, Guam and the Philippines were ceded outright to the United States, which agreed to pay $20,000,000 to Spain, and to satisfy the claims of its citizens against that power. By the treaty congress was to determine the civil rights and political status of the native inhabitants of the ceded territory.

As a result of the Spanish-American War, the United States found itself in a position of increased importance and prestige among the nations of the world. Especially in the Pacific, it was immediately involved in the diplomatic situation created by the efforts of European states to divide China into spheres of influence or of actual possession. The interests of the United States in the trade with China, as well as its new position in the Philippines, inclined it to oppose this policy, and Secretary of State John Hay showed himself to be one of the great American diplomats in his treatment of this difficult problem. In order to preserve Chinese entity and the "open door" for trade, he drew replies from the nations concerned, the result of which was to compel them to avow and moderate their intentions.

The acquisition of Puerto Rico and the acceptance of responsibilities in Cuba gave new importance to the isthmian canal and increased the relative weight of the United States in regard to its control. The popular excitement with which the voyage of the "Oregon" was followed, as it took its way 14,000 mi. around South America to participate in the destruction of the Spanish fleet in the battle of Santiago, showed the American people the need of such communication between the Atlantic and Pacific coasts.

But the immediate political issues were concerned with problems of the relation of the newly won lands to the United States government. Bryan had persuaded his party to join in ratifying the treaty of Paris, expecting to determine the status of the islands later. But attention soon turned to the insurrection which broke out (Feb. 4, 1899) in the Philippines under Emilio Aguinaldo, after it became probable that the administration intended to retain these islands, not under a weak protectorate, but as a possession to be ruled and "assimilated." It was not until the spring of 1902 that this insurrection was completely put down, and in the interval the question of the destiny of the islands and the harshness of the measures of repression aroused political debate. The Democrats and many Republicans charged the administration with a policy of imperialism.

Puerto Rico.—The same issue was involved, in its constitutional and economic aspects, in the treatment of Puerto Rico and Cuba. While the insurrection continued in the Philippines the government there was legally a military one, although exercised in part through civil officers and commissions. But in the case of Puerto Rico the question was whether the "Constitution follows the flag," that is, whether it extended of its own force without an act of congress to acquired territory, and covered the inhabitants with all the rights of citizens of the United States, as an integral part of the American people.

The Foraker act of 1900 imposed a special tariff for two years upon Puerto Rico, the proceeds to go to that island's own treasury. The act further asserted the principle that the inhabitants of the new possessions were not incorporated into the United States or entitled to all the privileges of citizens of the United States under the constitution, by declaring that statutory acts of the United States locally inapplicable should not be in force in Puerto Rico. The supreme court sustained this act in 1901, holding that Puerto Rico was not so strictly a part of the United States that separate customs tariffs could not be imposed upon the territory. The Foraker act also provided a government for the island. In Cuba the United States remained in authority until May 20, 1902. Details of the arrangements whereby the United States secured the substantial advantages of a protectorate without destroying the independence of Cuba, will be found in the article on CUBA.

Re-election of McKinley.—Meantime, in the election of 1900, the Democrats renominated Bryan on a platform which opposed the Republican administration's acts in relation to the newly acquired territory and declared that "imperialism" was the paramount issue. The platform reaffirmed its silver doctrine of the previous campaign and denounced the tariff as a breeder of trusts. The Republicans renominated McKinley and endorsed his administration. McKinley received an electoral majority of 137 and a popular plurality of 849,790. Before his second term was fairly begun he was shot by an anarchist while attending the Pan-American exposition at Buffalo, N.Y., and died on Sept. 14, 1901. His wisdom in choosing able cabinet officers, his sympathetic tact in dealing with men and with sections, as well as the victories of the Spanish-American War, had brought him popularity even among his political opponents. But McKinley, like Cleveland, lacked the imagination to perceive and the desire to voice the aspirations and demands that had been gathering force for many years for legislation and executive action that should deal with the problem of effective regulation of the economic forces that were transforming American society. This gave his opportunity to Theodore Roosevelt, who as vice-president now succeeded to office.

Roosevelt President. — It was in foreign relations, which Secretary Hay continued to conduct, that continuity with McKinley's administration was most evident. But even here a bolder spirit, a readiness to break new paths and to take short cuts was shown by the new president. Venezuela had long delayed the payment of claims of citizens of various nations. In 1901 the president. having been informed by Germany of its intention to collect the claims of its citizens by force, but without acquisition of territory, announced that the United States would not guarantee any state against punishment if it misconducted itself, provided that the punishment did not take the form of acquisition of territory. As a result. a blockade of Venezuela was undertaken by the joint action of Germany, Great Britain and Italy at the close of 1902. The diplomatic intervention of the United States early the next year resulted in Venezuela's agreement to pay the claims in part and to set aside a portion of its customs receipts to this end. But since the blockading powers demanded preferential treatment, the United States secured a reference of the question to The Hague court, which decided that this demand was justified. Santo Domingo offered a similar problem, having a debt incurred by revolutionary governments, beyond its power to pay, and being threatened with forcible intervention by European states. President Roosevelt, in 1904, declared that in case of wrongdoing or impotency requiring intervention in the western hemisphere the United States might be forced "to the exercise of an international police power." In 1905 Santo Domingo and the United States signed a protocol under which the United States government was empowered to take possession of the customhouse, conduct the finances and settle the domestic and foreign debts of Santo Doming~. In spite of the refusal of the senate to assent to this protocol, President Roosevelt put the arrangement unofficially into effect, until, in 1907, the senate consented to a treaty authorizing it with some modifications.

In the far east the Boxer insurrection in China had been followed by the combined military expedition of the powers to the relief of Peking (in which the United States shared). and the exaction of a huge indemnity, of which the United States relinquished nearly half of its share, as in excess of the actual losses. The United States protested against Russian demands upon China, and actively participated in the negotiations which resulted in Russia's agreement to evacuate Manchuria. The delays of that power and its policy toward China having led Japan to declare war, Secretary Hay's diplomacy was influential in limiting the zone of hostilities; and the offices of President Roosevelt brought about the conference between the two powers at Portsmouth, N.H.. which terminated hostilities in 1905. The dispute over the boundary between Alaska and Canada was narrowed by diplomatic discussion, and the remaining questions, involving the control of important ports at the head of the great inlets which offered access to the gold fields, were settled by arbitration in 1903 favourably to the American contentions.

The isthmian canal also received a settlement in this administration by a process which was thoroughly characteristic of the resolution of President Roosevelt. See PANAMA CANAL.

The Philippines. — In the Philippines early in 1901 municipal and provincial governments were provided for, and the president had been for a brief time granted full power to govern the archipelago. He appointed Judge William Howard Taft civil governor, and limited the power of the military governor to regions where insurrection continued. On July 1, 1902, congressional authority was substituted for that of the president, but Taft remained governor. The provisions of the constitution guaranteeing life, liberty and property were in general extended specifically to the dependency, and a legislative assembly was promised. the lower house elective and the upper house to consist of the Philippine commission. By negotiations with Rome Governor Taft secured for the Philippines the "friars' lands" which had been a source of friction. On Oct. 16, 1907 the first Philippine assembly was convened in the presence of Taft, then secretary of war.

The tariff question complicated American relations with both the Philippines and Cuba. Beet sugar and tobacco interests feared the competition of these products, and opposed freedom of trade between the United States and the new territories. The Philippine tariff of 1902 made a reduction of only 25% from the Dingley tariff in the case of the products of those islands. instead of the 75% urged by Taft; but the duties were to go to the Philippines. In the case of Cuba a more heated controversy arose over the tariff — Roosevelt strongly urged a substantial reduction in justice to Cuba at several regular and special sessions of congress; but not until the close of 1903 was a treaty in operation which, under the principle of reciprocity, admitted some products of the United States to Cuba at reduced rates, and allowed Cuban products a reduction of 20% from the Dingley tariff.

The Trusts. — The dominant historical tendencies at the beginning of the 20th century in the United States, however, were characterized by huge combinations of capital and labour, the rapid passing of natural resources into private possession, and the exploitation of these resources on the principle of individualism by aggregations of capital which prevented effective competition by ordinary individuals. Pioneer conceptions of individual industrial achievement free from governmental restraint were adopted by huge monopolies, and the result was a demand for social control of these dangerous forces.

After the Sherman Anti-Trust act of 1890 the combinations found in the favourable laws of states like New Jersey opportunity to incorporate under the device of the holding company, which was supposed to be within the law. A "promotion mania" set in in 1901. The steel industry, after a threatened war between the Standard Oil and Carnegie groups, was united by Morgan into the United States Steel corporation with stocks and bonds aggregating $1,400,000,000. This was only one of the many combinations embracing public utilities of all kinds. Where open consolidation was not effected, secret agreements, as in the case of the meat packers. effectively regulated the market. In the field of railway transportation, Edward Henry Harriman used the bonds of the Union Pacific to acquire the Southern Pacific with the Central Pacific, and by 1906 he was dictator of one-third of the total mileage of the United States. Meanwhile the Great Northern and the Northern Pacific had been brought into friendly working arrangements under James J. Hill, and tried to secure the Burlington railway. A fierce contest followed between the Hill, Morgan and Harriman forces, resulting in a compromise by which the Northern Securities company, a holding company for the joint interests of the contestants, was created. It was admitted by the counsel for this company that the machinery provided in this organization would permit the consolidation of all the railways of the country in the hands of three or four individuals. By using notes of one railway company, based on its treasury securities, one could acquire a controlling interest in others; and by watering the capital stock, recover the cost of the undertaking, while the public paid the added rates to supply dividends on the watered stock.

Following a similar tendency the great Wall street banking-houses were dominated by the large financial groups in the interest of speculative undertakings, the directors of banks loaning to themselves, as directors of industrial combinations, the funds which flowed into New York from all the banks of the interior. By a similar process the great insurance and trust companies of New York became feeders to the same operations. Thus a community of control over the fundamental economic interests of the nation was lodged in a few hands.

Such was the situation in domestic affairs which confronted Roosevelt when he became president. In his first message he foreshadowed his determination to grapple with these problems. In 1903 he instructed the attorney general to bring suit to dissolve the Northern Securities company as a combination in restraint of trade and in 1904 the supreme court held the merger illegal. But the effect was to increase the tendency to change from incomplete combination of financial interests to consolidated corporations owning the property, and to lead the government. on the other hand, to seek to regulate these vast business interests by legislation. The Elkins law, passed in 1903. increased the power of the Interstate Commerce commission to prosecute offenders, especially those who violated the antirebating clauses. In the same year the creation of the federal bureau of corporations provided for increased publicity in the affairs of these organizations.

Combinations of Labour. — Labour was combining in its turn. Not only did local unions in most of the trades increase in number and power, but workers in separate industries over large areas were combined for collective bargaining and a national organization, the American Federation of Labor, had a membership by 1905 of approximately 2,000,000. Labour legislation by the states increased under these influences, and political leaders became increasingly aware of the power of the labour vote, while employers began to form counter organizations to check the growth of the movement. In 1902 Pennsylvania members of the United Mine Workers of America struck. Inasmuch as their employers were the owners of the anthracite coal monopoly under the control of an allied group of coal-carrying railways, the contest was one of far-reaching importance, and soon brought about a coal famine felt throughout the nation. So threatening was the situation that President Roosevelt called a conference of the contestants, and induced them to submit their difficulties to an arbitration commission which, by its report, in the spring of 1903, awarded to the miners shorter hours and an increase of wages.

Steadily the United States enlarged its economic functions. In 1903 congress created a department of commerce and labour and made the secretary a member of the cabinet. The reports of this department gave publicity to investigations of the perplexing industrial conditions. The department of agriculture enlarged its staff and its activity, investigating different plants and animals, ascertaining means of checking insect pests, advising upon the suitability of soils to crops, seeking new and better seeds and circulating general information. The contemporaneous development of agricultural education in the various western and southern states whose agricultural colleges had been subsidized by land grants and appropriations by the federal government, and the experimental farms conducted by railways, all worked to the same end. The nation began also to awake to the need of protecting its remaining forests, which were rapidly falling into the hands of corporations by perversion of homestead and other land laws. President Cleveland had withdrawn large forest tracts. and in 1898 Gifford Pinchot was made head of a division of forestry in the department of agriculture. In 1901 the work was organized under a separate bureau, and four years later the national forests were placed under his management.

Reclamation. — The increasing demand for lands for agriculture led also, under Roosevelt, to the real beginning of national irrigation actively in the vast arid area of the far west. The reclamation service was created by the act of June 17, 1902, which set aside the proceeds of the sale of public lands in 13 states and three territories as a fund for irrigation works. The government itself reserved timber and coal tracts, water powers and other requisites for construction, and sold the irrigated lands to actual settlers in small farms, while retaining title to the reservoirs and the works. The income from the reclamation fund between 1901 and 1910 aggregated over $60,000,000. By the use of suitable crops and dry farming, agricultural occupation was extended into formerly desert lands.

Election of 1904. — In the election of 1904 the popularity of President Roosevelt, after his strenuous activity in challenging some of the strongest tendencies in American life, was put to the test. His political management exhibited the fact that he was trained in the school of the New York politician as well as in the reformer's camp, and he was easily nominated by the Republicans on a platform which endorsed his administration, and made no promise of tariff changes. The Democrats turned to the Conservative wing, omitted any reference to silver or the income tax, and nominated Judge Alton B. Parker, of New York. The issue of imperialism had been largely eliminated by the current of events and the antitrust issue was professed by both parties. In the outcome Roosevelt won by the unprecedented popular plurality of over 2,500,000 and an electoral majority of 196.

The state elections of the same period showed that a wave of reform and of revolt against former political forces was rising. In five states which Roosevelt carried by his popularity the machine Republican candidates for governor were defeated by reforming Democratic candidates, and in cities like Chicago and Philadelphia the issues of reform and radicalism won unexpected though temporary success. Roosevelt had "stolen the thunder" of the parties of social unrest, including the old populistic areas of the middle west and the labour element of the cities and also retained control of the Republican party machinery.

Roosevelt's Second Administration. — In his second administration President Roosevelt pressed his policies so hard and with such increasing radicalism that he lost control of the regular organization in congress before the end of his term. Speaker of the House Joseph G. Cannon of Illinois exhibited the full power of his office in concentrating party policies in the hands of the few regular leaders, while in the senate a directing group of New England men who had served for a long time, chiefly Nelson W. Aldrich and Eugene Hale, showed a similar mastery. Against this control a significant revolt, illustrative of revived discontent in the middle west, was made by the Republican Sen. Robert M. La Follette of Wisconsin, who had won his fight in that state against the faction friendly to the railways, and had secured primary elections, railway rate regulation on the basis of expert valuation of the physical property of the railways and a system of taxation which rested more heavily upon public utilities. In pressing similar policies upon congress he became isolated from the party leaders, but forced them to go on record by roll calls.

In New York a legislative investigation of the insurance companies disclosed such connections with the high financing of Wall street as to create widespread distrust and to lead to reform legislation. The attorney who conducted the investigation, Charles Evans Hughes, had shown such ability that he was chosen governor of New York in 1906. His administration was marked by independence of the party machine and a progressive policy. Foreign relations were conducted during the second administration of Roosevelt by Secretary Elihu Root from 1905. He fostered friendly relations with the other American nations, allaying their concern lest ambitious designs of their larger neighbour might endanger their independence. In Cuba a signal illustration of the good faith of the United States was exhibited when an insurrection in the summer of 1906 left the republic substantially without a government. Taft, then secretary of war, was sent, under the treaty provisions for intervention, to organize a provisional government. During his few days' service as governor general he set in motion the machinery for restoring order. But Roosevelt had plainly stated that if the insurrectionary habit became confirmed in Cuba it could not expect to retain continued independence.

Japanese Immigration. — Attention was again fixed upon the Pacific coast, not only by the earthquake and conflagration which in 1906 destroyed the business area and much of the residential section of San Francisco, but also by municipal regulations there against the presence of Japanese in the public schools. The incident seemed to threaten grave consequences, which were averted by the popularity of Roosevelt both in California and in Japan. In the Immigration act of Feb. 20, 1907, the problem of exclusion of Japanese labour, which underlay the difficulty, was partly solved by preventing the entrance to the continental United States by way of neighbouring countries of persons holding passports issued by a foreign government for going to other countries or dependencies of the United States.

As a demonstration of the naval power of the United States in Pacific waters, the president sent the American fleet on a cruise around the world, in the course of which they were received in a friendly spirit by Japan. The navy was increased to keep pace with the growth of that of other nations, both in numbers and size of vessels, in this period, but not to the extent demanded by the administration. Already a more efficient organization of both army and navy had been effected. While the nation prepared for war, it also engaged prominently in the successive international peace congresses between 1899 and 1907, aiming consistently to increase the use of arbitration.

Railway Regulation. — The tendencies of the government to deal with social improvement were exemplified by the laws of 1906 providing for pure food and meat inspection. The Railway Rate Regulation act of 1906 strengthened previous interstate acts by including pipelines (except for gas and water) under the jurisdiction of the Interstate Commerce commission, and extending the meaning of common carrier to include express and sleeping-car companies. Published rate schedules were required, not to be changed without 30 days' notice, and more stringent provisions were made to prevent rebating. The act provided for review by the federal courts, and did not permit the commission to investigate an increase of rates until the rates went into operation, nor did it provide for a valuation of the railways as a basis of rate-making which the commission had desired. Later acts partly met the demands of railway employees by increasing the liability of common carriers and by providing for shorter hours.

Panic of 1907.—Although Roosevelt had made concessions to the railways in the formation of the act of 1906, his utterances showed a tendency alarming to the large business interests and the holders of corporation securities generally. The unsettled business conditions were reflected in the stock market, and began to produce a reaction against the activity of government in this direction. The panic of 1907 started with the downfall of an attempted combination of a chain of banks, copper interests and other enterprises, and was followed by the collapse of the Knickerbocker 'Trust company in New York (Oct. 21, 1907). The country was generally prosperous, though much of the banking funds was tied up in New York city at this juncture. Clearinghouse certificates were resorted to; by Nov. 1 partial suspension was general throughout the nation; and banking facilities were more completely interrupted than at any time since the Civil War. The government greatly increased its deposits, and offered Panamá 2% bonds to the amount of $50,000,000, and 3% certificates for $100,000,000, with the object of providing the national banks a basis for additional note issues. But these were taken only to a small amount. as they proved useful for their moral effect chiefly. An enormous addition to the money supply was made in the course of the panic, both by governmental activity, gold imports and national bank notes. The crisis was brought to a close before the end of 1507 by the vigour of the government and the activity of the large financial interests under the lead of Morgan, who finally entered the field to stop the decline, at the same time that his associates in the Steel trust acquired possession of their last remaining rival of importance, the Tennessee Coal and Iron company.

The reaction after the panic, and the loss of influence resulting from this announcement that he would not permit his renomination for the campaign of 1908, left Roosevelt unable to exercise the compelling power which he had displayed in previous years. Congress under the control of the conservatives refused him legislation which he asked, but before he left the presidency he raised a new issue to national importance in his calling of a congress of state governors and experts to consider the need of the conservation of natural resources. This congress met in May 1508 and endorsed the proposal for vigorous attention by state and nation to the question.

Election of 1908.—In the campaign of 1908 he succeeded, against the opposition of both the extreme conservative and the radical wings, in procuring the nomination of Secretary Taft by the Republicans on a platform endorsing the Roosevelt policies, promising a revision of the tariff at a special session, on the basis of such protection as would equal the difference between the cost of production at home and abroad, together with a reasonable profit to American industries, and providing for maximum and minimum rates to be used in furthering American commerce and preventing discriminations by other nations. A postal bank was promised, a more effective regulation of the railways and a modification of the Sherman Anti-Trust act. The Democrats again selected Bryan as their candidate; demanded the enforcement of criminal law against trust magnates and such additional legislation as would prevent private monopoly; opposed the use of injunctions in cases where they would issue if no industrial dispute was involved; impugned the Republicans' good faith in tariff revision, promising for themselves a substantial reduction of duties; favoured an income tax and a guarantee fund by national banks to pay depositors of insolvent banks, or a postal savings bank, if the guaranteed bank could not be secured; demanded election of United States senators by direct vote of the people, legislation to prevent contributions by corporations to campaign funds and a more efficient regulation of railways. The Republicans won a sweeping victory, Taft's popular plurality reaching about 1,270,000 and his electoral majority 159. (F. J. T.)

From Roosevelt to Roosevelt

The total population of the continental United States in 1910 was 92,000,000. Of these, only 50,000,000 were native whites of native parentage; 13,000,000 were foreign-born and 19,000,000 others were of foreign-born or mixed parentage. The Negroes and Indians together numbered about 10,000,000. Everybody in the United States except the American Indian was an immigrant from some other country or a descendant of an immigrant. The main race groups were: (1) the descendants of the colonists, who were mainly Anglo-Saxons, with some Germans and Scotch-Irish and small elements of other races; (2) descendants of the Europeans who came over in great numbers from 1820 to 1870; (3) the large number of later immigrants and their children.

In the opening years of the 20th century the country was not yet aroused to the problems arising from this mixture of unassimilated races. Few voices were raised against admitting not only western Europeans, whose languages and customs were much like those of the United States, but men and women from east and southeast Europe and from western Asia. The only bar to immigration based on race was the prohibition, after 1888, of Chinese immigration and the practical exclusion of Japanese labourers by a gentlemen's agreement with the Japanese government (1907). The undigested load was becoming heavy.

The units of U.S. society uere held together by a strong, if complicated, democratic government, well fitted to rule a diverse population. The political forms were familiar to every schoolboy: (1) a group (in 1910) of 46 states, each with its own government rigidly conhned by the traditional principle of checks and balances into three departments, legislative, executive and judicial; (2) a widely distributed franchise almost equivalent to universal suffrage for adult males; (3) a belief that the courts were the highest authority, not only as to questions of personal rights and duties, but as to the validity of the laws and acts of the other two departments; and (4) local government of city and town, township and county. This combination of governments was expensive and not highly skilled, but was supported by the conviction of a large part of the population that it was the "best government on earth."

In the organization and conditions of business there could be traced some startling contradictions between the word liberty and the fact. Nominally all kinds of business not prohibited by law were open to all comers in free and honourable competition. In reality, by 1908, a considerable number of both employers and employees were engaged in a combat outside the laws, constant and conscienceless. It was hard for individuals and firms to compete with corporations, and hard for small corporations to compete with large ones. The railways were among the most conspicuous of the large corporations, and they, too, tended to combine into larger and more powerful units. The states could not deal adequately with these powerful bodies because most of the railways and many of the other corporations operated from state to state, and could not be controlled at either end by anything short of federal power.

Political organizations were on nearly the same basis as business companies: they also grew bigger and more powerful and gathered into fewer groups. Xominally, parties are simply associations of voters for common ends. Actually. they are armies acting under commanding leaders who in many cases hold no offices. The evils of this "invisible government," as Root called it, were apparent. The political philosophy of Americans was based on the belief that mankind was steadily growing better. Hence a tendency to rely upon laws and political devices for correcting the ills of popular government. What was most needed was the leadership of bold and farseeing men.

Finances and the Tariff (1908–13).—Every growing unit in the country was harassed by questions of taxation and expenditure. The U.S. government also sought new resources. and found them in the income tax. This was made possible by the 16th amendment to the constitution, which came into effect on Feb. 25, 1913. Another new resource of the federal government was a tax upon corporations levied on net income (Aug. 5. 1909). The important question of reorganizing the national banking system. so as to furnish a strong national institution, was debated from 1908 to 1912, and was the subject of an elaborate report by a national monetary commission; but no action was taken at that time. The net federal debt was $1,000,000,000, or only about $11 per head of the population.

A financial resource over which congress had sole authority was the tariff. Under strong pressure from members of the party to carry out the promises of the Republican convention of 1908, President Taft, a few days after his inauguration, summoned congress to meet in special session, for the purpose of revising the tariff.

As usual there was a long controversy. which resulted (Aug. 5. 1909) in the Payne-Aldrich tariff. The act created a permanent court of customs appeals, with power to determine finally all questions as to the value of imports, together with a tariff board, expected to make investigations and recommend specific measures which congress might adopt. As to rates, the act was not very different from its predecessor, except for a decided increase of duties on cotton and silk manufactures.

There was a loud outcry that the revision intended by the party platform was a revision downward and not upward. Nevertheless President Taft signed the bill, and in a speech delivered at Winona, Minn.. on Sept. 17, 1909, surprised the country by declaring that it was the "best tariff bill that the Republican party has ever passed."

Political Reform (1908–131.—When Roosevelt left the presidency in 1909 the position of president was at a high point. Most presidents had found their principal legislative influence in the veto; Roosevelt had followed the McKinley method of emphasizing his wishes in personal discussion with members of congress. He did more: he revived the Jacksonian method of announcing a legislative plan, and if congressmen hung back, of appealing over their heads to the country at large. A similar policy was adopted by President Taft, who had many of the qualities of leadership. He had served as first civil governor of the Philippines and as secretary of war in the cabinet of Roosevelt. who practically designated him as his successor. Nevertheless, as an avowed inheritor of Roosevelt's policies, he drew upon himself the opposition of Roosevelt's enemies while it soon became apparent that he was not relying upon Roosevelt's friends.

At this time the primary method of selecting candidates was spreading rapidly through the union. Candidates for each party mere selected by the ballots of the people. thus undermining the convention system. From nominations for local officers the new method had spread, by 1911, to state officers in numerous states; and after 1910 it began to be applied to the choice of delegates to the national party conventions. An unforeseen effect was that the official ballots were made upon the basis of party nominations, nith an opportunity for independent voting. The primary thus became a part of the system of public elections, and therefore the party system was engrafted on public law, as a part of the government. *(See* PRIMARIES.)

The distrust of conventions and controlled elections extended to the numerous and powerful bosses in city and state legislatures. Three new devices were set at work to curb them and to interest the electors in public measures. The first of these, the referendum *(see* REFERENDUM AND INITIATIVE), was by 1909 spreading rapidly through the western states, as a means of checking legislative action contrary to public sentiment. The referendum system furnished a mechanism, usually imbedded in state constitutions, by which on the demand of a sufficient number of voters, a statute could be held back from effect until submitted to a vote of the electors. What was to be done if the legislature refused to enact a statute demanded by the people? The initiative was invoked, by which a designated number cf voters could unite on a measure, which must then be submitted to the electors for their suffrages.

A third branch of this system of appeal to the people was the recall (q v), under which a public officer already chosen by popular vote (and in a few cases those who were appointed in some other way) could be subjected to an election and, should the majority decide against him, be thereby removed from office. In 1911–12 the question arose in connection with the proposed constitution of the new state of Arizona, which included a provision for the recall of judges. Because of this provision President Taft vetoed the act of admission. The state withdrew the clause, was duly admitted in 1912, and thereupon proceeded to reinsert the recall.

A still wider application of the principle of the responsibility of functionaries to the voters was the recall of judicial decisions, which was advocated by Roosevelt in 1912, but proved to be more than the country desired.

United States senators, until then chosen by state legislatures, were next made subject to popular choice. Urged by public sentiment, congress submitted (June 12, 1912) the 17th amendment, which was duly ratified and added to the constitution (May 31, 1913). Under this, all elections to the senate were to be made by direct popular vote. Another evidence of a rising feeling of responsibility in congress was a statute (Aug. 7, 1911) requiring candidates for the house and senate to submit statements of the money raised and expended in their behalf and limiting the amount which they themselves might spend. One purpose of both these measures was to make it difficult for men to purchase their way into the senate. On July 13, 1912 Sen. W. Lorimer of Illinois was practically expelled from the U.S. senate for buying votes in the legislature.

Another slow reform was in the ballot system. Most cities, towns and states were loaded down with long lists of the officers to be chosen. The result was an agitation for the reform commonly known as the short ballot, by reducing the number of elective officers and increasing the officers to be appointed by the few elective officials. Working difficulties were found in many of these reforms. It was hard to keep the public keyed up to the necessary pitch of thought and attention at every election; but it was evident that the American people intended to free themselves from the shackles of "invisible government."

Social Questions (1908–12).—The spirit of discontent extended to many questions outside of politics. Throughout the Taft administration there mas an increasing pressure for equal suffrage — that is, woman suffrage — which, introduced in the territory of Wyoming in 1869, had gradually spread among the far-western states, and then begun working its way eastward. Again. both state and national governments mere compelled to deal with the question of alcoholic beverages. From the earliest times there had been restriction on liquor selling and liquor sellers. By 1909 in almost all states there was some form of general legal restriction — prohibition, local option. high licence or a state dispensary system. The question became national, because the liquor trade transported its wares from one state to another; and that brought it aithin the interstate commerce clause of the constitution and the Interstate Commerce act. Eventually by the original Package act of 1890, congress adopted the policy of prohibiting shipments of liquor into prohibition states. Pure food laws in force before 1909 were supplemented by the Drug Label act of 1912, which greatly aided in preventing the adulteration of drugs.

Many questions arose out of immigration. The laws in 1909 forbade the entry of labourers under a contract to work in the United States, of convicts, diseased persons and the insane; but the execution of the laws was slack. The first statute looking toward decided control of immigration was that of Feb. 1907, which increased the grounds of exclusion, and at the same time provided a plan to help the immigrants in finding work. It also created an immigration commission, which in 1910 made a report in 41 volumes. strongly recommending the sifting of immigrants by testing their ability to read and write some language. Meanwhile, in the decade 1901–10 the number of immigrants rose to an average of nearly 1,000.000 a year. Later. however, the record showed that from 300,000 to 500,000 annually returned to their old homes, the actual rate of increase of population by immigration was no more than about ½% annually.

Labour Questions.—No legal obstacle stood in the way of the right to organize, first, by local trade unions, then by nationwide unions for single trades, and finally by national unions combining many trades. To this was slowly added by the unions the principle of the right to labour, which meant both that it was the duty of the community to see that the worker had a job and that at least the skilled workers had a kind of title in their employment, so that it became contrary to good morals for a scab to take the place of a striker.

The legal position of labour unions in these controversies was brought out by suits of national importance against unions. In the test case of *Gompers* v. Buck's Stove and Range Co., the charge was that the federation, by posting the company in its publications as "unfair to labour," was boycotting, and thus infringing legal rights. Samuel Gompers, president of the American Federation of Labor, was convicted for contempt of court on the ground that he had refused to obey a court order to abandon the boycott. In 1908 a suit was decided with a verdict of $74.000 damages against a union of the hatters of Danbury, Conn., who had attempted to boycott the products of a local hat manufacturer.

Another phase of the labour situation was the spread of employers' liability laws through various states, and the passing of an act of congress (April 22, 1908) for the protection of the employees of interstate railways. In June 1912 congress added to its previous enactment of an eight-hour maximum regular day for public employees, by providing that all contract work for the federal government must also be on the eight-hour basis. As most labourers were voters they brought powerful influences to bear on state legislatures and on congress in favour of labour. On the other hand. the courts, particularly those of the states, were slow to recognize the changes in industrial conditions.

In addition, the courts began to use a system of labour injunctions: workmen, labour unions and their members were ordered to abstain from committing acts which if committed would presumably violate a law and would thus lead to a prosecution, in which the question of guilt could be settled by a jury. Instead, the courts by injunction would decide on the responsibility and affix a penalty not specifically laid down in any statute.

Trusts and Transportation.—During the 20 years ending with 1910 it became clear that the most difficult question before the United States government was the regulation of the vast aggregates of capital, commonly called trusts, which, combined into corporations, aimed at the control of particular lines of business, and also of the railways. The efforts of congress to adjust the question were registered in two lines of restrictive statutes, headed by the Interstate Commerce act of 1887 and the Sherman Anti-Trust act of 1890. Upon these was built a structure of decisions by the United States supreme court. To carry out and partly to avoid these decisions, the Mann-Elkins act of June 18, 1910, widely extended the Interstate Commerce acts by including telephones, telegraphs, express and sleeping-car companies, and by setting up a commerce court which was to render decisions on transportation questions. Federal control of railways on the whole worked well. The commission was a striking example of disregard of the principle of separation of powers, inasmuch as it was a rule-making body, an executive body and a court which interpreted its own rules, subject as to some questions of appeal to the federal courts.

The great problem of the trusts was much farther from a solution than that of the railways because the large corporations were linked together through the holding and manipulation of stocks by capitalists and banks, and through the so-called interlocking of interests. The only effective way of dealing with large corporations whose activities extended from state to state was to bring suit against them for monopolizing or conspiring to monopolize in their lines of trade. It was considered a triumph when (May 9, 1911) the United States supreme court rendered decisions against two of the most powerful trusts—the Standard Oil company and the American Tobacco company. The court held that the antitrust legislation must be interpreted by the "standard of reason"—namely, that a combination was not unlawful or against the public interest unless it actually caused a restraint of trade and commerce among the federal states or with foreign nations. Having thus set up a "rule of reason" which congress had refused to enact, and having created an example of judicial legislation, the court proceeded in both the pending cases to hold that the companies were guilty of attempts to monopolize their lines of trade. As to penalties, the court contented itself with ordering the offenders to disintegrate. The general danger of vast aggregations of capital was ignored.

Foreign Affairs.—The fields of the diplomacy of the United States for many years had been American and Pacific, and in a much smaller degree European. In the second Hague conference of 1907 the United States delegates urged international arbitration; and in accordance with the general principles put forth at that conference, Root as secretary of state secured 25 arbitration treaties with as many countries (1908). The United States and Great Britain arranged (Jan. 27, 1909) to refer to The Hague tribunal their long-standing dispute on the Newfoundland fisheries. The result was a decision acceptable to both sides (Sept. 7, 1910). In 1911 the Republican majority under President Taft's leadership initiated a policy of commercial reciprocity with Canada. An agreement was made with the Canadian government by which each side should by legislation reduce or abolish duties on certain raw products and manufactures. With great difficulty the necessary bill was pushed through congress (July 1911); but two months later the Canadian electors refused to support the reciprocity agreement, and the plan broke down.

Notwithstanding the position of the United States as the responsible holder of the Philippine Islands, and hence an Asian power, the tradition of isolation continued to be a strong force in the public mind. Nevertheless no formidable public protest was made to a policy of special U.S. intervention in Mexico, the Caribbean and the isthmus region. The arrangements of 1902 made Cuba practically a dependency, subject in the last resort to decisions from the White House. President Taft continued the occupation of the Dominican Republic, consent of the senate under a treaty to that effect having been obtained by Roosevelt in 1907.

The Panama canal was now approaching completion and the little republic of Panamá. which it bisected, though nominally an independent state, was in fact under U.S. control. An act of congress (Aug. 24, 1912) laid tolls on shipping, from which U.S. ships engaged in coastwise trade were to be relieved. The British government lodged a protest on the ground that by its treaty with the United States the canal was to be opened on equal terms to the ships of "all nations"; President Taft, however, stood by the act, and the question was passed on to the next administration.

Still more serious were the relations with Mexico, where, in 1910, a revolution headed by Francisco Madero assailed the government of Porfirio Diaz and drove him after a few months out of the country. Mexico was thrown into confusion, and President Taft found it necessary to place troops on the border. In 1912 he proclaimed an embargo on the export of arms or military supplies to Mexico. Meanwhile the concessions and property of Americans in Mexico were threatened or destroyed. The Americans uho had interests in Mexico began a steady pressure for intervention by the United States.

Across the Pacific, clouds rose on the diplomatic horizon. The commercial treaties with Japan allowed a reciprocal freedom of residence and trade to the nationals of the two countries. The immigration of Japanese mas very distasteful to the people of California, who undertook to restrict Japanese children to separate schools. Behind this difficulty were the rising power of the Japanese and their national spirit, greatly enhanced by their victory over the Russians in 1905. In 1908 Roosevelt sent around the world a powerful naval fleet, which visited Japan and was received with elaborate courtesy by a welcoming Japanese squadron exactly equal in number, ship for ship. In the Root-Takahira reciprocal note of Dec. 1, 1908 (which was never submitted to the senate). the United States practically admitted Japan's special interest in Asian affairs. The question of Japanese immigration was settled for the time being by a renewal of the commercial treaty (July 24, 1911). It continued the previous gentlemen's agreement, according to which, though claiming a right of immigration into the United States, the Japanese government pledged itself not to issue passports to labourers.

Politics 1909–12.—In the action of congress on many of the important issues above discussed no party lines were drawn, though such measures as the tariff and new taxes were distinctly Republican. On the tariff, some members from middle western states, particularly Minnesota, voted against the Payne-Aldrich measure of 1909. Another disturbance was caused by resentment against the Speaker of the House Cannon, who through the union of various powers virtually had a veto on any measure or proceeding mhich he did not like. Cannon kept too tight a hand; hence (March 19, 1910) a group of Republican "insurgents" joined hands with the Democrats to reduce his prerogatives until Cannon became simply a partisan moderator.

A new issue upon which both parties were divided was covered by the general term conservation. Although most of the arable land had passed out of its possession, the federal government was still the possessor of great tracts of forest, of mineral lands and of water power. Congress in 1902 provided for a system of irrigation, the cost to be advanced by the government and repaid in installments by the users of the water. President Roosevelt became interested in stopping the waste of timber and minerals, in preserving part of the gifts of nature for future generations and in retaining public ownership of the utilities of the country, particularly the forests and streams. In 1910 new statutes provided for a fresh classification of land and for the reservation of coal by the government.

Roosevelt and Wilson.—By 1910 it became clear that the Republican party was weakening and that President Taft's popularity and influence were lessening. The state and congressional elections of 1910 were unfavourable to the Republicans. The insurgents, who soon came to be called Progressives, gained most of the Republican districts in the west, and the Democrats gained about 50 seats in congress. This result transferred to the Democrats the control of the house, while in the senate they secured 41 of the 92 members.

A group of dissatisfied Republicans gathered about Senator La Follette as a leader and presumptive candidate for president. Meannhile state legislatures were passing primary laws which included the election of delegates to national nominating conventions. This made it easier to break through the old-line organizations, as La Follette had done in his own state. Taft's friends and supporters naturally expected that the president would be renominated.

All these calculations were disturbed by the greatest personality in the country, Theodore Roosevelt. A few weeks after leaving the White House (1909) he started on an expedition to central Africa, and was, on his way back, received in Europe as the former president of the most important of republics and as a commanding personage. He returned to the United States (June 18, 1910) to find political conditions little to his liking. Most of his friends had disappeared from the administration: his policies seemed to him to have been slighted. Taft did not satisfy the former president, and the two drifted apart. On Aug. 31, 1910, at Osawatomie, Kan., Roosevelt set forth a program which he called "the New Nationalism," favouring publicity of the accounts and proceedings of trusts, a tariff commission, a graduated income tax, an adequate army and navy, conservation, protection of labour and the direct primary with the recall of elective officers. For the time being Roosevelt made no direct movement toward standing for the presidency. Meanwhile several of the western states, particularly California under the guidance of Gov. Hiram Johnson, accepted a radical program of political and social reform. A formal breach with Taft and the open candidature of Roosevelt seemed inevitable. The crisis came when (Feb. 12, 1912) President Taft in a speech alluded to the Progressives (evidently having Roosevelt in mind) as "Extremists—not Progressives; they are political emotionaries, or neurotics." This was taken as a challenge, and a few days later Roosevelt openly declared himself a candidate.

The Election of 1912.—As the convention held in Chicago approached, the lines of battle were developed. Behind Taft were William Barnes of New York, Boies Penrose of Pennsylvania, Winthrop Murray Crane of Massachusetts and other "standpat" leaders. Among those in favour of Roosevelt were James R. Garfield of Ohio, Pinchot of Pennsylvania and a strong body of Republican governors. Roosevelt himself went to Chicago, and threw his immense energy and enthusiasm into the campaign. The convention was a scene of unusual excitement.

The critical decision was made in the preliminary meetings of the national committee, which was strongly "standpat"; for that committee had to decide upon the right of claimants to be inscribed in the preliminary roll of delegates. Every contest except one was settled in favour of the Taft claimants. The shifting of 30 delegates from one side to the other would have brought about a stampede to Roosevelt, but they were not to be had. Roosevelt advised his delegates to take no further part in the proceedings. At the final roll call, June 22, there were 561 votes for Taft, 58 scattering and 107 for Roosevelt, besides 344 Roosevelt men not voting. In the last issue, therefore, Taft had a majority of 50 votes out of 1,070. In the minds of Roosevelt and most of his followers the nomination was a violation of the principles of popular government. Roosevelt openly advised a bolt. This was duly accomplished by a formal Progressive convention. It met in Chicago in August and nominated Roosevelt for president and Hiram Johnson for vice-president.

Meanwhile the Democratic convention met at Baltimore with Bryan in a position to dictate the choice. The apparently sure candidate was Champ Clark of Missouri, speaker of the house of representatives. But under the rules of the Democratic convention requiring a two-thirds majority, he was finally defeated by Woodrow Wilson, governor of New Jersey. The platforms of the two old parties were of the usual type. The Republicans declared for protective duties. The Democrats stood by their platform of a tariff for revenue only, additional regulation of the railways and presidential preference primaries. The Progressive platform was a general program of political reform and "an enlarged measure of social and industrial justice."

Woodrow Wilson's Victory.—Not platforms, however, but men, appealed to the voters. All three candidates took the field. From the first it was clear that the real fight was between Roosevelt and Wilson. The Progressives were well organized, and their convention and campaign included many women. The final question was whether Roosevelt could draw to himself a sufficient number of Democrats to reduce the Democratic vote below the winning point. The result in November showed that the Democrats in the main stood by their party candidates. The total popular Democratic vote, 6,293,454, was only about 115,000 less than in 1908. The total Taft and Roosevelt vote combined was almost exactly the same as that of the Republicans in 1908. Roosevelt polled 4,119,538 popular votes to 3,484,980 for Taft; but he carried only 6 states, with 88 electoral votes, against 2 states with 8 votes for Taft and 40 states with 435 votes for Wilson.

Woodrow Wilson.—On March 4, 1913 Wilson was inaugurated as president. As governor of New Jersey during 1911 and 1912 he had shown his skill as a party leader and his interest in reform. In 1912 he was taken up by Bryan, who saw in him an exponent of the political principles for which Bryan had stood and a president who could meet the Progressives on their own ground.

In making up his cabinet it was only reasonable that Bryan should enter it. He was made secretary of state, an office for mhich he had little adaptation. To a new cabinet office recently created by congress, the secretaryship of the department of labour, Wilson appointed W. B. Wilson, a strict labour organization man. Lindley M. Garrison, secretary of war, and Franklin K. Lane, secretary of the interior, were strong men. Albert S. Burleson, postmaster general, and Josephus Daniels, secretary of the navy, had insufficient training for their duties. David F. Houston of Missouri was made secretary of agriculture, William G. McAdoo, secretary of the treasury and James C. McReynolds, attorney general. Most of the members of the cabinet were men who could be trusted to follow the president's lead. One remarkable statesman not included in this list was Col. E. M. House of Texas, who for six years was the president's most trusted counselor and political friend without holding any political office. In the minor civil service Wilson carried out his principles by enlarging the classified list of posts which could be entered only by competitive examinations.

A genial man, who could be a delightful companion, full of experience and of dry humour. President Wilson had a powerful mind, an amazing skill of expression and an intense belief in the power of ideals to arouse and inspire a people. He thought he had no need of conferences. of feeling the public pulse, of mixing with members of congress and party leaders, of personally greeting the average voter.

Finance and Tariff, 1913.—The election of 1912 carried with it a safe Democrat majority in the senate and a two-to-one majority in the house. On April 8, 1913, the president created a surprise by appearing in person to address the two houses of congress jointly at the opening of a special session, instead of sending a written message. This practice he followed throughout his administration, with great effect. He felt himself not only chief magistrate of the nation. but head of the Democratic party, and practically the premier of the government from which ought to proceed plans for important legislation.

A special session was called particularly to frame a tariff act. Rep. Oscar Underwood (Ala.), chairman of the committee of ways and means, gave to the new measure his name and experience. The purpose of the statute nas to enlarge the free list of raw materials, foodstuffs and some manufactures, to make a moderate reduction of the protective duties and to correct some of the things that made the Payne-Aldrich act unpopular. Included in the statute was an income tax, at last made possible by the adoption of the 16th amendment (Feb. 25, 1913), which was expected to supply any revenue that might be lost by the reduction of duties. A tariff commission was created to make researches into the workings of the act and to find out what was the actual difference between the cost of labour in the United States and in other countries (Oct. 3, 1913).

The powerful influence of the president was again exerted to secure a systematic banking system, with the result that (Dec. 23, 1913) the Owen-Glass Federal Reserve Bank act was added to the statutes The principle was to create a national institution. which was to be divided into 12 regional banks, in each of which was a body of directors, besides the central organization in Washington, D.C. In these 12 subdivisions clustered such banks. whether national or state chartered, as chose to accept. The new institution was also to issue a new form of paper money. The system from the start was recognized as a large national asset. At the same time a Rural Credits act was passed (July 17, 1916), ahich created a special group of banks to lend money to farmers on the security of their farms.

Transportation.— Under a statute of March 1, 1913 the Interstate Commerce commission was authorized to enter on an elaborate valuation of the railway property throughout the country as the basis of a judgment as to what was a reasonable profit. The Panama canal was now approaching completion. This was the first great agency of transportation owned and managed by the United States government. President Wilson used to the utmost his personal influence for a bill to repeal discrimination in favour of U.S.-owned vessels, of nhich the British government had complained; it became an act. June 15, 1914. On Aug. 15 the first steamer passed through the canal from sea to sea and in a few months the canal was paying its own way. A new question of transportation was arising through the rapid development of motor vehicles. At first a plaything, then a luxury, by 1908 they were spreading throughout the land. The attention of the whole country was called to the absolute necessity of good roads. In 1916 congress passed an act appropriating approximately $85,000,000 to be paid in about five years to such states as would contribute equal sums for good roads. From this beginning the movement spread rapidly throughout the whole country.

The **Trusts.**—A few hours before the end of President Taft's term a congressional committee reported against the "great and rapidly growing concentration of the money control and credit in the hands of a few men." In June 1914, in a suit involving the International Harvester company, the United States supreme court upheld state antitrust laws.

Yet the trusts still flourished; and huge corporations, such as the U.S. Steel corporation, paid dividends on thousands of millions in stocks and bonds. President Wilson urged successfully a radical amendment of the Sherman act (Oct. 15, 1914) against discriminating freight agreements, interlocking directorates and holding corporations.

Another branch of the same attack on the money power was the Federal Trade commission, created Sept. 26, 1914, which was an attempt to find means of dealing with corporations engaged in interstate commerce other than banks and common carriers.

In the same direction went the blue-sky laws passed in this period by many states, to break up the practice of floating the stock of companies which had no property more substantial than the atmosphere.

Labour.— The example of capital, in rolling itself into masses too great to be controlled by ordinary means, was followed by labour. The American Federation of Labor was a loosely woven council of representatives from the great trade organizations. It did not undertake to call strikes, though it was likely to support them, and it had great effect in bringing about combined and simultaneous demands for the various items in the labour program. The leaders fixed upon an eight-hour day as the basic working time. The next item was the minimum wage, which made its way slowly and was not altogether acceptable to labour. Another demand was that U.S. citizens should have preference over aliens in employment. Labour in general was unfriendly to child labour and was, therefore. interested in a federal statute of Sept. 1, 1916, to prevent the transport of products made by child labour under specified conditions.

As the labour unions gained in numbers and strength they used their energies in favour of the closed shop, a system under which union men refused to work in any establishment where men not members of the union were also employed. From this idea rapidly developed the system of sympathetic strikes, in which members of one union back up another union by refusing to handle, use or transport products of nonunion labour. Hence boycotts, and perhaps ruin for employers who had no difficulty or quarrel with their own workmen. Never in the prior history of the U.S. had there been so many and such violent strikes as from 1913 to 1917. The Industrial Workers of the World (I.W.W.) organized long and tumultuous strikes among the silk weavers of Paterson, N.J., and the textile workers of Lawrence, Mass. In the trying years of 1916–17 violent strikes were directed not only against nonstriking. workmen, but against the public peace. In July 1917, at Bisbee, Ariz., the tables were turned. A kind of vigilance committee seized and carried out of town, with orders not to return, about 1,200 striking miners and their friends. No jury would convict those responsible for this illegal action. The most serious of all these labours struggles was the threatened strike in 1916 of the large and powerful unions of railway employees. President Wilson intervened and practically compelled congress to pass (Sept. 3, 1916) the Adamson act by which a basic eight-hour day was secured with pro rata for overtime. The supreme court upheld this statute, which went to the farthest verge thus far of the federal government's authority over labour matters.

Social Movements.— These struggles between the railways and the courts, between the trusts and congress, between labour and state governments. between strikers and the president of the United States, are part of U.S. history because they were vital. to the welfare of the country. The farmers everywhere were aroused, for they looked on railways as hostile to their interests, by overcharging for carrying their products; and they resented the trusts, which they believed raised prices. The antiliquor forces steadily developed strength. They urged out-and-out prohibition and secured it in more than half the states. At the end of 1917 war prohibition was enacted by the federal government and also prohibition in the District of Columbia. On Dec. 19. 1917, a two-thirds majority was secured in congress for a prohibition constitutional amendment — the 18th amendment — nhich was at once submitted to the states. Woman suffrage also advanced steadily. Congress submitted a woman suffrage amendment in 1919. Thus changes that had been 50 years on the way finally were brought about by the force of public opinion. A change was also visible in the attitude of the country toward immigration which congress was determined to reduce by an intelligence qualification. A new bill (Feb. 5, 1917) mas passed over Wilson's veto. Besides a literacy test it raised the head tax to $8 and excluded oriental labourers coming from certain geographical areas. mhich did not include Japan but did apply to Hindus and Malays.

Educational Progress. — The several years following 1909 were marked by a new sense of the possibility of general education, and the need for a more direct, searching and practical type of education. The country was accustomed to a system of graded public schools, offering the common school education, and leading up to a few endowed and private schools, and to thousands of public high schools, which were expected to prepare the small proportion of young men and women who went on to institutions of higher education. Secondary education was subdivided into literary, commercial and industrial schools. The institutions of higher learning set up new professional departments, including the intensive study of education and separate schools of science, engineering, agriculture and other specialties. Private enterprise created a great number of so-called business colleges, and a few very efficient trade schools.

Nevertheless there was general complaint that the schools did not relate themselves to the life of the community. A National Society for the Promotion of Industrial Education became the focus of a movement to organize what now became generally known throughout the country as vocational education. A national commission was appointed by President Wilson, in 1914, to consider the whole subject. The resulting Smith-Hughes act (Feb. 22. 1917) created a federal board for vocational education which framed an elaborate plan for instruction in the four vocational fields of agriculture, commerce, industry and home-making.

The act promised to appropriate federal funds to be paid to such states as would match these funds dollar for dollar.

Private enterprise accompanied this movement by building up advanced engineering and trade schools of a high type, such as the Carnegie institute at Pittsburgh; by improving the private commercial schools and by establishing advanced schools of business training in colleges. Some of the great manufacturers, especially of automobiles, set up schools within their own works.

When the United States plunged into World War I in 1917. the government established a variety of vocational schools to train men for the numerous specialties of military service. It made use of the shops and other vocational facilities of the existing schools and colleges. Great sums were raised by special drives among the alumni and friends of the endowed institutions, and the state universities were allotted hitherto unheard-of grants. The strictly vocational schools were admitted into fellowship with the other institutions.

Wilson's Foreign **Policy.**—Woodrow Wilson was naturally a man of peace, and so emphatically was Secretary Bryan. They set themselves to aid the cause of general peace by arbitration treaties. Secretary Bryan prepared a definite project for treaties by which the nations concerned should, in case of difficulties, pledge themselves to submit their grievances and claims to a special examining commission and to abstain from war or preparations for war until the commission should have had time to report. The presumption was that a sensible nation would submit to the judgment of an impartial tribunal. There was little difficulty in concluding more than 30 treaties upon this basis in the course of a year. hut none was put into effect. The truth was that the American people, as a whole little accustomed to international questions had no definite foreign policy.

Philippines and Caribbean. — The government of the Philippine Islands was altered by setting up the first Filipino assembly in 1907. In response to the pleading of President Taft, congress in 1909 grudgingly included them within the customs boundary of the United States. Under President Wilson, Gov. Gen. Cameron Forbes was withdrawn and Burton Harrison was appointed his successor, to carry out a policy of liberalization and preparation for independence. The Filipinos were allowed to hold a majority of the seats in the commission, which became a kind of administrative upper house. Filipinos were substituted for Americans in many of the civil offices. The people were thus given a definite opportunity to govern themselves. The Jones bill, enacted Aug. 29, 1916, greatly enlarged the power of the popular part of the government. and the commission ceased to exist. The act promised that the Filipinos should be given their independence when their ability to govern themselves should be demonstrated.

At the other end of the American sphere of influence, Cuba, while nominally independent, remained a protectorate of the United States. On March 2, 1917, the Puerto Ricans were for the first time made American citizens and received a popular government of two elected houses. President Wilson continued the administration of the Dominican republic which dated back to Roosevelt. He also took military control of Haiti in 1914, and followed it by a controlling treaty which was ratified by the senate (Feb. 28, 1916). He carried even further Taft's policy in Nicaragua by a treaty (ratified Feb. 18, 1916) which converted that country into a virtual protectorate. Another area came under control of the United States by a treaty for the annexation of the Danish West Indies proclaimed in 1917. These islands were duly organized under the title Virgin Islands of the United States. Little opposition was made to this creation of a virtual empire, including dependent provinces.

Latin America and the Orient, 1913–17.—The peaceful policy of the United States toward its neighbours was severely tested by disturbances in Mexico. In 1913 Francisco Madero, president of that republic, was murdered, presumably by order of Victoriano Huerta, an insurgent officer, who thereupon declared himself the head of the state. The almost invariable policy of the United States had been to recognize any de facto head of a Latin-American government without inquiring into the source of his title. But on this occasion President Wilson adopted what he called a policy of "watchful waiting." He steadily refused to recognize Kuerta against rival revolutionists. In April 1914 a trifling dispute arose at Tampico as to a salute of the U.S. flag and Wilson, apparently yielding to strong public sentiment, ordered the navy to attack and capture Veracruz, of which the United States remained in possession for several months. The real object was to discredit Huerta, who was compelled to flee the country. When in 1916 the brigand Pancho Villa raided Columbus, N.M., the president ordered a military expedition under Gen. John J. Pershing to advance into the interior of Mexico. It remained about eight months without capturing Villa or accomplishing any other definite result. The three friendly nations of South America — Argentina, Brazil and Chile, commonly known as the "ABC powers" — offered a kind of mediation. At their suggestion V. Carranza was recognized as president by the United States. Disorder continued, and in May 1920 Carranza was overthrown and killed by the troops of Álvaro Obregon. For a time thereafter Mexico emerged from the state of revolution.

This long controversy was highly disturbing to the desired close relations with Latin America in general. In spite of four Pan-American congresses and several scientific congresses, in spite of visits of Roosevelt and of Root and Philander Chase Rnox as secretaries of state to South America, thkre could be no harmony if the United States were to continue "administering" small and defenseless Latin-American nations and waging undeclared wars with Mexico. Nevertheless, President Wilson in a speech at Mobile. Ala. (Oct. 27, 1913), declared that the United States had no designs on the territory or independence of its Latin-American neighbours. Colombia, too, had a grievance arising out of the loss of the isthmus when the Panama canal zone was annexed in 1904. A treaty negotiated by Bryan to pay to Colombia $25,000,000 as a kind of reparation was ratified by the Republican administration in 1921.

In regard to the far east, Wilson had little opportunity to develop a policy. He began by disavowing the plans made under the advice of President Taft for a loan by U.S. bankers to China. He argued with the people of California because they insisted on passing a statute restricting alien ownership of land by Japanese residents. World War I soon united the United States and Japan in a common cause, and on Nov. 2, 1917, the Lansing-Ishii note, on the same plan as the Root-Takahira note of 1908, set forth that the United States recognized Japan's "special interests in China."

Neutrality. — The United States in 1914 expected to remain indefinitely at peace, as was shown by lack of anything that could be considered national military preparation in terms of modern warfare. When, on Aug. 4, 1914, President Wilson issued a proclamation of neutrality as between the two groups of European nations just engaging in a gigantic struggle, the authorized military establishment was about 107,000 men, of whom about 87,000 were enrolled. The United States had not one military airplane of approved type; had only four modern heavy field guns and no transport for them; had not a trench bomb or a mine thrower; nor considerable supplies of any weapons or equipment except 800,000 rifles; nor any officers experienced in the kind of warfare used in modern wars; nor any instruction camps for officers or men. The navy included a fleet of battleships recently built, but it was weak in small and swift vessels and particularly in submarines. The militia proved to be of little service, though Secretary Bryan publicly declared that the nation needed no preparation, for it "could raise a million men between sunrise and sunset."

Neither the foreign policy nor the diplomatic organization of the United States was fitted for such a crisis. The traditional Monroe Doctrine was expected to keep the nation out of dangerous controversies with the other American states. The counterpart principle of isolation forbade the United States to take any part in European crises or wars. As a neutral it stood by the principle of "freedom of the seas," by which was meant in particular the right to carry on commerce with all belligerents in case of war, subject to the limitations of the then acknowledged international law as to contraband and blockade. Soon after the beginning of World War I relief was organized on a large scale for the Belgian people, most of whose country was overrun and held by the Germans. This system soon included French refugees, the unhappy peoples of Serbia and Asia Minor and other combatant or noncombatant sufferers, besides the sick and wounded of the contending armies.

Difficulties With the Belligerents, **1914–17.**—The United States was compelled at once to take into account the relation between the war and U.S. industries, commerce and finance Heavy loans were placed in the United States by Great Britain, France and Russia. As fast as the money was borrowed it was spent in the United States for the purchase of food, clothing, animals and especially munitions. President Wilson issued a proclamation (Aug. 18, 1914) advising that the people remain neutral "not only in act but in word and in thought." Such neutrality mas impossible. In the first weeks of the war, German commerce was driven from the seas. The command of the sea by the Allies very nearly cut off trade of any kind between the United States and Germany and Austria, while commerce continued in ever-increasing volume with England and France. This disparity led to protests on the part of the German government, and also to lawless acts perpetrated or directed by agents dispatched by the German government for the purpose of paralyzing the munition factories. Violent antipathies were caused by the German methods of carrying on war, and particularly the treatment of the occupied areas of Belgium and France. The American population included hundreds of thousands of citizens of the belligerent countries, many of whom attempted to return to their homes in order to serve in the army. The road for such recruits was blocked for the Germans and their allies, but open to the Allies. For the first time in half a century the United States found within its own borders a sharp division on questions of foreign policy.

On the other hand, the war trade brought immense profits. The favourable balance of trade rose from $690,000,000 in 1913 to $1,770,000,000 in 1915 and $3,000,000,000 in 1916. This prodigious debit was balanced by about $3,000,000,000 sent to the United States in securities and gold, besides $2,000,000,000 in foreign war bonds. Under these circumstances genuine neutrality was out of the question. A decided preponderance of sympathy developed toward the western Allies, who were profitable customers, were in close and almost undisturbed dealing with the United States and were considered to be fighting against a ruthless, arrogant and dangerous autocracy.

International Controversies, **1914–17.**—The internal tension of the United States mas tightened by the insistence of Germany on the right to use new weapons, tactics and practices of war, without the traditional limitations of international law, without mercy to noncombatants, on the basis of "a law of necessity." No able-bodied German man or woman was really a noncombatant; the Germans insisted that they must regard all civilian enemies as combatants. There was no way to stop them without using similar new methods of warfare.

Great Britain, which in the London Maritime conference of 1908–09 had shown some disposition to enlarge the privileges of neutral commerce, now seized U.S. ships and shipments, and arbitrarily extended the list of contraband, until (Dec. 26, 1914) a dispatch signed by Secretary Bryan, but expressing the conclusions of President Wilson, made a protest. In the course of 1915 the British government began to apply the U.S. principle of "continuous voyage" as applied by the United States during the Civil War to cover shipments to neutral ports in cases where those shipments were likely ultimately to reach Germany; and also where they might replace products of the neutral countries that could thus be spared for Germany; or if the neutral countries declined to make a hard and fast agreement not to reship.

In 1916 the British were practically blockading neutral European ports and capturing vessels, U.S. and other, wherever they liked. The Central Powers set up a new war practice of using submarines as commerce destroyers. The U.S. government protested. A crisis came through the sinking by a submarine of the British passenger liner "Lusitania" (May 7, 1915), with the loss of 139 American lives. That sinking seemed a deliberate act of the Germans to test the temper of the United States. Apparently they were greatly surprised when the people of the United States rose in resentment. President Wilson, who had earlier insisted on "strict accountability," insisted on a sharp protest. Bryan thought milder measures sufficient, and on that issue resigned the secretaryship of state (June 8, 1915), being succeeded by Robert M. Lansing. The correspondence went on until October when Germany at last informed the U.S. government that merchant ships would not be sunk without warning and an opportunity to save noncombatant lives. Meanwhile, throughout 1915 and 1916, systematic violations of the neutrality laws of the United States by Germans and Austrians caused the dismissal of the Austrian ambassador to the United States and of two members of the German ambassador's staff.

"Preparedness." — By the end of 1915 it became clear that with or without their own desire, the people of the United States might find themselves involved in the war. President Wilson desired peace. A day or two after the sinking of the "Lusitania" he spoke of there being such a thing as "a nation that was too proud to fight." In his message of Dec. 1915 he urged national defense and the protection of American shipping. Long before this time World War I had brought about a violent change in the economic conditions of the country. The great demand for foodstuffs raised the price of grain and other farm products. The high cost of living became a political issue. The munition factories offered unheard-of uages and drew hundreds of thousands into improvised tonns. The war caused a great change in immigration. Hundreds of thousands of men left the United States for Europe, while the net immigration fell from 1,200,000 in 1914 to 300,000 in 1916.

The Election of 1916.—In the midst of this turmoil and confusion of business came the preliminaries of the presidential election of 1916. President Wilson carefully abstained from taking sides between the Allies and the Central Powers; but the aggressive submarine policy of Germany provoked a much sharper tone than did the aggressions by the English. He felt the need of caution, particularly because a growing group of men, among them Roosevelt, were coming to the conclusion that eventually the United States would have to join in the war.

The Republican nominating convention met in Chicago, June 7. A strong effort was made by friends of Roosevelt to capture the Republican convention, but the standpat Republicans had control of the party machinery. The Progressives—who in Nov. 1914 had cast 1,800,000 votes for congressional and state candidates—also met in convention in Chicago. Their purpose was to compel the Republicans to nominate Roosevelt as the only means of healing the breach. That effort failed: the Republicans nominated Justice Charles E. Hughes of the supreme court, who had been a reform governor of New York state. The days of the Progressive party seemed numbered.

In the Democratic convention (June 14) there was practically no opposition to Wilson and his running mate T. R. Marshall. The platform in many respects was similar to that of the Republicans. Both favoured woman suffrage, the conservation of national resources and national enforcement of child-labour laws; both reaffirmed the Monroe Doctrine. But the Democrats upheld tariff for revenue only; they endorsed the promise of ultimate independence to the Filipinos; they commended the establishment of a federal trade commission; and they approved a merchant marine owned and operated by the federal government. In the campaign Roosevelt publicly supported Hughes, though it was well-known that he felt no enthusiasm for him. The only slogan that caught the public ear was favourable to Wilson: "He kept us out of war." Wilson received about 9 000,000 popular votes against 8,500,000 for Hughes, and was chosen by a close vote in the electoral college.

Entry Into World War I.—President Wilson stood in a strong position in the United States and in the world. He had been reelected. His policy was approved. He felt that he had the nation politically united behind him. He hoped that the one great neutral nation might bring about peace. On Dec. 18, 1916, he sent a communication to the warring powers suggesting that they come to an understanding of each other's demands. On Jan. 22, 1917, in an address to the senate on foreign affairs, the president described the replies he had received to the identic note of Dec. 18.

> The Central Powers united in a reply which stated merely that they were ready to meet their antagonists in conference to discuss terms of peace. The Entente Powers have replied much more definitely, and have stated, in general terms indeed, but with sufficient definiteness to imply details, the arrangements, guarantees and acts of reparation which they deem to be indispensable conditions of a satisfactory settlement.

He went on to speak of an "organized common peace," and of a "peace without victory"; he outlined the principle of self-determination, declaring that "Governments derive all their just powers from the consent of the governed," and that "no right anywhere exists to hand people about from potentate to potentate as if they were property." The German answer was a brief note communicated by Ambassador Count von Bernstorff to Secretary Lansing (Jan. 31, 1917), withdrawing the pledge given in Oct. 1915 and renened in May 1916 that merchant ships would not be sunk without preliminary warning and announcing that the Germans would shortly resume unrestricted submarine warfare. High military authority in Germany believed that Americans would never sacrifice the large profits of export trade and incur the huge expenses of war merely for the sake of a question of neutral maritime rights.

Immediate steps were taken to make the U.S. navy ready for war. For a time the president dallied with a plan of arming merchant ships. One result of the controversy was the adoption by the senate (March 8) of a mild and cumbrous method of cutting short debate by closure. During February and March 1917 a few U.S. vessels were torpedoed by German submarines. On March 1 the government published an intercepted German dispatch to the Mexican government asking it to join in the war, promising it the "former Mexican provinces," long incorporated in the United States. The participation of the United States in the war was now inevitable. A formal declaration of a state of mar was signed by the president (April 6) after a house vote of 373 to 50 and a senate vote of 82 to 6, which stated that war had already been begun by Germany. Relations with Austria and Turkey were at once broken off, but the declaration of war with Austria was delayed until Dec. 7 and no declaration was ever made against Turkey or Bulgaria.

The breach with Germany was a spontaneous national action representing a national belief that the United States could no longer live in peace with such a nation as Germany had become. As President Wilson put it the war was to make the world "safe for democracy." Moreover, there was widespread sympathy with the three western powers, France, Belgium and Great Britain, which were closest to the United States in their political principles and system of government. Wrath was aroused by the German treatment of the people of Belgium and other conquered countries. In some minds there existed a genuine and well-grounded fear of a future attack upon the United States by Germany if the resistance of the Allies should be destroyed. Amid all the motives for the war, the one thing was that the American people recognized Germany as an enemy, and the enemies of Germany as natural friends and partners in the great enterprise of subduing "the Hun."

War Measures.—Passionate national spirit, patriotism and urgent reasons for war were all useless unless the United States could enroll, train, equip, convey and continuously supply an immense army. The U.S. navy, though the vessels were good and the crews skilled and well commanded, was in no position to give direct aid in the process of destroying the German army. What was most needed was to raise and convey to the fighting front a large force of U.S. troops.

Soon after the declaration of war by the United States, missions from the various Allied countries were sent to America. The British mission, headed by Arthur (later Lord) Balfour, British foreign secretary, reached Halifax April 20 and proceeded to Washington. The French mission, headed by Rene Viviani, the former premier, and including Marshal Joseph Joffre, landed April 24. Other missions came from Italy, Belgium, Russia, Rumania and Japan. The United States was able at once to help the western Allies in their pressing financial difficulties. Taxes were low and little felt; money abounded. Under acts of congress beginning Oct. 17, 1917, the Allies received essential credits, which amounted eventually to $9,500,000,000.

These enormous payments were made possible by the Liberty Loans. In June 1917, 4,000,000 people joined in offering $3,000,000,000 to the government; and at the end of World War I the interest-bearing debt had increased from $972,469,290 on Dec. 31, 1916, to $25,234,496,274, on June 30, 1919. These loans were supplemented by the War Revenue act (Oct. 17, 1917) and later statutes, which laid a variety of new taxes, increased the income tax heavily and combined with it an excess-profits tax to bring into the treasury unreasonable profits likely to be made in the war industries.

All traditional limitations on raising an army were discarded. On May 18 the Selective Service act was passed which provided for the enlistment of 1,000,000 men by "selective draft." When called up, the men had to be clothed, housed, fed and drilled. Thousands of officers were necessary, and training camps. both for men and officers, were established on a vast scale. In May 1917 a few U.S. destroyers reached England. On June 9 General Pershing, who had been selected as commander in chief, arrived in England. On June 26 a small detachment of United States troops reached Europe. New branches of military service were established, among them the chemical warfare service which provided materials for lethal gases and for gas masks and other means of resisting the enemy attacks. Congress, on July 24, appropriated $640.000.000 for aviation. By August about 700 000 men were enrolled in the army and 230.000 in the navy.

Control of Industry and Transportation.— The establishment of huge war industries put a great strain on the industry and transportation of the United States. On Aug. 10, 1917, a Food Control act gave the president powers never before conferred aith regard to food and fuel. Herbert C. Hoover of California, who had distinguished himself in the management of the American Red Cross in Europe, was made food administrator with large powers. Before World War I ended he had established "meatless" and "wheatless" days; the price of grain mas fixed; eventually the farmers were assured $2.20 a bushel for their wheat crops. H A. Garfield, fuel administrator, carried through drastic measures for stimulating the production of fuel, regulating shipments and distributing supplies. On March 21, 1918, the Federal Control act placed the management of all the railways in the country in the hands of the government during World War I and for a period after its close. McAdoo, secretary of the treasury, was made director general of the railways; later Walker D Hines an experienced railway man, succeeded him. One of the most serious needs of the times was a merchant fleet adequate to carry across the Atlantic the army and its supplies. The government undertook the great task of improvising such a fleet, and vast construction was authorized in both steel and wood.

War Activities at Home.—At once after the declaration of war the American people through official and unofficial channels gave support by civilian service and money contribution. Among the multifarious public agencies was a committee on public information, of which George Creel. journalist, was chairman, which kept up a lively system of publicity aided by the National Board for Historical Service. A censorship board censored all communications—mail, cable, radio—passing between the United States and foreign countries. As early as Aug. 29, 1916, the Council of National Defense was created by act of congress. Under it were created numerous special organizations. The Council of National Defense appointed a women's committee to co-ordinate the patriotic nork of the women throughout the country. The advisory commission of the Council of National Defense created a committee on transportation and communication. A railroad mar board undertook to secure unity of operation among all the railways, to subordinate private interests and to eliminate competition. Important coastwise steamship lines were added to this system. In 1918 the government assumed control of telegraph, telephone, marine cable systems and radios. Many scientists were engaged in research throughout the country under the Kational Research council. Commerce also was regulated.

By the Espionage act of June 15, 1917, the president was empowered to control exports, and he created a bureau of export licences and a trade board. A list was prepared of firms throughout the world with nhom Americans should not trade. The government formally took charge of all foreign trade Feb. 15, 1918, and seized all German ships interned in United States ports.

Gompers co-operated in organizing a committee on labour, and a mediation commission was appointed. The National War Labor board (April 9. 1918) acted throughout the country as a kind of supreme court to settle labour disputes. For the recruiting of essential labour and directing it into necessary industries a U.S. employment service was created.

Several private war agencies were established. Chief among these were the American National Red Cross, which was to be found wherever there was fighting, sickness, suffering or starvation: the Young Men's Christian association; Young Women's Christian association; Knights of Columbus (Roman Catholic); Salvation Army; Jewish Welfare board; American Library association; and War Camp Community Service.

While the people of the United States were practically a unit in favour of a vigorous prosecution of World War I, a few, chiefly foreign-born or sons of foreign-born, were opposed to the war or more often to the nations in concert with which the United States was fighting. Ever since 1914 the country had been irritated and aroused by a series of illegal, violent and often murderous acts which were traced to German and Austrian agents. Such were determined efforts to blow up the international bridge at Vanceboro. Me., and the locks of the Welland canal, Ont. The German consul general at San Francisco, Calif., was convicted and imprisoned for aiding German vessels in the Pacific in defiance of neutrality laws. Franz von Rintelen (after the war specially rewarded by the German government) was sent to the federal prison at Atlanta, Ga., for aiding in placing bombs on outgoing vessels with intent to destroy them.

The Navy.—Beginning with patrol work on the American coast as soon as war was declared, the activities of the United States navy extended to co-operation with the British and French in the tracking down of submarines and the protection of convoys and in the laying of the North sea mine barrage, extending from the Orkneys to Norway. The U.S. navy had some part in blockading the Austrian coast of the Adriatic, and it participated in maintaining that Allied command of the sea which in the end was fatal to Germany. By a remarkable convoy system more than 2.000.000 troops were carried safely 3.000 mi. overseas to France. In this work the utmost secrecy was necessary. In June 1917 a few cruisers and transports were provided and the first troops sent across. At intervals vessels assembled and sailed on definite routes under the protection of destroyers. According to the report of the secretary of the navy (1920), 911,047, or nearly half of the U.S. troops, were carried on United States navy transports; the rest chiefly by the British. Not one eastbound U.S. transport was torpedoed by the German submarines; and only three ships were sunk on their return voyage. Three small fighting ships were destroyed by the enemy.

During the campaign of 1918 efforts were made to extend the possible field of enlistment by the passage of the Man Power act of Aug. 27. All men between 18 and 45 were required to register with a view to service if needed. and 11,000,000 were registered. By a statute of Oct. 6, 1917 provision was made for a system of military and naval insurance available for all men in the service. (For military events. see WORLD WAR I.) (A. B. H.; X.)

Rehabilitation, 1919.—The task of post-bellum economic adjustment was long and costly. At the end of the war the federal government by means of war statutes was attempting to control the distribution of food, was in fact limiting and rationing manufactured goods and mas continuing to direct mining of coal and its shipment. The government was directing the operation of railways, and the telegraph and telephone services. It had taken over the property of aliens through an alien property custodian. For foreign commerce there was still the Shipping board, the Emergency Fleet corporation, the War Trade board and the War Finance board. Two million U.S. soldiers were overseas and wanted to come home as soon as possible. The United States had spent on the war about $35,500,000,000, including $9,500,000,000 lent to the Allies. Expenditures after peace came continued on a scale far beyond any previous experience of the country.

In the course of six months after the Armistice, about two-thirds of the troops were brought back, leaving behind them enormous stores, large parts of which were sold at heavy discounts to European governments. On June 1, 1920 the only U.S. troops left in Europe were en army of occupation in western Germany.

The Election of 1918.—The Armistice had come a few days after the state and congressional elections of the autumn of 1918. Despite the deep political and sectional divisions in both the Republican and Democratic parties that had preceded the declaration of nar in 1917, the nation had been a unit in waging war. Partisan politics did not enter into the organization of the armed forces. Little attention was paid to politics in the civilian administration of the war. Yet the administration of the president was subject to constant attack by prominent Republicans and by Republican members of congress, and in Jan. 1918 the Republican national committee began a campaign to capture control of congress in the autumn elections.

A few days before the elections, President Wilson issued a circular letter urging the voters to return a Democratic majority to the senate and the house. The result of the election, however, made the new house decidedly Republican and the senate Republican by two votes. It was apparent, therefore, that the administration in making the necessary adjustments after the war had to take into account the preponderant opposition in both houses of congress.

Throughout 1918 the influence of Roosevelt in the Republican organization was manifestly growing. It became clear that he would wield great influence in the Republican convention of 1920 and might be chosen as candidate of the party, despite his defection in 1912. But he died suddenly on Jan. 6, 1919.

The Peace Conference.—In Dec. 1918 President Wilson decided that he would attend the forthcoming peace conference in person, and designated as peace commissioners Secretary of State Lansing, Colonel House, Gen. Tasker Bliss of the army and Harry White, formerly minister to France. Wilson was one of the representatives of the four great powers—Great Britain, France, Italy and the United States—who prepared the articles of the treaty of peace.

A part of the treaty was the covenant of the League of Nations, a crystallization of long-debated suggestions for a world confederation of states. President Wilson was deeply interested in the foundation of such a league as was envisioned in the covenant, and was willing to agree to a suggestion of the French for a treaty of mutual protection in order to gain the support of the French for the proposed covenant.

U.S. Action on the Treaty, 1919.—It had been apparent during the course of the negotiation of the treaty that in the U.S. congress and electorate there would be vigorous debate on the covenant of the League and, indeed: upon the question of U.S. membership in such a league. President Wilson returned home for a short stay (Feb. 24–March 4), defending the general terms of the treaty and the covenant. On June 28, 1919, he and his four commissioners signed for the United States the formal treaty of Versailles, including the covenant of the League, which was so interwoven into the text of the treaty that it was impossible to ratify one without the other. The treaty had many powerful supporters among all parties, particularly former President Taft, the League of Free Nations association and the League to Enforce Peace. The senate was divided into strongly opposed groups. Most of the Democrats, under the lead of Sen. Gilbert Hitchcock (Neb.), followed the president in favouring the treaty with the covenant as it stood. A group of Republicans, headed by Sen. Henry Cabot Lodge of Massachusetts, favoured "amendments" to the treaty and "reservations" to the League. Another group desired reservations that would practically destroy both. A small group, including Sen. William Borah of Idaho and Senator Johnson of California, were against both the treaty and the covenant in any form or with any reservations.

The contest ostensibly centred about art. x of the covenant, under which the members of the League undertook "to respect and preserve as against external aggression the territorial integrity and existing political independence of all members of the League." The implacable group expressed fear lest the United States be drawn into foreign wars and insisted that "no American soldiers or sailors must be sent to fight in other lands at the bidding of the League of Nations." The president, on the other hand, regarded art. x as the heart of the whole treaty. He declined at the critical moment to accept either amendments or reservations, except certain minor alterations. After strenuous debate and by a test vote, Nov. 19, 1919, the senate refused to ratify the peace treaty with reservations—the vote being 53 to 38 in favour, but not the necessary two-thirds. In the regular session upon resubmission, the vote was 49 to 35, again not the necessary two-thirds. Thus after five months' discussion the treaty was rejected, and the United States was left in the situation of remaining technically at war with Germany and Austria though all hostilities had ceased a year before.

President Wilson, believing that he could arouse public sentiment to force senate ratification, had undertaken a tour of the country in September. He was greeted by great audiences, but the response of the country was not convincing. Not only did senate opponents speak before great audiences in rebuttal, but it was apparent in public discussion that many elements in the population were pledged to U.S. "isolation" from Europe.

The president's tour was abruptly ended when he collapsed, in Colorado, and a paralytic stroke in October removed him for months from active participation in work of the government.

On March 4, 1921. Wilson accompanied President-elect Warren G. Harding to the Capitol as the last act of his official life. Wilson had been president for eight years, during six of which he was the undisputed leader of his party. He was responsible for important revenue. banking and labour laws. He had a great hold on millions of citizens. For a time in Paris he was the foremost man in the world, and he succeeded in inducing foreign statesmen to accept the League of Nations. At the height of his career he lost the prestige gained as war president of the whole country. was no longer fully accepted by his party and ceased to be the one man who could appeal from congress to the people. He lived in Washington in retirement, physically unable to take part in public affairs. and died Feb. 3, 1924.

Presidential Election of 1920.—The peace revealed underlying elements of dissatisfaction. The soldiers received in many states a money bonus and an organized lobby demanded a bonus from congress. The general public complained bitterly against the rising cost of living. A multitude saw their incomes and expectations reduced by the fall in the purchasing power of the dollar. As the presidential election opened, the Democratic party was paralyzed by internal dissensions over the peace treaty and by lack of leadership of the president; it had no accepted policy in foreign relations or reconstruction and no commanding figure to put forward for the presidency.

The Republicans were rent by personal rivalries. Gen. Leonard Wood, Gov. Frank Lowden of Illinois and Senator Johnson were outstanding candidates. The convention at Chicago (June 9, 1920) passed them all by, and gave the nomination to Sen. Warren G. Harding of Ohio. He was backed by a strong group of standpatters. Calvin Coolidge. governor of Massachusetts, mas put on the ticket as vice-president. The Democratic convention held at San Francisco was confronted with similar difficulties. The nomination went to Gov. James Cox of Ohio, a man little known in national affairs, with Franklin D. Roosevelt of New York, who had served as assistant secretary of the navy. as candidate for the vice-presidency. In the campaign for the first time women were eligible to vote in every state. The election was a complete triumph for the Republicans, who elected Harding by a popular majority of about 7,000,000. and an electoral majority of 404 against 127 for Cox, besides securing solid majorities in both houses of congress.

The presidency was thus transferred to a man little experienced in national politics. whose task it was to take over the discordant elements and build out of them a coherent policy. President Harding began his administration under favourable auspices, although several members of his cabinet had been chosen in the face of strong opposition from various quarters. The new president displayed keen interest in all attempts to restore business to a sound basis and urged prompt action in the assistance of the railways. By nature conservative, he laboured to bring the country back to a state of "normalcy."

Harding's foreign policy was to remain outside the League of Nations. Special treaties of peace negotiated with Germany, Austria and Hungary were ratified by the U.S. senate Oct. 18, 1921. Of world-wide importance was his call for a conference at Washington of the different powers bordering on and interested in the Pacific ocean, to discuss both questions of the Pacific and the limitation of armaments. The conference assembled Nov. 12, 1921 and closed Feb. 6, 1922. The nine participants were the United States, Great Britain. France, Italy, the Netherlands, Belgium, Portugal, China and Japan. Important agreements were signed: to limit construction of capital warships; against improper use of submarines; against gas warfare; for maintenance of the status of Pacific insular possessions; and other questions involving relations with Japan and China (see WASHINGTON CONFERENCE).

Before Harding came to the presidency, two constitutional amendments had crystallized some of the results of the mar. The various prohibition measures passed by the congress led finally to passage and ratification of the 18th amendment. The service of women in the war, together with the votes they already enjoyed, caused congress (June 7, 1919) to submit the 19th constitutional amendment annulling all restrictions of sex on suffrage. It received the ratification of the 36th state on Aug. 24, 1920. and went into force Aug. 26.

Political and Social Conditions. — A study of the political, social and economic history of the United States must take account of the extraordinary national elation following World War I. It produced a profound effect upon the national mind and was the beginning of an enlargement of national life in every direction. The nation felt free to expand its influence in the Caribbean and the Pacific. Hence the maintenance and enlargement of a policy of paramount interest in the three normally independent countries — Cuba, Haiti and the Dominican Republic, and a strengthening of the control over Panama, Honduras and Nicaragua.

To carry out great national policies. the United States could call upon a population expanding from year to year. The total continental population rose from 92,000,000 in 1910 to 106 000,000 in 1920. Net immigration of 818,000 in 1910 sank to 19,000 in 1918. but rose in 1924 to 663,000. The wealth of the country, estimated at $187,000,000,000 in 1912 was counted at $321,000,000,000 in 1922, and was still swelling in volume. Against these figures, such burdens as a national debt of $25,000,000 000. bearing $1,000,000,000 of annual interest, besides $6,000,000,000 of state and municipal debts were insignificant. Manufacturing, transportation, mining, distribution and financial business were all prosperous.

Political rancour and party spirit diminished during these years. President Harding drew several strong men into his cabinet in March 1921. Secretary of State Hughes had been a justice of the U.S. supreme court and candidate for the presidency in 1916. Secretary of the Treasury Andrew Mellon nas a successful banker and financier uho had never before appeared in public life. Hoover, secretary of commerce, contributed his extraordinary gift of business organization. Henry C. Wallace, secretary of agriculture. was the editor of a great agricultural newspaper. President Harding's career was cut short by a very brief illness, however. and he died in San Francisco. Aug. 2. 1923.

President Coolidge, now elevated from the vice-presidency, set up a new regime in the White House. He proved to be a man of strong character, nho consulted those whom he trusted and then made up his own mind and stood by his decisions. Coolidge for the time being continued Harding's cabinet, but later changes were made. so that at the end of five years Secretary of the Treasury Mellon, Secretary of Commerce Hoover and Secretary of Labour James Davis were the only men left of Harding's first cabinet.

The growth in wealth and enterprise reacted upon the government where even the president's cabinet mas disturbed and dismembered by a painful series of accusations and investigations. For several years the government had conserved certain oil-bearing areas of public land as a supply of oil fuel for the navy. On April 7, 1922. jurisdiction over this matter was transferred from the navy department to the interior department by an order of President Harding. Under this authority Secretary of the Interior Albert B. Fall leased to the Sinclair interest a large tract in the Teapot Dome district in Wyoming, and also leased one of the California reserves to the oil magnate, Edward L. Doheny. There was an investigation by a senate committee under the chairmanship of Sen. Thomas J. Walsh of Montana. Secretary of the Navy E. Denby resigned and was replaced by Judge Curtis D. Wilbur of California. Meanwhile Atty. Gen. Harry M. Daugherty came under attack. A special committee of the senate under Sen. B. K Wheeler of Montana unearthed questionable procedures and Daugherty refused to allow the files of his office to be examined by the senate committee. President Coolidge demanded his resignation March 28. 1924. Criminal proceedings were instituted against Fall, Doheny and Daugherty, but legal technicalities were invoked by the defense and President Coolidge took a neutral attitude in these proceedings, which he considered to be outside the scope of the executive power. Daugherty was succeeded as attorney general by Harlan F. Stone of New York; then Stone was placed on the supreme court bench and Tohn G. Sargent of Vermont became attorney general.

In the congressional elections of 1922 the Republicans had retained small working majorities in both house and senate. There was, however, a return of earlier conditions in the appearance of a small group of independent Republicans. with La Follette as leader. who were able sometimes to hold the balance of power between the regular Republicans and Democrats. President Coolidge's conduct during his eight months in office seemed to justify the confidence of his party; and when the Republican convention met in Cleveland there was little opposition to his nomination. The vice-presidency offered difficulties. In the end the choice fell upon Charles G. Dawes, known through his association with the commission of 1923 which had devised a scheme for the payment of reparations by Germany. The Democratic convention, held in New York city, was the longest and fiercest in 60 years. The vote was divided between McAdoo, former secretary of the treasury, and Alfred E. Smith, who had won a national reputation as governor of New York.

The convention balloted 103 times; but neither candidate could secure the necessary two-thirds. The convention finally nominated John W. Davis of West Virginia, former ambassador to Great Britain. mith Charles Bryan (brother of William Jennings Bryan) as vice-presidential candidate. The campaign was quiet; in the election (Nov. 1924) Coolidge received 15.725 016 votes, as against 8,386,503 for Davis and 4 822.856 for La Follette, who gathered up many discontented Republicans and the considerable vote usually cast for Socialist and other minor candidates. La Follette, honever, had only the 13 electoral votes of his own state as against 136 for Davis and 382 for Coolidge. It was a substantial Republican victory, accompanied by a Republican majority over-all of 59 in the house and 16 in the senate.

Finance. — Throughout both his terms of presidential service Coolidge addressed himself to a policy of economy. He stood by the budget bill which President Harding had secured from an unwilling congress and continued the appointment of Gen. Herbert M. Lord as chief budget officer. This reform meant simply that congress would not begin to act on the main appropriation bills until a budget based upon the ascertained needs of all the various departments had been drawn up, totaled and submitted by the budget officials.

During World War I the income tax mas used to transfer some of the immense mar profits to the public treasury. Thenceforward the income tax was the largest factor in the national revenue and nas vigorously collected from individuals and corporations. The policy of the government was to break down the high scale of war expenditure, to dispense with superfluous employees and so to come back to the public needs in time of peace. Several acts of congress, begun in 1921, reduced the rate of income tax. The result nas that the amount paid in income taxes, nhich was $2.600.763.000 in 1919 and $3,956,936,000 in 1520, came down to $1 691.090.000 in 1923 but rose to $1 761,659,049 in 1925. By the act of Feb. 26, 1926, the rates were still further lowered but without any decrease in the total collected; and the provision in the statute of 1924, under which the amounts paid by individuals or corporations nere open to the public, was repealed.

The Underwood tariff of 1913, passed by the Democrats and somewhat altered in 1916 and 1921, was repealed by a Republican majority after the inauguration of President Harding; and an emergency act nas passed (Mav 27, 1521). Soon afterward the Republicans framed a nen bill. the Fordney-McCumber tariff, signed by President Harding Sept. 21, 1922. It included a provision, never before a part of a United States statute, under which the president (informed by a tariff commission) was to have power to alter rates of duty if necessary to "equalize the differences in cost of production in the United States over similar articles produced elsewhere." The receipts from duties on imports, which were $334,000.000 in 1910 and $324,000,000 in

1920, rose to $549,000,000 in 1925. The public debt, which for many years previous to 1917 stood at about $1,000,000,000, was $26,594,268,000 after the close of World War I (Aug. 31, 1919); but on June 30, 1926, had been reduced to $19,643,183,000, partly by selling surplus war material and chiefly by payments made out of surplus.

Industry and Commerce.—However much the wealth of the nation increased, large areas of the country were far from prosperous. The rural credits banks, established under President Wilson, furnished needed capital, and the farmers from 1917 to 1919 had a guaranteed government price of $2.20 per bushel for wheat. When that protection was taken off after the war, a group of members of congress in both house and senate, commonly called the agricultural bloc, demanded special consideration for the agriculturists. Prices had tumbled and agricultural land values, inflated during the war, fell back to or below ante-bellum prices. The cost of living had nearly doubled. Discontent was reflected in the large popular vote for La Follette in 1924. Various propositions were made by farmers' associations and sympathetic members of congress that the federal government permanently guarantee a price for the principal staples. The south was also affected by this movement because the inroads of the boll weevil for a time greatly reduced the output. In some degree the conditions of 1885–95 were reproduced; only it was no longer east against west so much as it was the farmers of all sections against the group of manufacturers and distributors wherever established.

In spite of federal suits and supreme court decisions substantially upholding federal control under the Sherman act, the Mann-Elkins act and other measures against combinations, consolidations of capital went on steadily. The railways, which had been sustained during World War I by the government, were returned to their owners in 1920. For several years, notwithstanding a great increase in passenger and freight rates during the war, they were unable to make a fair profit. Under the Esch-Cummins act of 1920 they uere alloned to retain a profit of 54% earnings, plus one-half of 1% to make provision for improvements chargeable to capital accounts, all excess over 6% to be evenly divided uith the government. Meanwhile the administrative commissions lost prestige. The Tariff commission was disregarded. The Labour board was unable to enforce its decisions. The Interstate Commerce commission and the Federal Trade commission suffered in prestige and influence from internal strains and quarrels. The special Shipping commission, created during the war to build up a national merchant fleet, was left with a large number of vessels for which profitable business could not be found. The supreme court decisions, under which great corporations like the Standard Oil company and the American Tobacco company were regulated, left them more prosperous than ever. The hold of the great banks and the smaller banks and bankers on the finances of the country was unshaken. Deposits in national and state-chartered banking institutions in 1925 aggregated more than $40,000,000,000.

Social Questions.—During World War I the United States offered extraordinary wages in order to activate the pursuits necessary to supply the armed forces. This led to a general rise in u-ages of skilled workers, some increase for the unskilled and considerable increase in the earnings of domestic and agricultural workers. The labour unions made it their business to see that no systematic reduction of wages should succeed. In 1923 and again in 1925 came serious strikes of the miners' unions. The last one endured 170 days, and was settled only with great difficulty.

The most serious social question and most difficult governmental problem was national prohibition (see PROHIBITION). In 1918, while 30 states had laws on their statute books for the restriction of the liquor traffic, 28 states prohibited it outright. A prohibition (18th) amendment to the federal constitution became a part of the constitution Jan. 16, 1919. On Oct. 28, 1919, the Volstead act for enforcing the amendment was passed by congress over the veto of President Wilson. It forbade the sale or transportation of "intoxicating liquor" which was defined as any liquor which contained one-half of 1% of alcohol. To administer this act required a large force of officials distributed over the country. The amendment contained a clause under which the states were to have "concurrent jurisdiction," which appeared to mean that state laws might continue in force and be carried out by state courts. From the very beginning there was an organized system of evasion of the laws. A regular system of bootlegging, illegal sale and transportation sprang up. It was countered by highjackers—that is, bandits who seized bootleggers' supplies and carried them off by force, knowing that they were not likely to be followed by officers of the law. An organized marine bootlegging trade placed a line of foreign sailing craft and steamers just outside the three-mile limit of the United States, whence they supplied the markets of the adjoining coasts.

The United States entered into treaties with Great Britain and other nations in which it was agreed that vessels carrying their flags might be captured within that distance from the United States coast which could be traversed in one hour by the vessel suspected of endeavouring to commit an offense. Within the United States large numbers of otherwise law-abiding persons bought and sold or gave away bootleg liquor, and the difficulties of executing the law were shown by the figures of national enforcement. In one fiscal year (1924–25) 20,000,000 gal. of distilled and fermented liquors were seized; 77,000 persons were arrested; 50,000 criminal cases were entered against bootleggers; 35,000 pleas of guilty were entered; and 38,000 convictions were obtained. A national law regulating the traffic in habit-forming drugs was enacted May 26, 1922.

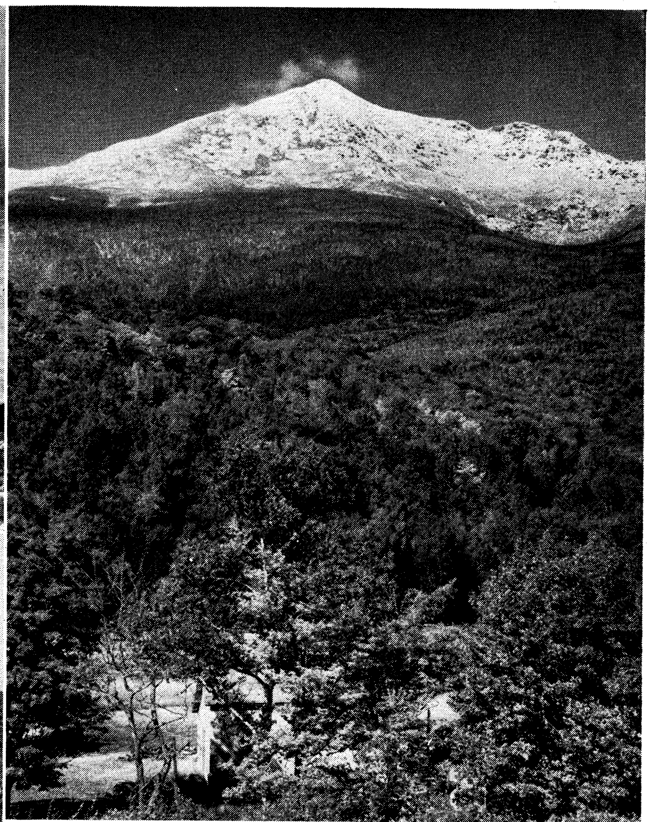
National Defense.—The armies were returned and disbanded after World War I as quickly as possible; but a demand was made at once for some immediate acknowledgment of their services. The government had attempted to head off this movement by an elaborate system of life insurance. It also instituted a large rehabilitation system for training disabled veterans in pursuits in which they could earn their own living. The government provided hospitals and care for sick and disabled soldiers. Provision was made for special privileges to former soldiers. On Sept. 20, 1922 a national bonus bill was defeated by President Harding's veto. On March 18, 1924 a bonus bill was passed by a large majority vote in congress; it was vetoed by President Coolidge but passed over his veto, May 17–19.

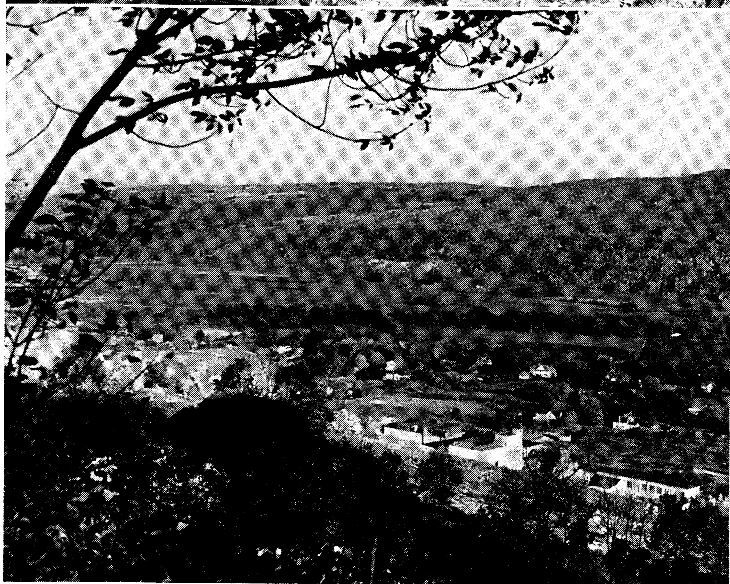
Notwithstanding the experience of the United States in 1917, when it declared a war without any mobile army, strong pressure was put on congress to reduce the regular army. By an act of Feb. 12, 1925 the force of the regular army was set at 125,000 enlisted men and 7,953 enlisted men of the Philippine scouts. Many veterans joined the American Legion, the most widely distributed society of servicemen; and that body had considerable influence in the legislation for former soldiers.

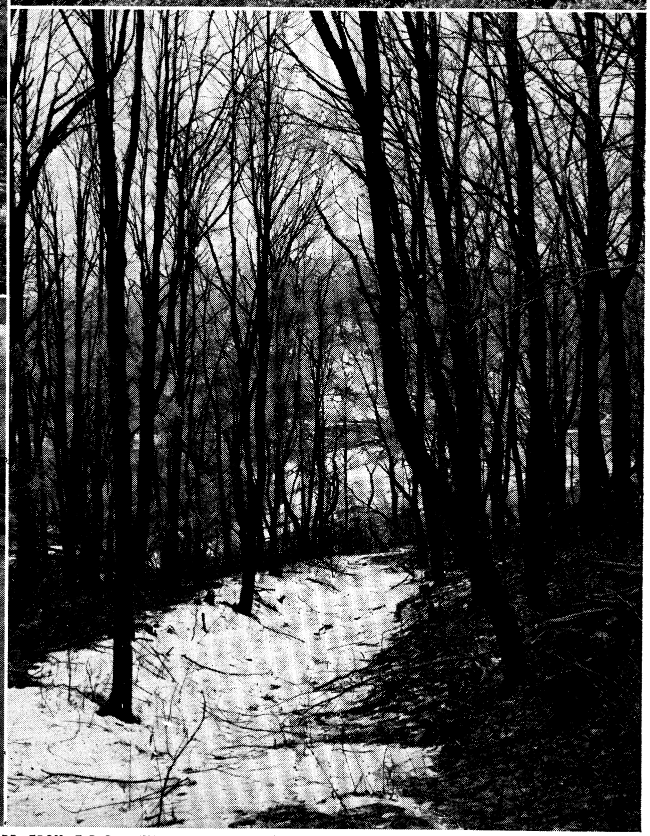
International Relations.—President Coolidge, accepting the resignation of Hughes from the department of state, appointed as his successor (Feb. 1925) Frank B. Kellogg, previously a senator and ambassador to Great Britain. Borah succeeded to the powerful chairmanship of the committee on foreign relations after the death of Lodge. A great improvement in the conduct of foreign relations uas introduced by the Rogers act, which took effect July 1, 1924, and under which the consular and diplomatic services were merged and the policy of training young men with the prospect of lifelong service was adopted.

The general policy of the United States toward other nations was much affected first of all by changes in international trade caused by the disruption of World War I; then by the refusal of the senate in 1919 to approve the Versailles treaty and further by a strong popular opposition to any formal relation with the League of Nations. A treaty with Germany (July 2, 1921) formally restored peace, provided for commerce and arranged for an adjustment of claims. Similar treaties were made shortly afternard nith Austria and Hungary. The Lausanne treaty with Turkey, signed on July 24, 1923, was defeated in the senate on Jan. 18, 1927.

An important question of the early 1920s, partly social and partly international, was that of immigration, which went through a new phase because of the rush of people from other parts of the world as soon as the war was ended. Complaint mas made that in the previous two decades the greater number of immigrants







SCENES IN NORTHEASTERN UNITED STATES

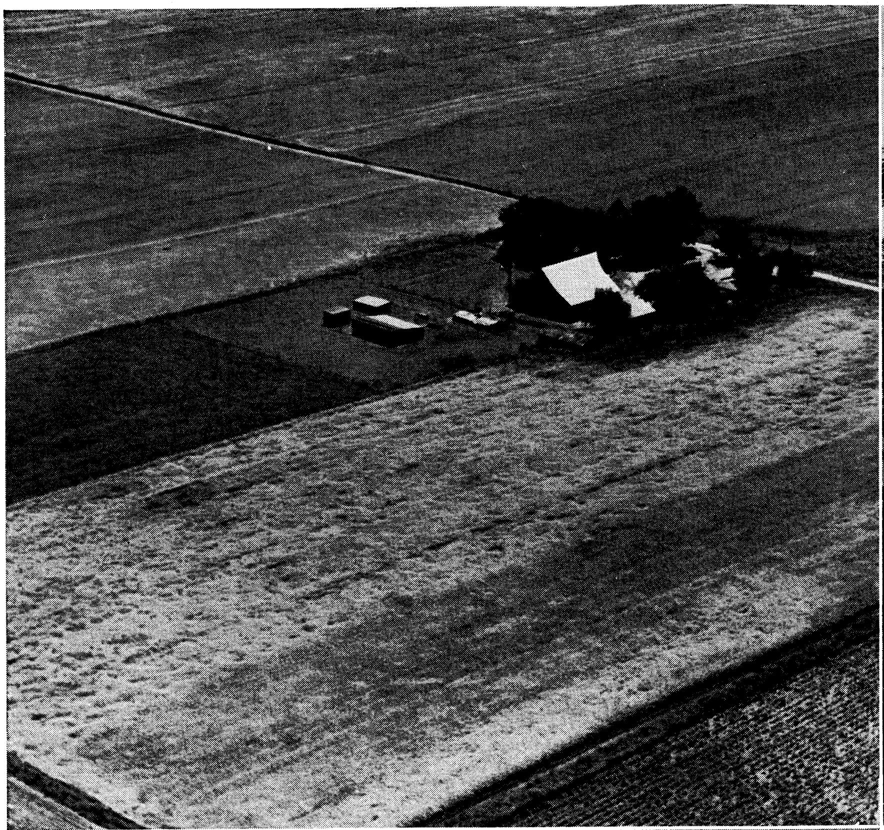
Top left: The Atlantic ocean rolling in on the Maine coast near Ogunauit

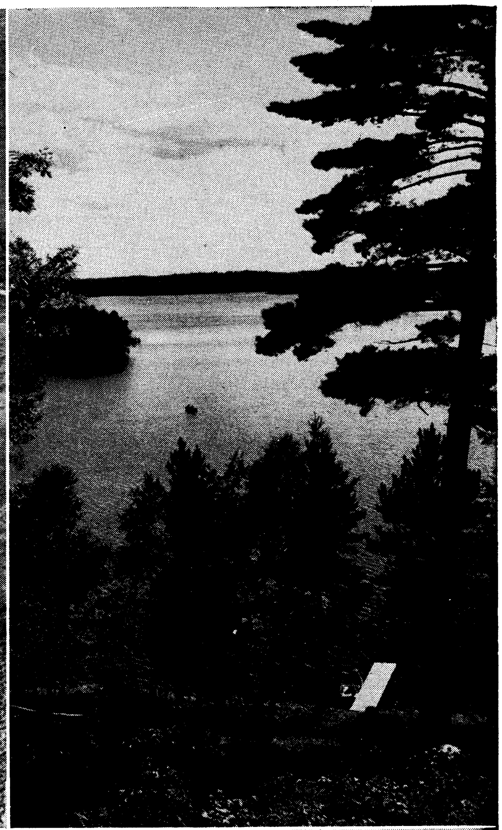
Top right: Mt. Adams, 5.798 ft. above sea level, in the Presidential range of the White mountains in north central New Hampshire

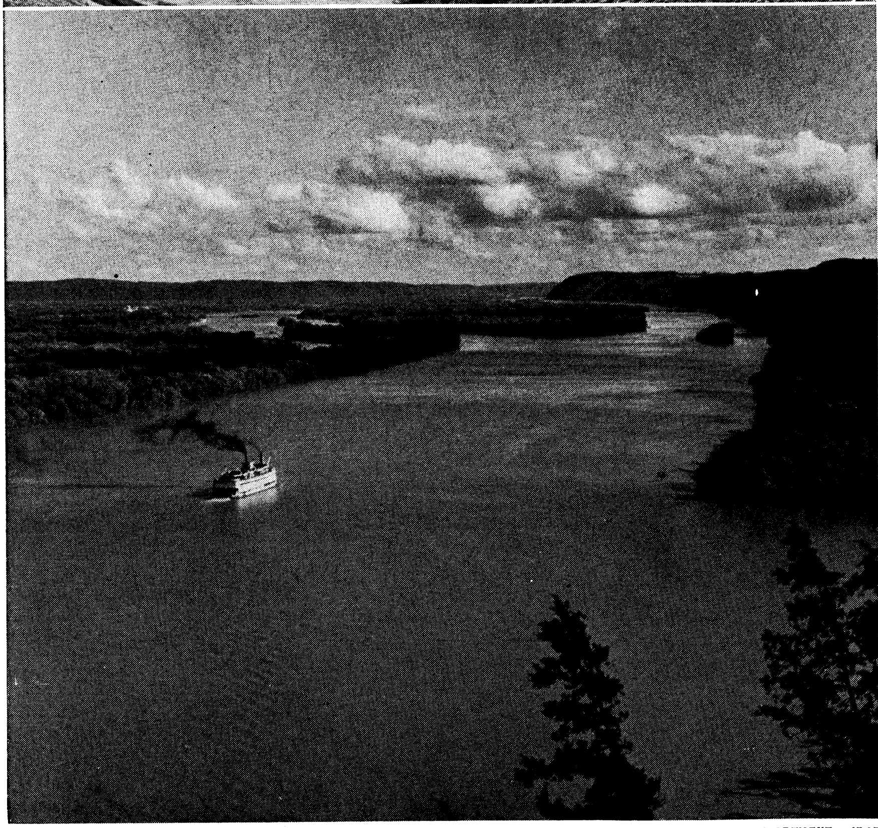
Centre left: Vineyards and wineries in the Finger lakes area of west central New York

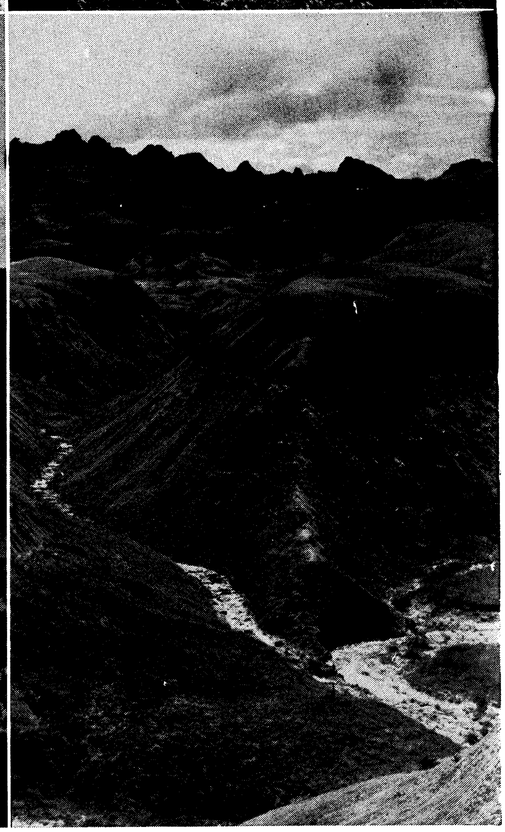
Bottom left: Aerial view of the Thousand Islands in the St. Lawrence river between Kingston. Ont.. and northern New York

Bottom right: Old Indian path in western Pennsylvania. George Washington, as a major in the Virginia militia, passed through this area in 1753 to deliver an ultimatum to a French garrison in northwestern Pennsylvania









BY COURTESY OF (TOP LEFT) STANDARD OIL CO. (N.J.), (TOP RIGHT) WISCONSIN CONSERVATION DEPARTMENT, (BOTTOM RIGHT) RAPID CITY CHAMBER OF COMMERCE; PHOTOGRAPH, (BOTTOM LEFT) LORD FROM MONKMEYER

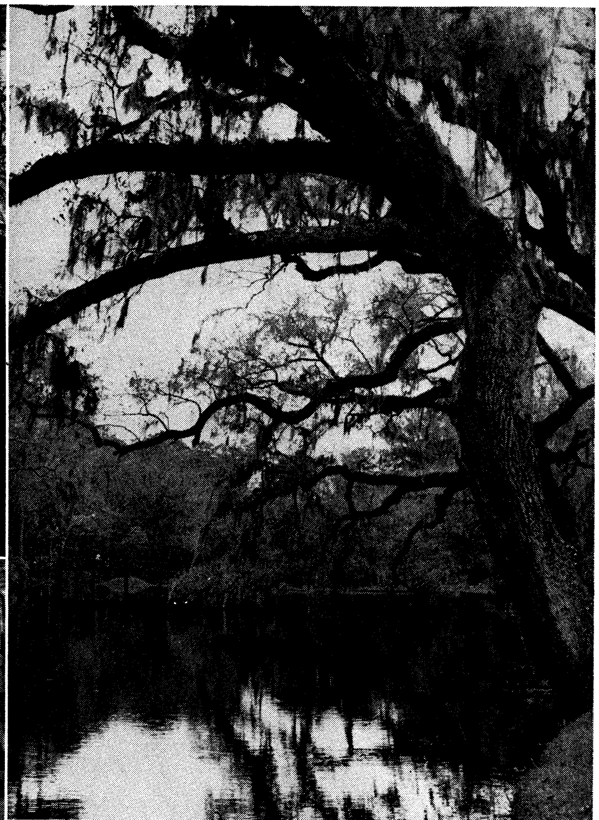
VIEWS OF CENTRAL UNITED STATES

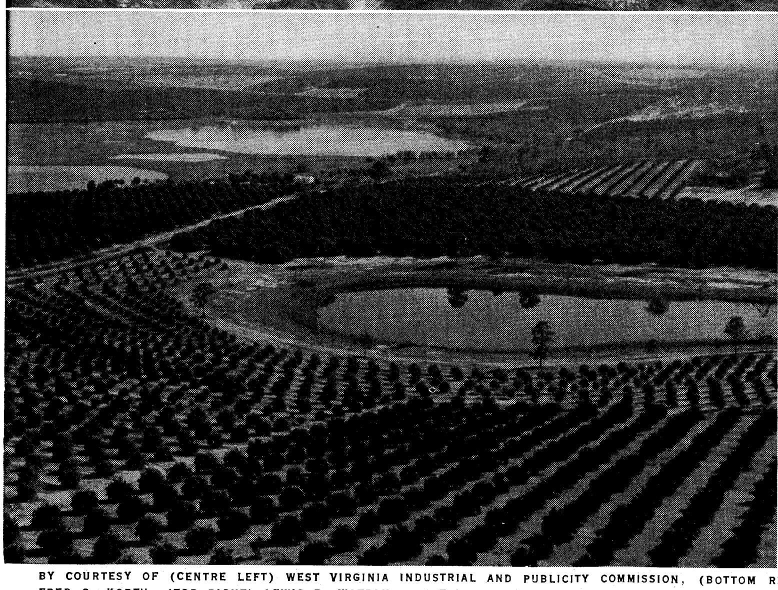
Top left: Aerial view of a typical wheat farm in the Kansas river valley, near Lawrence, Kansas

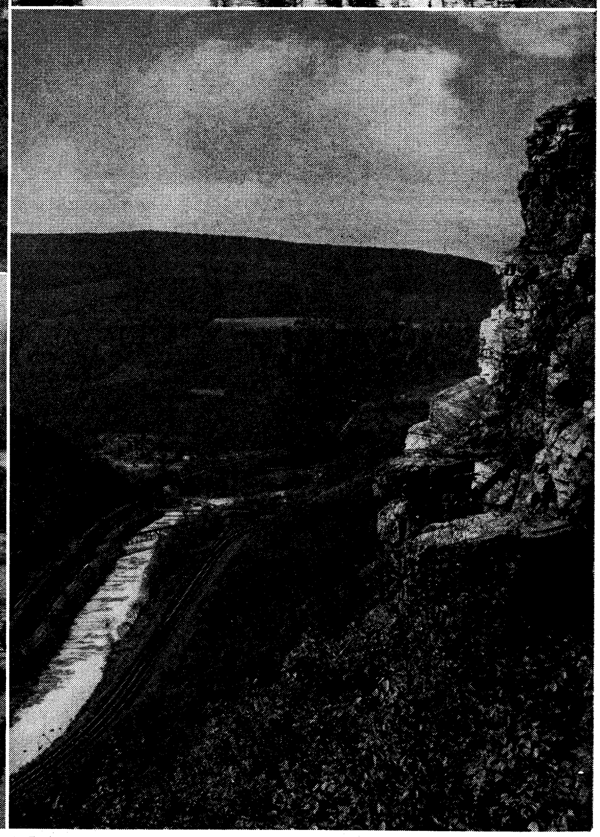
Top right: High lake, one of the many fishing lakes in northern Wisconsin

Bottom left: Excursion boat traveling south on the Mississippi river. The photograph was taken from Effigy Mounds National monument, Iowa

Bottom right: The White river Badlands of southwestern South Dakota, once covered by a salt sea, now is greatly eroded wasteland







BY COURTESY OF (CENTRE LEFT) WEST VIRGINIA INDUSTRIAL AND PUBLICITY COMMISSION, (BOTTOM RIGHT) MARYLAND DEPARTMENT OF INFORMATION; PHOTOGRAPHS, (TOP LEFT) FRED G. KORTH, (TOP RIGHT) LEWIS P. WATSON, (BOTTOM LEFT) MAX HUNN, (BOTTOM RIGHT) M. E. WARREN

SCENES IN ATLANTIC AND SOUTHERN STATES

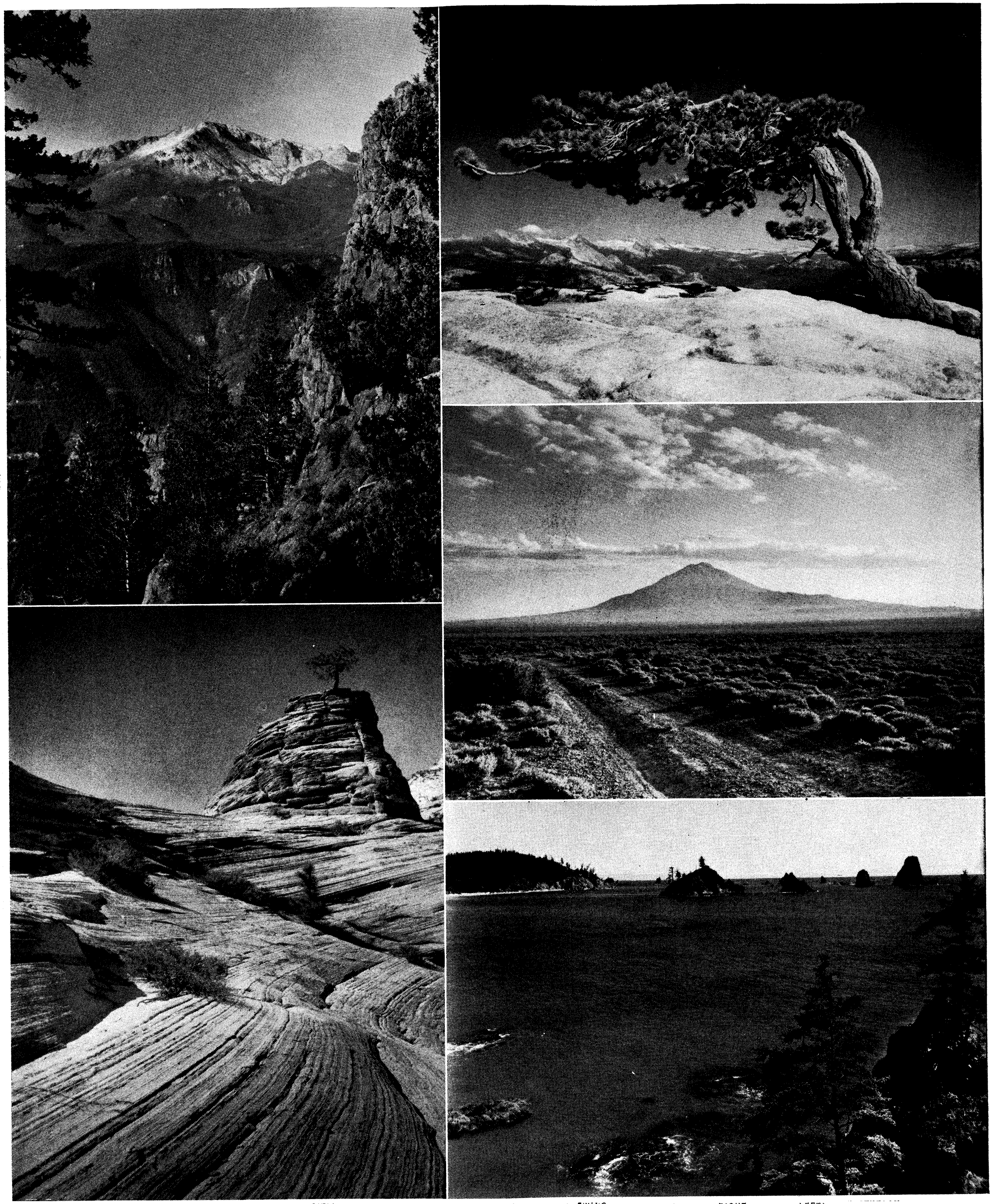
Top left: The foothills of the Cumberland mountains, eastern Kentucky

Top right: Live-oak trees, covered with Spanish moss, at Middleton gardens near Charleston, S.C.

Centre left: Stalactites and stalagmites in the Seneca caverns, Pendleton county, West Virginia

Bottom left: Citrus orchards of central Florida

Bottom *right:* The Cumberland narrows in western Maryland, which provided a passage for the Cumberland or National road through the Allegheny mountains



BY COURTESY OF (TOP LEFT, BOTTOM RIGHT) UNION PACIFIC RAILROAD PHOTO; PHOTOGRAPHS, (TOP RIGHT) EWING GALLOWAY. (CENTRE RIGHT, BOTTOM LEFT) RAY ATKESON

SCENES IN WEST-ERN STATES

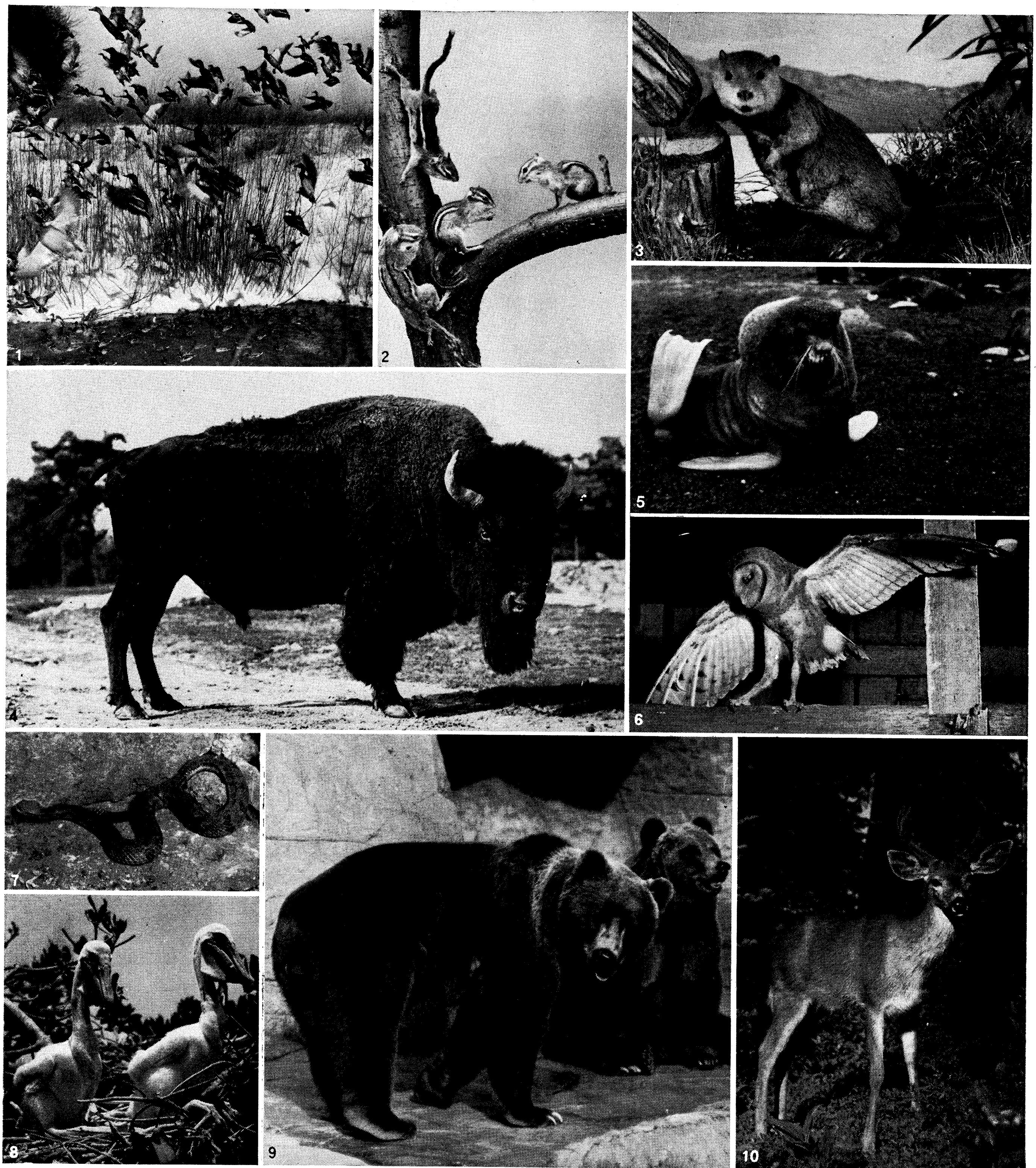
Top left: A view of Pike's peak (14,110 ft.) from the Rampart Range road, Colorado

Top right: Wind-shaped Jeffrey pine atop Sentinel Dome in Yosemite National park, California

Centre right: Sagebrush on a Nevada **desert**

Bottom left: Sandstone formation found along a highway in Zion National park, Utah

Bottom right: Giants' Graveyard, Strawberry bay, on the northwestern tip of the Olympic peninsula, Washington



BY COURTESY OF (5) HARRY W. MAY FROM FOUKE FUR CO., (7) VISUAL EDUCATION SERVICE; PHOTOGRAPHS, (1) THE TYLER STUDIO., PHOTO BY HERR SCHWARTZ, (2, 4, 10) A. DEYANEY, (3) DICK WHITTINGTON, (6) JOHN E. THIERMAN, (8) AUTHENTICATED NEWS, (9) PIX, INC.

ANIMALS OF THE UNITED STATES

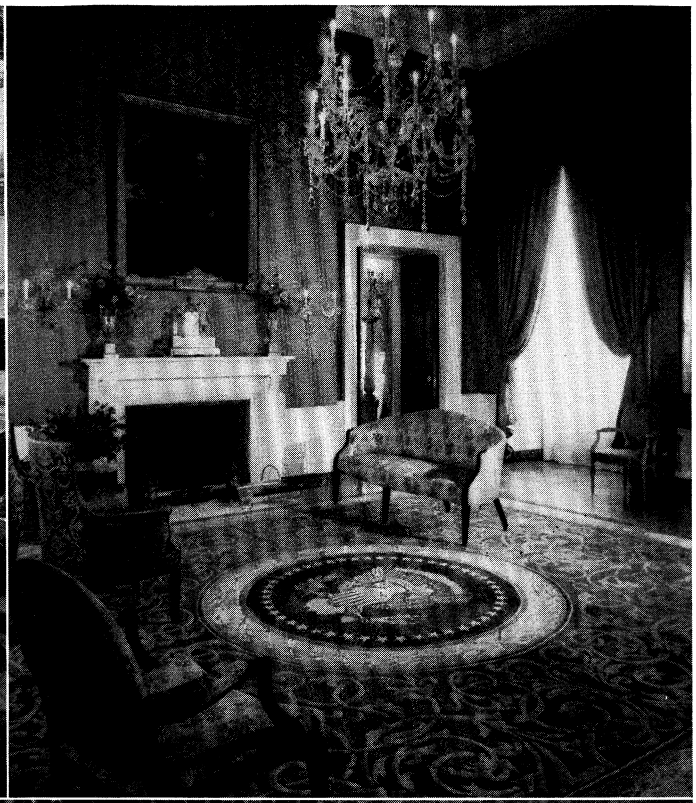
1. Wild ducks (Anatidae) cross the U.S. during the migration season. They range from the Arctic circle in the summer to Panamá in the winter
2. Chipmunks (*Tamias striatus*) are native to wooded areas from Canada to Georgia
3. The American beaver (Castor canadensis) lives near small streams in northern mountainous areas throughout the U.S.
4. American bison (Bison bison), popularly called buffalo, now survives only in protected areas
5. Fur seal (Otariidae) ranges in its migrations from islands off Alaska south to Lower California
6. American barn owl (Tyto *alba*) inhabits the entire warmer region of North America
7. Northern banded or timber rattlesnake (*Crotalus* horridus), found from southwestern Maine and northern Florida to the western Gulf states
8. Young pelicans (*Pelecanus occidentalis*) of the Florida Everglades
9. Grizzly bears (*Ursus horribilis*), formerly found in western North America, are almost extinct
10. Mule deer (*Odocoileus hemionus*), found only in North America, ranges from Alaska to Lower California

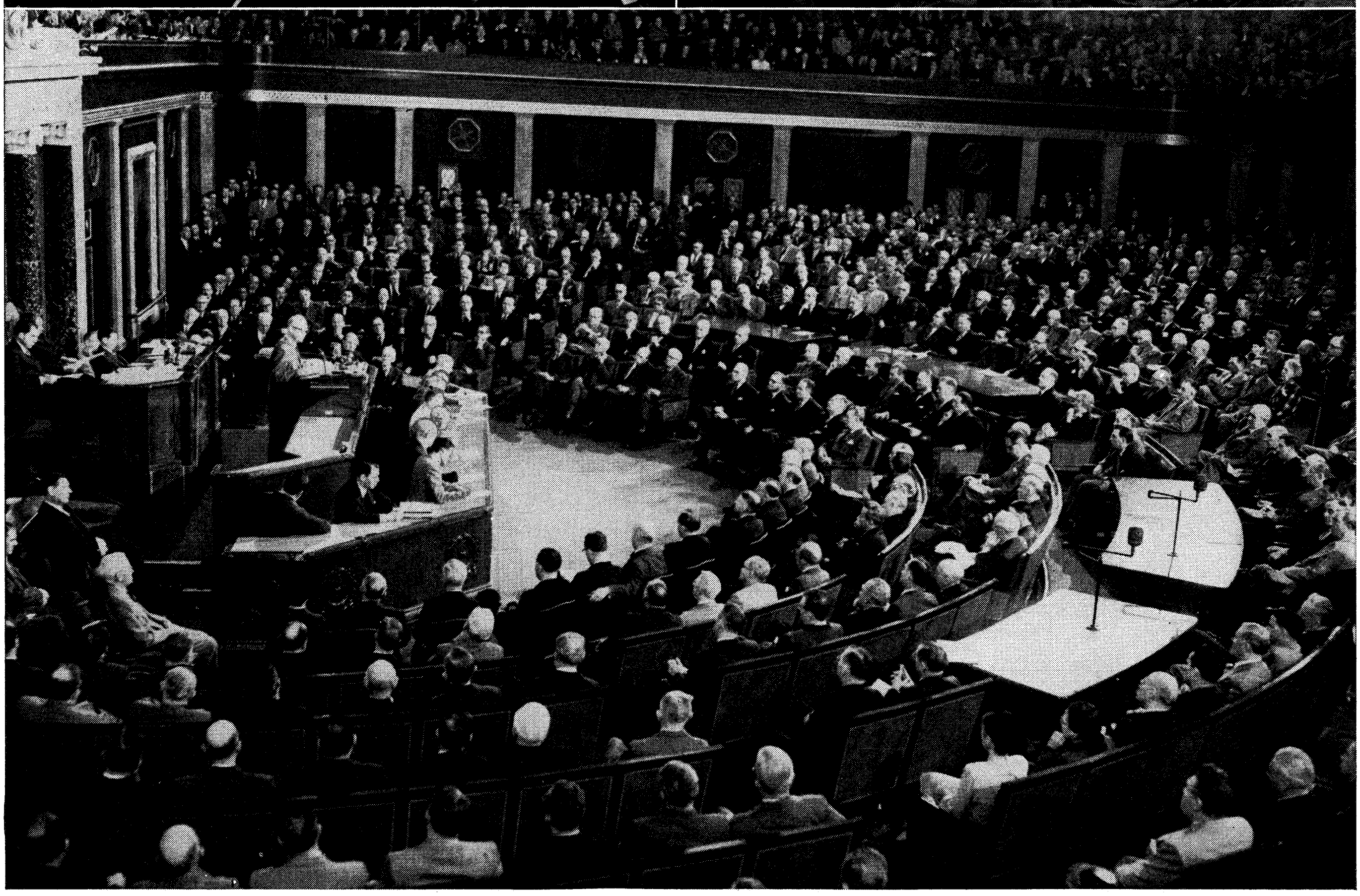
UNITED STATES OF AMERICA

BY COURTESY OF (1) FLORIDA STATE NEWS BUREAU, (9) AMERICAN FOREST PRODUCTS INDUSTRIES, INC., PHOTOGRAPHS, (2, 3, 5) RAY ATKESON, (4, 6, 7, 8) RUTHERFORD PLATT, (10) EUGENE ROSING, (11) LEWIS P. WATSON

PLANTS OF THE UNITED STATES

1. Spanish dagger (Yucca *aloifolia*), found along the southern Atlantic and Gulf coasts of the U.S., is widely used in landscaping
2. A grove of aspens (Populus *tremuloides*). Aspens grow from Pennsylvania to California, mostly in mountainous areas
3. Bear grass (Xerophyllum *tenax*) in bloom, native to mountainous districts from California to Montana
4. Mountain laurel (*Kalmia latifolia*) in bloom, surrounded by mossy lichens; both are found in rocky soil from Ontario, Can., to Florida
5. Suwarro or saguaro cactus (Cereus *giganteus*), native to arid districts of Arizona and southeastern California, grows to a height of 70 ft.
6. Jack pine (*Pinus* banksiana) near a Wisconsin lake. This variety of hard pine is found east of the Rocky mountains, from Minnesota to Kentucky
7. Apple (*Pyrus pumila*) and elm (*Ulmus americana*) trees. Apple trees range from the Atlantic to the Pacific coasts; elms west to the Rocky mountains
8. Western hemlock (*Tsuga* heterophylla) at Crater lake, Oregon. This tree grows from southeastern Alaska to northern Montana and central California
9. View of a northern hardwood forest in Pennsylvania. Large tree in the foreground is a sugar maple (*Acer saccharum*); smaller trees are beech (*Fagus grandifolia*) and black cherry (*Prunus serotina*)
10. Blue *or* Colorado spruce (*Picea pungens*), native to the central Rocky mountain region, grows from 80 to 150 ft. high
11. Cypress trees (Taxodium *distichum*) covered with Spanish moss (*Tillandsia usneoides*), typical of those found in gardens and swamps from Mexico to the southern Atlantic coast



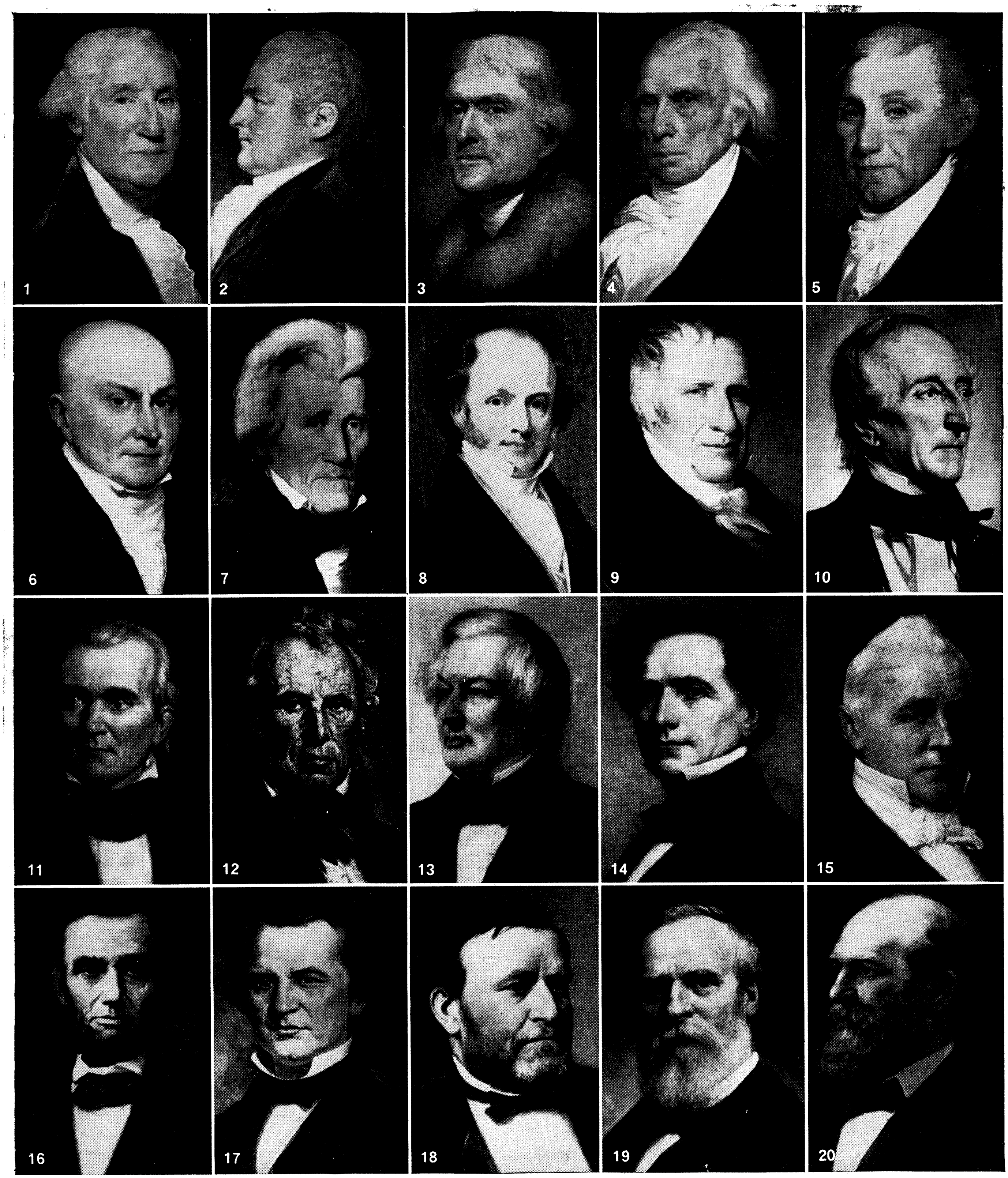


PHOTOS (TOP LEFT) A. DEVANEY. INC., (TOP RIGHT) WIDE WORLC, (BOTTOM) UNITED PRESS NEWS PICTURES

INTERIOR OF PUBLIC BUILDINGS, WASHINGTON, D.C.

Top left: Main reading room, the Library *of* Congress
Tap right: The Green Room, a sitting room in the White House. The presidential seal forms the centre of the rug
Bottom: A joint session of the U.S. congress meeting in the house chamber

UNITED STATES OF AMERICA



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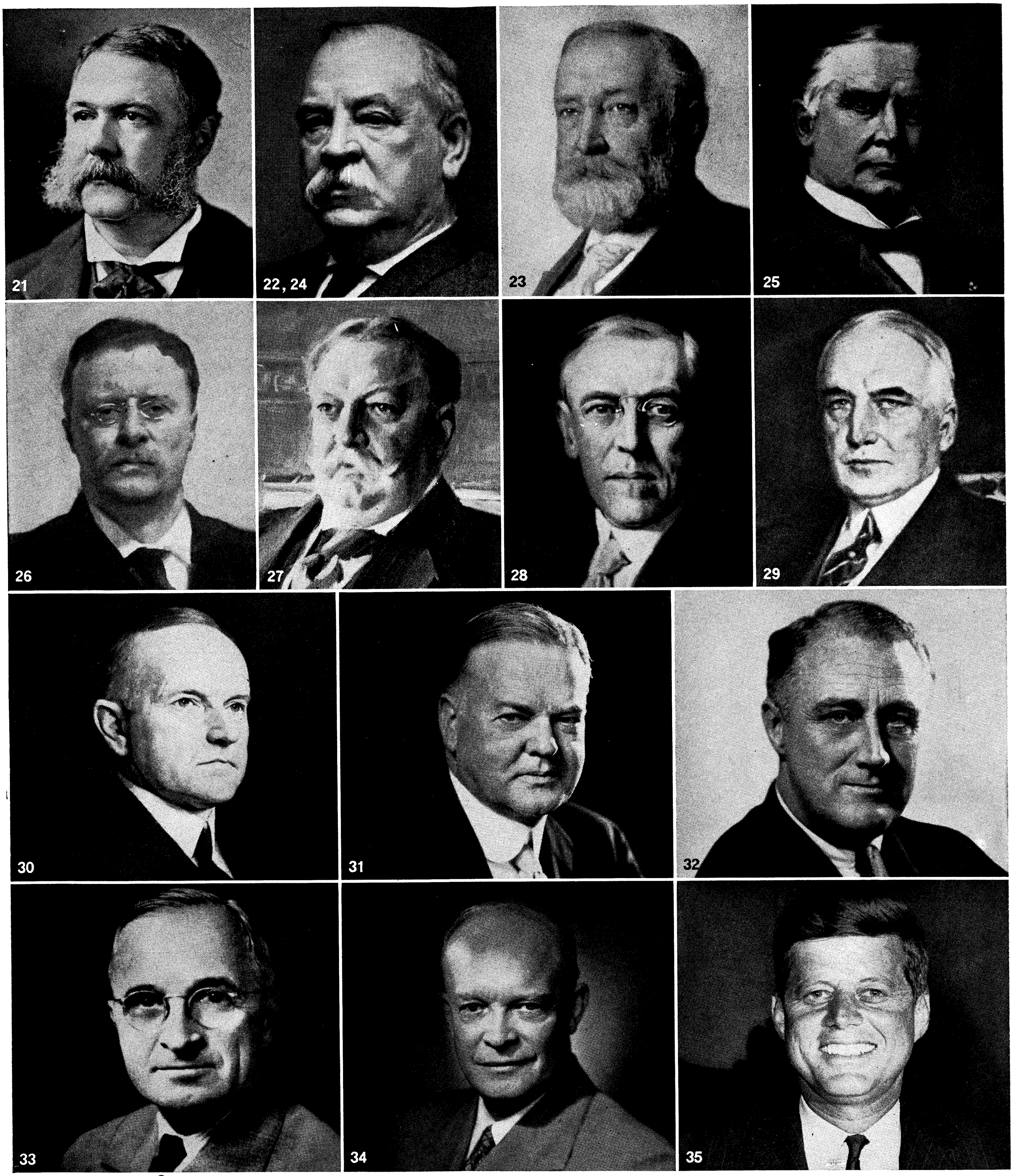
UNITED STATES PRESIDENTS FROM 1789 TO 1881

1. George Washington (term, 1789–97). Portrait by Gilbert Stuart
2. John Adams (1797–1801) by James Sharpless
3. Thomas Jefferson (1801–09) by Rembrandt Peale
4. James Madison (1809–17) by Asher B. Durand
5. James Monroe (1817–25) by Gilbert Stuart
6. John Quincy Adams (1825–29) by Chester Harding
7. Andrew Jackson (1829–37) by E. F. Andrews
8. Martin Van Buren (1837–41) by Henry Inman
9. William Henry Harrison (1841 for one month) by George Catlin
10. John Tyler (1841–45) by George P. A. Healy
11. James Knox Polk (1845–49) by George P. A. Healy
12. Zachary Taylor (1849–50) by George P. A. Healy
13. Millard Fillmore (1850–53) by George P. A. Healy
14. Franklin Pierce (1853–57) by George P. A. Healy
15. James Buchanan (1857–61) by E. F. Andrews
16. Abraham Lincoln (1861–65) by J. Redding Kelly
17. Andrew Johnson (1865–69) by E. F. Andrews
18. Ulysses Simpson Grant (1869–77) by Thomas LeClear
19. Rutherford Birchard Hayes (1877–81) by Daniel Huntington
20. James Abram Garfield (1881 for six months) by E. F. Andrews

UNITED STATES OF AMERICA



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UNITED STATES PRESIDENTS FROM 1881

21. Chester Alan Arthur (1881–85)
22, 24. Grover Cleveland (1885–89, 1893–97)
23. Benjamin Harrison (1889–93) by Eastman Johnson
25. William McKinley (1897–1901) by William D. Murphy
26. Theodore Roosevelt (1901–09) by John Singer Sargent
27. William Howard Taft (1909–13) by Anders Zorn
28. Woodrow Wilson (1913–21) by Stanley G. Middleton
29. Warren Gamaliel Harding (1921–23) by Howard Chandler Christy
30. Calvin Coolidge (1923–29) by Ercole Cartoto
31. Herbert Clark Hoover (1929–33)
32. Franklin Delano Roosevelt (1933–45)
33. Harry S. Truman (1945–53)
34. Dwight David Eisenhower (1953–61)
35. John Fitzgerald Kennedy (1961–)

UNITED STATES OF AMERICA

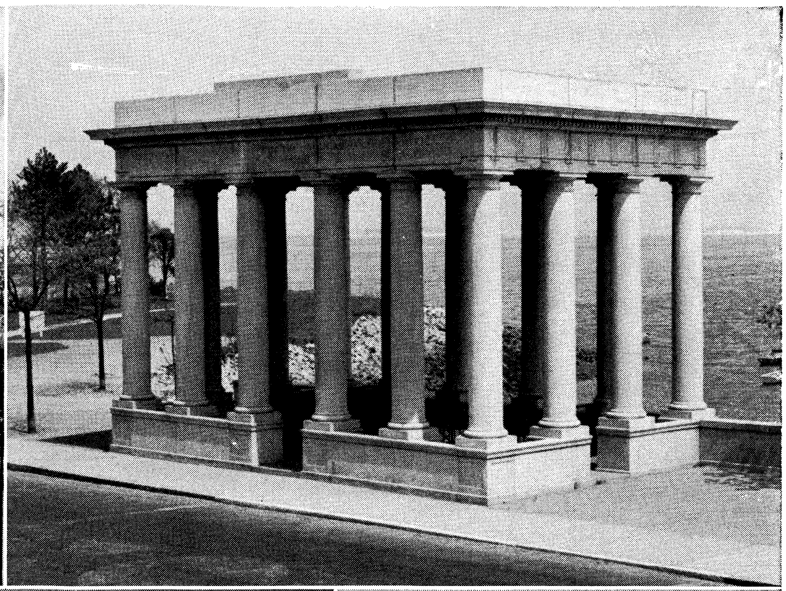
PHOTOGRAPHS, (1, 2, 4, 7, 8, 10, 12, 16) EWING GALLOWAY, (3, 5, 6, 9, 11, 13, 14, 15, 17) CULVER SERVICE

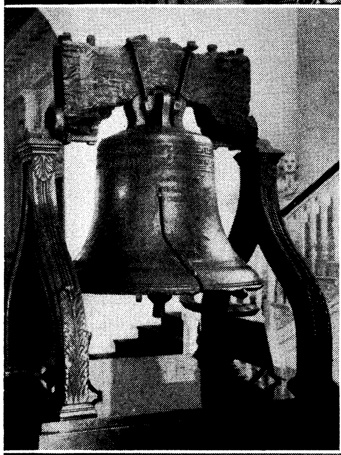
VICE-PRESIDENTS OF THE UNITED STATES

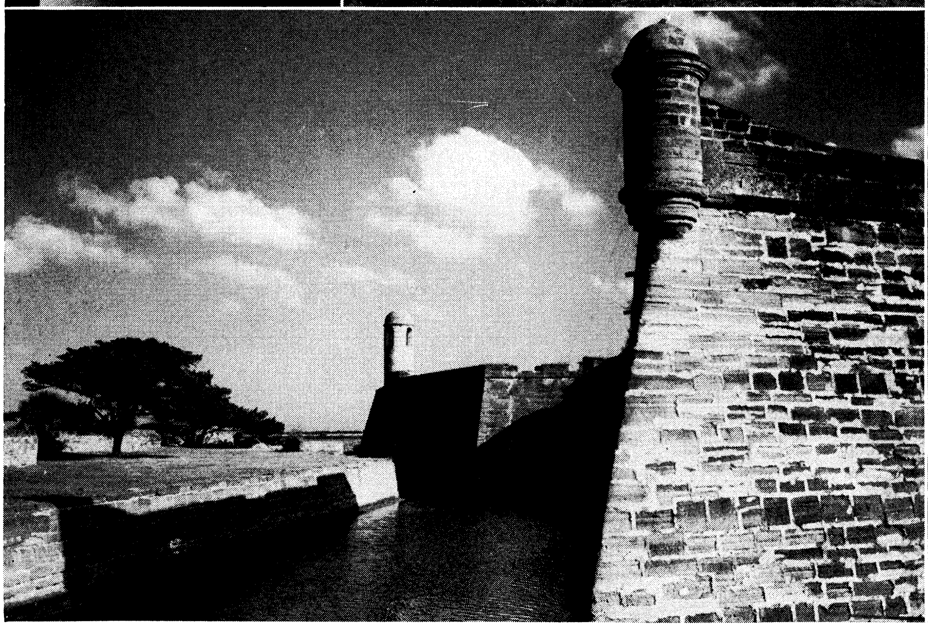
1. John Adams (term of office, 1789–97). 2. Thomas Jefferson (1797–1801), painting by Rembrandt Peale. 3. Aaron Burr (1801–05). 4. George Clinton (1805–12). 5. Elbridge Gerry (1813–14), miniature by John Ramage. 6. Daniel D. Tompkins (1817–25). 7. John C. Calhoun (1825–32). 8. Martin Van Buren (1833–37), painting by Henry Inman. 9. Richard M. Johnson (1837–41). 10. John Tyler (1841). 11. George M. Dallas (1845–49). 12. Millard Fillmore (1849–50). 13. William R. King (1853). 14. John C. Breckinridge (1857–61). 15. Hannibal Hamlin (1861–65). 16. Andrew Johnson (1865). 17. Schuyler Colfax (1869–73)

VICE-PRESIDENTS OF THE UNITED STATES

18. Henry Wilson **(1873–75).** **19.** William **A.** Wheeler **(1877-81).** **20.** Chester **A.** Arthur **(1881).** **21.** Thomas A. Hendricks (1885). **22.** Levi P. Morton (1889–93). **23.** Adlai **E.** Stevenson (1893–97). **24.** Garret A. Hobart **(1897-99).** 25. Theodore Roosevelt **(1901).** 26. Charles W. Fairbanks **(1905-09).** **27.** James **S.** Sherman **(1909-12).** **28.** Thomas R. Marshall **(1913-21).** **29.** Calvin Coolidge **(1921-23).** **30.** Charles G. **Dawes** **(1925-29).** **31.** Charles Curtis **(1929-33).** **32.** John N. Garner **(1933-41).** **33.** Henry **A.** Wallace **(1941-45).** **34.** Harry **S.** Truman **(1945).** **35.** Alben W. **Barkley** (1949–53). **36.** Richard M. **Nixon** (1953–61). **37.** Lyndon B. Johnson **(1961-)**







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SOME FAMOUS LANDMARKS IN UNITED STATES HISTORY

Top left: The Alamo, originally a Franciscan chapel, at San Antonio, Tex. There, in 1836, in the war for Texan independence, William B. Travis, Davy Crockett and James Bowie, with 180 men, withstood 4,000 Mexicans for 13 days

Top right: Granite portico over Plymouth rock, Plymouth, Mass., believed to have been the landing place of the Pilgrims, Dec. 21, 1620

Centre left: Liberty bell in Independence hall, Philadelphia, Pa. The bell was rung after the signing of the Declaration of Independence in 1776. First cracked in 1835 when it was rung at the death of Chief Justice John Marshall, it was later irreparably cracked on Washington's birthday in 1846

Centre: Fort McHenry, Baltimore, Md. During the bombardment of this fort by the British in 1814 Francis Scott Key wrote the words of "The Star-Spangled Banner"

Bottom left: Section of the moat of Ft. Marion, St. Augustine, Fla., originally built by the Spanish between about 1638 and 1756

Bottom right: San Jacinto monument, near Houston, Tex., commemorating Texas victory over a larger force of Mexicans in 1836. In the foreground, permanently moored in the San Jaointo river, is the U.S.S. "Texas," a World War II battleship

TABLE VI.—*U.S. Party Affiliations—Congressional and Presidential*

(Ad—administration; AM—Anti-Masonic; C—coalition; D—Democratic; DR—Democratic-Republican; Fed—Federalist; J—Jacksonian; NR—National Republican; Op—opposition; R—Republican; U—Unionist; W—Whig)

Congress	Term	Speaker	House*			Senate*			President
			Major party	Principal minority party	Other (exc. vac.)	Major party	Principal minority party	Other (exc. vac.)	
1st	1789–91	F. A. Muhlenburg	Ad-38	Op-26		Ad-17	Op-9		Fed—George Washington
2nd	1791–93	Jonathan Trumbull	Fed-37	DR-33		Fed-16	DR-13		Fed—George Washington
3rd	1793–95	F. A. Muhlenburg	DR-57	Fed-48		Fed-17	DR-13		Fed—George Washington
4th	1795–97	Jonathan Dayton	Fed-54	DR-52		Fed-19	DR-13		Fed—George Washington
5th	1797–99	Jonathan Dayton	Fed-58	DR-48		Fed-20	DR-12		Fed—John Adams
6th	1799–1801	Theodore Sedgwick	Fed-64	DR-42		Fed-19	DR-13		Fed—John Adams
7th	1801–03	Nathaniel Macon	DR-69	Fed-36		DR-18	Fed-14		DR—Thomas Jefferson
8th	1803–05	Nathaniel Macon	DR-102	Fed-39		DR-25	Fed-9		DR—Thomas Jefferson
9th	1805–07	Nathaniel Macon	DR-116	Fed-25		DR-27	Fed-7		DR—Thomas Jefferson
10th	1807–09	Joseph B. Varnum	DR-118	Fed-24		DR-28	Fed-6		DR—Thomas Jefferson
11th	1809–11	Joseph B. Varnum	DR-94	Fed-48		DR-28	Fed-6		DR—James Madison
12th	1811–13	Henry Clay	DR-108	Fed-36		DR-30	Fed-6		DR—James Madison
13th	1813–15	H. Clay and Langdon Cheves	DR-112	Fed-68		DR-27	Fed-9		DR—James Madison
14th	1815–17	Henry Clay	DR-117	Fed-65		DR-25	Fed-11		DR—James Madison
15th	1817–19	Henry Clay	DR-141	Fed 42		DR-34	Fed-10		DR—James Monroe
16th	1819–21	H. Clay and John W. Taylor	DR-156	Fed-27		DR-35	Fed-7		DR—James Monroe
17th	1821–23	Philip P. Barbour	DR-158	Fed-25		DR-44	Fed-4		DR—James Monroe
18th	1823–25	Henry Clay	DR-187	Fed-26		DR-44	Fed-4		DR—James Monroe
19th	1825–27	John W. Taylor	Ad-105	J-97		Ad-26	J-20		C—John Quincy Adams
20th	1827–29	Andrew Stevenson	J-119	Ad-94		J-28	Ad-20		C—John Quincy Adams
21st	1829–31	Andrew Stevenson	D-139	NR-74		D-26	NR-22		D—Andrew Jackson
22nd	1831–33	Andrew Stevenson	D-141	NR-58	14	D-25	NR-21	2	D—Andrew Jackson
23rd	1833–35	A. Stevenson and John Bell	D-147	AM-53	60	D-20	NR-20	8	D—Andrew Jackson
24th	1835–37	James K. Polk	D-145	W-98		D-27	W-25		D—Andrew Jackson
25th	1837–39	James K. Polk	D-108	W-107	24	D-30	W-18	4	D—Martin Van Buren
26th	1839–41	R. M. T. Hunter	D-124	W-118		D-28	W-22		D—Martin Van Buren
27th	1841–43	John White	W-133	D-102	6	W-28	D-22	2	W—William H. Harrison W—John Tyler
28th	1843–45	John W. Jones	D-142	W-79	1	W-28	D-25	1	W—John Tyler
29th	1845–47	John W. Davis	D-143	W-77	6	D-31	W-25		D—James K. Polk
30th	1847–49	Robert C. Winthrop	W-115	D-108	4	D-36	W-21	1	D—James K. Polk
31st	1849–51	Howell Cobb	D-112	W-109	9	D-35	W-25	2	W—Zachary Taylor W—Millard Fillmore
32nd	1851–53	Linn Boyd	D-140	W-88	5	D-35	W-24	3	W—Millard Fillmore
33rd	1853–55	Linn Boyd	D-159	W-71	4	D-38	W-22	2	D—Franklin Pierce
34th	1855–57	Nathaniel P. Banks	R-108	D-83	43	D-40	R-15	5	D—Franklin Pierce
35th	1857–59	James L. Orr	D-118	R-92	26	D-36	R-20	8	D—James Buchanan
36th	1859–61	William Pennington	R-114	D-92	31	D-36	R-26	4	D—James Buchanan
37th	1861–63	Galusha A. Grow	R-105	D-43	30	R-31	D-10	8	R—Abraham Lincoln
38th	1863–65	Schuyler Colfax	R-102	D-75	9	R-36	D-9	5	R—Abraham Lincoln
39th	1865–67	Schuyler Colfax	U-149	D-42		U-42	D-10		R—Abraham Lincoln R—Andrew Johnson
40th	1867–69	Schuyler Colfax	R-143	D-49		R-42	D-11		R—Andrew Johnson
41st	1869–71	James G. Blaine	R-149	D-63		R-56	D-11		R—U. S. Grant
42nd	1871–73	James G. Blaine	R-134	D-104	5	R-52	D-17	5	R—U. S. Grant
43rd	1873–75	James G. Blaine	R-194	D-92	14	R-49	D-19	5	R—U. S. Grant
44th	1875–77	Michael C. Kerr and Samuel J. Randall	D-169	R-109	14	R-45	D-29	2	R—U. S. Grant
45th	1877–79	Samuel J. Randall	D-153	R-140		R-39	D-36	1	R—Rutherford B. Hayes
46th	1879–81	Samuel J. Randall	D-149	R-130	14	D-42	R-33	1	R—Rutherford B. Hayes
47th	1881–83	Joseph W. Keifer	R-147	D-135	11	R-37	D-37	1	R—James A. Garfield R—Chester A. Arthur
48th	1883–85	John G. Carlisle	D-197	R-118	10	R-38	D-36	2	R—Chester A. Arthur
49th	1885–87	John G. Carlisle	D-183	R-140	2	R-43	D-34		D—Grover Cleveland
50th	1887–89	John G. Carlisle	D-169	R-152	4	R-39	D-37		D—Grover Cleveland
51st	1889–91	Thomas B. Reed	R-166	D-159		R-39	D-37		R—Benjamin Harrison
52nd	1891–93	Charles F. Crisp	D-235	R-88	9	R-47	D-39	2	R—Benjamin Harrison
53rd	1893–95	Charles F. Crisp	D-218	R-127	11	D-44	R-38	3	D—Grover Cleveland
54th	1895–97	Thomas B. Reed	R-244	D-105	7	R-43	D-39	6	D—Grover Cleveland
55th	1897–99	Thomas B. Reed	R-204	D-113	40	R-47	D-34	7	R—William McKinley
56th	1899–1901	David R. Henderson	R-185	D-163	9	R-53	D-26	8	R—William McKinley
57th	1901–03	David B. Henderson	R-197	D-151	9	R-55	D-31	4	R—William McKinley R—Theodore Roosevelt
58th	1903–05	Joseph G. Cannon	R-208	D-178		R-57	D-33		R—Theodore Roosevelt
59th	1905–07	Joseph G. Cannon	R-250	D-136		R-57	D-33		R—Theodore Roosevelt
60th	1907–09	Joseph G. Cannon	R-222	D-164		R-61	D-31		R—Theodore Roosevelt
61st	1909–11	Joseph G. Cannon	R-219	D-172		R-61	D-32		R—William H. Taft
62nd	1911–13	Champ Clark	D-228	R-161	1	R-51	D-41		R—William H. Taft
63rd	1913–15	Champ Clark	D-291	R-127	17	D-51	R-44	1	D—Woodrow Wilson
64th	1915–17	Champ Clark	D-230	R-196	9	D-56	R-40		D—Woodrow Wilson
65th	1917–19	Champ Clark	D-216	R-210	6	D-53	R-42		D—Woodrow Wilson
66th	1919–21	Frederick H. Gillett	R-240	D-190	3	R-49	D-47		D—Woodrow Wilson
67th	1921–23	Frederick H. Gillett	R-301	D-131	1	R-59	D-37		R—Warren G. Harding
68th	1923–25	Frederick H. Gillett	R-225	D-205	5	R-51	D-43	2	R—Warren G. Harding R—Calvin Coolidge
69th	1925–27	Nicholas Longworth	R-247	D-183	4	R-56	D-39		R—Calvin Coolidge
70th	1927–29	Nicholas Longworth	R-237	D-195	3	R-49	D-46	1	R—Calvin Coolidge
71st	1929–31	Nicholas Longworth	R-267	D-167	1	R-56	D-39	1	R—Herbert Hoover
72nd	1931–33	John N. Garner	D-220	R-214	1	R-48	D-47	1	R—Herbert Hoover
73rd	1933–35	Henry T. Rainey and Joseph W. Byrns	D-310	R-117	5	D-60	R-35	1	D—F. D. Roosevelt
74th	1935–37	J. W. Byrns and William B. Bankhead	D-319	R-103	10	D-69	R-25		D—F. D. Roosevelt
75th	1937–39	William B. Bankhead	D-331	R-89	13	D-76	R-16	4	D—F. D. Roosevelt
76th	1939–41	W. B. Bankhead and Sam Rayburn	D-261	R-164	4	D-69	R-23	4	D—F. D. Roosevelt
77th	1941–43	Sam Rayburn	D-268	R-162	5	D-66	R-28	2	D—F. D. Roosevelt
78th	1943–45	Sam Rayburn	D-218	R-208	4	D-58	R-37	1	D—F. D. Roosevelt
79th	1945–47	Sam Rayburn	D-242	R-190	2	D-56	R-38	1	D—F. D. Roosevelt D—Harry S. Truman
80th	1947–49	Joseph W. Martin, Jr.	R-245	D-188	1	R-51	D-45		D—Harry S. Truman
81st	1949–51	Sam Rayburn	D-263	R-171	1	D-54	R-42		D—Harry S. Truman
82nd	1951–53	Sam Rayburn	D-234	R-199	1	D-49	R-47		D—Harry S. Truman
83rd	1953–55	Joseph W. Martin, Jr.	R-221	D-211	1	R-48	D-47	1	R—Dwight D. Eisenhower
84th	1955–57	Sam Rayburn	D-232	R-203		D-48	R-47	1	R—Dwight D. Eisenhower
85th	1957–59	Sam Rayburn	D-233	R-200		D-49	R-47		R—Dwight D. Eisenhower
86th	1959–61	Sam Rayburn	D-283	R-153		D-64	R-34		R—Dwight D. Eisenhower
87th	1961–63	S. Rayburn & John McCormack	D-261	R-176		D-65	R-35		D—John F. Kennedy

*Composition at opening of first session.

came from southern and eastern Europe, and were not by tradition and inheritance of the same type as most of the previous immigrants. Several changes were made in 1918 to reduce the number of "undesirables." yet the year 1920–21 brought 800,000 immigrants. By an emergency act of 1921 a quota was provided, assigning to each nation 3% of the nationals in the United States according to the census of 1910. By the act of 1924 a permanent quota system was enacted, based on 2% of the number of nationals of that country shown to be in the United States by the census of 1890. After July 1, 1927, the limit was placed at 150,000 annually.

Among the incidents of foreign relations after World War I was the recognition of various new countries created by the treaty of Versailles: Poland, Latvia, Lithuania, Estonia, Finland, Czechoslovakia, Yugoslavia, Hungary and the enlarged Rumania. In 1924 the United States received a minister from the Irish Free State. The British government consented to the appointment of a Canadian representative at Washington.

The last U.S. troops were withdrawn from Germany in 1923. Meanwhile a joint commission on German claims was far advanced in its task. A troublesome difficulty was that a treaty with Prussia, entered into in 1828 and assumed in 1871 by the German empire, entitled German citizens in case of war to nine months to dispose of their property in the United States and leave the country. Instead, all discernible property of Germans, and particularly of German corporations, was seized at the beginning of the war and placed in the hands of a custodian of enemy property. Valuable German patents were turned over, for a very small payment, to U.S. manufacturing chemists. It was not until March 10, 1928, that President Coolidge signed a bill appropriating $50,000,000 to cover the value of the property seized.

Reparations and Allied Debts.—The United States was no party to the provisions of the Versailles treaty providing for German reparations, particularly to France, and the payment of an indemnity by Germany. However, the costs of the U.S. force of occupation were to be paid by Germany. In 1921 when Germany did not pay the stipulated sums to the Allies, the French occupied the Ruhr valley. The United States suggested a commission which, headed by Dawes, succeeded in working out a plan (1924) that was acceptable to France, Great Britain and Belgium, for a method of payment secured by a lien on German railways and factories. Financially the importance of the Dawes plan to the United States was that it cleared the way for considerable investments of private capital in German municipal and corporate securities.

A serious and difficult issue was that of the sums lent by the United States to other governments during World War I, aggregating $9,500,000,000. Without those large advances the Allies would have broken down economically before a U.S. army could have been placed in Europe. Nearly all the Allied European countries shared in these advances. At the end of 1922 the total principal was about $10,000,000,000 and the accumulated interest $1,500,000,000 more. This sum was funded in United States government bonds placed at about 4% interest, mostly in U.S. hands, upon the same footing as other obligations of the government. The interest was paid by the United States treasury. In 1923 the first important adjustment of the debt was made by an agreement with England (Feb. 28, 1923). The whole amount of the principal and interest then due was funded at $4,000,000,000 to be paid in annual installments beginning with $23,000,000 a year and increasing, until in the 62nd year the debt and accruing interest would be extinguished.

Latin America.—With Latin America the United States in the main enjoyed peaceful relations during this period. The longstanding question of the Isle of Pines was adjusted by a treaty (March 13, 1925), under which the title of Cuba was acknowledged. At the request of Chile and Peru, President Harding agreed in 1922 to arbitrate the dispute over the ownership of the Tacna-Arica region. After Harding's death President Coolidge took up the task and rendered his decision (March 4, 1925) to the effect that the delayed plebiscite of the inhabitants should now be taken; and General Pershing was made the head of a commission to preside over this process. Chile objected, and nothing was done.

With Mexico relations became strained by a dispute over the application of the new Mexican constitution of 1917 under which aliens were forbidden to hold lands or concessions. Mexicans claimed that this was in accord with the practice of several states in the United States. In 1925 Secretary of State Kellogg protested against the attitude of Mexico as unfriendly and declared that the government of Mexico was on trial before the world. In March 1926 a financial understanding was reached.

The League of Nations.—After the refusal of the United States to ratify the treaty of Versailles or to take part in the League of Nations, no official relations with the League were established. However, large numbers of U.S. citizens were interested in the work of the League and some of them were appointed to advisory committees in which, however, they did not represent the U.S. government. Eventually the United States consented to appoint official delegates or "observers" to the League commission on opium traffic. The United States became a party to treaties, with regard to the white-slave trade, drawn up by the League but to take effect for only such countries as might ratify them. Gradually even the warm friends of the League accepted the view that it was useless for the time being to urge participation by the United States in the League.

The World Court.—Down to 1914 the International Court of The Hague, founded in 1899 and strengthened in 1907, was functioning and rendered occasional decisions. It was, however, entirely ignored by the contending parties in the six wars that broke out from 1900 to 1914 and after World War I it remained ineffective. Root, who had a share in framing the court, came forward in 1920 as the leader of an unofficial group of experts in international affairs, to propose a new world court with wide powers and jurisdiction. An advisory committee of jurists sat at The Hague and drew up a plan for the Permanent Court of International Justice. The League of Nations accepted the project and established the court (Dec. 1920) and chose the judges (Sept. 1921). (*See* International Court of Justice.) The United States had no official relation with the court; but the force of U.S. public sentiment for a world league concentrated on a proposition for qualified entrance of the United States into the World Court. This was warmly urged by President Harding and later by Presidents Coolidge, Hoover and F. D. Roosevelt. Strong opposition was made in the United States on the plea that the court was an entering wedge to the League of Nations. The whole discussion was presently merged in consideration of proposals for the outlawry of war. (A. B. H.; E. E. R.)

President Coolidge and Congress.—In the mid-term congressional elections of 1926 the Democrats captured 7 of the contested seats in the senate, wiping out the Republican majority in the 69th congress, and gained 13 seats in the house, making the complexion of the 70th congress (1927–29) 237 Republicans, 195 Democrats, 3 Independents in the house, and 48 Republicans, 47 Democrats, 1 Farmer-Labourite in the senate. The election foreshadowed embarrassment for the administration. Elimination of the Republican margin in the senate made it necessary for that body to conciliate the insurgent members who had supported La Follette in 1924 and had been punished therefor by being dropped from important committee assignments in the 69th congress. The Republican progressives, like Robert La Follette (the younger), John Blaine, Lynn Frazier and Gerald P. Nye, were now restored to regular standing, and exacted from the floor leader, Charles Curtis, as the price of their support of the party the promise that "certain legislation of paramount interest to the people" (farm relief, investigation of U.S. policy in Latin America, a bill to regulate the issuance of injunctions) should be brought to a vote during the first session of the 70th congress. On these questions, as on several others of major importance, such as the details of tax reduction, the disposition of Muscle Shoals, the naval program, Mississippi flood control, the method of prohibition enforcement, President Coolidge found himself at odds with congress. He did not, however, attempt to drive congress, as Roosevelt and Wilson had done. With characteristic patience he held to his policies, vetoing 16 bills and resolutions in the first session of the 70th congress (Dec. 5, 1927–May 29, 1929), and insisting in his messages and speeches on obedience to law and on rigid economy.

National Finances.—The era of prosperity which set in at about the time of Coolidge's accession to the presidency continued unabated during his entire administration. Except in a few "spots," such as the bituminous coal and textile industries, production mounted steadily, consumption kept pace and labour was well employed and content. The national wealth. which had stood at about $7,000,000,000 in 1850, $25,000,000,000 in 1870. $65,000,000,000 in 1890 and $350,000,000,000 in 1920. was approaching the $450,000,000,000 mark by 1929. The annual income had reached $90,000,000,000 and annual savings were more than $17,000,000,000. The United States was investing about $2,000,000,000 of surplus wealth abroad and diminishing the national debt by nearly $1,000,000,000 each year. The abundant receipts of the treasury (more than half from income taxes), combined with the careful co-operation of the committees of the administrative departments under President Coolidge and Director of the Budget Herbert M. Lord, resulted in substantial surpluses at the end of every fiscal year. On Feb. 26, 1926, the president signed a bill for a tax reduction of $388,000,000.

In spite of the cut in taxes the surplus continued to mount. and on May 29, 1928. the president signed the third tax reduction hill of his administration (relieving corporations and certain industries but leaving the personal schedules unchanged), involving a cut of about $220,000,000. The refunding of the second and third Liberty Loans in 1928 effected a saving to the government of $75,000,000 a year in interest charges. As President Coolidge's term drew toward a close, however, the prospect for further tax reduction vanished, and there was even some apprehension that the treasury might be confronted for the first time in the administration with a deficit instead of a surplus. This was caused by certain extraordinary demands on the government, such as the appropriation of $75,000,000 for the refund of taxes illegally collected, of $50,000,000 for the settlement of claims arising out of taking over alien property during World War I, of nearly $50,000,000 for a public buildings program and of about $20,000,000 for initiating work on the vast $315,000,000 program for federal engineering work on the lower Mississippi river.

National Defense.—Since it was still the view that the geographic position of the United States brought immunity from fear of attacks by strong and hostile neighbours. the country followed the traditional policy of a small and well-equipped army supplemented by state militia. The regular army of about 132,000 men meant only 1.1 soldiers to every 1,000 of population and every $3,250,000 of national wealth. Reduction of land armaments was not a problem in which the United States was directly interested. But the government worked diligently for the reduction of naval armaments. After the failure of a proposed conference on disarmament, President Coolidge came out more positively for a "policy of adequate defense." A five-year building program had been approved by Secretary of the Navy Curtis D. Wilbur in the summer of 1926, calling for 71 new vessels (cruisers, submarines, destroyers and carriers) to cost nearly $800,000,000. Cutting this program to 15 cruisers and 1 aircraft carrier, the house, on March 17, 1928, passed a bill for the construction of the 16 vessels in three years at a cost of $274,000,000. The cruiser bill was put over to the short session of the senate; where it met sharp opposition, especially as it was pending at the same time as the ratification of the Kellogg pact for the renunciation of war as an instrument of national policy. However. the bill was passed on Feb. 5, 1929, by a vote of 68 to 12, and was signed by the president. On Feb. 28, 1929, congress agreed to a $12,370,000 addition to the naval appropriation for the new vessels, $200,000 to be available at once for starting the 1929 group of five and $200,000 to be available on July 1, 1929, for the beginning 1930 group. The progress of aviation began to play a great part in the field of national defense.

Efforts at Farm Relief.—In the midst of general prosperity the farmers complained that they mere poorer. The value of their capital investment had shrunk from $79,000,000,000 to $59,000,000,000 in the five-year period 1922-27, and the return on this capital was less than 3%. While overproduction kept the prices of their products down. state and local taxes and the cost of farm implements and machinery were rising. The farmers asked the government to come to their relief (as it helped the manufacturers by the tariff, and labour by the restriction of immigration) by purchasing their surplus product of wheat, corn. cotton, hogs and tobacco and selling it abroad for what it would bring in the world market, assessing the loss and the cost of the operation on the industries benefited (the "equalization fee"). The McNary-Haugen bills embodying these demands were kept before congress during the last three years of the Coolidge administration. The first bill failed of passage in the late spring of 1926, but in Feb. 1927 a McNary-Haugen bill went through both houses. President Coolidge vetoed it because it put the government into the farming business. though he was willing to help the farmers help themselves by generous contributions to co-operative marketing projects and by aid from the department of agriculture. The veto was accompanied by an opinion from Atty. Gen. John Sargent condemning certain features of the bill as unconstitutional. Nothing daunted. the advocates of farm relief came forward with a third McNary-Haugen bill: which passed congress by increased majorities in the spring of 1928, only to meet with a second veto from the president (May 23). The senate failed by the margin of 50 votes to 31 to pass the bill over the veto. On the first day of the short session of the 70th congress (Dec. 4, 1928) the fourth McNary-Haugen bill was introduced, this time without the equalization fee. No action was taken on it during the session, but President Hoover called an extra session of the 71st congress to meet on April 15, 1929, to deal with farm relief and the revision of the tariff. President Coolidge's vetoes of the farm relief bills roused opposition in the west and led to predictions that the farming sections of the country would not support an administration candidate for the presidency in the campaign of 1928. But Hoover carried every one of the agricultural states (see below).

Latin-American Relations.—The controversy with Mexico over its legislation to put into effect the provisions of art. 27 of the constitution of 1917, regulating alien exploitation of mineral and agricultural lands, was further embittered by the appeal made to the Roman Catholics of that country against Pres. Plutarco Calles' measures against the foreign clergy of the Roman Catholic Church in Mexico, and by the report that the Mexican Bolshevists were encouraging the rebels in Nicaragua in their resistance tc the U.S. marines. So serious was the situation at the beginning of 1927 that the United States senate by a unanimous vote asked President Coolidge to submit the controversy with Mexico to arbitration. The president ignored the request, but in the autumn he sent Dwight W. Morrow, of the firm of J. P. Morgan & Co., as ambassador to Mexico. Morrow's friendly and tactful diplomacy resulted in an early agreement with President Calles, and the amicable relations of the two countries were greatly strengthened when Col. Charles A. Lindbergh, after a nonstop flight from Washington, arrived at Mexico City (Dec. 14, 1927) as a U.S. "ambassador of good will."

President Coolidge, in spite of criticism in congress and in the liberal press of the country, held to his policy of maintaining about 5,000 marines in Nicaragua to quell the revolt against Adolfo Diaz and to protect U.S. lives and property. The forces of Diaz and Juan Sacasa agreed to lay down their arms when Coolidge sent Henry L. Stimson to Nicaragua with an ultimatum in April 1927. but the rebel leader Augusto Sandino continued a guerrilla warfare in which 20 U.S. marines were killed and 50 wounded. When Sandino was overcome, both parties agreed to an election, which was held under the supervision of U.S. troops (Dec. 4, 1928) and resulted in the victory of the Liberal candidate, José Moncada.

The sixth Pan-American congress was opened by President Coolidge in person. at Havana, Cuba, on Jan. 16. 1928. Hughes headed the U.S. delegation, and steered the conference away from the embarrassing political questions raised by the United States intervention in Nicaragua. A supplementary Pan-American Conference on Arbitration and Conciliation met at Washington, D.C.. on Dec. 10, 1928, which not only negotiated a score of arbitration treaties between the Latin-American nations, but was influential in keeping Bolivia and Paraguay from going to war over disputed territory.

The **Briand-Kellogg** Peace Pact.—On the tenth anniversary of the entrance of the United States into World War I (April 6, 1927), the French foreign minister, Aristide Briand, proposed that the United States and France should agree to a treaty renouncing war as an instrument of national policy, and agreeing to settle disputes of whatever origin or nature by pacific means. Secretary of State Kellogg replied, suggesting that the treaty be extended to other nations. On Aug. 27, 1928, the representatives of 15 nations met at Paris and signed the Briand-Kellogg pact. Secretary Kellogg represented the United States at Paris. On Jan. 15, 1929. the senate ratified the pact.

The Election of 1928.—President Coolidge having announced that he would not run for the presidency in 1928, the field was left open for Secretary of Commerce Herbert C. Hoover, who was easily nominated, receiving 837 out of the 1.084 votes cast in the first ballot, at the nominating convention at Kansas City, June 12–15, 1928. The delegates to the Democratic nominating convention at Houston, Tex.. on June 26–29, cast $849\frac{2}{3}$ votes out of 1,100 for Alfred E. Smith, then serving his fourth term as governor of New York. Senator Curtis of Kansas and Sen. Joseph T. Robinson of Arkansas were named as the respective vice-presidential candidates. Each of the four nominations was made on the first ballot cast. The platform of the Republican party promised farm relief and a careful revision of the tariff, defended the Coolidge policy in Nicaragua and adopted a prohibition plank written by Senator Borah, pledging the administration to a "vigorous enforcement" of the 18th amendment. The Democratic platform contained a scathing denunciation of the "sordid corruption and unabashed rascality" of Republican rule, which had left "agriculture prostrate, industry depressed, and workmen without employment," and pledged action instead of broken promises for the relief of the farmer. Governor Smith telegraphed to Chairman Robinson of the convention endorsing the platform in general, but adding that it was his duty as the chosen leader of the party to say that he advocated "fundamental changes in the present provisions for national prohibition." Hoover made only a few campaign speeches. Governor Smith, on the other hand, toured the country and discussed definite policies which he proposed to adopt if he were elected. On election day, Nov. 6, 1928, Hoover carried 40 of the 48 states, including four (Virginia, North Carolina, Florida and Texas) which had been Democratic since the days of Reconstruction. The electoral vote was 444 for Hoover to 87 for Smith. But the popular vote of 21,391,381 to 15.016.443 indicated no such crushing defeat for the Democratic candidate The Socialist candidate. Norman Thomas of New York, polled 267.835 votes; the Communist party candidate, William Z Foster, 21,181; the Socialist-Labour candidate, V L. Reynolds, 21,603; and the Prohibitionist candidate, William Varney, 20,106. Hoover's invasion of the solid south was attributed by the Democrats to the prejudice in that section against Governor Smith as a "wet" and a Roman Catholic, while the Republicans saw in it the swing of the south toward tariff-protected industry and the recognition of Hoover's wide experience as an executive. Soon after the election Hoover sailed from San Diego, Calif, on the battleship "Maryland," for a good-will tour to the countries of Central and South America. He visited Honduras, Nicaragua, Costa Rica, Ecuador, Peru, Chile, Argentina, Uruguay and Brazil.

Hoover retained Secretary of the Treasury Mellon and Secretary of Labour Davis of the Coolidge cabinet in office, the former remaining until Feb. 1932 when he was appointed ambassador to Great Britain, and was succeeded in the treasury department by Undersecretary Ogden L. Mills; and the latter resigning the secretaryship of labour in 1930 to run for U.S senator from Pennsylvania, being replaced in the cabinet by William N. Doak of Virginia. The eight new appointees (none from the states of the south which Hoover had carried) were Col. H. L. Stimson, governor general of the Philippines, for secretary of state; James W. Good of Iowa, secretary of war (succeeded in December by P. J. Hurley of Oklahoma); William De Witt Mitchell of Minnesota (a conservative Democrat), attorney general; Charles Francis Adams of Massachusetts, secretary of the navy; Walter F. Brown of Ohio, postmaster general; Ray L. Wilbur of California, secretary of the interior; Arthur M. Hyde of Missouri, secretary of agriculture; and Robert P. Lamont of Illinois, secretary of commerce, succeeded in 1932 by Roy D. Chapin of Michigan.

The Agricultural Marketing Bill.—In accord with the campaign pledge President Hoover called the 71st congress (senate 55 R., 39 D., 1 F. L.; house 269 R., 165 D., 1 F. L.) in special session on April 16, to consider the problems of farm relief and the revision of the tariff. After the senate had tried in vain to insert a debenture clause into it, an agricultural marketing bill was passed by large majorities and signed by the president on June 15. The bill aimed at the encouragement of producer-owned and producer-controlled co-operative associations, which should eliminate. wasteful methods of distribution and prevent the accumulation of surpluses which caused "undue and excessive fluctuations or depressions" in the prices of agricultural products. It created a federal farm board of nine members (including the secretary of agriculture), and provided a revolving fund of $500,-000.000 from which loans were to be made to the farmers' co-operatives at a rate of interest not to exceed 4%. For a few months the Federal Farm board promised to be a great success. New co-operatives were formed for the marketing of grain, fruit, cotton, vegetables and livestock, and the board approved loans to 132 co-operatives! totaling $165,000,000. But as farm prices continued to sag in the disturbed condition of world markets, it became evident that the farmers could not borrow themselves out of debt. The board then departed from its announced plan of not buying or selling farm products itself. The government entered the market and backed the grain and cotton Stabilization corporations by purchasing 330,000,000 bu. of wheat and more than 1.000.000 bales of cotton, in the endeavour to peg the prices of these commodities by holding the surpluses off the market. The endeavour failed; and at the close of 1931 the books of the board showed a loss of about 50% on the $378,000.000 advanced for the purchases. It was evident that the agricultural problem was no nearer solution in 1932 than it had been in 1922. The farmer, because of high taxes, tariff walls and world depression, could not sell his staple crops for what it cost to raise them.

The Hawley-Smoot Tariff.—A "limited revision" of the tariff had been advocated in the Republican party platform and recommended by President Hoover. But the bill passed (264 to 147) by the house on May 28, 1929, bearing the name of W. C. Hawley of Oregon, chairman of the ways and means committee, increased the duties on more than 1,000 articles, raising the average rates far above those of the Fordney-McCumber act of 1922. In the senate the insurgents (Borah, George Norris, La Follette, Brookhart. Frazier and Nye) fought against the high rates. The final vote on the bill (June 13–14, 1930) was 44 to 42 in the senate and 222 to 153 in the house. President Hoover signed the bill, justifying his action on the ground that the "flexible" provision permitting him to alter the rates within a compass of 50% on advice of the Tariff commission would enable him to remedy any injustices in the bill. The evil effects of continuing to maintain a Chinese wall around the country, when the health of world commerce depended on international co-operation, were soon evident. Before the close of 1931, about 25 foreign countries had raised their tariff malls, chiefly against U.S. goods, by way of reprisal. Debtor nations, whose only means of payment was the shipment of merchandise to the U.S., found their goods shut out by the customs barrier. In the 17 months preceding June 1930, C.S. exports had been $6,828,000,000 and U.S. imports $5,766,000,000. In the next 17 months these figures had dropped to $4,007,000,-000 and $3,262,000,000 respectively—a total shrinkage of $5,326,-000.000 in U.S. foreign trade. Widespread depression in Europe, revolutions in Latin America and riots and civil war in India and China were playing havoc with world trade.

The Wickersham Commission.—President Hoover was concerned with the widespread disregard for law, as evidenced by the operations of bootleggers, highjackers, kidnapers and racketeers and the failure of the courts to convict and punish criminals. The Cnited States led the world in the sinister statistics of homicide, burglary, holdups and graft. Gangsters armed with machine guns and provided with high-powered motorcars terrorized the cities and defied, bribed or cowed the sworn guardians of the law.

The court records showed that the chances that the criminal would be convicted and brought to punishment were only about 3 in 100.

On May 20 1929, President Hoover appointed a commission of 11 citizens, headed by former Atty. Gen. George W. Wickersham, end including Newton D. Baker, Dean Roscoe Pound of the Harvard law school, and 3 federal judges. to investigate and report on the "dominant national problem" of the observance and enforcement of the law. After 18 months of investigation the commission submitted the first installment of its report (Jan. 19, 1931). This report, described by one newspaper as "the most astonishing document ever submitted to our government by a responsible committee," instead of clearing up the confusion of opinion on prohibition only made it worse Ten of the 11 members signed the body of the report. which opposed the repeal of the 18th amendment or the modification of the Volstead act: but in individual opinions appended to the report only four members favoured the continuance of the law as it stood, while five recommended modification and two absolute repeal The commission subsequently submitted 12 reports dealing with the causes of crime, the machinery of the courts, penal institutions. police methods, probation and parole and the deportation of aliens

The Stock Market Crash.—Long before the Wickersham reports were submitted, public interest was absorbed in the sudden eclipse of the prosperity which had seemed to all but a few to be established on a firm and enduring basis. For the first six months of the administration the road to wealth for all seemed to stretch broad and smooth before the American people. The prices of stocks soared to fantastic heights. Billions of dollars were drawn from the banks into Wall street for brokers' loans to carry margin accounts. In the midsummer of 1929 about 300,000.000 shares of stock were being carried on margin.

In Oct. 1929 the market broke, and the wild rush to buy stocks gave way to an equally wild rush to sell. On Oct. 29, 16.-410,030 shares were thrown on the market for what they would bring. Prime securities tumbled like the issues of bogus gold mines. General Electric fell from 396½ on Sept. 3 to 210 on Oct. 29. American Telephone and Telegraph dropped 100 points. Du-Pont fell from a summer high of 217½ to 80; United States Steel from 261½ to 1664; Delaware and Hudson from 224¾ to 141; Radio common from 505 to 26. Savings of a lifetime were wiped out. Politicai and financial leaders at first affected to treat the matter as a mere spasm in the market. President Hoover and Secretary Mellon made optimistic predictions that business was "fundamentally sound" and that a great revival of prosperity was "just around the corner." In Jan. 1930 the president declared that the trend of business was "upward," in March, that the crisis would be over in 60 days, in May, that we had "passed the worst" and "would rapidly recover." Secretary Mellon saw "nothing in the present situation that warrants pessimism." But as the months passed it became evident that the nation was entering a period of severe depression. Foreign trade fell sharply, factories were closed, the number of unemployed grew alarmingly, mortgages were foreclosed, banks failed, dividends were passed, the prices of wheat, cotton. copper. oil and other commodities kept on sinking, the federal surpluses were turned into deficits and the buying power of the nation was paralyzed.

Efforts **for** Relief.—In Oct. 1930 President Hoover appointed a cabinet committee to formulate measures for the relief of unemployment. In December he laid before congress a vast program for road construction, public buildings, flood control and airways development, and signed 22 bills appropriating more than $300,000,000 for loans by the Federal Farm board. for emergency construction and for drought relief. In Oct. 1931 he got the bankers to form a $500,000,000 pool to help rescue the weaker banks from failure, and on Jan. 22, 1932, he signed the bill creating a $2,000,000,000 Reconstruction Finance corporation, empowered to make loans to banks, insurance companies, agricultural associations, railroads and other industries. The management of the board was vested in seven directors under the chairmanship of Dawes who had just resigned the post of ambassador at London. Democrats and Republicans joined in passing the bill.

The Plight **of** the Treasury.—It would have been comparatively easy lor the treasury to provide the relief clamoured for if it had continued to enjoy the abundant revenues and the surpluses of the Coolidge administration. But the depression which had stopped the wheels of industry had also dried up the sources of revenue. Federal taxes from all sources were supplying only 50% of the expenses of the government at the beginning of 1932. Appropriations for national defense, the veterans' service and interest on the public debt absorbed every dollar of the national income. The treasury deficit, which stood at $900.000.000 at the close of the fiscal year 1931, threatened to exceed $2,000.000.000 before June 30. 1932. Yet the demands on the treasury increased. In Feb. 1931 both houses of congress had overridden by huge majorities (328 to 79 and 76 to 17) President Hoover's veto of a bonus bill, extending cash loans to the war veterans up to 50% of the face value of their adjusted certificates, at an estimated cost of $1,000,000,000. Agitation was immediately started for the full cash payment of the certificates, amounting to another $2,000,000.000, although the American Legion in its convention at Detroit in Sept. 1931 disapproved this "raid on the treasury" by a vote of 902 to 507. The treasury was still further crippled by the loss of about $238,000,000 which should normally have been collected from the debtor nations in Europe, when President Hoover, in order to save Germany from imminent financial collapse, proposed a year's moratorium on all intergovernmental debts (June 20, 1931). both principal and interest.

Efforts to Balance the Budget.—The mid-term elections, coming in the midst of the depression, naturally turned against the administration. The 72nd congress, which met on Dec 7, 1931, saw the Democrats in control of the house (220 to 214) while the senate was almost equally balanced (48 R., 47 D.). However, 12 senators from the agricultural states of the west who bore the Republican label could be counted on to join the Democrats in opposition to any administration policies that smacked of favours to the "special interests." Considering the distress under which the country was labouring, congress declared it would "postpone politics," much as it had done in the emergency of World War I, and Speaker John Nance Garner of the house rallied the Democrats to support the president's recommendations for the enlargement of the credit facilities of the banks (the Glass-Steagall act) and the creation of the $2.000.000,-000 Reconstruction Finance corporation (Jan. 22, 1932). The leaders of both parties agreed that the budget must be balanced; but when it came to framing the necessary tax bill harmony ceased. Everybody knew that taxes must be increased if the deficit was to be wiped out, but nobody wanted them to be increased at his own expense. The advocates of "soaking the rich" demanded high taxes on incomes, inheritances and stock transfers. Those who favoured spreading the burden over the consumers supported the sales tax recommended by the ways and means committee of the house, The bill which was passed by the house (April 1, 1932) and (after some inconsequential changes by the senate) signed by the president on June 6, mas declared by Secretary of the Treasury Mills to be "inadequate' to check the growing deficit. About $1,118,000,000 was expected from its provisions, nhich raised the normal income tax to 8% on sums above $4.000, with supertaxes rising to 55% on incomes in excess of $1,000,000. 'Taxes were also levied on bank checks, telephone, telegraph and radio messages and the sales of various luxury articles such as automobiles, radios and phonographs. But congress resisted the president's efforts to cut down government expenses. In the first four months of the new fiscal year (July–Oct., 1932) the treasury deficit mounted by almost $700.000.000

Gestures Toward International Co-operation.— president Hoover was sincerely desirous of redeeming his inaugural pledge to co-operate with Europe in efforts for recovery from the political, financial and industrial chaos which World War I had produced throughout the whole world In 1929 an international committee of which Owen D. Young was chairman revised the Dawes plan (*see* REPARATIONS) of dealing with the reparations payments demanded from Germany. The Young plan, besides revising the amounts of the payments, tried to take the whole matter nut of the realm of politics and national revenge and make it a scientific procedure of international finance, controlled by and operating through a bank of international settlements established at Basle, Switz. In October of the same year, the British prime minister, J. Ramsay MacDonald, visited the Cnited States and held informal conversations with Secretary of State Stimson and President Hoover. The outcome was an invitation to the five naval powers of the Washington conference of 1921–22 to meet at London in Jan. 1930 for the purpose of controlling competition in those types of war vessels (cruisers, submarines, destroyers) which had not been included in the Washington agreement. The London conference lasted from Jan. 21 to April 22, 1930. France and Italy withdrew from the conference when they thought that their "security" in the Mediterranean was threatened; but the United States, England and Japan signed the London treaty, which extended the ban on battleship construction until 1936, fixed ratios for the building of auxiliary craft and established a definite naval "parity" between the United States and Great Britain. The treaty was disappointing to the advocates of naval limitation, however, because it permitted the nations to build up to a certain limit rather than scaling down naval construction and, by the "escalator clause," allowed them to increase the ratios if their security seemed to be threatened by other nations (France and Italy). Though Europe's armies were of less concern to the United States than the navies, the Cnited States sent a full delegation to the Limitation of Armaments conference at Geneva on Feb. 2, 1932—and accomplished nothing.

The League of Nations and the World **Court.**—While not departing from the official position of nonmembership in the League, the United States gave some endorsement to Hoover's pledge in his acceptance speech of Aug. 11, 1928, that the country would be "glad to co-operate with the League in its endeavours to further scientific, economic and social welfare and to secure the limitation of armaments." By the autumn of 1931 the government had signed more than 12 international agreements made under the League's auspices. In October of that year Prentiss B. Gilbert, U.S. consul general at Geneva, sat at the table of the League council when it discussed the Japanese aggression in Manchuria, and a U.S. general (Frank R. McCoy) served on the Lytton commission appointed by the League to visit Manchuria and report on the situation. The deadlock over the adherence to the World Court continued during the Hoover administration. Root (who had helped frame the original statute of the court) went to Geneva late in 1928 and secured the assent of the statesmen there to the "Root formula," which so guarded U.S. interests in the matter of advisory opinions that Secretary of State Stimson instructed the U.S. acting minister at Geneva to sign the protocol of adherence (Dec. 9, 1929). Just a year later President Hoover presented the protocol to the senate for ratification. Senator Borah and the other determined opponents of the court in the committee on foreign relations prevented the protocol from being reported out to the senate until May 1932. By that time the presidential campaign was beginning to absorb the attention of the country, and there was little probability that the senate would take any action on the protocol until the election was over. Then the emergency measures of the New Deal under Pres. Franklin D. Roosevelt so absorbed congress and the public that action on the World Court was not taken until Jan. 29, 1935. On that date 52 senators voted in favour of joining the court and 36 against—thus failing by 7 votes to register the two-thirds necessary for ratification.

Campaign of 1932.—The Republican national convention met at Chicago on June 14, 1932, and renominated Hoover and Curtis on the first ballot. The platform stood pat on the merits of the Hoover administration, warned against the danger to business interests and national finances if the Democrats should come into power, and rejected a plan for a repeal of the prohibition amendment. The Democrats met on June 27, in the same building that the Republicans had vacated a few days before. Though the primaries had given Gov. Franklin D. Roosevelt of New York a substantial majority of the delegates, he was still far short of the two-thirds (770) necessary for nomination. An anti-Roosevelt group headed by Alfred E. Smith, John J. Raskob and Jouett Shouse developed considerable strength in New England and New York Nine candidates were put in nomination. including, besides Roosevelt and Smith, four state governors and Speaker of the House Garner. Roosevelt had $666\frac{1}{4}$ votes on the first ballot, to $201\frac{3}{4}$ for Smith, $90\frac{1}{4}$ for Garner and $195\frac{3}{4}$ divided among the other candidates. On the fourth ballot Garner released his delegates to Roosevelt and McAdoo, who had been supporting Garner. threw the entire California delegation to the New York governor, who was nominated with 945 of the 1,154 votes. Roosevelt immediately flew from Albany to Chicago to deliver his acceptance speech to the assembled delegates. Garner was named for vice-president. In the campaign which followed, Roosevelt had little difficulty in persuading the people that a change of administration, a New Deal, was the only hope of recovery from the depression. Banks were failing by the hundreds. Mills and factories were shut down. The unemployed numbered more than 10,000,000. Mortgages on farms and homes were being foreclosed. National, state and local taxes were taking one dollar out of every three of the national income, and the public debt was increasing at the rate of $2,000,000,000 a year. A "bonus army" of 10,000 to 20,000 men marched on Washington in the midsummer, determined to remain until congress voted them full cash payment of their adjusted certificates. A thousand farmers in Iowa picketed the roads to prevent the delivery of their grain, milk and livestock at prices which did not pay them for production. Roosevelt toured the country attacking the Republican administration and promising economy, a balanced budget, relief for the farmers and rehabilitation of business. Prominent Republicans. including Senators Johnson and Norris, supported him openly. Toward the end of the campaign President Hoover attempted to stem the tide that was running more strongly against him every week. But it was of little avail. The verdict at the polls on Nov. 8 was a Democratic landslide. Roosevelt carried every state in the union except six (Maine, New Hampshire, Vermont, Connecticut, Delaware and Pennsylvania) with 472 electoral votes to 59 for Hoover, dnd a popular majority of approximately 7,000,000. The Democrats secured an overwhelming majority in both the house and the senate.

Two New Amendments.— The final short session of congress, which met in Dec. 1932, was the last of the "lame duck" sessions. For in Jan. 1933 the 20th amendment to the constitution was ratified, which provided that thereafter the congress elected in November should begin its session on the third day of the following January, and that the president should be inaugurated on Jan. 20. The last "lame duck" congress also passed a 21st amendment in Feb. 1933 (ratified in December) repealing the 18th (prohibition) amendment.

The New Administration.— The cabinet, announced on the eve of the inauguration, consisted of Cordell Hull of Tennessee (state); William B. Woodin of New York, who resigned in December and was succeeded by Henry Morgenthau, Jr. (treasury); Homer S. Cummings of Connecticut (attorney general); Gov. George H. Dern of Utah (war); Sen. Claude A. Swanson of Virginia (navy); James A. Farley of New York, chairman of the Democratic state and national committees (postmaster general); Harold L. Ickes of Illinois (interior); Henry A. Wallace of Iowa (agriculture); Frances Perkins of New York, the first woman to have a cabinet seat (labour); and Daniel C. Roper of Washington, D.C. (commerce). Besides these official heads of departments, President Roosevelt took intimate counsel from a number of advisers who were called the "brains trust" because many of them were college professors. Notable among them were Raymond Moley (for a time assistant secretary of state), Rexford G. Tugwell (later undersecretary of agriculture) and A. A. Berle of Columbia university, Felix Frankfurter (later supreme court justice) and O. M. W. Sprague of Harvard, and George F. Warren of Cornell. In his brief inaugural address the president scored the prevailing practices in industry and finance which he said had brought the country to distress in the midst of plenty, promised to drive the "money-changers" out of the temple, declared that the only thing the country had to fear was fear itself, and in words recalling Woodrow Wilson's inaugural of 20 years before asked the people to join him in a "national consecration" to the work

Table VII.—*Summary of Presidential Elections in the United States, 1860–1960*

(Successful candidate in boldfaced type; unsuccessful, in lightface type. Candidates receiving no electoral vote are not mentioned)

Year	Candidate	Party	Popular Vote	Electoral Vote
1860	**Lincoln**	Republican	1,866,452	180
	Douglas	Democrat	1,375,157	12
	Breckinridge	Democrat	847,953	72
	Bell	Union	590,631	39
1864	**Lincoln**	Republican	2,213,665	212
	McClellan	Democrat	1,805,237	21
1868	**Grant**	Republican	3,012,833	214
	Seymour	Democrat	2,703,249	80
1872	**Grant**	Republican	3,597,132	286
	Greeley	Democrat	2,834,125	66*
1876	**Hayes**	Republican	4,036,298	185
	Tilden	Democrat	4,300,590	184
1880	**Garfield**	Republican	4,454,416	214
	Hancock	Democrat	4,444,952	155
1884	**Cleveland**	Democrat	4,874,986	219
	Blaine	Republican	4,851,981	182
1888	**Harrison**	Republican	5,439,853	233
	Cleveland	Democrat	5,540,309	168
1892	**Cleveland**	Democrat	5,556,918	277
	Harrison	Republican	5,176,108	145
	Weaver	People's	1,041,028	22
1896	**McKinley**	Republican	7,104,779	271
	Bryan	Democrat	6,502,925	176
1900	**McKinley**	Republican	7,207,923	292
	Bryan	Democrat	6,358,133	155
1904	**Roosevelt, T.**	Republican	7,623,486	336
	Parker	Democrat	5,077,911	140
1908	**Taft**	Republican	7,678,908	321
	Bryan	Democrat	6,409,104	162
1912	**Wilson**	Democrat	6,293,454	435
	Roosevelt, T.	Progressive	4,119,538	88
	Taft	Republican	3,484,980	8
1916	**Wilson**	Democrat	9,129,606	277
	Hughes	Republican	8,538,221	254
1920	**Harding**	Republican	16,152,200	404
	Cox	Democrat	9,147,353	127
1924	**Coolidge**	Republican	15,725,016	382
	Davis	Democrat	8,386,503	136
	La Follette	Progressive	4,822,856	13
1928	**Hoover**	Republican	21,391,381	444
	Smith	Democrat	15,016,443	87
1932	**Roosevelt, F. D.**	Democrat	22,821,857	472
	Hoover	Republican	15,761,841	59
1936	**Roosevelt, F. D.**	Democrat	27,751,597	523
	Landon	Republican	16,679,583	8
1940	**Roosevelt, F. D.**	Democrat	27,244,160	449
	Willkie	Republican	22,305,198	82
1944	**Roosevelt, F. D.**	Democrat	25,602,504	432
	Dewey	Republican	22,006,285	99
1948	**Truman**	Democrat	24,105,695	303
	Dewey	Republican	21,969,170	189
	Thurmond	States' Rights Democrat	1,169,021	39
1952	**Eisenhower**	Republican	33,778,963	442
	Stevenson	Democrat	27,314,992	89
1956	**Eisenhower**	Republican	35,582,236	457
	Stevenson	Democrat	26,028,887	73†
1960	**Kennedy**	Democrat	34,221,401	303
	Nixon	Republican	34,109,188	219‡

*Greeley died before electoral vote was cast. †One electoral vote was cast for a noncandidate. ‡Fifteen electoral votes were cast for Sen Harry F. Byrd of Virginia, who was not a candidate.

of restoring prosperity through united effort.

Meeting the Crisis.—Shortly after the election President Hoover had invited President-elect Roosevelt to Washington to confer with him on measures that might ease the situation during the four months "interregnum" before the latter's inauguration. But Governor Roosevelt was not willing to commit himself to policies before the power and responsibility were actually in his own hands. The winter of distress wore on, and when inauguration day arrived the country was confronted with a crisis of the first magnitude. Beginning with Michigan in mid-February, state after state had closed its banks to prevent runs by panic-stricken depositors. In the eight days preceding March 4, more than $1,500,000,000 had been drawn from the banks which were still open. The New York banks closed that morning by order of Gov. Herbert Lehman, and by noon every bank in the country had shut its doors. After a White House conference lasting well into the night of Sunday, March 5, President Roosevelt issued a proclamation closing all the banks for four days; and at the same time summoned congress to meet in extra session on March 9. On that day the house. without the formality of a roll call, and the senate, with only seven dissenting votes, passed the administration's Emergency Banking bill, giving the secretary of the treasury power to appoint "conservators" (quasi-receivers) for all the national banks in the country and to reopen them according to his discretion. Confidence was restored and deposits began to flow into the banks again. But, unfortunately, too many of the weaker banks were reopened. The president's Economy bill. designed to save $500,000,000 by reducing federal salaries and veterans' pensions (signed March 20), was hailed with enthusiasm by the country; but its effect was neutralized a year later (March 28, 1934) when congress passed over the presidential veto the Independent Offices bill, restoring most of the cuts. On March 22, 1933, a bill was signed legalizing the sale of 3.2% beer, from which a revenue of from $100,000,000 to $150,000,000 was expected for the treasury.

The **AAA.**—The extra session sat from March 9 to June 16, 1933. In those 99 days an amazing amount of legislation was adopted. The Agricultural Adjustment act of May 12 was designed to raise the prices of farm products and relieve the farmers. who were burdened by a mortgage indebtedness of $8,500,000,000. The plan was to take about 40,000,000 ac. out of cultivation, and to reimburse the farmers for the value of the crops and the hogs they would lose by a processing tax levied on flour millers, meat packers, etc. Of course this would raise the price of bread, bacon and clothing, because the processor would pass along the tax to the consumer. Since there was a large group in congress who favoured inflation of the currency as the means of raising prices, it was necessary, in order to get the bill through, to adopt an amendment of Sen. Elbert Thomas of Colorado, empowering the government to issue $3,000,000,000 of paper money and to reduce the gold content of the dollar by not more than 50%. No greenbacks were issued. but on April 19 the government abandoned the gold standard by forbidding the export of gold, and the next January the president by proclamation reduced the gold content of the dollar to 59.06 cents. This action, which made public and private bonds payable at 60 cents on the dollar, was subject to violent attack, but the supreme court, in Feb. 1935, upheld the devaluation by a vote of five to four. The processing tax of the AXA brought in more than enough to pay the benefits to the farmers in the first year of its operation, but in 1935 was falling far behind. as cases involving its constitutionality came before the courts. In Jan. 1936 the supreme court, by a vote of six to three (Stone. Brandeis, Benjamin Cardozo) declared the AAA unconstitutional.

The **NRA.**—Perhaps the most startling measure of the New Deal was the National Industrial Recovery act of June 16, 1933, by which the government assumed control over the major industries of the country. Representatives of the industries were invited 'to come to Washington to work out with the NRA administrator, Gen. Hugh S. Johnson, codes of fair dealing to be followed. These codes fixed maximum hours and minimum wages, abolished sweatshop and child labour in many industries, gave labour the right to bargain with employers through representatives of their own choosing (as against the open shop or the company unions), and required businessmen to open their books to government inspectors. Violators of the codes would have the Blue Eagle (the symbol of co-operation) taken away from them, and industries refusing to formulate a code were brought under a blanket code imposed by the president. More than 700 codes were drawn up by representatives of business. From the first the SRA met violent opposition on both constitutional and economic grounds. The act was to expire in June 1935, and the administration was bent on asking for its extension when the supreme court, in the Schechter Poultry Corporation case. on May 27, handed down a unanimous decision that the codes by their wages and hours provisions exceeded the powers of congress under the interstace commerce clause, and that. hence the NRA was unconstitutional. At the same time the Frazier-Lemke Mortgage Relief act was unanimously declared unconstitutional.

Emergency Relief,——Two objects, not always easily separable, were envisaged in the program of the New Deal: immediate (emergency) relief for the millions of unemployed who could no longer be taken care of by private charity or state and local funds; and long-time plans for the recovery of business and agriculture, On May 12, 1933, a Federal Emergency Relief act appropriated $500,000,000 for direct aid, one-half the sum going as a gift to supplement the amounts raised by the states and the other half to match state appropriations in the ratio of one to three. This was followed by various acts to create jobs for the unemployed at federal expense, such as the Civilian Conservation corps and the Civil Works administration. By June 1934 the total "emergency" expenditures of the government under such public works schemes, the RFC and the AAA amounted to more than $5,000,000,000. Dismayed at the burden of public debt being piled up for a future generation to pay in taxation, critics of the New Deal called for an end to extravagant spending, tinkering with the dollar, price and wage fixing and, in the words of the Republican *New York Herald Tribune,* "the whole succession of unrelated and hastily devised remedies . . . that had produced an economic chaos with no end in sight." President Roosevelt still had the confidence of the people, however. In the mid-term elections of 1934 the administration won a complete victory. The Democrats secured 322 of the 435 seats in the house and 69 of the 96 senators for the 74th congress.

President Roosevelt asked and obtained from the new congress in Jan. 1935 the sum of $4,880,000,000, to be spent virtually at his own discretion. Scores of alphabetical agencies were at work dispensing huge sums for relief and for constructive work. The projects of the Tennessee Valley authority and the Grand Coulee and Bonneville irrigation plants were being pushed. The public debt in the autumn of 1935 passed the $30,000,000,000 mark—exceeding by nearly $4,000,000,000 the World War I debt at its peak. With the adjournment of congress in Aug. 1935, after the passage of the Social Security act providing for old-age and unemployment pensions, the attention of the country turned to the approaching presidential race.

The Recovery of Business.—Shortly after the adjournment of congress President Roosevelt wrote (Sept. 6, 1935) to Roy Howard, in reply to a letter asking for "the grant of a breathing spell to business and a recess from further experimentation," that the basic program of the administration "has now reached substantial completion and the breathing spell of which you speak is here—very decidedly so." Since the autumn of 1934 the upturn in business had been steady, if not rapid. Railroads, banks' and insurance companies mere paying back their loans from the RFC. Firms which had been deep in the red were cutting their deficits and going on to make profits. Dividends were resumed. Wages and salaries mere stepped up. The farm income rose from $5,300,000,000 in 1932 to $8,000,000,000 in 1935. Foreign trade, which had reached its nadir of $2,933,000,000 in 1932. increased to $1,329,000,000 in 1935. Opponents of the New Deal insisted that the tide of prosperity would be rising far more rapidly were it not for the uncertainty in business circles as to what further measures of government interference the president might recommend. Nevertheless the indisputable fact of business improvement, a fact which the president emphasized more and more strongly in his speeches and press conferences, was a powerful factor in holding lor him the continued confidence of the nation.

The Growing National Debt.—In spite of the fact that business was improving, the treasury was showing staggering deficits from year to year. The numbers of the unemployed still remained, after three years of enormous expenditures for relief, somewhere between 10,000,000 and 12,000,000. In his budget message of Jan. 1936 the president asked congress for $1,425,000,000 for relief work, in addition to the $4,880,000,000 which he had obtained the previous year. By June 1936 it was estimated that close to $9,000,000,000 had been appropriated for relief, direct and indirect, and two further features added to the immense burden of debt which the relief work was imposing upon the government. First. the disallotvance of the AAA by the supreme court on Jan. 6, 1936, cut off the revenue of nearly $1,000,000,000 accruing from the processing tax, which was relied on to compensate the farmers for curtailing their production of wheat, cotton, tobacco and hogs. Then, three days later, congress, by an overwhelming vote, passed over the president's veto the bonus bill, which provided for the immediate payment to World War I veterans of their adjusted cornpensation certificates, due in 1945. Eight months earlier (May 22, 1935) the president had appeared before congress to read in person his veto of a similar bill, and had been able to prevent the senate (by a vote of 54 to 40) from overriding his veto. But this time both houses repassed the bill immediately, and the treasury found itself obligated to the payment of more than $2,000,000,000. The veterans were paid on June 15, 1936, in ten-year 3% bonds of $50 each which they might turn into cash at will at any one of the 300 main post offices of the country.

The result of these outlays, both anticipated and unforeseen, was to raise the national debt at the end of the fiscal year 1935–36 to more than $34,500,000,000, or double the amount of the debt at the beginning of the Hoover administration. Republicans asserted that such pyramiding of the debt would endanger the credit of the government, and deplored the burden of taxation that its servicing would entail upon future generations. But administration leaders replied that the government was able to borrow all the money that it needed at the lowest interest rates in U.S. history.

The National Conventions of 1936.—On June 9, 1936, the Republicans met at Cleveland, O., to write their platform and select their candidates for the presidential campaign. The platform condemned the Roosevelt administration for its regimentation of business, its contempt for the constitution, its waste of the taxpayers' money, its flouting of the civil service regulations, its encouragement of class hatred and its march toward a dictatorship in concentrating unprecedented power in the hands of the executive. It recommended turning the administration of relief over to the states, with subsidies from the national government, pledged efficient aid to the farmer and the labourer, advocated the restoration of a stable currency and promised to balance the national budget without either neglecting the worthy poor or increasing taxes. For several weeks the tide of popular favour had been setting strongly toward Gov. Alfred M. Landon of Kansas as the Republican nominee. On the first ballot he received all the votes of the convention except those of 18 delegates from Wisconsin and 1 from West Virginia who voted for Senator Borah. Col. Frank Knox, owner of the Chicago *Daily News* and, like Landon, a follower of Theodore Roosevelt in 1912, was unanimously named for the vice-presidency. On June 23 (two days after the end of the 74th congress) the Democrats held their convention at Philadelphia, Pa., and renominated Roosevelt and Garner by acclamation. The president, in his acceptance speech, stood pat on his program of relief, recovery and reform, scored the "economic royalists," and pledged himself to the necessary readaptation of social and economic life within the bounds of the constitution. The Socialists nominated Norman Thomas again; the Communists put up Earl Browder; and a new party appeared under the title of the Union for Social Justice, sponsored by Father Charles E. Coughlin of Detroit, F. E. Townsend, and the political heirs of Sen. Huey P. Long of Louisiana, nominating as its candidate Rep. William Lemke of North Dakota.

The Campaign of 1936.—The main issue: of course, was the approval or disapproval of the New Deal. The Republicans were hampered by the fact that their representatives and senators in congress had voted for many of the administration measures and by the anomalous position of Governor Landon, who condemned the New Deal and at the same time promised to continue the program of relief and recovery. A split in the Democratic ranks had been threatened when prominent members of the party, calling themselves "Jeffersonian Democrats," led the formation of the Liberty league. Alfred E. Smith and former Secretary of State Bainbridge Colby accused President Roosevelt of having repudiated the party platform of 1932. It was believed that the opposition of these dissidents, added to that of the Coughlin-Lemke party, the long existing campaign of the utility companies against the TVA and the hostility of conservatives to deficit financing and to extensive control of business would so far reduce President Roosevelt's strength as to make his victory in any case a narrow one. Indeed a Literary Digest poll gave Landon a popular lead of 1,293,669 to 972,897 and predicted a Landon victory of 370 to 161 in the electoral college. But the vote on Nov. 3 registered an overwhelming victory for Roosevelt. He carried 46 of the 48 states (all except Maine and Vermont), with 523 electoral votes to 8 for Landon. His popular plurality over the Republicans exceeded 11,000.000. The various minor parties polled 1,490,861 votes combined. of which Lemke had 882,479. The Republicans elected governors in only three states (Vermont. New Hampshire and South Dakota) in which gubernatorial contests were held. The Democrats gained 12 seats in the house and 5 in the senate.

Foreign Affairs.—Absorbed in his program of relief and recovery at home, President Roosevelt had paid comparatively little attention to foreign matters. The questions of the Allies' debt to the United States and of limitation of armament were not pushed. The tariff and international trade got little attention. In Nov. 1933, the government recognized the U.S.S.R., sending William C. Bullitt as the first ambassador to that country since the overthrow of the tsar's regime. The government participated in the seventh Pan-American congress at Montevideo, Crug., in the same autumn, with Secretary Cordell Hull again leading the delegation. By the McDuffie-Tydings act of 1934 the United States gave independence (to be final in ten years) to the Philippine Islands and in 1935 Manuel Quezon was elected first president of the Commonwealth of the Philippines; and the United States at last freed Cuba from what the islanders considered an embarrassing dependence, by abrogation of the Platt amendment (May 1934). On June 12, 1934, the president signed a Reciprocal Tariff act, under which Secretary of State Hull negotiated 24 reciprocity agreements with foreign nations, which at once resulted in an increase in U S. foreign trade. What nas thought to be a guarantee of the preservation of US. neutrality in the event of another European war was provided by the Neutrality act of April 1935. forbidding Americans to furnish munitions or money to foreign belligerents and refusing protection to Americans sailing on belligerent ships.

But the launching of an attack on Ethiopia by Italy in the autumn of 1935, the steady encroachment of Japan on the territorial integrity of China and the outbreak, in July 1936 of civil war in Spain brought the problem of U.S. neutrality into sharp relief. While temporary neutrality legislation was passed in 1935 and 1936, the arguments continued in congress and the country between the advocates of a mandatory law, leaving no discretion to the president in case of the outbreak of war, and a flexible law. permitting the president to handle each case as it should arise.

The outcome was the War Policy act of May 1, 1937, which embodies a compromise. The mandatory provisions of an embargo on arms and ammunition, the prohibition of loans to belligerents and the refusal to allow Americans to travel on ships of the belligerents were retained; but the president was granted the all-important power of determining whether the law was to be put into effect by proclamation that a war actually existed, and was allowed wide discretion in other respects.

The President and Congress.—President Roosevelt was inaugurated for his second term on Jan. 20, 1937, in accordance with the 20th amendment to the constitution. The first session of the 75th congress, which assembled on Jan. 3, contained enormous Democratic majorities which had been returned in the party's victory in the election of 1936. Interpreting the victory as an endorsement of the New Deal, the president announced in his inaugural address that he had "just begun to fight" for his program, and in his message to congress he asked that "action now" be taken on proposed measures for the regulation of hours and wages, the relief of farm tenants, the extension of social security, the control of speculation, federal health insurance and a housing program for the elimination of slums. The president also wanted legislation for a more effective crop control, for the creation of six great regional projects like the TVA and for authorization to reorganize the agencies of public works, relief and loans according to his discretion. But the congress proved to be unwieldy and unmanageable. Factions developed. and adjournment came on Aug. 21, 1937, without the enactment of any of the major measures.

The "Recession" of 1937.—A sharp decline in prosperity set in during the latter half of the year. In midsummer the production index stood higher than it had in a decade. The first quarter's output of steel had exceeded by 600,000 tons the previous high record of 1929. The national income had risen from less than $40,000,000,000 in 1932 to nearly $70,000,000,000. Then there began a decline which sent the business index down from 111.2 in August to 88.9 in November. Steel production fell from 80% to 31% of capacity. The average price of 50 stocks fell from 135.5 to 82; relief rolls swelled and the number of unemployed rose to about 10,000,000. The president called an extra session of congress on Nov. 15 to try again to get through some of the measures which he had proposed at the beginning of the year. But the session adjourned six weeks later without accomplishing any more than its predecessor had done.

The Supreme Court Issue.—Still further friction between the president and congress developed when Roosevelt proposed the addition of six new justices to the supreme court (with the purpose of inducing the six actual members more than 70 years of age to resign), and advocated a similar "infusion of new blood" into the lower federal courts. The latter proposition did not arouse much interest, but the so-called attempt to "pack" the supreme court with men who would uphold the legislation of the New Deal met with immediate opposition. The court had nullified nine of the measures of the New Deal, including such important ones as the NRA and the AAA: and on the occasion of the NRA unanimous decision in May 1935 the president had commented impatiently on the judges who were still living in the "horse and buggy days." During the entire four years of his first term President Roosevelt had had no opportunity to make an appointment to the supreme court, whereas, President Taft, for example, had six vacancies to fill in his single term. The controversy over the court reform occupied much of the attention of congress during the spring and early summer, until the president gave up the struggle when the senate, by a vote of 70 to 22, defeated the reorganization plan on July 22. Meanwhile the court had receded somewhat from its hostility to "progressive" measures. On March 29 it upheld the Washington Minimum Wage law for women. On April 12 it sanctioned the Wagner Labor Relations act. On May 27 it held the Social Security act of 1935 constitutional. The decision in practically all these cases was by a five to four vote. Justices James McReynolds, George Sutherland, Pierce Butler and Willis Van Devanter taking the negative and Chief Justice Hughes and Stone, Brandeis, Owen J. Roberts and Cardozo the affirmative.

Rapid changes in the personnel of the court from the summer of 1937 on gave the president the opportunity to create a "liberal" tribunal without resorting to innovating proposals. On June 2 Justice Van Devanter, taking advantage of the law permitting retirement at the age of 70, left the court, and was replaced by Sen. Hugo Black of Alabama, a staunch advocate of the New Deal. In 1938 Justice Sutherland of Utah, another conservative, resigned, to be succeeded by Roosevelt's solicitor general, Stanley Reed of Kentucky. Justice Cardozo died the same year, and Felix Frankfurter of the Harvard law school was appointed in his stead. In 1939 the aged Justice Brandeis, an appointee of Wilson in 1916, left the bench and the president appointed William O. Douglas of Connecticut to succeed him. Justice Butler of Minnesota, a consistent conservative, died in 1939, and was replaced by the former governor of Michigan and of the Philippines, Atty. Gen. Frank Murphy. In 1941 Justice McReynolds, the most conservative member of the court, resigned, to give place to Sen. James F. Byrnes of South Carolina. Finally, in 1941 Chief Justice Hughes resigned after 11 years of service. The president promoted the Coolidge appointee Harlan F. Stone to the chief justiceship, and named Robert H. Jackson of New York (who had taken Murphy's place as attorney general) to fill the vacancy. So by 1942 every member of the court except Chief Justice Stone and Justice Roberts was an appointee of President Roosevelt.

The Labour Struggle. — The year 1537 saw the fiercest conflict in the field of labour since the demoralizing period immediately following World War I. The battle started late in 1935 with the formation. by John L. Lewis, president of the United Mine Workers of America, of the Committee for Industrial Organization (later changed to the Congress of Industrial Organizations [C I.O]) to supplant the craft unions of the A F of L by industrial or "vertical" unions comprising all the workers in a given industry, something on the pattern of the "one big union" advocated by the Industrial Workers of the World (I.W.W.) a generation earlier. The new weapon used by the C.I.O. in its bitter fights with automobile and steel industries was the "sit-down strike" in which the strikers entrenched themselves in the factories and refused to work or to let others in to work. Although this trespassing mas an infringement on property rights, Governor Murphy of Michigan, fearing bloodshed, refused to evict the strikers by force. President Roosevelt declined to take part in the struggle, calling down "a plague on both your houses." Secretary of Labor Perkins at first took a complacent view of the matter, saying that the legality of the sit-down strike had not been determined; but later she condemned the movement. It petered out after a few months, but the C.I.O. grew rapidly, until by midsummer of 1937 it claimed to have drawn away more than half the members of the older organization. General Motors came to terms with the C I.O. in March. and the major steel companies followed suit. Fully aware that the split in the ranks of labour was hurting the cause, the tno presidents of the rival organizations tried in a series of conferences to come to some agreement. But neither William Green of the A.F. of L. nor John L Lewis of the C I.O. would yield a point, in spite of the pleas of some of their important lieutenants for harmony. It was hoped that the National Labor Relations board (NLRB), set up under the Wagner-Connery act of July 1935, would serve to iron out disputes in the industrial field, as the Railway Labor board in 1526 had averted serious strikes on the railroads, and, indeed, up to the close of the year 1938, the NLRB did handle more than 10 000 cases involving approximately 2,000.000 workers with fair success. It provided protection to workers in interstate commerce industries, in the formation of associations to elect their own representatives to conduct collective bargaining with the employers, and forbade the latter to interfere with labour organizations or to refuse to bargain collectively. The board might issue "cease and desist" orders, subject to judicial review, to prevent employers from violating the act. However, the board encountered opposition from the beginning. The A.F. of L. complained that it constantly favoured the C.I.O. in its rulings and demanded its revision. The employers protested against its unfairness in allowing appeals from the workers only. Although the NLRA was declared constitutional by the supreme court in April 1937, the effort to have it amended or repealed was continuous. Between Jan. and Aug. 1937 more than 3.200 strikes affecting 1,470,000 workers were reported by the bureau of labour statistics. To be sure, the number of strikes decreased in the next two years, averaging 231 a month in 1938 and 192 a month in the first seven months of 1935, as against 395 a month in the year 1937. But still the hostility of the two great labour organizations to each other and of both to the NLRB continued, in spite of the president's sporadic efforts to bring peace in the labour ranks. A concession was made to industry in July 1939, when employers were given the right to call for an election to determine the proper body for collective bargaining. Also the supreme court by a six to two decision reversed a decision of the board which had ordered the Fansteel Metallurgical company to rehire the men discharged in the sit-down strike of 1937.

The outbreak of World War II in Sept. 1939 invested the labour controversy in the United States with more than a domestic significance. Following labour-management conferences. a new policy was adopted early in 1942. proscribing strikes and lockouts for the duration of the war. The president appointed a War Labor board of 12 men (4 labour leaders, 4 industrialists and 4 members of the public) with William H. Davis as chairman. Lewis (who had resigned the presidency of the C.I.O. after turning against Roosevelt and threatening to resign if the latter were re-elected) then proposed a united front in labour: both President Green of the A.F. of L. and Pres. Philip Murray of the C.I.O. should resign, and George Meany should become president of the merged organization. with Lewis as vice-president. But neither Green nor Murray (who was not consulted) favoured the suggestion; nor did President Roosevelt.

Political Rivalry. — When the president met the final session of the 75th congress on Jan. 3, 1938, he asked for legislation on farm relief and on wages and hours in industry. He disclaimed any hostility to business in general, but accused a minority of big businessmen of antisocial practices in tax evasion, unfair competition and the maintenance of high prices. As contrasted with the "do nothing" sessions of 1937, congress passed two acts of major importance. On Feb. 14 came the elaborate Crop Control act of 1938 which had for its purpose what Secretary Wallace called the "ever normal granary," that is, the maintenance of a fairly steady ratio between the production and consumption of the chief surplus crops of the United States: wheat, corn, cotton, tobacco and rice. The government was to store the surplus in fat years and release it in lean years, extending loans of the stored surpluses through the Commodity Credit corporation. A novel feature of the act mas the provision for a referendum among the raisers of the crops in question to determine whether or not they agreed to the quotas of production which were fixed by the Agricultural administration.

In June 1938 congress passed a Fair Labor Standards act (or Wages and Hours act) for industries entering into interstate commerce. The act was designed to "put a floor under wages and a ceiling above prices." Wages were to increase from a minimum of 25 to 40 cents an hour, and hours to decrease by the same sliding scale from a maximum of 44 to 40 a week. But in spite of these major measures, opposition to the president's program went on. A combination of Republicans and anti-New Deal Democrats slashed hundreds of millions from appropriation bills, defeated the reorganization of the executive departments: refused to amend the Neutrality act, ignored the request for the establishment of six regional projects like the TVA and so amended the tax bill of 1938 in favour of the corporations that the president allowed it to become a law without his signature.

As the head of his party the president deemed it proper to intervene in the primaries of 1938 by letters, conferences and speeches, to eliminate certain discordant Democrats (notably Sen. Millard Tydings of Maryland, Ellison Smith of South Carolina, Walter George of Georgia and Guy Gillette of Iowa and Rep. John O'Connor of New York) from congress. This course, taken against the advice of Chairman James Farley, proved to be a boomerang. All the senators attacked were easily renominated and re-elected, while two prominent New Deal senators (James Pope of Idaho and William McAdoo of Californiaj were defeated. Farley had predicted that the Republicans might gain 40 seats for the 76th congress, but they actually increased their numbers from 89 to more than 160 in the house, and gained 7 seats in the senate. They elected 1I governors, and outside the solid south polled 51.5% of the popular vote, as compared with 40.1% in the election of 1936.

World War II

The Problem of Neutrality. — The outbreak of war in Europe with Adolf Hitler's invasion of Poland on Sept. 1. 1939, and the immediate declaration of war on Germany by Great Britain and France brought a decided change in the attitude of the American people toward the foreign policy of the administration.

Since his inauguration in 1933, Pres. Franklin D. Roosevelt had subordinated questions of foreign policy to his battle for the reforms of the New Deal. To meet the overwhelming desire of the American people to keep out of war in any part of the world, congress had in the years 1935–37 provided the most stringent neutrality legislation in the nation's history. Deprived of discretion to discriminate between "aggressor" and "nonaggressor" belligerents, the president had asked the 76th congress in its first session (Jan 3–Aug. 5, 1939) to rescind the mandatory provisions of the Neutrality act of 1937. On July 11 the senate committee on foreign relations declined, by a vote of 12 to 11, to consider any changes in the law.

When the war came, Roosevelt, eager to keep the United States out of it but convinced that the only way to do so was to give all aid possible to France and Great Britain, called the congress in extra session on Sept. 21, 1939. for the purpose of amending the neutrality legislation. He wished to keep the "cash and carry" provision and the denial of war credits to belligerent nations He approved barring U S merchant ships from combat areas. But he pleaded that the embargo on arms be lifted in order that aid might be given nonaggressors. After a spirited debate, the senate on Oct. 27 repealed the embargo by a vote of 63 to 30, and the house concurred a few days later.

National Defense.—After the outbreak of World War II in Europe, the Latin-American republics were inclined to foster closer relations with the United States. Latin-American nations at the conference of Panamá in Oct. 1939 took a long step toward hemispheric defense in agreeing to pool their navies to patrol the 6.000 mi. of the eastern coast of South America from the mouth of the Amazon to Cape Horn. At Havana, Cuba, the following July, they adopted the policy announced by the United States of not recognizing the transfer of any region of the western hemisphere from one non-American power to another, and agreed to consult for the protection of any of the republics which might be threatened by subversive activity.

On May 28, 1940, as France was succumbing to the drive of the German armies which had previously swept through Denmark, Belgium and the Netherlands, President Roosevelt set up an advisory Council of National Defense with six cabinet members and seven expert industrial advisers.

When Hitler took Paris in June 1940, a Gallup poll indicated that 64% of the American people favoured military training in contrast with 37% favouring it after the Munich agreement of Sept. 1938. The Selective Service and Training bill introduced into the congress provided for the registration of men between the ages of 21 and 35 inclusive, no more than 900,000 to be called into service at any one time during peace. The act was to expire on May 15. 1945. Opposition mas strong. but the bill passed by majorities of about two to one and was signed by the president in Sept. 1940. The drawing of numbers began on Oct. 29. For the first time when the nation was not actually at war, the government resorted to compulsory military service.

The problems of national defense absorbed the attention of the administration increasingly during 1940 and 1941, affecting not only the policies of the army and the navy, but also the whole field of production, transportation, labour, finance and education. Late in 1940, as defense preparations were lagging, a "supercommission" of four was created as the Office of Production Management. After the United States formally entered the war, the president appointed Donald M. Nelson the head of a new War Production board.

The Election of 1940.—Despite the fact that the precedent of no more than two terms in the presidency seemed to be firmly established, the critical situation in 1940 led most of the Democratic leaders to insist that Roosevelt should run for a third term. The president, himself making no move to secure or refuse the nomination, was unanimously nominated on the first ballot at the convention in mid-July. Secretary of Agriculture Wallace was named as his running mate. The chief Republican aspirants mere Sen. Robert A. Taft of Ohio, Sen. Arthur Vandenberg of Michigan and Thomas E. Dewey of New York. The Republican national convention. however. responded to a widely supported movement for Wendell Willkie, president of the Commonwealth and Southern Utilities corporation, and nominated him on the sixth ballot with Sen. Charles L. McNary of Oregon as the candidate for the vice-presidency.

Willkie aroused great enthusiasm by a vigorous and forthright campaign, but his cause was weakened by the fact that he had had no experience in political life. He polled 22,305,198 votes to Roosevelt s 27,244,160 in the election in November, but carried only 10 states with 82 electoral votes to 449 for his opponent. The election made little change in the new congress, the Democrats gaining 7 seats in the house and the Republicans, 5 in the senate. The vote for minor parties (Socialist, Communist and Prohibition) was insignificant.

Aid to Great Britain.— In Sept. 1940 President Roosevelt had transferred 50 destroyers to Great Britain in exchange for leases for naval bases at eight points on the Atlantic coast from Newfoundiand to British Guiana. He told the first session of the 77th congress in Jan. 1941 that the United States must become the "arsenal of democracy." A few days after it had assembled, the house received bill 1776 calling for supply to the enemies of Hitler to help them win the war. Despite opposition by the noninterventionists, the Lend-Lease bill was passed in March 1941. The ties between the British Commonwealth and the United States became stronger. Prime Minister Winston Churchill and President Roosevelt met on the Atlantic ocean off the coast of Newfoundland on Aug. 14, 1941. and drew up the "Atlantic charter."

The Japanese Attack on the U.S.—The relations of the United States with Japan had for a decade grown steadily less friendly. On Jan. 26, 1940, the U.S. had abrogated its commercial treaty of 1911 with Japan. Yet Americans continued to sell to Japan materials Japan was using in its war against China. When Japanese armies invaded French Indochina in Sept. 1940, with the apparent purpose of establishing bases for an attack on the East Indies, the U.S. placed an embargo on scrap iron and steel intended for shipment to Japan. Japan retaliated by signing a triple alliance agreement with Germany and Italy (Sept. 27). Japanese Foreign Minister Yosuke Matsuoka, though asserting that his country wished to preserve peace with the Cnited States, acknowledged that if the Axis powers should become involved in war with the United States, Japan would be in duty bound to join them.

Meanwhile, the transfer of the 50 destroyers to Great Britain, the repeal of neutrality legislation, the aid given in the Lend-Lease act, occupation of the Danish islands of Greenland and Iceland as lying in waters "necessary for the defense of the United States" and the patrol of North Atlantic waters by U.S. destroyers —all these were in effect warlike measures against Germany, and the Germans did not hesitate to retaliate. During 1941 they sank American merchant vessels and launched torpedoes at three U.S. destroyers. President Roosevelt did not ask the congress for a declaration of war, but on Sept. 11 he gave orders to naval vessels protecting lines of commerce to "shoot at sight" on any hostile craft.

Although the administration had anticipated a possible attack by Japan somewhere in the Pacific, both the American government and its military advisers were surprised when Japanese planes descended on Pearl Harbor, Hawaii, on Sunday morning, Dec. 7, 1941. In this attack, 3 American battleships were destroyed, 16 other war vessels were sunk or disabled, grounded planes were destroyed and about 3,000 casualties were inflicted. Simultaneous attacks were made by the Japanese on the Philippines (Manila falling at the beginning of Jan. 1942) and on Wake, Guam and Midway Islands in the Pacific. On Dec. 8 the congress of the United States declared war on Japan with a single dissenting vote. (For military events of the war, *see* WORLD WAR II, especially *After Pearl Harbor; see* also PEARL HARBOR ATTACK.)

(D. S. Mu.; E. E. R.)

Following the Japanese attack on Pearl Harbor, the president asked congress for a formal declaration of war on Germany and Italy. As a result of conferences between the president and Prime Minister Churchill later that month, a union of nations (originally 26) was formed early in 1942 and plans were made for joint conduct of the war.

The Nation at War.—The first year of the war for the United States mas one of disaster, of mounting defeat and of definite uncertainty as to the outcome. It was not until a year after American entrance into the war that the Axis powers had been placed upon the road to defeat. This did not mean that the Allies had won. although by Nov. 1942 in Africa, Europe and Asia the tide had turned. The year 1943 was one of continuous advance against the enemies everywhere. In May the Allies achieved control of

North Africa and were preparing for the attack upon Italy. In early July. Sicily was invaded and the advance upon the mainland of southern France began. Two months later Italy surrendered. Meanwhile. the battle of the Atlantic had been won. Likewise. the spring and summer of 1943 witnessed the advance of American forces in the islands of the Pacific. This was accompanied by such destruction of Japanese ships and planes as to ensure early exhaustion of Japanese naval and air power.

In 1943, the year of conferences, six major meetings took place. At Casablanca in January. when the decision was made to invade Italy, came the declaration for "unconditional surrender." In May in Washington, D.C., came the decision to increase the bombing of Germany. At Quebec in August came the decision to invade German-occupied France in a "second front" and to launch a far eastern military expedition under joint control. In October Secretary of State Cordell Hull journeyed to Moscow and there, with Foreign Secretary Anthony Eden of Great Britain and Foreign Commissar Vyacheslav Molotov of the U.S.S.R., made a preliminary agreement for the establishment of the United Nations organization, together with declarations favourable to setting up democratic regimes in Italy and Austria and a demand for trial and punishment of war criminals. At Cairo in November Roosevelt and Churchill, meeting with Pres. Chiang Kai-shek of the republic of China, affirmed a war against Japan until its unconditional surrender. Territories taken from China were to be restored, China was to have control of Manchuria and it was agreed by the three powers that in due course Korea was to be free and independent. Later in the month at Tehran, Roosevelt, Stalin and Churchill agreed upon plans for the launching of the second front in Europe. (See World War II Conferences, Allied.)

In June 1944 a cross-channel landing took place in the invasion of German-occupied Normandy. By the end of August most of France was occupied by Allied forces, and Belgium and Luxembourg as well. In August, at Dumbarton Oaks in Washington, D.C., representatives of the United States, Great Britain, the U.S.S.R. and China met and agreed upon a charter for a permanent international organization for the maintenance of world peace and security. In mid-September President Roosevelt again met with Prime Minister Churchill in Quebec, and they tentatively agreed upon plans for dealing with Germany after the war. Summer successes of 1944 in the Pacific were followed by re-entrance of American forces into the Philippines in October. When the year 1945 opened. it was clear that the invasion of the islands of Japan was soon to come.

Election of 1944.—Once before in national history a presidential election had been held while the issue of war was in the balance. As in 1864, so in 1944 there was no thought on the part of responsible leaders that the election would not be held. Indeed, there were men who felt a greater need of the elective process because of the fourth-term candidacy of President Roosevelt. Prior to his nomination, in his messages to congress, the president had made clear his program for peace as well as for war. He pointed out that the costs of war, thus far, had been six times the costs of World War I. He estimated that the actual war cost would exceed $200,000,000,000 by the middle of the year. At the same time looking to the future, he called for a "five-point plan" to deal with the days of peace to follow the war. He envisaged a vast government spending plan and a new eight-point economic "bill of rights." These were to include the right to a job—to earn money for adequate food, clothing and recreation. For farmers, there was to be a decent living; for businessmen, freedom from unfair competition. There was to be protection for all in old age and during sickness and unemployment.

In mid-February congress had passed a tax bill which, although approved by both administration and legislative party leaders, did not meet the plans of the president. His veto message caused a violent outburst in the press and among his own party supporters. The bill was passed over his veto by overwhelming majorities.

The year was marked by violent labour disputes and long-drawn-out controversy between the president and his representatives and the representatives of organized labour (in particular, musicians and coal miners) and of business. Each added some uncertainty to a wartime election.

In their national convention held in June, the Republicans nominated Governor Dewey of New York. with Gov. John W. Bricker of Ohio as the vice-presidential candidate. As had been expected for several months, the Democratic convention meeting in July nominated Eranklin D. Roosevelt for a fourth term The vice-presidential candidate was not the incumbent, Wallace, but Sen. Harry S. Truman of Missouri.

Labour took an unusually active part in the campaign. The Political Action committee (P A.C.) and Congress of Industrial Organizations had been active in the preliminary campaign for Wallace as vice-presidential candidate, and in October Murray of the C.I.O. and Sidney Hillman of the P.A.C. issued statements calling on labour to support the Democratic ticket.

There had been early discussion of the "soldier vote," estimated at nearly 10,000,000. Various devices were used to poll it, but it did not change the final result, which was decisive. Roosevelt polled 25,602,504 votes to 22,006,285 for Dewey. Only 367.474 votes, or less than 1%, were cast for other parties. It mas notable that, although the electoral majority was overwhelming (432–99), the minority vote was not only great (45.9% of the total vote), but spread over two-thirds of the nation. Congress remained in the possession of the Democrats.

Aftermath of World War II

End of the **War.**—Most important in 1945 mere events that brought the end of the war. Second in importance were problems of inter-Allied co-operation. President Roosevelt, in February following his fourth inauguration. met with Marshal Stalin and Prime Minister Churchill at Yalta in the Crimea. There, policies were agreed upon to enforce the unconditional surrender of Germany: to divide it into zones for occupation and policing by the respective Allied forces; to provide for reparations from Germany; and to establish a United Nations organization. A series of secret agreements made at the Yalta conference were later revealed. Chief among these was the agreement that the U.S S.R. would enter the war against Japan after the German surrender, the condition being a restoration and increase of Russian influence in the far east. (See Yalta Conference)

President **Truman.**—Upon the death of President Roosevelt on April 12, 1945, scarcely three months after the beginning of his fourth term. Harry S. Truman became president of the United States The problems he faced were known to him only in a general may, for he had not had close association with the administration. The United Nations conference took place as planned, opening on April 25 in San Francisco On May 7 all German forces were unconditionally surrendered. On July 2 President Truman presented the United Nations charter to the senate. Five days later he sailed for Europe, where he met at Potsdam with Stalin and Churchill (later succeeded by Clement R. Attlee) to discuss the surrender ultimatum addressed to Japan and to plan for the control of Germany and the adjustment of various European territorial problems.

The Problem of World Peace.—In the preliminary steps toward the establishment of a United Nations organization there had been disagreements as to forms and procedures, and in particular as to the location of headquarters, finally established at New York city. By the end of the year the question of the veto (by any one of the five permanent members of the Security council) had become the leading problem. The Russians insisted that the veto power of one member might be used to oppose even a motion to permit debate. The Russian position upon the matter of debate was finally relaxed, and a compromise was reached as well on the demands of the small powers for greater influence, especially in amending the charter of the UN. Preliminaries for the United Nations charter had been approved by the house on June 7. The charter was approved by the senate on July 28.

The Atomic Bomb.—Japan having failed to respond to the Potsdam surrender ultimatum, an American plane dropped a single atomic bomb on the city of Hiroshima. Two days later the Russians declared war on Japan. advancing upon Manchuria and Korea. A second atomic bomb dropped on Nagasaki on Aug. 9

brought the surrender of the Japanese, which was signed on the' battleship "Missouri" in Tokyo harbour on Sept. 2. The American armed forces. except those assigned to occupation of Germany and Japan. were speedily returned home. Russian forces were strongly entrenched in eastern Europe and in the far east, positions the significance of which was later revealed by unfolding events.

The Congress.—The domestic problems that pressed at once upon President Truman were the demands of labour and the danger of inflation follom-ing removal of wartime controls in an immediate effort to return to a peace economy. The 79th congress, however, passed few of the president's major recommendations. A number of southern Democrats who were opposed to continuance of New Deal policies joined the Republican minority on occasion to form an opposition bloc. The' congressional elections of 1946 were of unusual interest because Truman's leadership had never been tested. and because shifts in domestic policies following the end of the war had given new impetus to both political parties. There was more interest on the part of the voters than in 1942, as was evidenced by a vote greater by nearly 7,000,000. The Republicans carried 30 states and gained control of both houses of the congress.

Legislation reducing taxes passed by the 80th congress was vetoed by President Truman, as was the Taft-Hartley bill; although the latter was subsequently passed over his veto. This legislation banned the closed shop forbidding the hiring of nonunion men; permitted employers to sue unions for broken contracts or damages inflicted during strikes; required unions to observe a 60-day "cooling-off" period before striking; required unions to make public their financial statements; forbade union contributions to political campaigns; ended the collection of union dues by employers; and required union leaders to take oath that they were not members of the Communist party.

Other action taken by congress in 1947 included the proposal. for ratification by states, of a constitutional amendment limiting the presidency to two terms (ratified in Feb. 1951 as the 22nd amendment) ; a law fixing the presidential succession, after the vice-president: in the speaker of the house and then the president pro tem of the senate; an act merging the armed forces into a single department of defense. The congress approved a $400,-000.000 appropriation to implement what came to be called the Truman doctrine, a proposal to bolster by economic and military aid—in this case to Greece and Turkey—countries threatened by Communist domination. This mas followed by a broader plan that came to be known as the Marshall plan: inasmuch as it was first proposed by Secretary of State George C. Marshall. The billions voted by congress beginning in April 1948 were administered under an Economic Cooperation administration! and within a few years the nations of western Europe which benefited were recovering their productivity.

A major episode in the continuing "cold war" with the Soviet Union occurred during 1948–49, when the Russians blockaded all land traffic between west Germany and the Allied sectors of Berlin. The U.S. and Great Britain were, nevertheless, able to maintain a gigantic air lift for the delivery of food and supplies. The blockade was officially ended in May 1949. On Sept. 21, U.S. military government in Germany was replaced by a high commission.

Election of 1948.—The election of 1948 was marked by unusual features. A considerable number of the Democratic party organization members were opposed to the nomination of Truman. Some disagreed with his policies, both domestic and foreign; others were convinced that his defeat was a certainty. Many of those differing with his policy in foreign affairs: particularly with the utterances of the administration in the political conflict with the U.S.S.R.. united in supporting an independent movement. eventually presenting R'allace as a candidate on the platform of a newly formed Progressive party.

The more extreme members of the Democratic party in a number of southern states left the Democratic convention after the adoption of a platform stressing civil rights and formed an independent party, the States' Rights Democrats (Dixiecrats), and nominated Gov. J. S. Thurmond of South Carolina for president. The national Democratic convention renominated Truman with Sen. Alben W. Barkley of Kentucky as vice-presidential candidate, and called for repeal of the Taft-Hartley act.

The Republican party entered the campaign confident of success, and after a sharp contest in convention, united in supporting Governor Dewey of New York for president and Gov. Earl Warren of California for vice-president. The Republican campaign was listless, the candidates calling for retention of the Taft-Hartley act and for a limitation upon the activities of the federal government. President Truman campaigned actively and with unusual vigour. The result was unexpected. for all public opinion polls had indicated Truman's defeat. Despite his loss of four states because of States' Rights defection (1,169,021 votes) and the loss of 1,156,103 votes (presumably nearer Democratic than Republican) cast for Wallace. Truman won 24,105,695 votes (303 electoral votes) to 21,969.170 for Dewey (189 electoral votes).

Second Administration of Truman.—Both houses of the 81st congress were Democratic as they organized in Jan. 1949. The president called for a vigorous advancement of his Fair Deal program to aid underprivileged people by housing, full employment and higher minimum wages, higher price supports for farmers, conservation of water power and an extension of social security. With the exception of the Social Security act of 1950, which added almost 10.000.000 persons to the beneficiaries of old-age insurance, only a small part of the Fair Deal was achieved.

Additional funds were voted for the economic recovery program and for national defense, but proposals for higher taxes were defeated. In foreign affairs, bipartisan co-operation continued. Congress in July 1949 ratified the North Atlantic treaty which had been signed in Washington. D.C.. by the foreign ministers of the United States, Great Britain, Canada, France, Belgium, the Netherlands. Luxembourg. Italy. Denmark, Norway, Iceland and Portugal. obligating the signatories to rearm under a system of integration in an organization known as NATO. (Greece and Turkey joined in 1952.)

The congressional campaign of 1950 was carried out largely on local, regional and personal issues. Democrats retained control of both houses, but by a sharply reduced margin in the house and by only two seats in the senate.

The Decade 1950–60

The Communist Threat.—The collapse of nationalist China in 1949 as Communist forces swept Chiang Kai-shek's army from the mainland and the announcement in September of that year that an atomic explosion had taken place in the U.S S.R. emphasized the fact that events beyond U S. national borders were to influence the development of national policy in nearly every field of activity. These events gave impetus to President Truman's "Point Four" program launched in 1950 for aid to impoverished nations that might otherwise turn to the Soviet Union for help. In January of that year the president also announced that he had directed the U S Atomic Energy commission to produce a hydrogen bomb that would be vastly more powerful than an atomic bomb. (See Atomic Energy: *The Atomic Bomb.*)

The Korean War.—In this precarious world situation, the U.S. suddenly found itself largely responsible for the conduct of a highly concentrated but major war against Communist forces in Korea On June 25, 1950, armed forces of the Korean People's Republic, supported by Soviet Russia, advanced south of the 38th parallel separating the northern Communist state from the southern Republic of Korea established in 1948. The issue was presented by the U S. to the United Nations, where strong measures were advocated to suppress aggression in Korea. (See Korean War.)

Led by the U.S , the UN Security council (the Soviet member not attending) voted for intervention by armed forces of the United Nations Under the command of General of the Army Douglas MacArthur. the campaign for liberation of South Korea proceeded satisfactorily after initial setbacks, and the Communist North Korean forces were driven north of the 38th parallel. As the year ended, however. the situation in North Korea was reversed; the United Nations armies were forced into a costly and precarious retreat by overwhelming numbers of Chinese Communists, whose entrance into the struggle had been foreseen as a possibility but was not expected. The situation of the United States, as the leader in an attempt to suppress aggression by Communist forces in the far east. now became critical, and congress supported the president in a gigantic program for defense. On Dec. 16, 1950. President Truman declared a national emergency and outlined plans for placing the nation on a war basis.

Gen. Douglas MacArthur, whose view of the conduct of the war in Korea was in sharp contrast with the policy of the administration, was recalled from his commands by President Truman on April 11, 1951. MacArthur was succeeded by Lieut Gen. (later Gen.) Matthew B. Ridgway, commander of the U.S. 8th army in Korea.

Armistice talks to end the Korean war began on July 10, 1951, but not until July 27. 1953, was the armistice signed. After further difficult negotiations over the status of prisoners, an exchange of prisoners was completed by Sept. 6, 1953. Efforts to negotiate the unification of Korea ended in failure at Geneva, Switz., in June 1954.

Peace Treaties.—The United States had meanwhile taken the lead in concluding a peace treaty with Japan; the treaty was signed in San Francisco on Sept. 8, 1951, by 49 nations not including the Soviet Union. At the same time, Japan and the U.S. agreed upon a bilateral security treaty, which provided that U.S. troops could be stationed in Japan for an indefinite period, and the U.S. signed defense pacts with the Philippines, Australia and New Zealand.

At the height of the Korean war, in Dec. 1950, General of the Army Dwight D. Eisenhower was appointed commander of the new supreme headquarters of the Allied powers in Europe (SHAPE), charged with creating effective military forces for the North Atlantic Treaty organization (*q.v.*) as a deterrent to Communist aggression in western Europe.

On July 1, 1952, the senate approved a peace agreement between western Germany and the western Allies. Eastern Germany remained under the control of the U.S.S.R. As in the case of Korea, the U.S.S.R. retained control of the territory occupied by it at the end of World War II, and drew an "iron curtain" between eastern and western Europe.

Election of 1952.—While he was serving SHAPE in western Europe. General Eisenhower's name was entered in Republican state presidential primaries, a number of which he won. After he retired from his military post, the general's supporters campaigned actively for his nomination. When the national Republican convention met in Chicago it was about evenly divided between him and Sen. Robert A. Taft of Ohio. but Eisenhower was nominated on the first ballot. Sen. Richard M. Nixon of California was named the Republican vice-presidential candidate.

The Democratic national convention, also held in Chicago, nominated Gov. Adlai E. Stevenson of Illinois as its presidential candidate and Sen. John Sparkman of Alabama for vice-president. Like Eisenhower, Stevenson had been a reluctant candidate in the early stages of the preconvention campaign.

Eisenhower vigorously attacked the Democratic administration, charging it with responsibility for events leading up to the Korean war and promising that he would make an inspection trip to Korea before his inauguration if he were elected. In the Republican campaign, scandals among top Democratic administrators were charged along with accusations of Communist infiltration in government offices. President Truman vigorously defended his administration and supported Stevenson, who conducted an energetic and impressive campaign.

In the November election, the popular vote of more than 61,000,000 was the largest in the nation's history. Eisenhower swept 39 states (442 electoral votes), while Stevenson carried 9 states (89 electoral votes). Eisenhower, shattering several political precedents, carried the southern states of Florida, Virginia, Tennessee and Texas. The Republicans gained control of the house and also won a narrow 48-to-47 margin in the senate, not including one independent Republican. Gubernatorial contests in 30 states resulted in 20 Republican victories.

Domestic Policies.—The new president had run far ahead of his party ticket, attracting portions of the labour vote that had been consistently Democratic for 20 years, as well as a substantial Negro city vote and a widespread middle-western farm vote. His middle-of-the road policy in domestic affairs weakened the influence of labour elements in the Democratic party and strengthened liberal elements in the Republican party. Outstanding among his appointments were those of Gov. Earl Warren of California as chief justice of the supreme court and John Foster Dulles as secretary of state.

After taking office. Eisenhower was not supported by the united action of his party members in house and senate. His differences with the extreme "right" elements were most marked The president won important victories in legislation only because of frequent Democratic support.

The administration was plagued throughout the first two years by political demonstrations of the senate subcommittee charged with investigation under the loyalty-security program. President Eisenhower took the position that loyalty and security maintenance were the responsibility of the executive branch of the government. Yet he did not interfere with the sensational activities of the subcommittee whose chairman, Sen. Joseph R. McCarthy of Wisconsin, later became himself the subject of a special senate committee investigation. The senate voted 67–22 to "condemn" McCarthy for abuse of senatorial privileges.

The years 1953–56 were characterized by general prosperity. Confidence on the part of investment capital contributed to business development. The federal reserve board checked expansion of bank credit by adopting a "tight money" policy intended to check inflation. The national budget was brought into balance, despite huge expenditures for national defense, because taxes were maintained at the necessary level and employment and earnings were high.

The most important decision of the supreme court in a half century was unanimously delivered on May 17, 1954, to the effect that racial segregation in elementary and secondary public schools in the United States was unconstitutional. This decision resulted in a division of sentiment in both political parties, especially the Democratic party, and became one of the most controversial issues of the 1950s.

Foreign Policy.—President Eisenhower's attempts to improve international relations were ably seconded by his energetic and professionally equipped secretary of state, John Foster Dulles. who traveled widely on diplomatic missions. But the administration suffered a series of defeats in promoting the objectives of the United States. With the termination of the prolonged Korean armistice discussions in the summer of 1953, a stalemate ensued in the far east; Communist strength in that area continued to grow, soon extending throughout southeast Asia.

Eisenhower's "atoms for peace" plan launched in 1953 was a step toward using the development of nuclear science for the welfare of the world. His proposals for international control of atomic armaments and his suggestion for open-sky inspection of military installations were not adopted but they conferred an important initiative on the democracies in the controversy with Soviet Russia over arms limitation. The Geneva conference of the heads of the Big Four powers in the summer of 1955 was influenced by Eisenhower's spirit of fair play and his insistence upon good faith. The results, however, were inconclusive and the main feature of the conference was Soviet propaganda threatening the middle east.

Eisenhower's Re-election.—The president's personal role in government was basically altered in the months following his heart attack on Sept. 24, 1955. Although he gradually resumed the general responsibilities of the presidency, the temporary disability raised once more two matters for debate nhich had never been quite absent from the discussions of the presidency in the previous 35 years. The first was the increasing burden placed upon a president of the United States; the second was the calibre of men nominated as candidates for the vice-presidency. The gradual return to health of the president was interrupted by a severe attack of ileitis and a surgical operation on June 9, 1956. Recovering, he resumed his duties and, well in advance of the Republican national convention held in San Francisco in August, let it be known that he would accept the nomination for re-election. His nomination was unanimous and was enrhusiastically given. Vice-President Nixon was also renominated by unanimous vote of the convention.

Adlai E. Stevenson was again nominated by the Democrats on the first ballot of their convention in Chicago. He asked the convention to vote on the vice-presidential nominee and Sen. Estes Kefauver of Tennessee, who had made an impressive showing in several state primaries, was nominated.

The outcome of the election, in the absence of outstanding domestic issues; was determined in large measure by external events. Late in October an apathetic electorate was aroused when eastern Europe and the middle east burst into flames. A crisis had come to the administration in September, following the seizure of the Suez canal in July by Egyptian president Gamal Abdel Nasser and the counterefforts of France and Great Britain in protest. The subsequent outbreak of anti-Communist revolt in Poland; a violent anti-Communist revolution throughout Hungary; an invasion of Egyptian territory by national forces of Israel claiming self-defense against border depredations; the swift attack of Great Britain and France upon Egypt with the immediate purpose of regaining control of the Suez canal—these events made headlines during the final days of the presidential campaign.

Stevenson, meanwhile, had proposed the ending of hydrogen bomb tests by international agreement because of the danger from radioactive fall-out. He also urged a cut in the draft for Selective Service.

The electorate voted overwhelmingly for President Eisenhower. He carried all but seven states with a popular vote of 35,582.236 to Stevenson's 26,028,887. It mas more a personal victory than a party victory. however. for the Democrats won a majority in both house and senate, thus ensuring a divided government for the term beginning Jan. 20. 1957.

Eisenhower's Second Administration.—The Democratic majority in house and senate was divided, especially on civil rights, while division among the Republican minority in congress was reminiscent of the progressive-conservative split of the 1920s. President Eisenhower's vetoes defeated Democratic plans on public housing, enlarged social security and deficit spending.

In the mid-term elections. the economic recession of 1957–58 and especially the continued increase in unemployment were determining influences. The Democrats continued to gain and won a widespread national victory: including 32 governorships. The new congress. meeting in Jan. 1959, comprised 64 Democrats and 34 Republicans in the senate, and 283 Democrats and 153 Republicans in the house. In addition, two senators and a congressman came from the new state of Alaska, formally admitted to the union on Jan. 3, 1959. The resolution admitting Hawaii as the 50th state was signed by the president on March 18.

The various problems of attempted racial desegregation. especially in the schools, that had aroused widespread discussion throughout the country following the supreme court decision of 1954. increased in intensity. Not only was public-school integration hotly contested by seven southern states; peaceful demonstrations of Negroes asking service at "white!' lunch counters ("sit-in" movements) led to police action.

In July 1959, 500,000 steelworkers went on strike, recalling to public attention the steel crisis of 1952. At that time President Truman had ordered Secretary of Commerce Charles Sawyer to seize control of the nation's steel mills in order to avert a strike in the industry while the nation was still at war in Korea. Two months later the U.S. supreme court held. by a vote of 5 to 3, that the executive order was unconstitutional. and the steel mills were returned to private management. The strike of 1959 lasted for 116 days before the government acted to obtain an injunction forcing the workers back for 80 days while efforts were made for government arbitration. No decision completely satisfactory to either side was reached, but work in the steel industry was resumed. Organized labour lost support among the public at large through charges of illegal use of union funds, chiefly in the Teamsters' union. Investigation of union leadership by committees of the congress led to passage in 1959 of the Landrum-Griffith hill aimed at corruption in labour unions and the establishment of procedures to maintain democratic elections within unions.

The **U.S.** in World Affairs.—The continuance of the "cold war" was emphasized in the public mind by the Soviet Union's successful launching of the first earth satellite on Oct. 4, 1957. The implications of this achievement seemed catastrophic in shifting the balance of power in the world to the Soviet Union until. on Jan. 31. 1958, the U.S. army launched the free world's first earth satellite. Within the U.S., the dramatic arrival of the "space age" brought with it increased attention to the long-range program of education necessary for scientists and the increased'costs of experimental programs, both public and private.

The Communist threat to southeast Asia brought the U.S. again to the brink of war when the Chinese Communists attacked Quemoy Island near Formosa in late Aug. 1958. The previous month President Eisenhower had ordered American troops to Lebanon, in response to a request by the Lebanese government. to prevent its overthrow by elements unfriendly to the western powers. In late November the Soviet Union threatened again to isolate the city of Berlin. On the last day of December, bloody revolution came close to the U.S. as Cuban rebels under the leadership of Fidel Castro seized the government and forced Pres. Fulgencio Batista into exile.

The hospitalization of Secretary of State Dulles in early March 1959 led to increased activity in foreign affairs by the president himself. He called for a firm stand in the Berlin crisis. On April 15, President Eisenhower announced the resignation of Dulles and on April 18 designated Undersecretary of State Christian Herter as his successor. Herter was sworn in on April 22. Dulles died on May 24. Herter represented the U.S. at the western foreign ministers' meeting in Paris, April 28–30, and at the Big Four foreign ministers' conference in Geneva, May 11–Aug. 5.

Eisenhower's Personal Diplomacy.—The president on Aug. 26. 1959, flew to Europe, where he conferred with British Prime Minister Harold Macmillan, French President Charles de Gaulle and west German Chancellor Conrad Xdenauer, returning to Washington on Sept. 7. On Sept. 15 Soviet Premier Nikita Khrushchev, at President Eisenhower's invitation, began a tour of the U.S. which included visits to Washington, D.C., New Tork city, Los Angeles, San Francisco. Coon Rapids, Ia., and Pittsburgh. Pa.

President Eisenhower had accepted personal diplomacy by heads of states as a desirable innovation in the "cold war." In Dec. 1959 he traveled 22,000 mi. in 19 days, visiting countries as far apart as Iran, Afghanistan, India and Pakistan in the east, and Morocco, Tunisia, Spain and France in the west, including as well Italy, Greece and Turkey. Early in 1960 he made a brief trip to Latin America, where he visited five countries.

Premier Khrushchev proposed that a "summit" conference be held in hlay 1960 at Paris to discuss relaxation of world tensions. The proposal was accepted by the western powers and Prime Minister Macmillan, President de Gaulle and Chancellor Adenauer journeyed to Washington during the spring for discussion of mutual interests in preparation for the conference. But as the heads of state met in Paris, Premier Khrushchev, citing the shooting down of a U.S. reconnaissance plane over Soviet territory on May 1. broke up the conference in a torrent of rage.

After some initial denials by U.S. authorities, President Eisenhower had taken full responsibility for the flight of the unarmed U-2 plane and revealed that such flights throughout the past four years had yielded important information for the defense of the free world. The incident appeared to indicate to the entire world U.S. capacity to "penetrate" Soviet Russian skies. Both the U.S. and the U.S.S.R. had also demonstrated that they would soon be able to carry out aerial reconnaissance by earth satellites.

After the collapse of the Paris meetings. President Eisenhower pursued his original plan to visit the far east in the early summer of 1060. He included the new states of Alaska and Hawaii in this tour and also visited the Philippines, Okinama, Formosa and Korea. Violent outbreaks of anti-American feeling in Japan brought about cancellation of his intended visit to Tokyo. On his return to Washington, in answer to critics, he restated his belief in the efficacy of personal diplomacy.

A Decade of National Growth.—The decade 1950–60 had been marked by steady increase in population, reaching the figure of more than 179,000,000 as reported on June 1, 1960, by the bureau of the census. The shift of population from east to west continued, with a new emphasis upon movement from urban to suburban areas. Widespread prosperity, increased productivity and higher incomes for all wage groups had resulted in an impetus to construction and building activities of all kinds. Recessions in 1953--54 and 1957–58 did not alter the generally prosperous character of the 10-year period, although agricultural income lagged, and there was general agreement that no satisfactory solution had yet been found for the perennial farm problem.

The Election of 1960.—The national conventions of July 1960 were held in an atmosphere of mounting tension in international relations. The Soviet Union threatened the program of the United Nations in its use of an international police force to suppress disorders arising out of Belgian withdrawal from the African Congo. The Soviet Union not only gave economic aid to Cuba, where the revolutionary government headed by Castro seized the properties of U.S. firms, but it also threatened to use Cuba as a base for military action against the United States. Meanwhile Soviet propaganda activities increased throughout Latin America.

The presidential candidates of both parties were comparatively young men. Richard M. Nixon, who during both terms had been Eisenhower's vice-president, was 47 years of age. John F. Kennedy, the Democratic candidate, had served eight years in the U.S. senate and was four years younger than Nixon.

A national movement of uncertain strength had called for the third nomination of Stevenson as the Democratic presidential candidate. Senator Kennedy won a majority on the first ballot at the Los Angeles convention and the nomination was made unanimous. Sen. Lyndon B. Johnson of Texas, who had had the support for the presidency of more than 400 delegates, was nominated for the vice-presidency.

At the Republican party convention in Chicago, despite a declaration of position by the conservative members led by Sen. Barry M. Goldwater of Arizona, no serious rival of Vice-President Nixon appeared. Gov. Nelson Rockefeller had withdrawn his candidacy for nomination for either the presidency or the vice-presidency, and Nixon was nominated by acclamation after the first ballot. Henry Cabot Lodge, U.S. ambassador to the United Nations since 1953, was unanimously nominated for the vice-presidency.

Surface unity in both parties did not obscure vital differences within each. The Democratic party, attempting to combine—through its candidates, Kennedy and Johnson—northern liberals with southern conservatives, staked its efforts to win the presidency on a promise of more benefits to the people through the federal government. In world affairs the Democrats promised to strengthen the position of the U.S., which they claimed was not keeping pace with the U.S.S.R. The Republican party hoped to heal the long-standing schism between its liberal and conservative elements. It claimed the Eisenhower administration had not only advanced in every field of government action for the people's benefit without forsaking the traditional American system of free enterprise, but had also been successful in preventing war. Both parties recognized the deadly danger inherent in the Communist world policy of infiltration and subversion, and both emphasized the crucial part that foreign policy would play in the next administration.

The most dramatic feature of the campaign was a series of television appearances, widely described as debates, during which the two candidates stated their positions and answered questions from newsmen.

In the general election on Nov. 8, Kennedy defeated Vice-President Nixon in a closely contested race: and the Democrats retained their control of both the senate and the house of representatives.

Kennedy won 303 electoral votes to Nixon's 219, with Sen. Harry F. Byrd, who had not been a candidate, receiving 15 electoral votes. (E. E. R.)

V. POPULATION

Growth and Geographic Expansion.— Results of the 1960 census indicated that the population of the United States, excluding armed forces overseas, was 179,323,175 on April 1, 1960. This compares with a population of 3,929,214 as reported in the first census in 1790. In the late colonial and early national periods. population increased approximately 30% a decade, doubling every 25 years. Numbers more than quadrupled from 1800 to 1850; more than trebled from 1850 to 1900; and nearly doubled from 1900 to 1950. The increase of 27,997,377 (excludes Alaska and Hawaii) between 1950 and 1960 is the largest increase in population for any decade. The increase between 1940 and 1950 was 19,028,086 and that for the decade of the 1930s was only 8,894,229 The rate of increase during the 1950s was greater than that for any decade after 1910.

Table VIII.—*Area and Population: 1790 to 1960*

Census date	Area (sq. mi.)	Population			
		umber	Per sq.mi.	Increase over preceding census	
				Number	Per cent
1790 (Aug. 2) . .	888,811	3,929,214	4.4	. .	. .
1800 (Aug. 4) . .	888,811	5,308,483	6.0	1,379,269	35.1
1810 (Aug. 6) . .	1,716,003	7,239,881	4.2	1,931,398	36.4
1820 (Aug. 7) . .	1,788,006	9,638,453	5.4	2,398,572	33.1
1830 (June 1) . .	1,788,006	12,866,020	7.2	3,227,567	33.5
1840 (June 1) . .	1,788,006	17,069,453	9.5	4,203,433	32.7
1850 (June 1) . .	2,992,747	23,191,876	7.7	6,122,423	35.9
1860 (June 1) . .	3,022,387	31,443,321	10.4	8,251,445	35.6
1870 (June 1) . .	3,022,387	39,818,449	13.2	8,375,128	26.6
1880 (June 1) . .	3,022,387	50,155,783	16.6	10,337,334	26.0
1890 (June 1) . .	3,022,387	62,947,714	20.8	12,791,931	25.5
1900 (June 1) . .	3,022,387	75,994,575	25.1	13,046,861	20.7
1910 (April 15) . .	3,022,387	91,972,266	30.4	15,977,691	21.0
1920 (Jan. 1) . . .	3,022,387	105,710,620	35.0	13,738,354	14.9
1930 (April 1) . .	3,022,387	122,775,046	40.6	17,064,426	16.1
1940 (April 1) . .	3,022,387	131,669,275	43.6	8,894,229	7.2
1950 (April 1) . .	3,022,387	150,697,361	49.9	19,028,086	14.5
1960 (April 1)* . .	3,615,208	179,323,175	49.6	28,625,814	19.0

'Includes Alaska and Hawaii, which were not included prior to 1960

The growth of the population during the 1950s was essentially the result of an excess of births over deaths. Net civilian immigration is estimated to have amounted to less than 3,000.000, whereas the excess of births over deaths was approximately 25,000,-000. For the 1940s net immigration is estimated at 1,898.000 and the excess of births over deaths at 17,056,000. From 1955 to 1960 the population increased annually by about 2,900,000—the largest such increase in the country's history.

Decennial rates of growth remained fairly unchanging at high levels in the years from 1790 to 1860, declined irregularly but quite rapidly from 1860 to 1940, then increased from 1940 to 1960. The absolute amount of the increase moved upward from decade to decade with only two exceptions—the years from 1910 to 1920 and those from 1930 to 1940. In the decades from 1790 to 1860, while the intercensual increase remained above 30%, the amount of the increase grew from 1,379,269 in the years from 1790 to 1800 to 8,251,445 in the years from 1850 to 1860. Almost 16,000,000 were added in the single decade from 1900 to 1910. The decade including World War I brought an interruption in the continued increase in the numbers added, but the prosperous decade of the 1920s

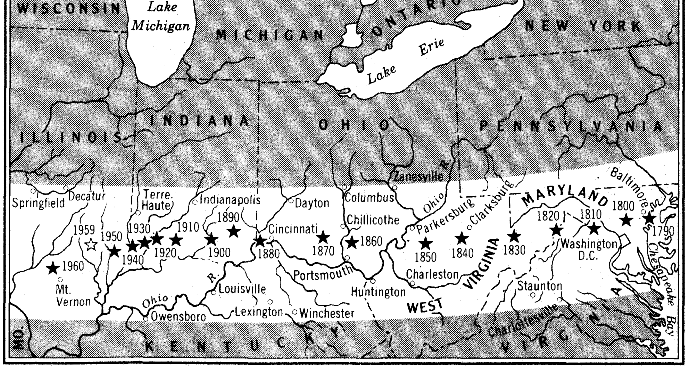


FIG. 7.— CENTRESOF POPULATION FROM 1790 TO 1960
(Unshaded star indicates revised 1950 centre after admission of Alaska and Hawaii in 1959)

TABLE IX.—*Population of the United States by Regions, Divisions and States: 1950 and 1960*

Region, division and state	1960	1950
United States	179,323,175	151,325,798
Regions:		
Northeast	44,677,819	39,477,986
North central	51,619,139	44,460,762
South	54,973,113	47,197,088
West	28,053,104	20,189,962
Northeast:		
New England	10,509,367	9,314,453
Middle Atlantic	34,168,452	30,163,533
North central:		
East north central	36,225,024	30,399,368
West north central	15,394,115	14,061,394
South:		
South Atlantic	25,971,732	21,182,335
East south central	12,050,126	11,477,181
West south central	16,951,255	14,537,572
West:		
Mountain	6,855,060	5,074,998
Pacific	21,198,044	15,114,964
New England:		
Maine	969,265	913,774
New Hampshire	606,921	533,242
Vermont	389,881	377,747
Massachusetts	5,148,578	4,690,514
Rhode Island	859,488	791,896
Connecticut	2,535,234	2,007,280
Middle Atlantic:		
New York	16,782,304	14,830,192
New Jersey	6,066,782	4,835,329
Pennsylvania	11,319,366	10,498,012
East north central:		
Ohio	9,706,397	7,946,627
Indiana	4,662,498	3,934,224
Illinois	10,081,158	8,712,176
Michigan	7,823,194	6,371,766
Wisconsin	3,951,777	3,434,575
West north central:		
Minnesota	3,413,864	2,982,483
Iowa	2,757,537	2,621,073
Missouri	4,319,813	3,954,653
North Dakota	632,446	619,636
South Dakota	680,514	652,740
Nebraska	1,411,330	1,325,510
Kansas	2,178,611	1,905,299
South Atlantic:		
Delaware	446,292	318,085
Maryland	3,100,689	2,343,001
District of Columbia	763,956	802,178
Virginia	3,966,949	3,318,680
West Virginia	1,860,421	2,005,552
North Carolina	4,556,155	4,061,929
South Carolina	2,382,594	2,117,027
Georgia	3,943,116	3,444,578
Florida	4,951,560	2,771,305
East south central:		
Kentucky	3,038,156	2,944,806
Tennessee	3,567,089	3,291,718
Alabama	3,266,740	3,061,743
Mississippi	2,178,141	2,178,914
West South Central:		
Arkansas	1,786,272	1,909,511
Louisiana	3,257,022	2,683,516
Oklahoma	2,328,284	2,233,351
Texas	9,579,677	7,711,194
Mountain:		
Montana	674,767	591,024
Idaho	667,191	588,637
Wyoming	330,066	290,529
Colorado	1,753,947	1,325,089
New Mexico	951,023	681,187
Arizona	1,302,161	749,587
Utah	890,627	688,862
Nevada	285,278	160,083
Pacific:		
Washington	2,853,214	2,378,963
Oregon	1,768,687	1,521,341
California	15,717,204	10,586,223
Alaska	226,167	128,643
Hawaii	632,772	499,794

showed a resumption of the earlier trends with a population increase of 17,064,426. The increase between 1930 and 1940, when the rate of growth had declined to 7.2%, was smaller than that for any other decade after 1870 but it was more than that for any decade before 1870. Prior to 1950 the largest number ever added during a decade was 19,028,086, the increase during the 1940s.

In the formative years of the nation, population growth, the expansion of areas of settlement and increase in the national territory proceeded in rough relationship to each other. The area of the United States was 888,811 sq.mi. at the time of the first census. The Louisiana Purchase in 1803 nearly doubled the land area. Florida was added in 1819. Between 1840 and 1850 the land area was increased by two-thirds through the annexation of Texas in 1845, the establishment of title to the Oregon territorv in 1836 and the cession by Mexico in 1848 of the southwestern areas, including California, Nevada, Utah, most of Arizona and parts of Colorado, Wyoming and New Mexico. The Gadsden Purchase in 1853 completed the territorial expansion of conterminous United States. Alaska and Hawaii were admitted as states in 1959.

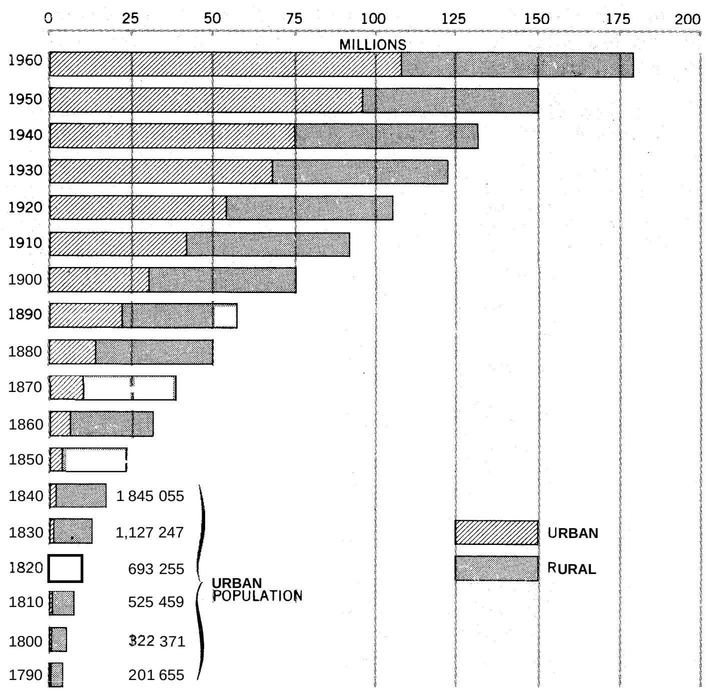
In 1790 nearly all of the 3,929,214 inhabitants lived along the Atlantic seaboard; less than 5% were living west of the Appalachian mountains. On the average, settlement had penetrated about 250 mi. from the east coast, but there had been a number of extensions farther west, with settlements along the Ohio, Kanawha and Cumberland rivers. There were beginnings of occupation at Elmira and Binghamton, N.Y., and there were settlements at the places now known as Detroit: Mich., Green Bay, Wis., Mackinac, Mich., Prairie du Chien, Wis., and Vincennes, Ind. By 1900 the area of coritinuous settlement had moved westward to approximately the 100th meridian in the western half of the Great Plains states. East of that line there were only isolated areas which did not yet have a density of two or more persons per square mile. These were in southern Florida, northern Maine and northern Minnesota. West of that line, density of settlement was generally low, but there were already areas of considerable settlement. Ey 1950 the settled areas more nearly covered the entire country, and the arid regions of the Great Plains, the mountain and Pacific coast states were interspersed with rnany settled areas.

Centre of Population.— The growth of the population and the occupation of the area of the United States have led to a persistent westward movement of the centre of population. As defined by the U.S. bureau of the census, the centre of population is ". . . that point which may be considered as the center of population gravity of the Cnited States: in other words, the point on which the United States would balance if it were a rigid plane without weight and the population were distributed thereon with each individual assumed to have equal weight and to exert an influence on a central point proportional to his distance from that point."

In 1790 the centre of population was located 23 mi. E. of Baltimore. By 1950 it had moved 686 mi. westward and was near Olney in Richland county, Ill. By 1960 it moved 57 mi. W. of that point (near Centralia, Clinton county, Ill.), taking into account the addition of Alaska and Hawaii to the United States. The movement of the centre of population reflects the rapid growth of the population in the western states and the fact that the growth in the northern and southern states has been nearly equal with a slight preponderance in later years in the southern states.

Urbanization.— The United States is largely an urban nation. Approximately two-thirds of the inhabitants live in urban areas and a considerable proportion of the remainder live in close relation to a large city. Throughout the national history the urban population grew more rapidly than the rural. Between 1790 and 1950 the total population increased about 38 times, the rural population less than 15 times. In every decade except 1930 to 1940 the urban population grew much more rapidly than the rural.

Table X shows the urban population and the number of urban places at selected dates from 1790 to 1960. For 1960 the urban population includes not only the inhabitants living in incorporated



BY COURTESY OF THE U S BUREAU OF THE CENSUS

FIG 8 — URBAN AND RURAL POPULATION OF THE U S 1790 TO 1960. (1960 DATA BASED ON PRELIMINARY FIGURES)

TABLE X.—*Total and Urban Population of the United States*

Census year	Total population	Urban population: Number	Urban population: Percent of total	Number of urban places of: 100,000 or more	Number of urban places of: 25,000 or more	Number of urban places of: 2,500 or more
1790	3,929,214	201,655	5.1	...	2	24
1820	9,638,453	693,255	7.2	1	5	61
1850	23,191,876	3,543,716	15.3	6	26	236
1880	50,155,783	14,129,735	28.2	20	77	939
1910	91,972,266	41,998,932	45.7	50	228	2,262
1940	131,669,275	74,423,702	56.5	92	412	3,464
1950	150,697,361	96,467,686	64.0	106	484	4,284
1960*	179,323,175	125,270,616	69.9	130	765	5,445

*Includes Alaska and Hawaii.

and unincorporated places of 2,500 and over, but also those in the thickly settled suburban areas around cities of 50,000 or more.

In 1790 the nation had only 24 places with a population of more than 2,500 persons but by 1950 there mere 4.284 such .places. Five of these had a population of more than 1,000,000 persons each. Forty-one had more than 250,000 each, and 106 had more than 100,000 each. By 1960 there were five cities over 1,000,000, fifty-one over 250,000 and 130 cities of 100,000 or more.

TABLE XI.—*Cities of 500,000 or More in 1960*

City	Population	City	Population
New York, N.Y	7,781,984	San Francisco, Calif.	740,316
Chicago, Ill.	3,550,404	Boston, Mass.	697,197
Los Angeles, Calif.	2,479,015	Dallas, Tex.	679,684
Philadelphia, Pa.	2,002,512	New Orleans, La.	627,525
Detroit, Mich.	1,670,144	Pittsburgh, Pa	604,332
Baltimore, Md.	939,024	San Antonio, Tex.	587,718
Houston, Tex.	938,219	San Diego, Calif	573,224
Cleveland, O.	876,050	Seattle, Wash.	557,087
Washington, D.C.	763,956	Buffalo, N.Y.	532,759
St. Louis, Mo.	750,026	Cincinnati, Ohio	502,550
Milwaukee, Wis.	741,324		

Metropolitan Areas.—The economic and social influence of a city is not limited to the territory included within its political boundaries. For most of the larger cities there is a closely built-up area immediately outside the city limits which is essentially a part of the city. Beyond that there tends to be an area less closely built-up, but nevertheless intimately linked to the city. For many purposes, all the population that is closely related to the city needs to be taken into account. The total area is frequently included under the term metropolitan area. Standard metropolitan statistical areas include cities of 50,000 or over, the county or counties in which they are located and the adjoining county or counties which meet certain prescribed conditions of integration with the central city. In New England the political units used are towns.

TABLE XII.—*Population of Standard Consolidated Areas and Standard Metropolitan Statistical Areas With 1,000,000 or More*

Areas	1960 Census	Areas	1960 Census
Standard consolidated areas:		St. Louis, Mo.-Ill.	2,060,103
New York-Northeastern New Jersey standard consolidated area	14,759,429	Washington, D.C.-Md.-Va.	2,001,897
Chicago, Illinois-Northwestern Indiana standard consolidated area	6,794,461	Cleveland, O.	1,796,595
Standard metropolitan statistical areas:		Baltimore, Md.	1,727,023
New York, N.Y.*	10,694,633	Newark, N.J.*	1,689,420
Los Angeles-Long Beach, Calif.	6,742,696	Minneapolis-St. Paul, Minn.	1,482,030
Chicago, Ill.†	6,220,913	Buffalo, N.Y.	1,306,957
Philadelphia, Pa.	4,342,897	Houston, Tex.	1,213,158
Detroit, Mich.	3,762,360	Milwaukee, Wis.	1,194,290
San Francisco-Oakland, Calif.	2,783,359	Paterson-Clifton-Passaic, N.J.*	1,186,873
Boston, Mass.	2,589,301	Seattle, Wash.	1,107,213
Pittsburgh, Pa.	2,405,435	Dallas, Tex.	1,083,601
		Cincinnati, O.-Ky.	1,071,624
		Kansas City, Mo.-Kan.	1,039,493
		Atlanta, Ga.	1,017,188
		San Diego, Calif.	1,033,011

*Part of the New York-Northeastern Xew Jersey standard consolidated area.
†Part of the Chicago, Illinois-Northwestern Indiana standard consolidated area.

Of the total population increase in the United States between 1950 and 1960 84.2% occurred in the 212 standard metropolitan statistical areas which included 112,885,178 persons, or 63% of the total. The rate of growth within the standard metropolitan statistical areas was very uneven. Although the central cities in 1950 included nearly three-fifths of the total population of the areas, they had only about one-fifth of the total increase that occurred in such areas. While the central cities increased by approximately 9%, the suburban areas outside these cities increased by about 48%. Among the 212 standard metropolitan statistical areas, 203 gained population and 9 lost population between 1950 and 1960. However, of the 258 central cities in the metropolitan areas. 185 gained population and 73 lost. Four of the five cities of 1.000.000 or more population in 1950 lost population during the 1950 to 1960 decade (New York, Chicago, Philadelphia and Detroit). while one (Los Angeles) gained. Standard metropolitan statistical areas as a whole increased their population by 26 4%; the remainder of the country increased by only 7%.

Declining Farm Population.—As the nation has become increasingly urbanized. there has been a decline in the proportion of its population living on farms. After the mid-1930s there was also a decline in the number of persons living on farms. In 1910 the farm population included 32,077,000 persons, or 34 9% of the total population. By 1950 the farm population amounted to 25,058,000. or 16 6% of the total population, and by 1959 it had declined to 21,172,000, or 12% of the total. A continued large-scale migration of population from the rural areas, and particularly from farm areas to cities, has been one of the major population movements of the 20th century.

Racial Composition.—In 1790, eight of each ten persons were white. two were Negroes. Indians were few in the settled areas. In 1960, 88 6% of the population was classified as white and 11.4% as nonwhite—the majority of which was Negro. Less than 1 in each 100 persons was American Indian or Asian. In 1960, out of a total population of 179,323,175, 158,831,732 were white, 18,871,831 were Negro, 523.591 were Indian, 464,332 were Japanese and 237,292 were Chinese.

During the 19th century the proportion of the population which was white increased more rapidly than the proportion of Negro, in part because the great majority of immigrants to this country were white. In later years the nonwhite population grew more rapidly than the white. From 1950 to 1960 the white population increased by about 16% and the nonwhite population by 26%. This difference arises from the marked excess of the birth rates of the nonwhites which is only partially offset by a higher death rate. Betneen 1910 and 1920 there had been little change in the proportion of nonwhites. It was 10 3 in 1920 and 10.2 in both 1930 and 1940. and 10 5 in 1950. The 1960 proportion is still less than that at the beginning of the century, when it was 12.1.

Persons of Foreign Origin.—In the 136 years from 1819 to 1955, more than 40000,000 aliens entered the United States. About 34,000,000 of these were from Europe. The early immigrants came predominantly from western Europe and the peak immigration from northern and western Europe came in the decade from 1881 to 1890. By this time there were already substantial numbers of immigrants from the countries to the east and south, and after this the numbers and proportions of immigrants from eastern and southern Europe increased substantially. Between 1901 and 1910 approximately 8,000,000 Europeans emigrated to

TABLE XIII.—*Nativity and Parentage of Foreign White Stock by Country of Origin, 1950*

Country of origin	Foreign born	Native white of foreign or mixed parentage	Country of origin	Foreign born	Native white of foreign or mixed parentage
Total	10,161,168	23,589,485	Yugoslavia	143,956	239,920
England and Wales	584,615	1,443,230	U.S.S.R.	894,844	1,647,420
Scotland	244,200	463,325	Lithuania	147,765	249,825
Northern Ireland	15,398	29,890	Finland	95,506	172,370
Ireland (Eire)	504,961	1,891,495	Rumania	84,952	130,100
Norway	202,294	652,380	Greece	169,083	195,235
Sweden	324,944	864,695	Italy	1,427,145	3,143,405
Denmark	107,897	318,710	Spain	45,565	69,490
Netherlands	102,133	272,535	Portugal	54,337	117,675
Belgium	52,891	85,500	Other Europe	86,375	128,030
Switzerland	71,515	215,660	Asia	180,024	239,525
France	107,924	253,665	Canada—French	238,409	519,495
Germany	984,331	3,742,615	Canada—other	756,153	1,468,325
Poland	861,184	1,925 015	Mexico	450,562	891,980
Czechoslovakia	278,268	705,890	Other America	120,297	101,240
Austria	408,785	816,465	All other and not reported	146,833	157,300
Hungary	268,022	437,080			

the United States, 6,000,000 of them from eastern and southern Europe. After the enactment of the quota legislation, the balance shifted again. Between 1951 and 1954, 518,000 European immigrants came to the United States, of whom 411,000 were from northern and western Europe. With the reduction in the number of immigrants beginning in the 1920s, the proportion of the population that is foreign born steadily declined. In 1900, 13.4% of the white population was reported as foreign born. By 1930 this had dropped to 11.4% and in 1950 it was only 6.7%. This was less than the proportion reported in 1850.

Under the classification foreign white stock, the census reports included foreign-born white persons and persons with one or both parents foreign born. In 1950 this classification included 22.4% of the population. Early in 1900 it had been 34%.

Persons born in Italy were most numerous among the foreign-born white population in 1950, numbering about 1,427.000. Second were Germans with 984,000. There were 861,000 immigrants born in Poland, 884,000 born in the United Kingdom and 505,000 born in Ireland. However, the relative rankings were different in relation to country of origin for persons born in the United States of foreign parentage. There were 23,589,000 native white persons of foreign or mixed parentage. The largest number of these were of German parentage—3,743 000, and of Italian parentage—3,143,000. Persons of English, Irish, Polish and Russian descent were next in numbers.

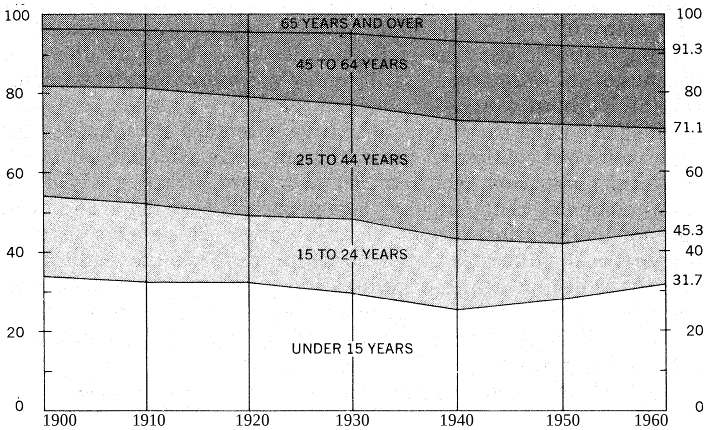
Age and Sex.—In the 1950s the numbers of the very young and of the older population grew more rapidly than the number of persons at other ages. Estimates for 1959 indicate that between 1950 and 1959 the number of children 5–13 years old grew about two and one-half times as rapidly as the total population, and the number of persons 65 and over grew about one and one-half times as rapidly as the total.

Table XIV.—*Population Change, by Age: 1950 to 1959*
(In thousands)

Age	Population including armed forces abroad			Population change			
				July 1, 1958, to July 1, 1959		April 1, 1950, to July 1, 1959	
	July 1, 1959	July 1, 1958	April 1, 1950	Number	Per cent	Number	Per cent
All ages	177,103	174,054	151,132	+3,050	+1.8	+25,971	+17.2
Under 5 years	19,795	19,512	16,164	+283	+1.4	+3,632	+22.5
5 to 13 years	32,388	31,144	22,180	+1,244	+4.0	+10,208	+46.0
14 to 17 years	10,990	10,634	8,409	+356	+3.3	+2,581	+30.7
18 to 24 years	15,872	15,525	16,081	+347	+2.2	−209	−1.3
25 to 34 years	23,042	23,390	23,893	−347	−1.5	−851	−3.6
35 to 44 years	23,783	23,560	21,491	+223	+0.9	+2,292	+10.7
45 to 64 years	35,853	35,242	30,720	+612	+1.7	+5,134	+16.7
65 and over	15,380	15,047	12,195	+333	+2.2	+3,185	+26.1

The economic development of the country was accompanied by great changes in the age structure of the population. In 1880, 38% of the population were under 15 and only 3% were 65 and over. By 1950 the proportion of persons under 15 had dropped to 27%, but by this time 8% of the total were 65 and over. After 1950 there was a relatively sharp increase in the proportion of children under 15 and a continuation in the growing proportion of persons 65 and over. The median age of the population, *i.e.*, the point which divides the population with one-half older and one-half younger, was 29.3 years in 1959. This was approximately one year less than it had been in 1950, but was more than six years above the median of 22.9 reported in 1900.

Sex Composition.—In 1950 for the first time in U.S. history the census showed more females than males in the population. At that time the excess of females was about 1,800,000. Females generally outnumber males in the adult age groups. There was an excess of 3,200.000 females 25 years of age and over, and about 1,500,000 females 65 and over in 1959. Males continued to outnumber females in the age group under 25. The excess of females in the older ages is attributed essentially to the fact that women have lower death rates than men at all ages. The age and sex composition of the nonwhite population is different from that of the white, primarily as a result of its much higher birth rate. The nonwhite population is substantially "younger" than the white



BY COURTESY OF THE U S BUREAU OF THE CENSUS

FIG. 9 — PER CENT OF DISTRIBUTION BY AGE OF THE POPULATION OF THE U.S., 1900 TO 1960. (FIGURES FOR 1940 AND LATER YEARS INCLUDE ARMED FORCES ABROAD; 1960 DATA BASED ON PRELIMINARY FIGURES)

population, having a median age in 1959 of 22.9 years as compared with 30.2 years for the white population.

Families and Households.—The decline in size of households has been persistent and widespread. The average size was 5.7 in the white population of 1790, 4.8 in the total population of 1870 and 3.4 in the total population of 1950. After 1950 there was an increase in the average size of families, that is, related persons living together, a decrease in the number of cases in which two or more families live in the same household and an increase in the number of households which included no relatives of the head. The average number of persons per household in 1959 was approximately the same as that in 1950, but the average size of families increased from 3.54 persons in 1950 to 3.66 persons in 1959. Families in rural areas tended to be larger than families in urban areas and farm families were larger than rural nonfarm families.

The total number of households in the United States in March 1959 was 51,300,000 and had been 43,600.000 in March 1950, and the average annual increase was 861,000. However, there was an annual average decline in the number of rural farm households amounting to 98,000. Thus the average annual increase of the urban and rural nonfarm households was 959,000.

Education.—Education has been a major force in the develop-

Table XV.—*Level of School Completed by Persons 25 Years Old and Over and 25 to 29 Years Old, by Colour, for the United States: 1940 to 1959*
(The small number of Persons not reporting on years of school completed were included in base of percentages but mere not distributed)

Date, age and colour	Per cent by level of school completed			Median school years completed
	Less than 5 years of elementary school	4 years of high school or more	4 or more years of college	
White				
25 years and over				
March 1959	8.0	42.9	7.9	11.0
March 1957	9.0	40.8	7.5	10.6
October 1952	9.1	38.4	6.9	10.1
April 1950	10.8	33.4	6.0	9.3
April 1947	10.4	32.6	5.4	9.0
April 1940	13.5	24.1	4.6	8.4
25 to 29 years				
March 1959	3.0	63.3	11.0	12.3
October 1952	3.8	56.7	10.0	12.2
April 1950	4.6	51.7	7.7	12.1
April 1940	5.9	37.8	5.8	10.4
Nonwhite				
25 years and over				
March 1959	23.5	20.0	3.2	8.1
March 1957	26.9	17.8	2.8	7.7
October 1952	30.3	14.7	2.4	7.1
April 1950	31.5	13.2	2.2	6.8
April 1947	31.4	13.2	2.4	6.9
April 1940	41.1	7.5	1.8	5.8
25 to 29 years				
March 1959	7.8	39.1	4.6	10.9
October 1952	15.2	27.8	4.6	9.3
April 1950	15.6	22.9	2.8	8.7
April 1940	26.7	12.1	1.3	7.1

ment of a single people with a single language from immigrants with many diverse backgrounds. The percentage of illiterates in the population aged ten and over declined slowly in the last decades of the 19th century. Illiteracy was more prevalent among the foreign-born whites than among the native whites, but it was far higher among the natives of native parentage than among the American-born children of the immigrants. By 1930 only 4.3% of the total population aged ten and over were illiterate. In 1959 it was estimated that 2.2% of the population 14 years old and over and not living in institutions were illiterate. This is the smallest proportion of illiterates ever recorded in this country. Illiteracy rates have declined for both whites and nonwhites, but the decline has been more rapid for the nonwhites. Among persons 14 to 24 years old in 1959, the illiteracy rates were 0.5% for whites and 1.2% for nonwhites.

By 1959 the average years of school completed by persons 25 years old and over was 11.0. This compares with 9.3 in 1950 and 8.4 in 1940. The average was about one-half year greater for women than for men in 1959.

College graduates constitute a relatively small percentage of the adult population (8%). Among men 25 to 29 years old, the proportion who had completed four or more years of college went up especially sharply in the 1950s, and by 1959 it was 15%.

Economic Activity. — There have been a number of significant changes in the economic activity of the population throughout the nation's history. The proportions engaged in agricultural and related industries, and in private household services, have shown a long-time decline. The proportions engaged in manufacturing, transportation, communication and trade continue to move slowly upward. There have been substantial increases in the proportions of persons engaged in clerical occupations, professional service and public administration.

Rates of participation in economic activity after 1870 declined for the younger persons and for those 65 and over. There has also been a decrease in the predominance of men in the economically active population as increased numbers of women have entered the labour force. In 1910 there were almost 3,900 men for each 1,000 women among gainful workers, but the labour force in 1950 had approximately 2,600 men for each 1,000 women.

Labour-force participation rates are low at age 14. They increase rapidly from 15–19 and through 24. At that age 86% of the men and 38% of the women were in the labour force. For men, rates increase to a maximum of 95% at ages 34–41, decline

Table XVI.—*Employment Status of the Population, by Sex: Annual Averages, 1959*
(Current survey levels)

Employment status	Total: Number (000s)	Total: Per cent	Male: Number (000s)	Male: Per cent	Female: Number (000s)	Female: Per cent
Total, all ages	176,895	100.0	87,554	100.0	89,341	100.0
Labour force, 14 years old and over	71,946	40.7	49,081	56.1	22,865	25.6
Not in labour force	104,949	59.3	38,473	43.9	66,476	74.4
Labour Force						
Total	71,946	100.0	49,081	100.0	22,865	100.0
Armed forces*	2,552	3.5	2,519	5.1	33	0.1
Civilian labour force	69,394	96.5	46,562	94.9	22,832	99.9
Employed	65,581	91.2	44,089	89.8	21,492	94.0
At work full time	48,920	68.0	35,157	71.6	13,783	60.3
At work part time	13,501	18.8	6,942	14.1	6,559	28.7
Usually work full time	5,371	7.5	3,663	7.5	1,708	7.5
Usually work part time	8,130	11.3	3,279	6.7	4,851	21.2
With a job but not at work	3,161	4.4	2,010	4.1	1,151	5.0
Unemployed	3,813	5.3	2,473	5.0	1,340	5.9
Not in Labour Force						
Total	104,949	100.0	38,473	100.0	66,476	100.0
Under 14 years old†	.	.	$	.	.	.
14 years old and over						
Keeping house	34,487	32.9	83	0.2	34,404	51.8
Going to school	7,761	7.4	3,871	10.1	3,890	5.9
Unable to work	1,777	1.7	1,065	2.8		1.1
In institutions‡	1,444	1.4	878	2.3		0.8
Other	7,395	7.0	6,000	15.6	1,395	2.1

*Independent estimate of armed forces, including those stationed overseas.

†Excluded from labour force by definition. Special surveys in 1950 indicated an estimated 600,000 age 10 to 13 working in agriculture and 500,000 in other industries in a peak summer month.

‡Based on 1950 federal census.

Note: Annual averages are arithmetic means of observations for survey week in each month; detail may not add exactly to totals because of rounding.

slowly to age 50 and then decline rapidly until they become very low for persons 75 and over.

For women, rates of labour-force participation increase to age 20, decline to about age 30, then increase again to age 44, after which there is a rapid decline.

During and after World War II there was a significant increase in the numbers and proportions of women in the labour force. By 1960 approximately one-third of all workers were women and approximately one-third of women 14 and over were in the labour force. The increases had been particularly large for women over 35.

Prospective Growth. — During the country's history there have been many changes in the rates and prospects of growth. The average family in 1960 had less than half as many children as a family of 1790, but the expectation of life of those who are born was perhaps two and one-half times as great. Cities and suburban areas have replaced farms and villages as the places where the majority of the people live.

At the beginning of the 1960s the United States was adding approximately 3,000,000 persons to its population each year. Although this increase is less than 2% per year, if continued for a half century it would mean more than doubling the numbers, such as that which occurred between 1910 and 1960. Increases in the numbers of births after World War II have been the results of a combination of trends. After 1940 there was an increase in the proportion of women aged 15–44, who had given birth to at least one child. There were substantial increases in the proportion who had borne at least two children. The proportion who had borne five or six children changed little, but there was a major decrease in the proportion who had borne seven or more children.

Earlier marriage, earlier childbearing and longer duration of married life may lead to relatively rapid population growth. On the other hand, the higher birth rates during the 1950s were in part a crowding together of births which under other circumstances would have occurred during a longer period of time. They represent decisions as to childbearing during a time of relatively high employment and income levels and it is difficult to tell to what extent there have been long range changes in family values and attitudes toward children.

If one could assume that the birth rates of 1955–57 would continue, the population of the United States might be expected to reach 214,000,000 by 1970 and 260,000,000 by 1980. If, however, birth rates should drop to the rates experienced in 1942–44 the population in 1970 might be only 203,000,000 and that for 1980, 231,000,000.

It is impossible to foretell whether either of these sets of birth rates will exist, or whether during the 1960s and 1970s the American people will have a different set of birth rates. However, the relatively high birth rates in the 1950s resulted in a relatively large number of persons who will be passing through the grade and high school ages and into the labour force in the 1960s and 1970s. It is also clear that as a result of past trends the number and proportion of persons 65 and over will continue to grow rapidly for many years. (C. T.)

VI. ADMINISTRATION AND SOCIAL CONDITIONS

A. Constitution

The following pages contain the constitution of the United States and the 23 amendments (with effective dates).

Constitution of the United States of America

Preamble

We the People of the United States, in Order to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the common defence, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America.

Article I

Section 1. All legislative Powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives.

Section 2. The House of Representatives shall be composed of Members chosen every second Year by the People of the several States, and the Electors in each State shall have the Qualifications requisite for Electors of the most numerous Branch of the State Legislature.

No Person shall be a Representative who shall not have attained to the Age of twenty five Years, and been seven Years a Citizen of the United States, and who shall not, when elected, be an Inhabitant of that State in which he shall be chosen.

Representatives and direct Taxes shall be apportioned among the several States which may be included within this Union, according to their respective Numbers, which shall be determined by adding to the whole Number of free Persons, including those bound to Service for a Term of Years, and excluding Indians not taxed, three fifths of all other Persons. The actual Enumeration shall be made within three Years after the first Meeting of the Congress of the United States, and within every subsequent Term of ten Years, in such Manner as they shall by Law direct. The Number of Representatives shall not exceed one for every thirty Thousand, but each State shall have at Least one Representative; and until such enumeration shall be made, the State oi New Hampshire shall be entitled to choose three, Massachusetts eight, Rhode Island and Providence Plantations one, Connecticut five, New York six, New Jersey four, Pennsylvania eight, Delaware one, Maryland six, Virginia ten, North Carolina five, South Carolina five, and Georgia three.

When vacancies happen in the Representation from any State, the Executive Authority thereof shall issue Writs of Election to fill such Vacancies.

The House of Representatives shall chuse their Speaker and other Officers, and shall have the sole Power of Impeachment.

Section 3. The Senate of the United States shall be composed of two Senators from each State, chosen by the Legislature thereof, for six Years; and each Senator shall have one Vote.

Immediatelv after they shall be assembled in Consequence of the first Election, they shall be divided as equally as may be into three Classes The Seats of the Senators of the first Class shall be vacated at the Expiration of the second Year, of the second Class at the Expiration of the fourth Year. and of the third Class at the Expiration of the sixth Year, so that one third may be chosen every second Year; and if Vacancies happen by Resignation, or otherwise, duiing the Recess of the Legislature of any State, the Executive thereof may make temporary Appointments until the next Meeting of the Legislature, which shall then fill such Vacancies.

No Person shall be a Senator who shall not have attained to the Age of thirty Years, and been nine Years a Citizen oi the United States, and who shall not, when elected, be an Inhabitant of that State for which he shall be chosen.

The Vice President of the United States shall be President of the Senate, but shall have no Vote, unless they be equally divided.

The Senate shall chuse their other Officers, and also a President pro tempore, in the Absence of the Vice President, or when he shall exercise the Office of President of the United States.

The Senate shall have the sole Power to try all Impeachments. When sitting for that Purpose, they shall be on Oath or Affirmation. When the President of the United States is tried, the Chief Justice shall preside: And no Person shall be convicted without the Concurrence of two thirds of the Members present.

Judgment in Cases of Impeachment shall not extend iurther than to removal from Office, and disqualification to hold and enjoy any Office of honor, Trust or Profit under the United States: but the Party convicted shall nevertheless be liable and subject to Indictment, Trial, Judgment and Punishment, according to Lam.

Section 4. The Times, Places and Manner of holding Elections for Senators and Representatives, shall be prescribed in each State by the Legislature thereoi; but the Congress may at any time by Law make or alter such Regulations, except as to places of chusing Senators.

The Congress shall assemble at least once in every Year, and such Meeting shall be on the first Monday in December, unless they shall by Law appoint a different Day.

Section 5. Each House shall be the Judge of the Elections, Returns and Qualifications of its own Members, and a Majority of each shall constitute a Quorum to do Business; but a smaller Number may adjourn irom day to day, and may be authorized to compel the Attendance of absent Members, in such Manner, and under such Penalties as each House may provide.

Each House may determine the Rules of its Proceedings, punish its Members for disorderly behaviour, and, with the Concurrence of two thirds, expel a Member.

Each House shall keep a Journal of its Proceedings, and from time to time publish the same, excepting such Parts as may in their Judgment require Secrecy; and the Yeas and Nays of the Members of either House on any question shall, at the .Desire of one fifth of those Present, be entered on the Journal.

Neither House, during the Session of Congress, shall, without the Consent of the other, adjourn for more than three days, nor to any other Place than that in which the two Houses shall be sitting.

Section 6. The Senators and Representatives shall receive a Compensation ior their services, to be ascertained by Law, and paid out of the Treasury of the United States. They shall in all Cases, except Treason, Felony and Breach of the Peace, be privileged from Arrest during their Attendance at the Session of their respective Houses, and in going to and returning irom the same; and for any Speech or Debate in either House, they shall not be questioned in any other Place.

No Senator or Representative shall, during the Time for which he was elected, be appointed to any civil Office under the Authority of the United States, which shall have been created, or the Emoluments whereof shall have been increased during such time; and no Person holding any Office under the United States, shall be a Member of either House during his Continuance in Office.

Section 7. All Bills for raising Revenue shall originate in the House of Representatives; but the Senate may propose or concur with Amendments as on other bills.

Every Bill which shall have passed the House oi Representatives and the Senate, shall, before it becomes a Law, be presented to the President oi the United States; If he approve he shall sign it, but if not he shall return it, with his Objections to that House in which it shall have originated, who shall enter the Objections at large on their Journal, and proceed to reconsider it. If after such Reconsideration two thirds of that House shall agree to pass the Bill, it shall be sent, together with the Objections, to the other House. by which it shall likewise be reconsidered, and if approved by two thirds of that House, it shall become a Lam But in all such Cases the Votes of both Houses shall be determined by yeas and Nays, and the Names of the Persons voting ior and against the Bill shall be entered on the Journal of each House respectively. If any Bill shall not be returned by the President within ten Days (Sundays excepted) after it shall have been presented to him, the Same shall be a Law, in like Manner as if he had signed it, unless the Congress by their Adjournment prevent its Return, in which Case it shall not be a Law.

Every Order, Resolution, or Vote to which the Concurrence of the Senate and House of Representatives may be necessary (except on a question of Adjournment) shall be presented to the President of the United States; and before the Same shall take Effect, shall be approved by him, or being disapproved by him, shall be repassed by two thirds of the Senate and House of Representatives, according to the Rules and Limitations prescribed in the Case of a Bill.

Section 8. The Congress shall have Power To lay and collect Taxes, Duties, Imposts and Excises, to pay the Debts and provide for the common Defence and general Welfare of the United States; but all Duties. Imposts and Excises shall be uniform throughout the United States;

To borrow Money on the credit of the United States;

To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes;

To establish an uniform Rule of Naturalization, and uniform Laws on the subject of Bankruptcies throughout the United States;

To coin Money, regulate the Value thereof, and of foreign Coin, and fix the Standard of Weights and Measures;

To provide for the Punishment of counterfeiting the Securities and current Coin of the United States;

To establish Post Offices and Post Roads;

To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries;

To constitute Tribunals inferior to the supreme Court;

To define and punish Piracies and Felonies committed on the high Seas, and Offences against the Law of Nations;

To declare War, grant Letters of Marque and Reprisal, and make Rules concerning Captuies on Land and Water;

To raise and support Armies, but no Appropriation of Money to that Use shall be for a longer Term than two Years;

To provide and maintain a Navy;

To make Rules for the Government and Regulation of the land and naval Forces;

To provide for calling forth the Militia to execute the Laws of the Union, suppress Insurrections and repel Invasions;

To provide for organizing, arming, and disciplining the Militia, and for governing such Part of them as may be employed in the Service of the United States, reserving to the States respectively, the Appointment of the Officers, and the Authority of training the Militia according to the discipline prescribed by Congress;

To exercise exclusive Legislation in all Cases whatsoever, over such District (not exceeding ten Miles square) as may, by Cession of particular States, and the Acceptance of Congress, become the Seat of the Government of the United States, and to exercise like Authority over all Places purchased by the Consent of the Legislature of the State in which the Same shall be, for the Erection of Forts, Magazines, Arsenals, dock-Yards, and other needful Buildings.—And

To make all Laws which shall be necessary and proper for carrying into Execution the foregoing Powers, and all other Powers vested by this Constitution in the Government of the United States, or in any Department or Officer thereoi.

Section 9. The Migration or Importation of such Persons as any oi the States now existing shall think proper to admit, shall not be prohibited by the Congress prior to the Year one thousand eight hundred and eight, but a Tax or duty may be imposed on such importation, not exceeding ten dollars for each Person.

The Privilege of the Writ of Habeas Corpus shall not be suspended, unless nhen in Cases of Rebellion or Invasion the public Safety may require it.

No Bill of Attainder or ex post facto Law shall be passed.

No Capitation, or other direct, Tax shall be laid, unless in Proportion to the Census or Enumeration herein before directed to be taken.

No Tax or Duty shall be laid on Articles exported from any State.

No Preierence shall be given by any Regulation oi Commerce or Revenue to the Ports oi one State over those of another: nor shall Vessels bound to, or from, one State, be obliged to enter, clear, or pay Duties in another.

No Money shall be drawn irom the Treasury, but in Consequence of Appropriations made by Lam; and a regular Statement and Account of the Receipts and Expenditures of all public Money shall be published from time to time.

No Title of Nobility shall be granted by the United States: And no Person holding any Office of Profit or Trust under them, shall, without the Consent of the Congress, accept of any present, Emolument, Office, or Title, of any kind whatever, from any King, Prince, or foreign State.

Section 10. No State shall enter into any Treaty, Alliance, or Coniederation; grant Letters of Marque and Reprisal; coin Money; emit Bills oi Credit; make any Thing but gold and silver Coin a Tender in Payment of Debts; pass any Bill of Attainder, ex post iacto Law, or Law impairing the Obligation of Contracts, or grant any Title of Nobility.

No State shall, without the Consent of the Congress, lay any Imposts or Duties on Imports or Exports, except what may be absolutely necessary ior executing its inspection Laws: and the net Produce of all Duties and Imposts, laid by any State on Imports or Exports, shall be for the Use of the Treasury oi the United States: and all such Laws shall be subject to the Revision and controul of the Congress.

No State shall, without the Consent of Congress, lay any Duty of Tonnage, keep Troops, or Ships of War in time of Peace, enter into any Agreement or Compact with another State, or with a foreign Power, or engage in War. unless actually invaded, or in such imminent Danger as will not admit of delay.

Article II

Section 1. The executive Power shall be vested in a President of the United States of America. He shall hold his Office during the Term oi four Years, and, together with the Vice President, chosen for the same Term, be elected, as follows

Each State shall appoint, in such Manner as the Legislature thereof may direct, a Number of Electors, equal to the whole Number of Senators and Representatives to which the State may be entitled in the Congress; but no Senator or Representative, or Person holding an Office of Trust or Profit under the United States, shall be appointed an Elector.

The Electors shall meet in their respective States, and vote by Ballot for two Persons, of whom one at least shall not be an Inhabitant of the same State with themselves. And they shall make a List of all the Persons voted for, and of the Number of Votes for each; which List they shall sign and certiiy, and transmit sealed to the Seat of the Government of the United States, directed to the President of the Senate. The President of the Senate shall, in the Presence of the Senate and House of Representatives, open all the Certificates, and the Votes shall then be counted. The Person having the greatest Number of Votes shall be the President, if such Number be a Majority of the whole Number of Electors appointed; and if there be more than one who have such Majority, and have an equal Number of Votes, then the House of Representatives shall immediately chuse by Ballot one of them for President; and if no Person have a Majority, then from the five highest on the List the said House shall in like Manner chuse the President. But in chusing the President, the Vote shall be taken by States, the Representation from each State having one Vote; A quorum for this Purpose shall consist of a Member or Members from two thirds of the States, and a Majority of all the States shall be necessary to a Choice. In every Case, after the Choice oi the President, the Person having the greatest Number of Votes of the Electors shall be the Vice President. But ii there should remain two or more who have equal Votes, the Senate shall chuse from them by Ballot the Vice President.

The Congress may determine the Time oi chusing the Electors, and the Day on which they shall give their Votes; which Day shall be the same throughout the United States.

No Person except a natural born Citizen, or a Citizen of the United States, at the time of the Adoption of this Constitution, shall be eligible to the Office of President; neither shall any Person be eligible to that Office who shall not have attained to the Age of thirty five Years, and been fourteen Years a Resident within the United States.

In Case oi the Removal of the President from Office, or of his Death, Resignation, or Inability to discharge the Powers and Duties of the said Office, the Same shall devolve on the Vice President, and the Congress may by Law provide for the Case oi Removal, Death, Resignation or Inability, both of the President and Vice President, declaring what Officer shall then act as President, and such Officer shall act accordingly, until the Disability be removed, or a President shall be elected.

The President shall, at stated Times, receive for his Services, a Compensation, which shall neither be encreased nor diminished during the Period ior which he shall have been elected, and he shall not receive within that Period any other Emolument from the United States, or any oi them.

Before he enter on the Execution of his Office, he shall take the following Oath or Affirmation:—"I do solemnly swear (or affirm) that I will faithfully execute the Office of President of the United States, and will to the best of my Ability, preserve, protect and defend the Constitution of the United States."

Section 2. The President shall be Commander in Chief of the Army and Navy of the United States, and of the Militia of the several States, when called into the actual Service of the United States; he may require the Opinion, in writing, of the principal Officer in each of the executive Departments, upon any Subject relating to the Duties of their respective Offices, and he shall have Power to grant Reprieves and Pardons for Offences against the United States, except in Cases of Impeachment.

He shall have Power, by and with the Advice and Consent of the Senate, to make Treaties, provided two thirds of the Senators present concur; and he shall nominate, and by and with the Advice and Consent of the Senate, shall appoint Ambassadors, other public Ministers and Consuls, Judges of the supreme Court, and all other Officers of the United States, whose Appointments are not herein otherwise provided for, and which shall be established by Law: but the Congress may by Law vest the Appointment of such inferior Officers, as they think proper, in the President alone, in the courts of Law, or in the Heads of Departments.

The President shall have Power to fill up all Vacancies that may happen during the Recess of the Senate, by granting Commissions which shall expire at the End of their next Session.

Section 3. He shall from time to time give to the Congress Information of the State of the Union, and recommend to their-consideration such Measures as he shall judge necessary and expedient; he may, on extraordinary Occasions, convene both Houses, or either of them, and in Case of Disagreement between them, with Respect to the Time oi Adjournment, he may adjourn them to such Time as he shall think proper; he shall receive Ambassadors and other public Ministers; he shall take Care that the Laws be faithfully executed, and shall Commission all the Officers of the United States.

Section 4. The President, Vice President and all civil Officers of the United States, shall be removed from Office on Impeachment for, and Conviction of, Treason, Bribery, or other high Crimes and Misdemeanors.

Article III

Section 1. The judicial Power of the United States shall be vested in one supreme Court, and in such inferior Courts as the Congress may from time to time ordain and establish. The Judges, both of the supreme and inferior Courts, shall hold their Offices during good Behavior, and shall, at stated Times, receive for their Services, a Compensation, which shall not be diminished during their Continuance in Office.

Section 2. The judicial Power shall extend to all Cases, in Law and Equity, arising under this Constitution, the Laws of the United States, and Treaties made, or which shall be made, under their Authority;—to all Cases affecting Ambassadors, other public Ministers and Consuls;—to all Cases of admiralty and maritime Jurisdiction;—to Controversies to which the United States shall be a Party;—to Controversies between two or more States;—between a State and Citizens oi another State;—between Citizens of different States,—between Citizens of the same State claiming Lands under Grants of difierent States, and between a State, or the Citizens thereof, and foreign States, Citizens or Subjects.

In all Cases affecting Ambassadors, other public Ministers and Consuls, and those in which a State shall be Party, the supreme Court shall have original Jurisdiction. In all the other Cases before mentioned, the supreme Court shall have appellate Jurisdiction, both as to Law and Fact, with such Exceptions, and under such Regulations as the Congress shall make.

The Trial oi all Crimes, except in Cases of Impeachment, shall be by Jury; and such Trial shall be held in the State where the said Crimes shall have been committed: hut when not committed within any State, the Trial shall be at such Place or Places as the Congress may by Law have directed.

Section 3. Treason against the United States, shall consist only in levying War against them, or in adhering to their Enemies, giving them Aid and Comfort.- No Person shall be convicted of Treason unless on the Testimony of two Witnesses to the same overt Act, or on Confession in open Court.

The Congress shall have power to declare the Punishment of Treason, but no Attainder oi Treason shall work Corruption of Blood, or Forfeiture except during the Life of the Person attainted.

Article IV

Section 1. Full Faith and Credit shall be given in each State to the public Acts, Records, and judicial Proceedings of every other State. And the Congress may by general Laws prescribe the Manner in which such Acts, Records and Proceedings shall be proved, and the Effect thereof.

Section 2. The Citizens of each State shall be entitled to all Privileges and Immunities of Citizens in the several States.

A person charged in any State with Treason, Felony, or other Crime, who shall flee from Justice, and be found in another State, shall on Demand of the executive Authority of the State from which he fled, be delivered up, to be removed to the State having Jurisdiction of the Crime.

No Person held to Service or Labour in one State, under the Laws thereof, escaping into another, shall, in Consequence of any Law or Regulation therein, be discharged from such Service or Labour, but shall be delivered up on Claim of the Party to whom such Service or Labour may be due.

Section 3. New States may be admitted by the Congress into this Union; but no new State shall be formed or erected within the Jurisdiction of any other State; nor any State be formed by the Junction of two or more States, or Parts of States, without the Consent of the Legislatures of the States concerned as well as of the Congress.

The Congress shall have Power to dispose of and make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States; and nothing in this Constitution shall be so construed as to Prejudice any Claims of the United States, or of any particular State.

Section 4. The United States shall guarantee to every State in this Union a Republican Form of Government, and shall protect each of them against Invasion; and on Application of the Legislature, or of the Executive (when the Legislature cannot be convened) against domestic Violence.

ARTICLE V

The Congress, whenever two thirds of both Houses shall deem it necessary, shall propose Amendments to this Constitution, or, on the Application of the Legislatures of two thirds of the several States, shall call a Convention for proposing Amendments, which, in either Case, shall be valid to all Intents and Purposes, as Part of this Constitution, when ratified by the Legislatures of three fourths of the several States, or by Conventions in three fourths thereof, as the one or the other Mode of Ratification may be proposed by the Congress; Provided that no Amendment which may be made prior to the Year One thousand eight hundred and eight shall in any Manner affect the first and fourth Clauses in the Ninth Section of the first Article; and that no State, without its Consent, shall be deprived of its equal Suffrage in the Senate.

ARTICLE VI

All Debts contracted and Engagements entered into, before the Adoption of this Constitution, shall be as valid against the United States under this Constitution, as under the Confederation.

This Constitution, and the Laws of the United States which shall be made in Pursuance thereof; and all Treaties made, or which shall be made, under the Authority of the United States, shall be the supreme Law of the land; and the Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of any State to the Contrary notwithstanding.

The Senators and Representatives before mentioned, and the Members of the several State Legislatures, and all executive and judicial Officers, both of the United States and of the several States, shall be bound by Oath or Affirmation, to support this Constitution; but no religious Test shall ever be required as a Qualification to any Office or public Trust under the United States.

ARTICLE VII

The Ratification of the Conventions of nine States shall be sufficient for the Establishment of this Constitution between the States so ratifying the Same.

DONE in Convention by the Unanimous Consent of the States present' the Seventeenth Day of September in the Year of our Lord one thousand seven hundred and Eighty-seven and of the Independence of the United States of America the twelfth IN WITNESS whereof We have hereunto subscribed our Names,

	Go. Washington—Presidt. and deputy from Virginia
New Hampshire	John Langdon Nicholas Gilman
Massachusetts	Nathaniel Gorham Rufus King
Connecticut	Wm. Saml. Johnson Roger Sherman
New York	Alexander Hamilton
New Jersey	Wil: Livingston David Brearley. Wm. Paterson. Jona: Dayton
Pennsylvania	B. Franklin Thomas Mifflin Robt Morris Geo. Clymer Thos. FitzSimons Jared Ingersoll James Wilson Gouv. Morris
Delaware	Geo: Read Gunning Bedford jun Tohn Dickinson Richard Bassett Jaco: Broom
Maryland	James McHenry Dan of St. Thos. Jenifer Danl. Carroll.
Virginia	John Blair— James Madison Jr.
North Carolina	Wm. Blount Richd. Dobbs Spaight. Hu Williamson
South Carolina	J. Rutledge Charles Cotesworth Pinckney Charles Pinckney Pierce Butler.
Georgia	William Few Abr Baldwin

[1]Rhode Island sent no delegates to the federal convention.

Amendments to the Constitution of the United States

"*Resolved*, By the Senate and House of Representatives of the United States of America, in congress assembled, two-thirds of both Houses concurring, that the following articles be proposed to the Legislatures of the several States, as amendments to the Constitution of the United States; all or any of which articles, when ratified by three-fourths of the said Legislatures, to be valid to all intents and purposes, as part of the said Constitution, namely:"

*The Ten **Original** Amendments*
(Dec. *15,* 1791)

Article I—Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances.

Article II—A well-regulated militia being necessary to the security of a free State, the right of the people to keep and bear arms shall not be infringed.

Article III—No soldier shall, in time of peace, be quartered in any house without the consent of the owner, nor in time of war, but in a manner to be prescribed by law.

Article IV—The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no warrants shall issue but upon probable cause, supported by oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

Article V—No person shall be held to answer for a capital or other infamous crime unless on a presentment or indictment of a grand jury, except in cases arising in the land or naval forces, or in the militia, when in actual service, in time of war or public danger; nor shall any person be subject for the same offence to be twice put in jeopardy of life or limb; nor shall be compelled in any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use without just compensation.

Article VI—In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the State and district wherein the crime shall have been committed, which districts shall have been previously ascertained by law, and to be informed of the nature and cause of the accusation; to be confronted with the witnesses against him; to have compulsory process for obtaining-witnesses in his favor, and to have the assistance of counsel for his defence.

Article VII—In suits at common law, where the value in controversy shall exceed twenty dollars, the right of trial by jury shall be preserved, and no fact tried by a jury shall be otherwise re-examined in any court of the United States than according to the rules of the common law.

Article VIII—Excessive bail shall not be required, nor excessive fines imposed, nor cruel and unusual punishments inflicted,

Article IX—The enumeration in the Constitution of certain rights shall not be construed to deny or disparage others retained by the people.

Article X—The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people.

Subsequent Amendments

Article XI—(Jan. **8,** 1798)—The judicial power of the United States shall not be construed to extend to anv suit in law or equity, commenced or prosecuted against one of the United States, by citizens of another State, or by citizens or subjects of any foreign state

Article XII—(Sept. *25,* 1304)—The electors shall meet in their respective States, and vote by ballot for President and Vice-President, one of whom at least shall not be an inhabitant of the same State with themselves; they shall name in their ballots the person voted for as President, and in distinct ballots the person voted for as Vice-President; and they shall make distinct lists of all persons voted for as President, and of all persons voted for as Vice-President, and of the number of votes for each, which list they shall sign and certify, and transmit, sealed, to the seat of the Government of the United States, directed to the President of the Senate; the President of the Senate shall, in the presence of the Senate and House of Representatives, open all the certificates, and the votes shall then be counted; the person having the greatest number of votes for President shall be the President, if such number be a majority of the whole number of electors appointed; and if no person have such majority, then from the persons having the highest numbers, not exceeding three, on the list of those voted for as President, the House of Representatives shall choose immediately, by ballot, the President. But in choosing the President, the votes shall be taken by States, the representation from each State having one vote; a quorum for this purpose shall consist of a member or members from two-thirds of the States, and a majority of all the States shall be necessary to a choice. And if the House of Representatives shall not choose a President, whenever the right of choice shall devolve upon them, before the fourth day of March next following, then the Vice-President shall act as President, as in the case of the death or other constitutional disability of the President. The person having the greatest number of votes as Vice-President shall be the Vice-President, if such number be a majority of the whole number of electors appointed, and if no person have a majority, then from the two highest numbers on the list the Senate shall choose the Vice-President; a quorum for the purpose shall consist of two-thirds of the whole number of Senators, and a majority of the whole number shall be necessary to a choice. But no person constitutionally ineligible to the office of President shall be eligible to that of Vice-President of the United States.

***Article* XIII**—(Dec 18, 1865)—1. Neither slavery nor involuntary servitude, except as a punishment for crime whereof the party shall have been duly convicted, shall exist within the United States, or any place subject to their jurisdiction.

2. Congress shall have power to enforce this article by appropriate legislation.

Article XIV—(July 28, 1868)—1. All persons born or naturalized in the United States, and subject to the jurisdiction thereof, are citizens of the United States and of the State wherein they reside. No State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty, or property without due process of lam, nor deny to any person within its jurisdiction the equal protection of the laws.

2. Representatives shall be apportioned among the several States according to their respective numbers, counting the whole number of persons in each State, excluding Indians not taxed. But when the right to vote at any election for the choice of electors for President and Vice-President of the United States, Representatives in Congress, the executive and judicial officers of a State, or the members of the Legislature thereoi, is denied to any of the male members of such State, being of twenty-one years of age, and citizens of the United States, or in aay way abridged, except for participation in rebellion or other crime, the basis of representation therein shall be reduced in the proportion which the number of such male citizens shall bear to the whole number of male citizens twenty-one years of age in such State.

3. No person shall be a Senator or Representative in Congress, or elector of President and Vice-President, or hold any office, civil or military, under the United States, or under any State, who, having previously taken an oath, as a member of Congress, or as an officer of the United States, or as a member of any State Legislature, or as an executive or judicial officer of any State, to support the Constitution of the United States, shall have engaged in insurrection or rebellion against the same, or given aid and comfort to the enemies thereof. But Congress may, by a vote of two-thirds of each House, remove such disability.

4. The validity of the public debt of the United States, authorized by law, including debts incurred for payment of pensions and bounties for services in suppressing insurrection and rebellion, shall not be questioned. But neither the United States nor any State shall assume or pay any debt or obligation incurred in aid of insurrection or rebellion against the United States, or any claim for the loss or emancipation of any slave; but all such debts, obligations, and claims shall be held illegal and void.

5. The Congress shall have power to enforce by appropriate legislation the provisions of this article.

Article XV—(March 30. 1870)--1. The right of the citizens of the United States to vote shall not be denied or abridged by the United States or by any State on account of race, color, or previous condition of servitude.

2. The Congress shall have power to enforce the provisions of this article by appropriate legislation.

Article XVI—(Feb. 25, 1913)—The Congress shall have power to lay and collect taxes on incomes, from whatever sources derived, without apportionment among the several States, and without regard to any census or enumeration.

Article XVII—(May 31, 1913)—1. The Senate of the United States shall be composed oi two Senators from each State, elected by the people thereof, for six years; and each Senator shall have one vote. The electors in each State shall have the qualifications requisite for electors of the most numerous branch of the State Legislatures.

2. When vacancies happen in the representation of any State in the Senate, the executive authority of such State shall issue writs of election to fill such vacancies: Provided, That the Legislature of any State may empower the Executive thereof to make temporary appointment until the peopie fill the vacancies by election as the Legislature may direct.

3. This amendment shall not be so construed as to affect the election or term of any Senator chosen before it becomes valid as part of the Constitution.

Article XVIII—(Jan. 29, 1919)—1. After one year from the ratification of this article the manufacture, sale, or transportation of intoxicating liquors within, the importation thereof into, or the exportation thereof from the United States and all territory subject to the jurisdiction thereof for beverage purposes is hereby prohibited.

2. The Congress and the several States shall have concurrent power to enforce this article by appropriate legislation.

3. This article shall be inoperative unless it shall have been ratified as an amendment to the Constitution by the Legislatures of the several States, as provided in the Constitution, within seven years from the date of the submission hereof to the States by the Congress.

***Article* XIX**—(Aug 18, 1920)—1. The right of citizens of the United States to vote shall not be denied or abridged by the United States or by any State on account of sex.

2. The Congress shall have power by appropriate legislation to enforce the provision of this article.

Article XX—(Feb. 6, 1933)—1. The terms of the President and Vice-President shall end at noon on the 20th day of January, and the terms of Senators and Representatives at noon on the 3rd day of January, of the years in which such terms would have ended if this article had not been ratified; and the terms of their successors shall then begin.

2. The Congress shall assemble at least once in every year, and such meeting shall begin at noon on the 3rd day of January, unless they shall by law appoint a different day.

3 If, at the time fixed for the beginning of the term of the President, the President elect shall have died, the Vice-President elect shall become President. If a President shall not have been chosen before the time fixed for the beginning of his term, or if the President elect shall have failed to qualify, then the Vice-President elect shall act as President until a President shall have qualified; and the Congress may by law provide for the case wherein neither a President elect nor a Vice-President elect shall have qualified, declaring who shall then act as President, or the manner in which one who is to act shall be selected, and such person shall act accordingly until a President or Vice-president shall have qualified.

4. The Congress may by law provide for the case of the death of any of the persons from whom the House of Representatives may choose a President whenever the right of choice shall have devolved upon them, and for the case of the death of any of the persons from whom the Senate may choose a Vice-President whenever the right of choice shall have devolved upon them.

5. Sections 1 and 2 shall take effect on the 15th day of October following the ratification of this article.

6. This article shall be inoperative unless it shall have been ratified as an amendment to the Constitution by the legislatures of three-fourths of the several States within seven years from the date of its submission.

***Article* XXI**—(Dec. 5, 1933)—1. The Eighteenth Article of amendment to the Constitution of the United States is hereby repealed.

2. The transportation or importation into any State, Territory, or possession of the United States for delivery or use therein of intoxicating liquors, in violation of the laws thereof, is hereby prohibited.

3. This article shall be inoperative unless it shall have been ratified as an amendment to the Constitution by conventions in the several States, as provided in the Constitution, within seven years from the date of the submission hereof to the States by the Congress.

Article XXII—(Feb. 26, 1951)—1. No person shall be elected to the office of the President more than twice, and no person who has held the office of President, or acted as President, for more than two years of a term to which some other person was elected President shall be elected to the office of the President more than once. But this Article shall not apply to any person holding the office of President when this Article was proposed by the Congress, and shall not prevent any person who may be holding the office of President, or acting as President, during the term within which this Article becomes operative from holding the office of President or acting as President during the remainder of such term.

2. This article shall be inoperative unless it shall have been ratified as an amendment to the Constitution by the legislatures of three-fourths of the several States within seven years from the date of its submission to the States by the Congress.

Article XXIII—(March 29, 1961)—1. The District constituting the seat of Government of the United States shall appoint in such manner as the Congress may direct:

A number of electors of President and Vice-President equal to the whole number of Senators and Representatives in Congress to which the District would be entitled if it were a State, but in no event more than the least populous State; they shall be in addition to those appointed by the States, but they shall be ccnsidered, for the purposes of the election of President and Vice-President, to be electors appointed by a State; and they shall meet in the District and perform such duties as provided by the twelfth article of amendment.

2. The Congress shall have power to enforce this article by appropriate legislation.

B. Government

An account of the governmental system of the United States must be descriptive of the organization of national and state governments. It must also analyze certain of the fundamental characteristics that distinguish the U.S. government from other governments. With this twofold object in mind, the discussion of the constitution and government of the United States is organized on the following plan: (1) the constitutional framework; (2) the federal system; **(3)** judicial review; (4) separation of powers; (5) the independent executive; (6) the national government; (7) state governments; (8) local government in the states; (9) elections and political parties.

1. The Constitutional Framework. — Under a federal system it would be extremely difficult to operate without a written document defining the respective powers of the states and the central government. Consequently, it was to be expected that articles of confederation would be framed for the creation of the first union of the American states and that, when improvement was needed, these articles would be replaced by a written constitution.

There was no similar necessity that written constitutions be framed for the government of the American states. Yet the colonies had been accustomed to written instruments of government. Certain of them operated under royal charters. Massachusetts largely retained the forms of its charter government until 1780, Connecticut until 1818 and Rhode Island until 1842. In most colonies the royal commissions to governors gave some written basis for government. Moreover, the leaders in the colonies were familiar with and largely adherents of the theory that government is a result of social compact, and theories of natural rights were strong.

It was therefore natural that upon separation from England the several states should embody in written form a declaration of their rights and the general organization of their governments. Before the framing of the national constitution, constitutions had been framed and adopted by all the original 13 states except Connecticut and Rhode Island. The framers of the national constitution therefore had before them the texts of state constitutions and were familiar with the experience under these constitutions. Each state is still governed by a written constitution.

The constitution of the United States, framed in 1787 and adopted in 1789, is a brief and well-drafted document. Its influence has been felt, not only in the United States, but in the federal systems of Switzerland, Argentina, Brazil, Canada and Australia. It outlines the organization of the three departments of the national government, defines the powers of that government and the relationship between the nation and the states. The first ten amendments, adopted in 1791, were the direct results of criticisms of the constitution at the time of its adoption and may almost be regarded as parts of the original document (see Bill of Rights, United States). Of the other amendments, the 11th, adopted in 1798, overcame a decision of the United States supreme court to the effect that a state might be sued by a citizen of another state. The 12th amendment, adopted in 1804, corrected a defect in the original constitution as to the method of choosing the president and vice-president. The 13th, 14th and 15th amendments were the immediate outcome of the Civil War. The 13th amendment (1865) abolished slavery, the 15th (1870) forbade denial of the right to vote "on account of race, color, or previous condition of servitude." The 14th amendment (1868), regarded for a while by the courts as limiting itself to the protection of the freed slaves, has become, by expansion of the terms "due process of law" and "equal protection of the laws," the means through which the United States supreme court determines the policy of state enactments in the field of social legislation. The 16th amendment in 1913 gave congress an effective power to levy a federal income tax. Popular election of United States senators under the 17th amendment, adopted in 1913, has somewhat reduced the importance of the state, as did the 18th amendment (1919) transferring the liquor problem to the national government. The 19th amendment (1920) nationalized women's suffrage. The 20th amendment (1933) altered the time of the beginning of terms of president, vice-president, senators and representatives; changed the time for sessions of congress; and provided for certain contingencies which may arise as the result of the death or failure to qualify of a president-elect. The 21st amendment (1933) repealed the 18th amendment and restored the control of intoxicating liquors to the states. The 22nd amendment (1951) limited the presidential tenure of office to two elective terms. The 23rd amendment (1961) gave the residents of Washington, D.C., the right to vote in presidential elections. On the whole. the process of amendment, while to some extent enlarging federal powers, has been less influential in this direction than the decisions of the U.S. supreme court.

2. The Federal System. — A fundamental feature of the U.S. constitutional system is the division of political authority between two levels of government — state and national. The constitution as originally enacted attempted to parcel out power in such a way as to allow the central government to deal effectively with problems that were national in scope while leaving the states free to handle matters that were of purely local concern. It was widely expected that this would leave the states in a pre-eminent position. After the Civil War and especially during the 20th century, however, U.S. history has seen a steady rise in the influence and authority of the national government. Although the states still remain vital centres of legal power in the federal system, they have been increasingly overshadowed in the public eye by the events and personalities of national politics.

The Articles of Confederation, adopted in 1781, constituted a legal symbol of union, but the central government under these articles had no coercive power over the states and no power whatever capable of exercise directly upon the citizens of the states. The national constitution was intended to remedy this situation by creating a central government with large powers and with authority to exercise these powers, not merely upon the states but directly upon all citizens of the country. When the first congress assembled in New York in April 1789, the union had a membership of 11 states. North Carolina and Rhode Island soon joined the states of the original 13 states.

The Role of the States. — Under the original constitution of the United States, the states, as such, are guaranteed their territorial integrity and are expressly recognized as units in the organization of the national government. They have equal representation in the United States senate. They are treated as units in the election of president and vice-president and of members of the national legislature. They have a decisive share in the amendment of the constitution of the United States.

When the national government was being formed, a sharp conflict of interests arose between the small and the large states. The smaller states contended for complete equality among the states in the organization of the national government, and the larger states contended for influence in proportion to population. A compromise was reached by which the states are equally represented in the United States senate, irrespective of population, and in proportion to their population in the house of representatives. By the terms of the constitution no state may without its consent be deprived of its "equal suffrage in the Senate."

Representation in the national house of representatives is based upon population. Under the constitution, each ten years, after the decennial federal census, the congress of the United States determines how many members will constitute the house of representatives. This number is then divided into the total population of the states. In this manner a ratio of representation is obtained. Each state is entitled to as many representatives as this ratio is contained in its population, although each state, no matter how small its population, is entitled to at least one representative. After the division of the representative ratio into the population of each of the states, large fractions of population may remain. and the states having the largest iemainders received additional representatives, as long as the number agreed upon was not exceeded. The problem of fractions presented difficulties. A method known as the method of major fractions was used in 1910; choice of several methods of computation was provided by an act of 1929; and by an act of 1941 the method known as the method of equal proportions was adopted. No apportionment was made after the census of 1920, and provision was made in 1929 for automatic reapportionment of the existing number of representatives in case congress did not enact an apportioning act within 60 days after receiving the decennial statistical information on which apportionment is based. By an act of 1941 automatic decennial reapportionment was provided without change in the existing number of representatives. The number of representatives and the method of apportionment are subject to change by congress. The boundaries of the congressional districts are on the other hand, determined by each state legislature. Using this power, many state legislatures under rural dominance have drawn the lines of congressional districts so as to iavour rurai at the expense of urban or suburban areas.

In the election of the president and vice-president of the United States, the framers of the national constitution provided for so-called electoral colleges. Each state chooses a number of presidential electors equal to the number of its members in the national house of representatives, plus its two senators (thus it was necessary to amend the constitution [art. xxiii] to enable the residents of Washington, D.C., to vote for electors). The plan of the constitution was that these electors should actually exercise a choice as to who should be president. However, almost since the beginning of the government, candidates for the presidency and vice-presidency have been nominated by the great political parties of the country in advance of the choice of electors. These political parties also nominate within each state their candidates for presidential electors. The candidates of any party for electors are usually pledged in advance to vote for the candidates nominated by that party for president and vice-president. For this reason, everybody knows who will be president immediately after the November election, at which the electors themselves are chosen. In this respect, as in others, unwritten law, developed by usage, has altered the operation of the written text of the constitution. In recognition of the fact that presidential electors are merely a device for casting a certain number of votes allotted to the state, at least one-third of the states now provide for a direct vote for candidates for president and vice-president and omit from their ballots the names of candidates for presidential electors. Although each state has power to appoint its presidential electors in such a manner as the legislature thereof may direct, each state has. except in a few cases, chosen such electors by popular vote, its electoral vote then being cast for the presidential candidate with the larger popular vote in the state, even though such vote may not have been a majority.

There have been several proposals for altering the method by which presidents are elected. The simplest of these new plans provides for the abolition of the electoral college and the election of a president by direct popular vote. Another proposal is that the electoral vote in each state be divided among all candidates in proportion to the popular vote they received in that state. It has also been suggested that each state be divided into a number of election districts for the purpose of electing a president, and that single electors be chosen from each district rather than voting for all electors on a state-wide basis as is presently done. The ostensible purpose of these proposals is to prevent the election of a president who has a majority in the electoral college but not in the popular vote. Both Hayes in 1876 and Harrison in 1888 were elected president under the electoral college system although receiving a smaller popular vote than their principal opponents.

Two methods are provided for amending the constitution of the United States. An amendment may be proposed by two-thirds of the members of both houses of congress and goes into effect when ratified by the legislatures of three-fourths of the states or by conventions in three-fourths of the states, as congress shall determine. Congress is required by the constitution to call a convention for proposing amendments on the application of the legislatures of two-thirds of the several states No such convention has ever been called. and until 1933 congress always provided for the ratification of federal amendments by state legislatures rather than by conventions called for this purpose. In 1933 Longress chose the alternate method of ratification and submitted the question of repealing the 18th amendment to state conventions. Adopted later in the year, this proposal became the 21st amendment.

Because of their role in the amending process, the states still have a decisive influence with respect to any change in the national constitution. In other respects, the states have lost some of their prestige as units in the government of the nation. The decreased political importance of the state as a unit in national affairs has been caused in part by the development of rapid means of travel and of communication. The constant shifting of population from one state to another prevented the nener states from developing the solidarity possessed by the original 13. The very increase in the number of states also reduced the importance of each as a unit in the national government.

Furthermore, since the establishment of the federal system national politics has dominated. The ambitious political leader looks to advancement from state to national office. Nominations for the presidency are the most conspicuous prizes in the political system. The popular election of United States senators by each state under the 17th amendment itself tended to reduce emphasis upon the state as a political unit and to treat it as merely an electoral area in the organization of the national government. While the states still determine affirmatively who shall vote in state and national elections, the 15th and 19th amendments forbid discrimination because of race, colour, previous condition of servitude or sex. and the United States supreme court held that the 14th amendmenr forbids state legislation with respect to like discriminations in party primaries. As soon as national and state elections came generally to be held upon the same day. there was a full establishment of the dominance of national politics.

The Division of Power.—The states under the federal system are units in the formation of a nation, not governments independent of a nation. Before the Civil War a number of conflicts arose between national and state power, in nhich first one group of states and then another asserted its authority to proceed indeperdenrly of the nation. Pennsylvania, Massachusetts, Virginia, South Carolina and other states in turn opposed the supremacy of national power under the constitution. The Civil War settled finally and conclusively that the states are merely units, although indispensable units, in the formation of a single national framework of government.

The limitations imposed upon the states by the constitution clearly indicate the purpose of establishing a single national systeni. States are forbidden, without the consent of congress, to "Keep troops. or Ships of War in time of Peace, enter into any Agreement or Compact with another State, or with a foreign Power or engage in War. unless actually invaded, or in such imminent Danger as will not admit of delay." They are forbidden to enter into treaties, alliances or confederations. These types of limitations upon the states indicate a definite purpose to deprive the states of any independent existence as governments in themselves. and this purpose is supported by the language making the "Constitution, and the Laws of the United States which shall be made in Pursuance thereof; and all Treaties made, or which shall be made. under the Authority of the United States" the supreme law of the land.

The power of congress to consent to an agreement or compact by one state with another state is important, particularly where states are close to each other. Such consent has authorized co-operation between states in the construction and use of bridges and tunnels, the apportionment of waters, harbour development, improvement of navigation, flood control. sanitation or abatement of pollution, conservation of fisheries: recreation, crime prevention and the regulation of oil production. Political compacts, however, have not been undertaken between. states.

The powers of the national government are such as are granted to it by the constitution of the United States. They must be found within the terms of that document. It has no others. This basic principle was implied but not expressed in the constitution as first adopted. So important was its expression in the constitutional text regarded that the 10th amendment provides that "powers not delegated to the United States by the Constitution. nor prohibited by it to the States, are reserved to the States respectively, or to the people." The states gave up certain powers in establishing the national government. They set out these powers in a written document and expressly reserved all other pomers to themselves or to the people. The powers of the nation, found within the terms of this written document, are superior to the poners of the states.

Who is to determine, in case of doubt or conflict, whether such a superior power, asserted by the government of the United States, is within the terms of the constitution? Before the Civil War, states often asserted the authority to determine for themselves what powers belonged to the national government, but such assertions were unsuccessful. After 1816 the legol principle nas established that the line between national and state powers is to be drawn by the United States supreme court, an organ of the national government.

What are the powers granted to the national government? Express legislative powers, couched in most cases in broad language, are conferred on congress, by a series of 18 paragraphs in art, i, sec. 8, of the constitution. In even more general terms powers are conferred on the executive and judicial departments of the United States. Certain powers are of such a character that they must be exercised exclusively by the national government, as, for example, the levying of federal taxes, borrowing money on the credit of the United States, constituting federal tribunals inferior to the supreme court and the establishment of a uniform rule of naturalization. Others are made exclusively national by constitutional prohibitions upon the states. The federal power to coin money is supplemented by forbidding states to coin money. The federal war pomers are made exclusive by prohibitions upon the states. The federal treaty-making power is supplemented by forbidding state treaties and by inhibiting state compacts nithout the consent of congress. Other powers are of such a character that they may be exercised by either of two governments, but not by both. The grant of such a power to the national government makes it exclusive.

Of necessity, many of the powers granted to congress are not exclusive. In such matters, states may exercise power also, provided state action does not conflict with the superior powers of the national government in the same field. Congress has complete power to regulate bankruptcies. but during a good part of the time after 1789 there was no federal bankruptcy law, and the matter was left to the states. Congress has only in small part exercised its power to fix the standard of weights and measures. and there is valid state legislation upon this subject in all the states. The constitution itself expressly provides for concurrent authority over the militia. Gnder a general grant of power to regulate interstate commerce. congress has full power, but the states may legislate in regard to local needs and circumstances unless congress otherwise directs.

Although all powers of the national government must be found within the terms of a written document, this by no means implies that all powers must be expressly granted by that document. The constitution of the United States grants a number of important poners in broad terms to congress and to the other departments of the national government. It further empowers congress "to make all Laws which shall be necessary and proper for carrying into Execution the foregoing Powers, and all other Powers vested by this Constitution in the Government of the United States, or in any Department or Officer thereof."

Throughout the earlier decades of government under this constitution, political and legal contests centred about the meaning of the nords "necessary and proper," one party emphasizing the word "necessary" as narrowing the powers conferred and the other the word "proper" as broadening them. The rule of broad and liberal construction announced by Chief Justice John Marshall in 1819 has prevailed:

> Let the end be legitimate, let it be within the scope of the Constitution, and all means mhich are appropriate, which are plainly adapted to that end, and which are not prohibited, but consistent with the letter and spirit of the Constitution, are constitutional.

Substantially all powers not national belong to the states, and such powers must be determined in large part by a process of subtraction. Naturally no precise result can be obtained when the powers to be subtracted are based on broad implications and are not definitely determined. The important national powers with respect to interstate commerce, taxation, treaties, post offices and post roads and maritime jurisdiction have been construed broadly, almost nithout exception.

The United States supreme court has long been engaged in determining the line between national and state power. This is a continuing judicial duty in a federal system. It is impossible to draw any definite or permanent line between national and state functions. The steamboat and the railroad, the telephone and the telegraph, the airplane, the radio and television were potent factors in the development of national power. Railroad regulation began with the states but tended to come almost completely under national control, rapid progress in this direction having been made after the creation of the Interstate Commerce commission in 1887. The so-called antitrust movement began with the states, but restrictive commercial practices came largely under national supervision with the Sherman Anti-Trust act of 1890 and the creation of the Federal Trade commission in 1914. Where a problem is national in character. its solution will by some means fall to the national government. The broad and flexible powers of that government are capable of further expansion as new needs develop with economic. social and technological changes.

Along with the increase in national powers and in the activities of the national government has come also a similar increase in the functions performed by the state government. State governments now do more than ever before and cost more in proportion.

Powers of state governments are broad and comprehensive. Subject only to the condition that the government shall be republican in form, the states organize their own central and local governments and provide revenues for the support of these governments. The state courts administer the great body of law affecting the rights of individuals and for the suppression of crime. Education, though aided by the national government, is under the control of the states and of the local governments created by them. The same statement applies to the construction and maintenance of highways and to the great mass of governmental details with which the citizen comes in daily contact. The American remained in much the position described by James Bryce in the 19th century:

> The State, or local authority constituted by State statutes, registers his birth, appoints his guardian, pays for his schooling, gives him a share in the estate of his father deceased, licenses him when he enters a trade (if it be one needing a license), marries him, divorces him, entertains civil actions against him, declares him a bankrupt, hangs him for murder. The police that guard his house, the local boards which look after the poor, control highways, impose water rates, manage schools—all these derive their legal powers from his State alone.

But attention should be called to the fact that developments after 1933 greatly increased the importance of the national government, not only in the functions which it performs but also in its influence over state governments. Unemployment compensation and old-age pensions are theoretically under state control, but in fact federal control over state action is maintained through conditional federal subsidies and through a federal tax subject to 90% credit upon state compliance with federal requirements. Through a broad construction of federal power to regulate "coinmerce . . . among the several States" there came a federal control over labour disputes and over hours and wages of labour where a substantial part of the commodities dealt with has passed from one state to another or is to be marketed across state lines, or where the transaction is associated with the means of interstate traffic. Through the same power the national government came to determine the planting acreage of crops and the conditions and prices in the marketing of milk. Through the enormous funds spent on public welfare programs the national government also established a substantial role for itself in that area.

Showing up the power of the states depends upon the more efficient conduct of state governments and upon more effective co-operation among the states as to problems which extend beyond the boundaries of a single state. Insurance was in 1944 held subject to control by congress as interstate commerce, but congress left control to the states and the continuance of such state control would most probably depend upon the efficiency and uniformity of state regulation.

The Two Systems of Government. — Throughout the territory of each state two governments operate — the nation with its administrative and judicial organizations for the enforcement of national law and the state with its administrative and judicial organizations for the enforcement of state law. Federal revenues are collected through officers controlled from Washington; state revenues are collected by independent state and local officers. Taxes levied by the two are in some cases similar in character. The nation and a number of states impose income taxes, but their administration is independent. Violations of state law are tried and punished in state courts; violations of national law in separate federal courts. However, a decision by the United States supreme court in 1945 made violation of state law by a state officer punishable in federal courts where the disobedience of state law by the state officer is violative of due process of law under the 14th amendment. In some cases the laws of the two are directed to the same purpose, and are substantially identical. The constitutions of both forbid that a person be twice put in jeopardy for the same offense, but in legal theory the two governments are so distinct that one act, forbidden by substantially identical laws of each, may be punished by each as a separate offense.

The reasons for this sharp distinction between the two governments are historical. The Articles of Confederation sought to act through the governments of the several states and not directly upon the citizens of the states. Government under these articles faiied because each state finally determined for itself whether it would enforce the policies of congress. The national government, organized under the constitution, had it thought proper, might have sought to use the states as agencies for the enforcement of national law, as is largely done under the federal system of Switzerland. But under the circumstances it was natural to build up an independent sdministrative and judicial system. This system has steadily grown with the expansion of national activities.

For many years it was the established principle in the United States that the exercise of independent powers by the nation and the state forbade either government to tax the employees or securities of the other. This principle, which was based on the theory that "the power to tax is the power to destroy," was later in large part replaced by the principle that each government may without discrimination tax the income of employees of the other; and the same principle may eventually be applied to the taxation of securities issued by the national, state and local governments. However, the U.S. supreme court expressed the view that the national government may enter upon an enterprise personal in nature and forbid state taxation thereon, but that a similar state enterprise may be taxed by the national government.

3. Judicial Review. — The constitution was regarded from an early date as law of a superior order and of a more permanent character than legislative acts. Under the first state constitutions legislatures were the dominant organs of government. They abused their wide powers and helped develop a feeling that legislative authority should in some measure be curbed. In New Jersey in 1780 a statute was declared invalid as violative of the state constitution. Other decisions of this character gradually accumulated. Apparently the framers of the federal constitution were of the opinion that it would be the iunction of the federal courts to preserve the powers of state and nation under the federal constitution. Such a power in the federal courts carries with it authority, in a case involving the issue, to declare either a federal or a state law invalid as violative of the constitution of the United States. Since Chief Justice Marshall's opinion in 1803, in *Marbury* v. Madison, the principle of judicial power to declare laws unconstitutional has been established in the federal system. The authority of state courts to declare state laws invalid as violative of state constitutions is equally well established. Except for a few provisions which are regarded as committed to the political organs of government, it may therefore be said that placing language in a written constitution makes such language judicially enforceable as against the legislative bodies. Whereas parliament is the supreme lawmaker under the English system of government, in the United States the written constitution as finally construed by the courts is supreme. Where constitutional provisions are clear and precise, this supremacy of the constitution as judicially construed makes little difficulty. But where language is used that is not capable of precise definition, as that of the 14th amendment that no state shall "deprive any person of life, liberty, or property without due process of law," the court may in fact determine not only the constitutionality but also the wisdom of legislative action.

The exercise of broad judicial power in such a manner as to control legislative policy has, however, largely ceased; the "due process of law" clause, the principle of the separation of powers and the broad language of the constitution with respect to federal powers are now construed not only in such a manner as to enlarge national authority but also in such a manner as to leave larger powers in the hands of the political departments of government— the president and the congress in the national system.

Not the least important function of the courts in the U.S. system of government is the protection of individual and minority rights from encroachment by the state. This is a highly controversial side of the supreme court's activity, since it brings the judiciary into conflict with the executive and legislative branches of government. Thus, a primary characteristic of civil and political rights in the United States is the fact that they are judicially enforceable even against congress and the president. In England on the other hand, civil liberties rest upon the support of public opinion rather than the courts.

4. Separation of Powers. — National and state governments in the United States are each organized into three departments. The theory of separation of powers is formally announced in 40 state constitutions. In the remaining state constitutions and in the constitution of the United States the same constitutional result arises from the fact that these documents create three departments of government and vest the legislative power in one, the executive power in another and the judicial power in a third.

There are no clear lines separating one governmental function from another, and the courts have therefore been unable to develop consistent lines of division. Legislative power having once been delegated to congress and the state legislatures, the courts frequently say that legislative power may not be further delegated, but the very necessities of modern life hare made it necessary, in the United States as in England and on the continent, to vest a large amount of subordinate legislative authority in permanent administrative bodies within the executive department. In order to avoid terming this a delegation, the courts have come to designate such powers as quasi-legislative, rather than legislative. In the same manner, administrative bodies within the executive department have come to exercise powers that are sustained on the ground that they are quasi-judicial rather than judicial. The result is therefore not dissimilar from that in countries that have not attempted to set up three separate departments through judicially enforceable constitutions. But such flexibility as develops under the U.S. plan comes more slowly and can be achieved only with judicial approval. A study of U.S. political institutions must, therefore, always take into account the greater rigidity in governmental structure resulting from the constitutional principle of separation of powers, although that rigidity has been to a large extent abandoned through less strict judicial construction.

5. The Independent Executive. — The federal government and the states of the United States have adopted the presidential system of executive leadership as distinguished from the cabinet or ministerial system found in England and most other countries. Under the presidential system there is an independent executive

(president or governor) elected for a fixed term and holding office during that term irrespective of whether he is or is not in political harmony with both legislative bodies or either of them. The members of the legislative bodies are elected at fixed times and for fixed terms, and no power is vested in the executive to dissolve them or to force elections at any other times than those fixed. The principle of separation of powers as applied in the United States precludes any member of the executive department from having a seat in a legislative body. Under this system the president or governor has real executive authority, and in all states but North Carolina the governor has and exercises large power to control legislation by an executive veto. Under the presidential system, the executive and the legislature may at times not be in political harmony. This is, in fact, the case in many of the states and in the national system. In the states of New York and New Jersey, for example, the governors have often been members of the Democratic party, while both houses of the state legislature have been controlled by the Republican party. The power ordinarily vested in the legislative bodies to impeach and remove the executive is judicial in character, and efforts have only occasionally been made to employ the power of impeachment to remove an executive politically hostile to the two houses of the legislature. In 1868 such an effort was made, unsuccessfully, to remove Andrew Johnson from the presidency of the United States.

The presidential system has some disadvantages as compared with the cabinet form of government, but it accords with the U.S. doctrine of separation of powers. When the country faces a crisis, as during the Civil War and World Wars I and II, popular sentiment maintains political harmony between the president and congress; and the executive tends to become the dominant factor in government. The presidential system of the United States in fact met the serious problems of the world wars with less difficulty than did the ministerial systems of England and France.

***6. The* National Government.**—Congress.—Legislative power in the national system is exercised by a congress composed of two houses. The two houses have grown—the senate from 26 to 100 members, and the house of representatives from 65 to 435 members.

With respect to the house of representatives, art. i, sec. 2 of the constitution provides that: "when vacancies happen in the Representation from any State, the Executive Authority thereof shall issue Writs of Election to fill such Vacancies." With respect to the senate, the 17th amendment provides that: "when vacancies happen in the representation of any State in the Senate, the executive authority of such State shall issue writs of election to fill such vacancies: Provided, That the Legislature of any State may empower the Executive thereof to make temporary appointment until the people fill the vacancies by election as the Legislature may direct."

United States senators are elected for six-year terms, and terms are so arranged that one-third of its members retire every two years. From 1913 the elections in each state have been by popular vote of the whole state, except that temporary appointments to fill vacancies are permitted. Members of the house of representatives are elected for two years, and the whole membership changes at the same time. Each state is required to be divided into districts equal to the number of members it has in the house of representatives; but if the number of representatives apportioned to a state is increased, and the state legislature makes no reapportionment of districts within the state, then the additional representative or representatives are elected by the state at large; if the number of representatives apportioned to a state is decreased, and the state legislature makes no reapportionment of districts within the state, then all representatives are elected by the state at large. Each member of the house of representatives is required to be a resident of the state from which he is chosen; political and sectional interests make it practically impossible for a person to be elected for a district within the state in which he does not reside. The result is that an able and experienced person ceases to be a member of congress if he fails of re-election by his district. In addition to the elected members, one resident commissioner from Puerto Rico has a seat in the house but does not have a vote.

Prior to the adoption of the 20th amendment the president, vice-president, senators and members of the house of representatives assumed office on March 4 following their election; and the congress met annually on the first Monday of December. Under this plan newly elected members of the senate and house, elected in November of an even-numbered year, did not take office until March 4 of the succeeding year; and, unless the president called a special session of congress, the newly elected members did not actually begin to function until the regular session in the succeeding December, more than a year after their election. It was possible that the session meeting from Dec. 3 of the even-numbered year until March 4 of the odd-numbered year be controlled by members who had already failed of re-election, and who might therefore be regarded as no longer representing their constituents. In order to avoid control of a session of congress by defeated members, who were termed "lame ducks," the 20th amendment was adopted, under which the terms of the president and vice-president begin on Jan. 20 following their election; the terms of senators and representatives begin on Jan. 3 following their election and congress assembles each year on Jan. 3. The regular sessions of congress usually adjourn in the early summer. The president may on extraordinary occasions convene the two houses in special session.

The organization and procedure of the two houses of congress are to a limited extent determined by congress and to a larger extent by the size and traditions of the two houses. The rules of the senate permit great freedom of debate; those of the house of representatives restrict debate and expedite business. Under the senate rules obstructive tactics may be and are often resorted to, though such tactics relate in fact to relatively few measures. The house of representatives, with its larger membership, would be helpless with complete freedom of debate, yet both houses accomplish a large amount of legislative business.

The house of representatives elects from its own members a speaker as presiding officer. The vice-president of the United States is the presiding officer of the senate. The work of both houses is largely done in committee. The committee systems of both houses developed largely by accident and many committees in each house, once created for important tasks, remained long after their usefulness had ceased. The senate in 1921 and the house of representatives in 1927 reorganized their committees and materially reduced their number. But further increases immediately began, and multiplicity of committees, with conflicts of their jurisdiction in each house, led to confusion and interfered with joint action by committees of the two houses. With legislation enacted in 1946, 15 standing committees replaced 32 in the senate and 19 replaced 48 in the house. The act also specifically defined the authority of each committee, and encouraged co-operation between the two houses. Under this system subcommittees have tended to proliferate.

Committees in each house are controlled by the political party having a majority of the members of that house. Appointment to important committees is based largely on seniority in term of service: and a member serving continuously over a long period is likely to become chairman of an important committee if his political party is in control. Seniority as such naturally plays a larger part in the house of representatives than in the senate with its smaller number of members, though the business of the senate is in good part controlled by a small group of experienced members. Leadership in the two houses is always exercised by a few members of the dominant party. For many years before 1911 the real leadership in the house of representatives was largely vested in the speaker, who made the appointments to standing committees. After 1911 the speaker was relegated more distinctly to the position of presiding officer, and committees were elected by the house itself on the basis of selections first made by the party organizations. The majority and minority floor leaders have large influence. In the senate there is less individual leadership than in the house of representatives. (See also CONGRESS, UNITED STATES.)

The National Executive.—In discussing the presidential system, the relation between the president and congress has been generally described. Originally there were no constitutional limitations upon a president succeeding himself, but a tradition long existed that a president should not serve for more than two terms, a tradition based on the example set by Washington and other early presidents. This tradition was broken by Franklin D. Roosevelt. who was elected successively in 1932. 1936, 1910 and 1944, and who served from 1933 until his death on April 12, 1935. The 22nd constitutional amendment. proposed in 1937 and ratified by three-fourths of the states in 1951, provides that: "No person shall be elected to the office of the President more than twice, and no person who has held the office of President. or acted as President, for more than two years of a term to which some other person was elected President shall he elected to the office of the President more than once." This amendment was made specifically inapplicable to the person holding the office of president during the time of proposal and adoption of this amendment.

The constitution expressly authorizes the president to make certain appointments to office and the expansion of the national administration has greatly increased the number of officers owing their appointments to him. The more important appointments are subject to confirmation by the senate. The United States supreme court has determined that where power to appoint to an executive office is vested in the president, this carries with it a complete power to remove from office. It was an effort on the part of congress to impose restrictions upon the president's power to remove even his more direct advisers that led to the impeachment of President Johnson. who escaped conviction by one vote. However, the president's power of removal may be limited by act of congress with respect to quasi-legislative or quasi-judicial officers. who are required to discharge their duties independently of executive control: and the use of such officers (particularly as members of independent commissions) has greatly increased with the extension of federal control with respect to commercial transactions of various types. including labour disputes and the activities of the transportation mediuins.

The president's control over the national executive administration is primarily exercised through the heads of ten executive departments. appointed by the president. These departments are: department of state; department of the treasury: department of defense; department of justice; post office department; department of the interior; department of agriculture; department of commerce; department of labour; department of health, education and welfare. Department heads (the cabinet) are responsible to the president. and the extent to which he meets with them and seeks their advice rests entirely on his discretion. In addition to these ten departments there are numerous hoards and offices. The federal executive organization under the president is not systematically organized by the constitution, and plans for its reorganization came under consideration early in the 20th century. During World Wars I and II the creation of new governmental agencies was necessary. and wide powers were conferred upon the president to redistribute the functions of governmental agencies. The need for reorganization in time of peace had become increasingly apparent n-ith the expansion of activities of the national government. Definite steps toward such reorganization were taken by an act of congress in 1933 which vested some power in the president for a two-year period and by an act approved April 3, 1930. which vested authority in the president to submit reorganization plans to congress before Jan. 21, 1931, the organization submitted by the president to take effect within 60 days after submission unless the two houses should disapprove by concurrent resolution. Substantial improvements were obtained under this act. Some readjustments were obtained under a similar act of 1935, which. however, did not give sufficient power to the president. A reorganization act of 1949 was based upon investigation by a commission headed by former President Hoover. Under this act the president might submit reorganization plans to take effect upon the expiration of the first period of 60 calendar days of continuous session of congress. unless rejected by a so-called constitutional majority of one of the tno houses of congress. All presidents since Franklin Roosevelt have been granted extensive reorganizational authority. (See also GOVERNMENT DEPARTMENTS : *United States.*)

The great mass of the lesser employees are selected under a merit system, for whose conduct a civil service commission was first created in 1883. (See CIVIL SERVICE: *The United States.*) The finances of the national government were to a large extent systematized through the creation of a bureau of the budget in 1921 and through an improved committee organization effected in the house of representatives in 1927 for the consideration of national appropriations and expenditures.

The president's influence in the national government rests upon (1) powers granted him by the constitution and by federal statute; (2) political factors not found in constitutions or statutes; (3) the personality of the president,

The president's position as head of a large executive organization, with wide powers of appointment and removal, in itseli makes the position important. The authority to veto legislation. subject to being overridden by two-thirds of the two houses, gives him a power that may be employed with effect. The authority to recommend measures to congress is only oi such value as may be given to it by the position and influence of the president making the recommendation. He is charged with the conduct of foreign relations, though here his authority is materially crippled by the requirement that two-thirds of the senators must concur in treaties. But the president's political position is equally as important as his constitutional power. He is in effect the chieftain of his party. He is also the outstanding figure in U.S. politics.

The possibilities of exercising power are great. The extent to which power is actually exercised depends upon the personality of the prcsident and his capacity for political leadership. The influence of the presidency varies with the man who occupies the office and with the circumstances that surround him. as in time of war.

As far as the vice-president is concerned. his chief official duty is to preside over the senate. though he does not play a direct part in the deliberations of that body. He does cast a deciding vote. however, in the case of a tie. In the absence of the president he presides over cabinet meetings. Under Presidents Truman and Eisenhower an increasing effort was made to elevate the position of the vice-president by granting him mcinbcrship on the National Security Council and in other ways.

The machinery for nominating party candidates ordinarily chooses a vice-presidential candidate almost purely on the basis of political expediency and with little consideration of the fact that the vice-president may succeed to the presidency. Yet within the first half of the 20th century three vice-preiidents — Theodore Roosevelt. Coolidge and Truman—succeeded to the presidency as a result of death. arid thereafter were elected to the office.

In the case of death or disqualification of both president and vice-president, the Presidential Succession act of 1947 provided that succession to the presidency be first to the speaker of the house of representatives; nest to the president pro tempore of the senate: and successively to members of the cabinet who are heads of departments.

The president receives for his services the sum of $100.000 per year with an added $50,000 per year for expenses. The salary of the vice-president is $30.000 per year.

Federal Judiciary.—The constitution of the United States provides for a supreme court and "such inferior courts as the Congress may from time to time ordain and establish." For the enforcement of federal law, congress has provided a complete judicial system paralleling that of the states. The judges of these courts are appointed by the president of the United States and hold their offices during good hchaviour. They are removable only by the cumbersome machinery of impeachment.

At the head of the judicial system is the supreme court of nine justices, which sits at Washington, D.C. There are 11 judicial circuits of the United States. each with at least 3 judges, one being the District of Columbia with 9 judges, the 11 together having 68 circuit judges. To each circuit is assigned a justice of the United States supreme court. one of the justices being assigned to two circuits and the chief justice being assigned to both the District of Columbia and an additional circuit. The pressure of business in the United States supreme court, hcwever, has made it impossible for the justices of the supreme court to go on circuit. The district court is the court of original jurisdiction. In erecting districts for the organization of this court. states lines are regarded. The smaller states constitute single districts; the larger are divided. For the districts in which federal judicial business is especially heavy, more than one district judge is provided. For example, four districts with 26 judges exist in New York. There are 93 districts with more than 200 judges, and the number of judges constantly increases. In addition to the general system of courts here outlined, there are a court of claims, court of customs and patent appeals, the tax court of the United States and federal courts for the District of Columbia and the territories.

With the two systems of courts — federal and state — exercising jurisdiction over the same territory, it is necessary that there be certain principles as to their relationship. Such principles may be chiefly summarized as follows:

1. On questions of federal constitutional lam, the United States supreme court is the final court of review. If the highest court of a state holds a federal statute or treaty to be invalid, or a state statute valid that is alleged to violate the federal constitution or federal statutes, the losing party has a right to appeal to the highest federal court. Where federal constitutional issues are otherwise involved in state courts, the United States supreme court may, in its discretion, review the state decision.

2. Substantially all cases involving enforcement of criminal law of the federal government are tried in federal courts.

3. With few exceptions, cases of admiralty and maritime jurisdiction and bankruptcy proceedings are tried in the federal courts.

4. Under federal statutes, the federal courts alone have jurisdiction of suits against the Cnited States, and of suits for the enforcement of federal revenue, immigration and other similar laws directly affecting the administration of the federal government.

5. In civil cases involving as much as $3.000, and (a) arising between citizens of different states or (b) arising under the constitution, lans or treaties of the United States, the parties have the choice of suing either in state or federal courts; but if the plaintiff sues in the state court, the defendant may transfer the case to the federal court.

6. By statute it is provided "that the laws of the several States, except where the constitution, treaties or statutes of the United States otherwise require or provide, shall be regarded as rules of decision in trials at common law, in the courts of the United States, in cases where they apply." By decisions of the United States supreme court, the federal courts must apply not only state statutes but also the law as found in the decisions of the state courts. Until the adoption of uniform rules of civil procedure for United States district courts in 1937, the procedure in such courts in cases at common law was required to conform, as near as may be, with the procedure "in like causes in the courts of record of the State within which such district courts are held."

Through legislation of 1925 an effort has been made to reduce the number of cases that must be decided by the United States supreme court. That court has a limited original jurisdiction, the most important cases of such jurisdiction being cases to which a state is a party. Cases not infrequently arise in which one state sues another state. Aside from its original jurisdiction. cases come to the Cnited States supreme court either from the highest state courts or from the lower federal courts. The decisions of the Cnited States supreme court are of primary importance in the fields of constitutional and public law. (See also SUPREME COURT OF THE UNITED STATES, THE.)

7. State Governments. — The state governments of the United States have certain common characteristics. Each state is legally the equal of every other state in the federal system. Each controls the organization of its own state and local governments. Each has a written constitution providing for three departments of government, with a legislature of two houses (with one exception) elected by popular vote and a popularly elected governor as head of its executive department. Each state has a judicial system not essentially dissimilar in external organization from that of the other states. Each state has created'local governing areas for the performance of certain functions.

Superficially, all the state governments appear to be more or less alike and appear to be doing the same things. The constant shifting of population has prevented the development of sharp differences in governmental organization. Not only this, but from one state to another there has been a great deal of copying of political and legal institutions. However, each state is distinguished from other states, not only in size and population, but also in location, climatic conditions and resources; and these differences reflect themselves in the political and governmental organization of the states.

State Constitutions. — The constitutions in force in the states vary a great deal in length and in content. Some were adopted in an earlier period, and some bear recent dates. The constitution of Connecticut, adopted in 1818, together with subsequent amendments, requires only about 16 printed pages; the Louisiana constitution of 1921 requires 90 pages. The constitutions of Oklahoma, California and a number of other states are highly detailed. Massachusetts boasts that it is governed by the constitution of 1780; but this constitution has been altered in form by so many amendments that it would hardly be recognized by its original framers. By amendment or by the adoption of new constitutions, the states have attempted to readjust their institutions to. meet changing needs. The national constitution has proved a model for much of the development in the field of state constitutional history, particularly with reference to the establishment of three co-ordinate departments of government.

In most of the states the state constitutions organize three departments of government in some detail. They contain elaborate declarations or bills of rights, and most of them contain provisions regarding the organization of local government. Limitations on the power of state legislatures have multiplied. Moreover, the framers of constitutions are inclined to include in these documents regulations of any matters of great public interest at the time. State constitutions have in this way come to contain many matters of temporary detail, and such detail requires frequent amendment.

The state constitutions provide for methods of change. The methods employed are three: (1) constitutional conventions; (2) legislative proposal of amendments; (3) proposal by popular initiative petition. All but 12 of the state constitutions expressly provide for constitutional conventions; in all of these 12 it is recognized as proper to employ conventions for constitutional change. Ordinarily conventions assemble as a result of popular vote and submit their recommendations for popular approval.

Proposals of constitutional amendment may be made by the legislatures in all states except New Hampshire where chdnges may be made only by constitutional convention. Methods of amendment through legislative proposal differ, but in all states except Delaware a legislative proposal of amendment must be submitted to and approved by popular vote before it becomes effective. Details of the amending process vary. In some states. as California. Louisiana and New York, the adoption of amendments through legislative proposal is easy; in others, as Illinois and Minnesota, the constitution is substantially impossible to amend.

The proposal of constitutional amendments through popular initiative petition, folloned by popular vote, is a fairly late development; but this plan was adopted by 14 states. Among these states there is varying ease or difficulty in employing the initiative plan of amendment. In Oregon and four other states it is as easy to amend the constitution through initiative petition and popular vote as it is to enact a statute through the same devices. Where the plan of popular initiative has been adopted, it has merely been added to the two already existing devices of constitutional conventions and proposals by legislative action.

State Legislatures. — In all of the states except Nebraska, legislative power is exercised by a body composed of two houses. Constitutional amendments for the organization of a legislative body composed of only one house were proposed in Oregon in 1912 and 1914, in Oklahoma in 1914 and in Arizona in 1916. All of these proposed amendments failed, but the plan of a unicameral legislature was adopted by Nebraska in 1934. After Vermont abandoned

TABLE XVII.—State Flowers, Birds, Trees, Mottoes and Nicknames

State	State flower	State bird	State tree	State motto	Nickname is)—or slogan
United States	Goldenrod □ Columbine □	Bald eagle □		"In God We Trust"	—
Alabama	Camellia	Yellowhammer	Longleaf (southern) pine	Andemus jura nostra defendere ("We Dare Defend Our Rights")	Cotton state, Yellowhammer state, Lizard state, Heart of Dixie (slogan) △
Alaska	Forget-me-not	Alaska willow ptarmigan	(none)	(none)	The Last Frontier, America's icebox
Arizona	Saguaro cactus blossom	Cactus wren	Paloverde	Ditat Deus ("God Enriches")	Grand Canyon state, Apache state
Arkansas	Apple blossom	Mockingbird	Short-leaf pine	Regnat populus ("The People Rule")	Land of Opportunity, Wonder state
California	Golden poppy	California valley quail	Sequoia semper-virens (redwood)	Eureka ("I Have Found It")	Golden state
Colorado	Rocky mountain columbine	Lark bunting	Colorado blue spruce	Nil sine numine ("Sothing Without the Deity")	Centennial state
Connecticut	Mountain laurel	Robin	White oak	Qui transtulit sustinet ("He Who Transplanted Still Sustains")	Nutmeg state, Constitution state, Land of steady habits
Delaware	Peach blossom	Blue Hen chicken	American holly	"Liberty and Independence"	The First state, Diamond state, Peach state
District of Columbia	American beauty rose	—	—	Justitia omnibus ("Justice to All")	Our nation's capital
Florida	Orange blossom	Mockingbird	Palmetto palm (cabbage palmetto)	"In God We Trust"	Sunshine state, Peninsula state
Georgia	Cherokee rose	Brown thrasher	Live oak	"Wisdom, Justice and Moderation"	Empire state of the south, Peach state, Cracker state
Hawaii	Red hibiscus	Nene □ (Hawaiian goose)	Kukui	Ua Mau Ke Ea O Ka Aina Ka Pono ("The Life of the Land Is Perpetuated in Righteousness")	Aloha state
Idaho	Syringa	Mountain bluebird	Western white pine	Esto perpetua ("May You Last Forever")	Gem state
Illinois	Sative Violet	Cardinal	Oak	"State Sovereignty, National Union"	Prairie state, Land of Lincoln (slogan), Sucker state
Indiana	Peony	Cardinal	Tulip tree	"The Crossroads of America"	Hoosier state
Iowa	Wild rose	Eastern goldfinch	(none)	"Our Liberties We Prize; and Our Rights We Will Maintain"	Hawkeye state, Corn state, Breadbasket state, The beautiful land
Kansas	Sative sunflower	Western meadow lark	Cottonwood	Ad astra per aspera ("To the Stars Through Difficulties")	Sunflower state ◇
Kentucky	Goldenrod	Cardinal	Tulip tree	"United We Stand, Divided We Fall"	Bluegrass state
Louisiana	Magnolia	Eastern brown pelican □	Magnolia	"Union, Justice and Confidence"	Pelican state, Creole state, Bayou state, Sugar state
Maine	White pine cone and tassel	Chickadee	White pine	Dirigo ("I Guide")	Pine tree state
Maryland	Black-eyed Susan	Baltimore oriole	White oak	Scuto bonae voluntatis tuae coronasti nos ("With the Shield of Thy Good Will, Thou Hast Covered Us")	Free state, Old Line state
hfassachusetts	Mayflower (Trailing arbutus)	Chickadee	American elm	Ense petit placidam sub libertate quietem ("By the Sword We Seek Peace, But Peace Only Under Liberty")	Bay state, Old Bay state, Puritan state, Baked Bean state, Old Colony state
Michigan	Apple blossom	Robin	White pine	Si quaeris peninsulam, amoenam circumspice ("If You Seek a Pleasant Peninsula, Look About You")	Wolverine state, Water Wonderland (slogan)
Minnesota	Pink and white lady's-slipper	Loon	Red pine	L'Etoile du Nord ("The Star of the North")	North Star state, Gopher state, Land of 10,000 Lakes (slogan), Land of Sky-blue Waters (slogan)
Mississippi	Magnolia	Mockingbird	Magnolia	Virtute et armis ("By Valor and Arms")	Magnolia state, Hospitality state

the unicameral system in 1836, the Nebraska legislature of 1937 was the first to be so organized. It is composed of a single chamber of 43 members elected on a nonpartisan basis. In all other states, the smaller of the two houses is called the senate. All but eight of the states call their larger house a house of representatives. but the eight have such varying titles as assembly, general assembly and house of delegates. Nearly half of the states use the term legislature to designate the two houses together; but 20 use the term general assembly and 3 use the term legislative assembly. Massachusetts uses the term general court, which was first employed in the colonial charter and New Hampshire uses the same term. In view of the fact that the legislative bodies have somewhat varying names in the several states, it has been customary to refer to the larger of the two houses as the lower house and to the smaller as the upper house.

To a large extent the exact number of members of the two houses, or of one of the two houses, is left to legislative determination. subject to constitutional restrictions. The size of the two houses varies a good deal from one state to another. The Minnesota senate is the largest, with 67 members, and that of Hawaii the

TABLE XVII.—*State Flowers, Birds, Trees, Mottoes and Nicknames (continued)*

State	State flower	State bird	State tree	State motto	Nickname (s)—or slogan
Missouri	Hawthorn	Bluebird	Dogwood	Salus populi suprema lex esto ("Let the Welfare of the People Be the Supreme Law")	Show Me state
Montana	Bitterroot	Western meadow lark	Ponderosa pine	Oro y plata ("Gold and Silver")	Treasure state
Nebraska	Goldenrod	Western meadow lark	American elm	"Equality Before the Law"	Cornhusker state, Beef state, Tree Planter's state
Nevada	Sagebrush	Mountain bluebird □	Single-leaf piñon	"All for Our Country"	Sagebrush state, Silver state, Battle Born state
New Hampshire	Purple lilac	Purple finch □	Paper birch	"Live Free or Die"	Granite state
New Jersey	Purple violet	Eastern goldfinch	Red oak	"Liberty and Prosperity"	Garden state
New Mexico	Yucca flower	Road runner	Piñon	Crescit eundo ("It Grows As It Goes")	Land of Enchantment, Sunshine state ⧍
Sew York	Rose	Bluebird □	Sugar maple	Excelsior ("Ever Upward; Higher")	Empire state
North Carolina	Dogwood	Cardinal	(none-southern pine predominates)	Esse quam videri ("To Be Ratber Than to Seem")	Tar Heel state, Old North state
North Dakota	Wild prairie rose	Western meadow lark	American elm	"Liberty and Union, Now and Forever, One and Inseparable"	Flickertail state, Sioux state
Ohio	Scarlet carnation	Cardinal	Ohio buckeye	"With God All Things Are Possible"	Buckeye state
Oklahoma	Mistletoe	Scissor-tailed flycatcher	Redbud	Labor omnia vincit ("Labour Conquers All Things")	Sooner state
Oregon	Oregon grape	Western meadow lark	Douglas fir	"The Union"	Beaver state
Pennsylvania	Mountain laurel	Ruffed grouse	Hemlock	"Virtue, Liberty and Independence"	Keystone state
Rhode Island	Violet	Rhode Island red	Red maple □	"Hope"	Little Rhody, Plantation state
South Carolina	Yellow jessamine	Carolina wren	Cabbage palmetto	Animus opibusque parati and Dum spiro spero ("Prepared in Mind and Resources' and "While I Breathe I Hope")	Palmetto state
South Dakota	American pasque flower	Ring-necked pheasant	Black Hills white spruce	"Under God the People Rule"	Coyote state, Sunshine state, Land of Infinite Variety ◇
Tennessee	Iris	Mockingbird	Tulip tree	"Agriculture and Commerce"	Volunteer state
Texas	Bluebonnet	Mockingbird	Pecan	"Friendship"	Lone Star state
Utah	Sego lily	Sea gull	Blue spruce	"Industry"	Beehive state, Deseret
Vermont	Red clover	Hermit thrush	Sugar maple	"Freedom and Unity"	Green Mountain State
Virginia	Dogwood	Cardinal □	Flowering dogwood	Sic semper tyrannis ("Thus Ever to Tyrants")	Mother of Presidents, The Old Dominion, Cavalier state
Washington	Coastal rhododendron	Willow goldfinch	Western hemlock	Al-Ki ("Bye and Bye")	Evergreen state, Chinook state
West Virginia	Rhododendron maximum (big rhododendron)	Cardinal	Sugar maple	Montani Semper Liberi ("Mountaineers Are Always Freemen")	Panhandle state, Mountain state ◇
Wisconsin	Wood violet	Robin	Sugar maple	"Forward"	Badger state, America's dairyland (slogan) ◇ ⧍
Wyoming	Indian paintbrush	Meadow lark	Balsam poplar (cottonwood)	"Equal Rights"	Equality state, Wonderful Wyoming, Sagebrush state, Cowboy state

□ Unofficial.
◇ State animal: Kansas, American buffalo (bison); South Dakota, cqyote; West Virginia, black bear; Wisconsin, badger and white-tailed deer (wildlife).
⧍ State fish: Alabama, tarpon; Wisconsin, muskellunge; New Mexico, cutthroat trout.

smallest, with 15. The size of the lower house ranges from 24 in Alaska to 443 in New Hampshire. The membership of the lower houses is especially large in several of the New England states because of the system of town representation, but in these states the senate is relatively small.

In a majority of states, senators are elected for four years and representatives for two years. In some states, one-half of the members of the senate are elected every two years, so that the senate has continuous membership, as contrasted with the house, whose membership is chosen as a whole at each election. In Alabama, Louisiana, Maryland and Mississippi, however, four-year terms have been provided for members of both houses; and a number of states have a two-year term for members of both houses.

In some states financial measures must originate in the lower house, and in most of the states the senate has certain powers with respect to confirmation of executive appointments. The provisions for impeachment of public officers also ordinarily prescribe that charges shall be brought by the lower house and tried by the senate. On the whole, however, it may be said that from the standpoint of legislation the two houses of state legislature have equal powers and do not represent different points of view in the community. Distinct differences that existed in many states in earlier times have substantially ceased to exist, although in a number of states differences in territorial representation have grown up.

In the earlier state governments the substantially equal representation of local areas was not grossly unfair, because of the absence of great inequalities in their population. To a large extent, the idea of geographical representation survives in a number of states. The lower houses of Connecticut, New Hampshire and

Vermont, and both houses of Rhode Island, are based upon town representation, and with the growth of large urban communities this basis has become highly unequal. The same situation prevails elsewhere in the country. A study published in 1955 showed only two states—Massachusetts and Wisconsin—with equal representation in both houses of the legislature.

This representative system is the result of two conflicting forces. In most of the states some attention is paid to local governmental areas. It is common for constitutional provisions to forbid the crossing of county boundaries in the establishment of representative areas. On the other hand, the principle of equal representation upon the basis of population has steadily developed. The commoner plan is to provide for the periodical reapportionment of membership in the two houses upon the basis of population. Delaware, however, permits a reapportionment only by constitutional change; and other states, while providing for periodical reapportionment, limit the basis of representation in such a manner as to preserve an inequality. In California, New York and some other states representation in one house is based on population and in the other in large part upon the counties as units, in an effort to balance urban and rural interests and to prevent domination of the legislature by a single large community.

Members of the state legislature are chosen from local districts by popular vote. Proportional representation has been proposed, but has not been adopted for the choice of members of state legislatures, although in municipal elections it has come to some use. All states adopt the plan under which a candidate is elected who receives a plurality of the votes in his district; though Illinois from 1870 provided for three members of the lower house in each electoral district, each voter having the choice of voting for three or cumulating his votes for one or two candidates.

Under the first state constitutions provision was generally made for the annual election of members of legislative bodies and for annual legislative sessions. Frequent and regular sessions of the legislature were deemed essential safeguards of popular rights and were at that time thought sufficient safeguards. By mid-20th century, however, most state legislative bodies met in January of odd-numbered years. Constitutions ordinarily prescribe the number of days for which the session may continue, Biennial sessions are held in even years in Kentucky, Mississippi and Virginia. Annual sessions are held in 19 states. Massachusetts adopted the plan of biennial sessions in 1938 and returned to annual sessions in 1944. Alabama and Mississippi experimented for a time with quadrennial sessions.

As is the case with congress, the work of state legislatures is largely done through committees. There is little in the way of an effective legislative program or organized leadership in the two houses. A number of states have sought to devise a more definite legislative policy through the creation of legislative councils composed of representatives of the two houses, such councils to remain continuously in existence and to consider important matters of legislation with the aid of a permanent body of experts. An efficient and influential governor occasionally exercises a distinct leadership in important matters of constructive legislation, but over legislative enactments in general his influence is negative rather than affirmative.

The governor has a veto power over legislation in all of the states except North Carolina; and the veto can, in most of the states, be overcome only by a two-thirds vote, although only a three-fifths vote is required in some states and a bare majority in others. There has also been a definite increase of the governor's control over appropriations, through the vesting in him of a power to veto items in appropriation bills. Such a power exists in all but ten of the states. There has been a tendency in some states to extend the governor's veto power still further. The Washington and South Carolina constitutions confer upon the governor the power to veto any item or section of a bill presented to him, and a similar power exists in Alabama. In addition, several states have given the governor wide powers with respect to the state budget.

The veto power is not an idle weapon in the governor's hands. Its use and effectiveness depend upon several factors—the extent of the governor's constitutional power, the personality of the governor and the political agreement or disagreement at the time between the governor and the two houses. Of about 16,500 measures passed in 1923, for example, by the legislatures of 44 states, more than 1,100 were disapproved in their entirety, and more than 1.000 parts of bills were disapproved. Of the bills disapproved, 104 were repassed by legislatures; and of the parts vetoed, only 40 were repassed.

State Executives.—In the first state constitutions the executive department was subordinate to the legislature. In most states the governor and certain other state officers were chosen by the legislature; and an executive council, also chosen by the legislature, was substantially placed on guard to prevent executive usurpation. Such an attitude toward the governor was natural in 1776; but the governor's power almost immediately began to grow. New York in 1777 made its governor popularly elective, though at the same time it created two councils—the council of revision and the council of appointments—to share with the governor the powers of veto and of appointment to office. Massachusetts (1780) and New Hampshire (1784) followed with the plan of popular election. Executive councils remain in Massachusetts, Maine and New Hampshire.

In all states the governor became a popularly elected officer and hence independent of legislative dominance. Other state officers also became popularly elective, though some are still chosen by state legislatures. Until late in the 19th century the functions of state government were few and were chiefly conducted by a small group of popularly elected officers. As new needs developed, the constitutions themselves provided for new offices, which have usually been filled by popular election. Illinois has six such officers in addition to the governor; Idaho and Nebraska, seven each. Chief among the state executive offices, independent of the governor in most states, are: lieutenant governor; secretary of state; superintendent of public instruction; attorney general; treasurer; and auditor or comptroller.

By creating a group of state officers, all popularly elected in the same manner, state constitutions in fact create a plural executive, although the theory of state government presupposes a single head of the executive department. But only to a slight extent are constitutional powers directly conferred upon the lieutenant governor, secretary of state and other popularly elected state officers. The governor has thus had the opportunity to become the chief state executive in fact as well as in constitutional theory. The increase in the governor's executive power has come about primarily through the creation of new offices by statute and the vesting in the governor of power to appoint to such offices. In this manner, as new state functions were assumed, numerous offices were created, without reference to any efficient supervision by the governor. Some states had as many as 200 independent officers, most if not all of whom were appointed by the governor, but over whom it was physically impossible for the governor to exercise an effective supervision. A later movement sought to organize executive functions into a small group of departments, each under a director appointed by and responsible to the governor. One of the chief difficulties in building up an effective state executive system is that the governors of almost a third of the states are elected for terms of only two years. In the other states the term is four years. There has, however, been an increase in state executive powers and leadership, but any possibility of leadership is greatly handicapped by the fact that the majorities of one or both of the houses of the state legislature may often be politically opposed to the governor. This lack of political harmony is commoner in the states than in the national government.

State Courts.—Generally the states have courts of three types:

1. Justices of the peace, having a limited and inferior jurisdiction in both civil and criminal cases. Justices of the peace are ordinarily elected from towns or to nships or from districts created for the purpose within the county. The jurisdiction of justices of the peace is strictly limited by statute, and their courts are not courts of record. Appeals are allowed from their action to a court of general trial jurisdiction, and ordinarily the trial in the higher court is a trial de novo. The system of justices of the

THE GREAT SEALS
OF THE UNITED STATES OF AMERICA

THE GREAT SEALS OF THE UNITED STATES AND OF THE INDIVIDUAL STATES

The design for the Great Seal of the United States of America was adopted June 20, 1782 peace paid on a fee basis has not proved satisfactory and has been replaced in the larger communities. Virginia and Missouri have taken steps which may lead altogether to the abandonment of the system. To some extent a major defect in the system has been met by placing the justice of the peace on a salaried basis:

2. In all states there are courts of general trial jurisdiction, known as superior courts, district courts, circuit courts and in some states by a still different name. The court of general trial jurisdiction ordinarily has a general authority to try all cases in law and equity. Five states still retain the old English plan of separate courts for the trial of cases at law and in equity, but most of the states have abolished this distinction. In some states, as in Arizona, California and Ohio, the court of general trial jurisdiction is organized upon a county basis, and there is a separate court for each county. The commoner plan, however, is to have the court of general trial jurisdiction go on circuit from one county to another, at least in the smaller counties of the state.

3. Each state has a court of review, the function of which is chiefly that of hearing appeals from the courts of general trial jurisdiction. This court is ordinarily termed the supreme court; in Kentucky, Maryland and New York it is called the court of appeals and slightly different names are used in several other states. The highest court is usually given some original jurisdiction, but ordinarily this original jurisdiction is small and its use is strictly limited by the court itself in order that time may be available to hear appeals from other courts.

Once these three features are outlined, state judicial organization becomes to a large extent a mass of diversities. In many larger communities a municipal court has been organized which not only replaces justices of the peace but is granted a much more extended jurisdiction. In a number of states there is also a so-called county court, with some jurisdiction, both civil and criminal, and usually also a fairly large authority with respect to rather distinctly administrative matters, such as those relating to county affairs, elections and charities. Where county courts exist independently of the court of general trial jurisdiction, they are often vested with authority in probate matters as well.

There are also other types of trial courts with special jurisdiction. Every large community has a juvenile court, and separate probate courts are not uncommon. Other specialized courts, such as domestic relations courts, morals courts, boys' courts, speeders' courts and small claims courts have been established in many larger communities, often as branches of a municipal court. In some cases there are separately organized criminal courts, although ordinarily criminal jurisdiction is exercised by the courts of general trial jurisdiction. In all of the states the prosecution of criminal offenses is by and in the name of the state and is conducted by prosecuting attorneys, who are usually elected by the voters of the county.

The state judicial organization has placed great emphasis upon appeals from lower to higher courts. No case of any importance is regarded as settled until it has been taken to the highest court. Increased complexity of appellate court organization has been forced by the growing number of appeals to be heard. The increased mass of appellate work has been handled in three ways: (1) by increasing the number of judges of state supreme courts; (2) by authorizing such courts to sit in sections; and (3) by creating intermediate appellate courts, standing midway between the trial courts of general jurisdiction and the highest court.

There are three methods of selecting judges in the United States: (1) In 39 states, with the exceptions hereafter noted in California, Missouri and Alaska, judges of the highest court are elected by the people; in all of these states except one the trial judges are chosen in the same manner; (2) in four states the judges are elected by the legislature, and in one they are appointed by the legislature upon the nomination of the governor; (3) in 6 states the highest judges are appointed by the governor, subject to confirmation by the governor's council in Maine, Massachusetts and New Hampshire, and to confirmation by the senate in Delaware, New Jersey and Hawaii. Certain inferior judges in other states are also appointed by the governor.

A plan adopted by California in 1934 removes that state from any one of the classes indicated above. The California plan, which applies to justices of the supreme court and of the district courts of appeal, provides that upon the expiration of the term of office of any such judge, such judge may file a declaration of candidacy to succeed himself. If he does not do so, the governor nominates a suitable person, subject to confirmation by a commission composed of the chief justice of the supreme court, the attorney general of the state and a justice of one of the district courts of appeal. The name of the candidate to succeed himself, or of the candidate nominated by the governor and confirmed by the commission, is then placed upon the ballot at the next general election and the electors vote upon the question as to whether he shall be elected. If a majority vote "yes" he is elected to or continues in office. Under this plan a candidate has no opposing candidate, but an election determines whether he shall become or remain a judge. By popular vote in any county the same plan may be adopted for the superior court judges of that county.

In 1940 Missouri adopted a plan similar to that of California with respect to judges of the supreme court, the courts of appeal and the circuit and probate courts in the city of St. Louis and Jackson county. The Alaska constitution provides for the appointment of supreme and superior court judges by the governor from nominations made by a judicial council. The judges are approved or rejected, on a nonpartisan ballot, by the voters at the first general election three years after an appointment.

A major problem in judicial administration is the existence of crowded dockets. In some areas this has assumed near astronomical proportions. In New York alone, more than 1,000,000 civil and criminal disputes are brought before the state's judicial system each year. This congestion has brought great pressure for more efficiency in the procedures of state courts.

8. **Local Government in the States.**—What is ordinarily referred to as the "state government" is the central organization located at the state capital. But this central organization does only a comparatively small part of the work of the state. Unlike the national government, which establishes its central organization for substantially all national activities, the state conducts a large part of its governmental business through locally elected officers. There is no one system of local government for the states or even for any one of them. The geography of local government in each state is a patchwork, with the same territory often occupied by from 10 to 12 separate governing bodies, each with slightly varying boundaries and with independent powers. In the 50 states, there are more than an estimated 95,000 local governing units, of which more than 3,000 are counties (parishes in Louisiana); approximately 17,000 are towns or townships; a like number are cities or villages; and more than an estimated 45,000 are school districts. In addition, there are more than 14,000 special units.

Certain types of organization may be termed the usual forms of local government. There are (1) the county, which is found in all of the states, though the name parish is employed for a similar unit of local government in Louisiana; (2) towns or townships which, in most of the states where they exist, are merely subdivisions or units of the county, although the New England town was the original area for local government and is more important than the county; (3) the city. In addition to the city, which is theoretically the chief unit of local government for urban areas, most state laws provide for the incorporation of small communities as villages, with a simpler form of government than that provided or permitted for cities. Besides these usual types of local government, other forms are common to all the states. Park and sanitary districts in more settled areas, drainage and irrigation districts in rural communities, road districts, school districts and numerous others will be found, often occupying the whole or a part of the same territory as that covered by the county, town or city.

The County.—Aside from several New England states in which the county is merely a convenient area for direct state administration, county government has certain common characteristics. There is a locally elected county board, of varying size and composition, and there are a number of locally elected county officers who perform their duties largely without subordination to the county board, except as they may often depend upon the county board for appropriations. County boards are usually grouped into two classes: (1) small boards of commissioners elected at large by the county; (2) large boards elected by townships and cities within the county. In a number of states, however, counties are divided into districts for the election of a small county board. In each county will be found a clerk (or clerks) of court and a sheriff. Each county provides a courthouse and a jail. Ordinarily there are locally elected county judges and treasurers and a prosecuting officer elected by the voters of the county. In many states the county is a unit of school administration, and there is a county superintendent of schools, usually elected. In the second half of the 20th century a movement was actively underway toward a more centralized executive organization in the county.

Town and Township.—New England towns have areas of from 20 to 30 sq mi., and usually include both rural territory and more compact village settlements. About three-fourths of them have fewer than 2,500 inhabitants each, and hence may properly be classed as rural communities. The large communities usually become incorporated as cities, and generally the creation of city government terminates the existence of town government within the city limits. The town meeting is the chief organ of government. (See also MASSACHUSETTS: Government.)

So-called town or township systems of government are found in the great central group of states extending from New York to Nebraska. The forms of township government in these states may be classified as follows: (1) those which, as in New York, have the town meeting and township representation on the county board; (2) those, as in Minnesota, which have the town meeting but no township representation on the county board; and (3) those, as in Pennsylvania, which have merely a local township organization, but no representation on the county board and no town meeting.

Efforts have been made to introduce the township system in the states of the south and the west, but there the counties are ordinarily divided into subordinate districts, largely for administrative purposes, and such districts though sometimes called townships, usually have little if anything of independent authority in the field of local government.

City Government.—The growth of urban population has naturally led to the development of cities as the chief agencies for meeting local needs occasioned by more compact population. The forms of city government in the United States are primarily three: (1) the mayor-council system; (2) the commission plan; and (3) council-manager government.

The mayor-council plan is the most general. It is to a large extent organized upon the analogy of the national government. There is a popularly elected mayor with powers which have steadily tended to develop. The mayor normally has a veto power and a fairly large power of appointment, although several of the more important officers, such as clerk and treasurer, are usually elected. Under the mayor there is ordinarily a group of departments whose heads are appointed either by the mayor alone or by the mayor with the approval of the council. Usually there is a council composed of a single house whose members are elected from wards into which the city is divided, although occasionally some or all of the members are elected from the city at large.

The fundamental characteristic of the commission plan of city government is an elective commission, usually of three or five members, having large municipal powers, both legislative and executive. Each of the commissioners is the head of a department: and there are as many main city departments as there are commissioners. This system has usually been accompanied by the initiative and the referendum on municipal ordinances and a power to recall the members of the commission by petition and popular vote.

Though discussion of the council-manager type of city government had begun earlier, it first received serious consideration upon its adoption by the city of Dayton, O., in 1913. Over 1,400 cities in the U.S. were governed under the manager plan in the early 1960s. Under it there is a commission or council, whose members are usually elected from the city at large, often by the use of proportional representation. This body determines the policy of city government and selects a manager to administer the affairs of the city. Through the commission plan, which originated in 1901 and for perhaps 15 years had great sway in U.S. city development, and through the manager plan, which tended to replace the commission plan, much was done toward the reconstruction of U.S. city government. Later, however, the strong mayor plan came back into favour as a device for municipal reform. particularly in the larger cities. (See also CITY MANAGER.)

Special Units.—A primary problem of local government in the United States is the existence of a large number of units which are neither economically nor politically self-sustaining. In the case of school districts, recognition of this inadequacy inspired a consolidation movement that eliminated many of the units no longer capable of supporting an effective educational system. Elsewhere proposals have been made to abolish units of township and county government that can no longer perform significant governmental tasks. However, except in the case of the school district (from 1942 to 1959 the total number of school districts declined from 108,579 to an estimated 45,394) it has proved very difficult to bring about any substantial reduction in the number of governmental units. During the period after World War II the number of municipalities and special districts actually increased. The growth of special districts is particularly pronounced. It reflects a variety of pressures, especially the need for new forms of government in metropolitan areas.

The Metropolitan Area.—Especially after World War II, metropolitan areas came to present a problem of particular concern. The presence of a multiplicity of governmental units operating within one metropolitan region makes it difficult to develop coherent local policy on matters such as zoning, transportation and crime control. Moreover. the emigration of the population from city to suburb deprives urban areas of an important source of tax revenue while demands for municipal services are accelerating. Suburban counties organized to meet the needs of sparsely populated rural areas suddenly find themselves faced with the necessity of serving and controlling a vast suburban population. These problems of change and adjustment gave rise to demands for radical alteration in traditional political boundaries and forms of government in metropolitan U.S.

9. Elections and Political Parties.—Conduct of Elections.—Constitutional responsibility for the conduct of elections rests with the state governments (except in the case of Washington, D.C.). State laws set up election machinery and determine the qualifications for voting, subject to the federal restrictions against discrimination because of race, colour, previous condition of servitude or sex.

Through a succession of changes the states have established virtually universal suffrage for males and females above the age of 21 years. Georgia and Kentucky reduced the voting age to 18. Suffrage for women became national in 1920 through the adoption of the 19th amendment to the federal constitution. Educational qualifications for voting have been imposed in some states, for example, New York; and qualifications as to education or tax paying imposed in a number of southern states tend to discourage voting by Negroes. In order to identify those qualified to vote, state laws require registration of voters everywhere except in Arkansas and Texas. Nonvoting, even by those legally entitled to the suffrage, is common.

At the national level only members of the two houses of congress and presidential electors are chosen by popular vote. A much more numerous group of state officers and an even larger number of county. city and other local officers are elected. When all of these types of offices are united on one ballot or in one election, the voter is at times faced with the problem of choosing 100 or more officials from among several times that number of candidates. Moreover the voter may be asked to vote on issues as well as men, through the initiative, the referendum, the constitutional amending process and the fact that, under many state laws, proposals of municipal bond issues and other local questions must be submitted for popular approval. The short-ballot movement made some headway in cutting down the number of elective offices, but the U.S. voter continued to be faced with the extraordinarily difficult problem of informing himself on a large number of candidates for primary as well as general elections. (See also ELECTORAL SYSTEMS.)

Political Parties.—At the national level, U.S. political history has been characterized by a two-party system. Occasionally a third party has risen to importance as was the case with the Progressive party under the leadership of Theodore Roosevelt in 1912. In the early years of the nation, the Federalist party represented the interests of a stronger nationalism; the Republican party under Thomas Jefferson, the interests of the states. By the period of Andrew Jackson the Jeffersonian Republicans had become dominant and had changed the name of their party to Democratic. By this time also, the Federalists had disappeared, and the Whigs became the other great party. The Whigs were eventually replaced by the Republicans, who elected Abraham Lincoln to the presidency in 1860. From that time, the Republican and Democratic parties were the only groups with the political capacity to win a national election. (See History: The Struggle for National Government, 1783–1865, above.)

Political parties originated as voluntary organizations. But they soon came to exert considerable influence over election to local, state and national offices; no one except a candidate of one of the two leading parties had much possibility of being elected. The methods of the political party thus became of importance to the government itself. Eventually political parties became an indispensable part of the governmental process, and they are controlled in great detail by state legislation.

Government Regulation of Parties.—One of the first respects in which political parties came under official control was the printing of the ballot. Before 1888 parties printed their own ballots and naturally determined also the conditions under which the names of their candidates should appear upon such ballots. Serious abuses arose under this arrangement, particularly with respect to the secrecy of the ballot. Beginning in 1888 the states adopted the official or so-called Australian ballot. Under the official ballot system, ballots are printed at governmental expense. This expense is usually borne not directly by state government but by the local bodies charged by the state with the conduct of elections. In providing for the printing of ballots or the provision and maintenance of voting machines (*q.v.*), state laws at the same time necessarily determine the conditions under which party organizations shall be entitled to have the names of their candidates appear.

Under the Australian ballot system, the parties take a great deal of interest in the manner in which candidates are listed. Massachusetts and 16 other states adopted a plan whereby the names of the candidates are grouped under the titles of the offices; the party to which each candidate belongs follows his name. This arrangement makes it necessary for the voter to mark separately on his ballot the name of each candidate for whom he desires to vote. Twenty-seven states, however, adopted the so-called party-column ballot. The party-column ballot varies in different states, but its fundamental purpose is to facilitate straight-ticket voting. Usually all the candidates for one party appear in a single column so that a voter may vote for all of them by placing one mark on the ballot or moving one counter on the machine. If the voter does not wish to vote the party ticket, he is put to the burden of marking (or moving a counter for) each of the candidates for whom he wishes to vote, or at least each candidate not belonging to his own party.

The methods of party nomination next came under state control. Serious abuses in the party convention system for the nomination of candidates and the framing of party platforms led to legislation regulating the convention, but such regulation did not appear sufficient. The primary election system (see PRIMARIES) was established in some form in all the states, although a strong political movement against primary elections resulted in some gain for the older convention system. Where the primary system was adopted, conventions normally remained with more limited functions such as the adoption of a party platform.

Control by law over the official ballot and over the methods of party nomination was naturally followed by a detailed regulation of the machinery of party organization. Through primary elections, the party voters in most of the states choose their party committeemen. State laws determine the power of such party committeemen and also determine the manner in which they shall form the various party governing bodies. State laws also determine how party organizations shall frame platforms. Governmental regulation of political parties was largely occasioned by a feeling that party organizations themselves control the government and that they should, therefore, be subject to legal control. As the costs of political campaigning rose, the necessity of regulating the financial affairs of parties drew increasing attention.

The Party in Operation.—When it is first created, a party may stand for political principles which set it apart from other parties. Ordinarily, however, parties serve as convenient devices for the operation of government and for presenting political issues to the voters when such issues arise. Political issues are not created merely by the existence of two opposing parties; and during much of the time no real issues exist on the basis of which parties may oppose each other. At such times parties proclaim principles but have no sharp differences. When issues are altogether absent, parties still perform the functions of narrowing the choice of the voter and of uniting candidates into groups for final elections.

The belief that national parties should not control the election of local and judicial officers led to a movement for nonpartisan elections. In a number of states judicial officers are nominated and elected through ballots bearing no party designations. But a candidate must actually be sponsored by a political organization if he is to fare well in any election. The nonpartisan movement accomplished more in municipal than in state elections.

The climactic function of the party in U.S. politics is the nomination and, if possible, the election of a president. It is, in fact, the existence of the presidential office which primarily serves to hold the parties together as national coalitions. Otherwise, state and local party organizations might have little reason for coming together in a nationwide alliance. Here it is important to note that effective power resides in the state and local rather than the national party headquarters. Decentralization is characteristic of U.S. political parties as it is of its constitutional system. Some strengthening of the staffs at national party headquarters failed to bring about any substantial drift of power away from state organizations.

The quadrennial conventions at which presidential candidates are nominated are the chief instrument through which the national parties function. Voting power at both the Republican and Democratic conventions is parceled out among the states in terms of (1) population; and (2) the extent to which the state has supported either party at a previous election. Each of the states selects its own delegations to the national conventions. In about two-thirds of the states the selection is made by party conventions or committees. In the other third selection is made by the voters through the primaries. (See NATIONAL CONVENTION [U.S.].)

The tactics used in winning elections underwent considerable change in the post-World War II years. At one time an effective party organization was a primary prerequisite for a successful campaign. The activity of party workers served to "sell" a candidate to the voters, and the organization enjoyed correspondingly great influence, particularly in state and local politics.

With the arrival of new mediums of communication, particularly radio and television, however, a candidate was able to reach the voter directly. The party organization, therefore, lost some importance as a channel of communication between candidate and voter, though, needless to say, organizational support remained a valuable political asset. A related development which party organizations sometimes viewed with misgiving was the emergence of the volunteer, nonparty organization for the purpose of supporting candidates, especially in presidential elections. While these volunteer groups drew many individuals into political activity who would not work through the machinery of regular political parties, they were to some extent competitors with party organizations for patronage and the other rewards of power.

(W. F. D.; C. A. BA.; F. E. RO.)

C. TAXATION

Under the national constitution, congress is authorized to levy taxes only "to pay the debts and provide for the common defense and general welfare of the United States." Generous interpretation of these clauses by the U.S. supreme court has given broad latitude to the national taxing power. Some restrictions remain, however. For example, the constitution prohibits congress from taxing exports and the national legislature is required to apportion direct taxes among the states in accordance with population. In 1895 the supreme court held that the income tax was a direct tax, and it required a constitutional amendment (the 16th) to enable congress "to lay and collect taxes on incomes. from whatever sources derived," without regard to apportionment among the states.

The taxing power is frequently used for regulatory as well as revenue purposes. Tariffs, for example, are commonly imposed more for the purpose of discouraging imports than to raise money. Congress has even used the taxing power to outlaw certain forms of economic activity; *e.g.,* the sale of white phosphorous matches and the issuance of bank notes by the states. As a rule the courts have upheld such taxation when the activity it affects lies within the scope of congressional authority. The taxing power was increasingly used, particularly after 1932, to achieve broad social purposes, including economic stabilization. *(See* TAXATION.)

For most of its history, the national government relied on customs duties for a great part of its revenue. By the middle of the 20th century, however. it had come to depend mainly on income taxation, corporate and personal. Out of $68,158,000,000 revenue for the fiscal year 1959, for example, approximately $37,000,000,000 was obtained from personal and $17,000,000,000 from corporate income taxation. These taxes thus accounted for more than 80% of all tax income of the national government. (See *Trade and Finance,* below.)

Both state and local governments have been increasingly hard pressed to find sources of revenue adequate to their needs. State governments, in particular, have ranged widely in their quest for financial support. During 1958 total state tax revenue amounted to nearly $15,000,000,000, drawn principally from sales, income and motor fuel taxes, as well as licensing fees. In addition, the states received about $7,000,000,000 in other income, principally grants-in-aid from the national government.

Units of local government rely heavily upon the general property tax to finance their activities. During 1957, for example, $12,618,000,000 out of a total of $14,511,000,000 in local tax income came from property taxes. Some cities have turned to an income or earnings tax to help meet their fiscal needs. A principal advantage of this form of taxation is that it enables a city to tax wage earners within its boundaries who live in the suburbs and are not, therefore, directly subject to a municipal property tax. *(See* TAXATION, LOCAL: *State and Local Taxation in the United States; see* also *National Finance,* below.)

D. LIVING CONDITIONS

Any discussion of living conditions must be comparative, in both the chronological and spatial sense. All nations have ideal standards of living by which they measure progress, but these vary from nation to nation. Most Americans and many visitors to the United States have agreed with Émile Levasseur, a 19th-century observer, who said in *The American Workman,* The Johns Hopkins Press (1900):

> Real wages being higher in the United States, the American workman lives more comfortably than the European . . . He has acquired settled habits of consumption and enjoyment, his food is more substantial . . . he dresses better; he is more comfortably lodged . . . he insures his life, and is provident in his own way; he spends more for amusement and upon the societies with which he is affiliated: in other words, he has *a higher standard of life* than the European workman.

The way people live depends on many things: the land: for instance—what kind of food it provides and what other resources of fibres and minerals it yields. The United States is a continental empire with nearly every type of geographic environment. Although most of it lies in the temperate zone, portions of it are subtropical and its largest state lies mainly within the Arctic circle. It has mountains, deserts, grasslands and fertile river valleys. The United States is now highly urbanized and industrialized. It is also a very heterogeneous nation—and people of diverse racial and national backgrounds have many different tastes and preferences which persist despite the homogenizing influences of the economic, social and political milieu.

The people of the United States, favoured with the opportunities offered by the expanding area of the country throughout most of its history and with tremendous resources, have been able to enjoy a high level of living with respect to the basic necessities. Only in some areas and at certain times have there been conditions of severe want and deprivation. In modern times relatively smaller proportions of income have been spent on food, clothing and shelter and there have been progressively greater outlays on the secondary necessities, such as lighting. refrigeration, transportation and education, and on luxuries. Criticism of living conditions in the United States has therefore taken the form of deploring inefficient utilization of the resources of the land and the energies of the people, rather than dissatisfaction with U.S. standards as compared with those of other countries.

Family and Personal Income.—Before the American Civil War, differences in the level of living among Americans were real enough, but they were concealed to some extent by the peculiar economic conditions of the south and by the relative unimportance of monetary income on the frontier. Although the judgment of Levasseur quoted above was reasonably correct, it was being disputed, by 1500. by many social philosophers and economists who were concerned about the poverty, slums, disease and ignorance that existed in the midst of prosperity.

In the 1930s it was frequently stated that one-third of the American people lived at or below subsistence level. By the 1960s even the gloomiest observers assumed that this figure had been reduced. However, the census bureau in 1959 reported that the median family income in the U.S. was $5,400. Of the nation's 45,000 000 families, 12% received incomes of $10,000 or more, 43% incomes ranging from $5,000 to $10,000 and 23% less than $5,000. If, as mas sometimes said, at least $6,500 and preferably $10.000 was needed to maintain a family of four at a "good" level of living, many U.S. families were on the edge of or below that level. Both money income and real income showed cyclical variations after World War II, although the spread between them was growing. Various governmental measures, beginning with the New Deal, seemed to have checked the more violent swings of the business cycle, but periods of economic distress known as recessions caused hardship in certain areas and among the lower income classes.

In the south, as a whole, incomes were substantially below the national average; in 1953, for example, only 31% of southern families had real inccmes over $5,000. The north central region was periodically depressed. The government also recognized the existence of hundreds of smaller depressed areas. Causes of distress included work stoppages in the steel and automobile industries, the persistent falling off in the demand for coal, cotton, lead, wool and hides, and technological unemployment. Distress in the farming areas, most acutely felt in the 1920s and '30s and again in the '50s, had many causes, including the high cost of goods and equipment the farmer must buy, the high cost of credit and uncertain prices for farm products. During the 1950s farm income sank $3,500,000,000 and 700,000 farm units were liquidated.

Certain classes of families have very small incomes. Families with a female head, frequently a widow, average only half the income of husband-wife families. Minority groups—Negroes, Mexicans, Puerto Ricans—and marginally employable whites are often in a low income bracket. Of the 12,000,000 American families in which the head of the family is 55 or older, nearly 6,500,000 have total incomes under $4,000 and 3,800,000 have incomes under $2,000. For these people, the basic needs of income, medical care and housing pose acute problems. Many are dependent on public assistance for support.

Employment. — The worst unemployment of modem U.S. history occurred during the depression of the 1930s, but there have been other periods of unemployment, usually correlating with business recessions. In the early 1960s, many economists no longer regarded full employment as a reasonable goal, but they felt that 3% unemployment was optimum and regarded 5%–6% as unsatisfactory though not necessarily calamitous. Naturally, the ability of the nation to sustain such a burden could be comprehended only in terms of savings, insurance and public or private expenditures for relief.

Of the civilian labour force, there were in the early 1960s about ten times as many workers in the nonagricultural industries as in farming, and the number of the latter was constantly declining. Stated another way, the population was continuing its long-term shift from rural to urban. Furthermore, the rural ideals of family living were more and more reflecting urban pressures. Within the urban population, the percentage of employed persons in industrial work seemed to be declining while the percentage of white-collar workers was rising. The latter tend to have higher "standards" and greater demands are made upon them by the sociopolitical-economic situation in which they live. Partly because of this and partly because of the practice of encouraging overtime and the addition of large numbers of young people and women to the labour force, there was some evidence that the bargaining power of union workers was declining from its 1948 peak.

Consumption. — The percentage distribution of total expenditures of urban consumer units, as estimated in the mid-1950s, was as follows:

Food	31.3	Household operation*	14.7
Housing	11.6	Clothing	10.2
Transportation	13.0	Medical care	5.5
Personal care	2.4	Recreation, education	6.0
Other goods and services	4.9		

*Includes also: fuel, light and refrigeration 4.4%; furnishings and equipment 5.9%.

Such data do not disclose differences in expenditures by income class or size of family or the differences in object of expenditures. However, there are two safe conclusions that may be drawn: most families allocate about one-third of their expenditures to food; and with food, as with clothing, housing and other satisfactions, increased purchasing power has meant more money spent for what might be called luxuries rather than bare necessities.

Housing. — In all countries, there is a close relation between income and housing. If the photographs in U.S. magazines and newspapers fairly represent the sort of housing Americans want, they prefer comfortable, detached single-family villa houses or tall, well-constructed apartment houses. As with most standards, this is only partially realized.

In 1950–60 the decennial percentage increase in number of housing units was 27%, or about 58,500,000. The smallest increases during this period were in Arkansas (2.2%), Mississippi (3.4%) and West Virginia (5.8%) — states where general living conditions were poor. From 1950 to 1956 there was a slight increase in "owner-occupancy"; the median value of owned homes went up from $7,900 to $10,700 and rentals rose from $38 to $50. About 65% of new properties and well over half of previously occupied properties were mortgaged. On the whole, U.S. dwelling units have more total rooms and more bedrooms than comparable European dwelling units.

Health.--On a comparative basis, sociologists found that the American people were healthier than most of the peoples of the world. In 1960 Americans paid more than $20,000,000,000 in medical expenses, six times as much as in 1940. A somewhat larger amount, $25,000,000,000, was expended for health services and health facilities, a fourth of which was assumed by national, state and local governments.

However, the picture was not entirely satisfactory. Congressional investigations indicated that the cost of many drugs was high, and other studies concluded that the whole apparatus of medical care was inadequate and costly. During the 1950s many persons went into debt or went without essential care when serious illness struck — older citizens especially were disadvantaged by lack of funds to pay medical expenses. With a growing and aging population, the number of hospital beds per 1,000 population was declining and provisions for persons suffering from mental illness were far from adequate. Attempts to meet these problems included private health insurance and suggestions that federal funds be provided for health insurance, medical schools, research and hospitals.

Food. — The problem of providing food for the U.S. family has many ramifications, involving eating habits, dietary values, systems of production and processing, imports and exports; subsidies, technical assistance and controls; and marketing and advertising. As an element in the living standards of a people, food takes first place. Studies of the amounts of standard foods that can be bought with an hour's take-home pay show that food in the United States costs less in proportion to income than in most other parts of the world. Nevertheless, about one-fifth of the American people do not have the means to provide themselves with adequate food.

Education. — In civilized communities the intellectual level of the citizens is an important element in their standard of living. There is a direct relation between amount of education and income. In the early 1960s education had become the next to the largest single category of U.S. public expenditure, second only to national defense. This burden rested primarily on states and local school districts. In addition, vast sums were expended by parents, private persons and foundations for parochial and higher education. How much was spent for other purposes that might be termed educational could not be calculated, although a rough estimate might be made from data on sales of courses, books, periodicals, admissions to lectures and the like. Outside the U.S. only the small highly developed countries of western Europe spent more on education or attached as much value to it. In spite of this, the post-World War II population expansion resulted in a shortage of an estimated 150,000 classrooms, and teachers continued to be underpaid in relation to many other professions.

(R. V. Pe.)

E. Welfare Services

Welfare in the sense of economic security for the masses did not become a major government function in the United States until well into the 20th century. Before the American Revolution responsibility for aiding the economically helpless fell to the parishes and to voluntary church or individual efforts; orphaned and dependent children were apprenticed to masters who trained them in return for their services, and charity was more or less available as need occurred. Until the late 19th century all provisions were local and most were private rather than public. Orphanages, almshouses and now and then specially endowed schools variously met the needs of poverty in preindustrial communities, according to provisions made by churches, individuals, special voluntary organizations and local units of government.

The waves of unemployment and hardship that first troubled the country during the economic depressions of the mid-19th century, especially that of 1837, required new welfare services. Emergency provisions in the form of soup kitchens and the like were thrown together in the cities. Something like system entered industrial-age welfare work only in the 1880s, when charity organization societies began to investigate and participate in relief efforts.

At the time when the leading industrial nations of Europe, the United Kingdom and the German empire, were launching programs of public responsibility for basic welfare, an awakening to the problem of industrial-age types of poverty in the United States was stimulated from several directions. Depression conditions during most of the 1870s, the middle 1880s and the middle 1890s called attention to desperate living conditions, in the eastern cities especially. Henry George and socialist agitation multiplied the awareness, and important writings by professors of economics and sociology confirmed the needs. The Salvation Army, the social work of Protestant and Roman Catholic churches and the voluntary work of secular organizations all promoted concern with welfare. Action mas spotty and hardly sufficient anywhere. but by the 20th century social work had become a profession and many facets of the welfare problem were being explored and somewhat improved.

The elimination or restriction of labour by women and children and the improvement of industrial slums were the phases of welfare which first led to political action. Many states enacted child-labour laws during the 1870s, and 1880s, and this kind of reform was gradually extended and made effective during the 20th century. Federal-government interest in the field appeared in White House conferences on child welfare in 1909 and 1919 and in the distinguished work of the children's bureau under Grace Abbott and her successors. Although child-labour lans passed by congress in 1916 and 1919 were held unconstitutional by the supreme court and the child-labour amendment submitted in 1924 was never ratified, New Deal legislation in 1938 brought a degree of federal control into the child-labour field.

On the side of housing. the leading efforts of state reform were made by New York. It passed the first tenement house law in 1867 and a more effective one in 1901. In 1938 special taxation mas authorized to support new housing for low-income groups in New York city. Meanwhile the federal government entered the field, establishing the United States Housing authority in 1937 and, subsequently, the Federal Housing administration and the Federal Public Housing authority. By the middle of the 20th century, the national government was engaged in large-scale expenditures for slum clearance and urban renewal and rehabilitation activities.

The two central problems of social security, protecting the worker against catastrophic loss of income during unemployment beyond his control and providing old-age pensions for large numbers of people within the industrial economy, proved during the 1930s to be federal problems after all. Many reasons explain why the United States government had not acted earlier on such a pattern of social insurance as had been established in most countries of Europe and the British Commonwealth: the financial and political strength of private insurance companies in the C.S. the tradition that social legislation belongs to the states, opposition to the gronth of bureaucracy and so on. But the shock and suffering of the great depression of 1929 and after and the enlargement and experimentalism of New Deal policy broke down the resistance. Early relief measures of the Roosevelt administration supplied variously dole and employment for the unemployed, and in 1935 a landmark in the history of U.S. social legislation was reached with the passage of the Social Security act. By mid-century the United States had a massive system of old-age and unemployment insurance which, including old-age assistance, aid for dependent children and aid for the blind and totally and permanently disabled, was accepted and developed by leaders of both major parties and almost all political persuasions.

For specific phases of C.S. welfare services see the sections on the United States in PHILANTHROPY; CHILDREN, LAWS CONCERNING; CHILD WELFARE; CHILD LABOUR; HOUSING; RELIEF; and SOCIAL SECURITY.

F. LAW ENFORCEMENT

The enforcement of law in the United States has traditionally been centred in the hands of local police officials. It is the police department in the case of cities and the sheriff's office in rural areas, acting as agents of the state, which exercise jurisdiction over the great body of ordinary crimes and misdemeanours. However, the mobility which the development of rapid transportation gave the laubreaker made crime control increasingly difficult for police officers having only limited jurisdiction. As a result, law enforcement became more and more a matter of direct state and national concern.

The chief agency of national law enforcement is the Federal Bureau of Investigation (*q.v.*), which has been granted responsibiity for enforcing a long list of national statutes. The FBI was organized in 1934 to stem the rising tide of criminal activity that sprang up in the wake of prohibition and the depression. During and after World War II it came into prominence as a result of its efforts to combat espionage. Other national agencies that play an important role in the law-enforcement process include the secret service (*q.v.*), the bureau of internal revenue, the bureau of narcotics and the coast guard (*q.v.*).

The states also moved toward the establishment of law-enforcement agencies to supplement the activities of local police departments. Although the movement for a state police met with some resistance from those who feared the establishment of any centralized police system. more than half the states set up a law enforcement agency with state-wide police jurisdiction. Each of the other states maintains a highway-patrol system for traffic-law enforcement.

Efforts at improving law enforcement have concentrated on facilitating co-operation among law-enforcing agencies and lifting the level of competence in police administration. The need for greater co-operation was dramatized by investigations of organized crime in the United States. These inquiries uniformly shon that criminal activity is encouraged by the opportunity a federal system provides lawbreakers to escape from one jurisdiction to another. A further benefit of interagency co-operation is that it enables local officials to use the facilities available at higher echelons of government; *e.g.*, state crime laboratories and the fingerprint service maintained by the FBI. This gives local law enforcement a technical skill it would not otherwise possess. *(See* also POLICE.)

For a description of the federal and state court systems in the United States, *see* under *Government,* above.

G. EDUCATION

The educational system of the United States may be said to have two outstanding characteristics: availability of primary and, in most cases, secondary education to almost all children, and decentralization. The public provision of free, compulsory schooling has been a cornerstone of U.S. educational thought from the early days of the republic, and by the middle of the 20th century universal education was very close to being an accomplished fact.

Unlike the highly centralized systems of Europe, education in the United States has always been largely a local responsibility. The role of the federal government has been limited principally to guidance and federal financial assistance has been peripheral. The authority for maintaining public schools rests with the states, and day-to-day administration is in the hands of approximately 45,000 local school districts. Aside from the relatively small amount of federal aid, financing is by a combination of state and local revenues, with the ratio varying from almost 90% local revenue in Nebraska and New Hampshire to more than 80% state revenue in Delaware. The number of local districts decreased by more than half after World War II, mostly as a result of consolidation of rural schools, More than a tenth of U.S. children attend private schools, about 90% of them Roman Catholic.

State colleges and universities and, especially in the larger cities, publicly supported junior colleges are important in U.S. higher education. Nevertheless. a large percentage of post-secondary school training is provided by privately endowed institutions, most of them, at least originally, with denominational connections.

As it passed the middle of the 20th century, the United States experienced a grouing concern about its system of education. The domestic tension created by the supreme court decision of 1954, which declared the segregation of races in public schools unconstitutional was matched by cold-war comparisons with the U.S.S.R. and by a public anxiety that U.S. schools were training young Americans less effectively than Russian schools were training young Russians.

Public concern over education was not really new. From the time of the American Revolution education has been understood in the United States to be the special bearer of national strength and character. Laws passed by the New England colonies in the 17th century had long since placed that part of the country ahead of the rest of the world in respect of making universal literacy a matter of public policy, and before the Revolution Virginia and each of the colonies north of Delaware had built a college of its own.

During the first half-century of the republic private colleges multiplied in all regions including the newly settled west; state universities sprang up, particularly in the south and the west; and important extensions and reforms of primary education were launched in New England, in the middle Atlantic states and in the old northwest. The fact that the quality of much schooling in America was low, far-removed from centres of learning and little-controlled by people of professional knowledge and competence — a problem not yet eliminated at mid-20th century — hardly diminished the significance of the effort. During and after the Revolution church had been separated from state. Under the policy of the republic religion would grow or not according to religion's own strength, but education was being built into the public system. Thomas Jefferson's goals of educating all citizens to the point of literacy and providing higher education to those most qualified for public leadership became in time matters of national principle and policy.

In the century and a quarter following the reforms of the 1830s which substantially established the principle of a tax-supported common-school system open to all children, education in the U.S. passed through three main phases. From about 1835 to the Civil War, the standards of the public primary schools were raised, under the pressures and ideals of social reform, principally by way of establishing new state boards or commissions and by the establishment of normal schools for the education of teachers, especially in the northeast. The old private or semiprivate academy gave way to the new public high school, a secondary school for everyone. The role of women in education increased, as the earliest women's and coeducational colleges were established and as women entered the teaching profession, particularly in the primary schools. Engineering and scientific schools began to appear. both independently, as in the case of Rensselaer Polytechnic institute at Troy, N.Y., and in association with the older colleges, as in the cases of the Lawrence school at Harvard and the Sheffield school at Yale. Adult education made its first important appearance in the American lyceum movement.

During the second main phase, from the Civil War until the end of the 19th century, primary and secondary schooling extended rather than changed. The immigration of those years, enlarging the Roman Catholic element in the population, resulted in a great expansion of the Catholic parochial schools. Reconstruction in the south led to the establishment at last of public-school systems more or less on the northern pattern, but with the races segregated. Many private institutions, including training schools like the Hampton (Va.) and Tuskegee (Ala.) institutes and universities such as Howard at Washington, D.C., Atlanta in Atlanta, Ga., and Fisk at Nashville, Tenn., were established for Negroes. At the same time a real revolution occurred in higher education. The word university had appeared earlier, when Harvard and Pennsylvania acquired law and medical schools. Now, however, certain institutions began to expand into centres not simply for transmitting but for gathering and creating learning. An old school, Harvard, and a new one, Johns Hopkins at Baltimore, were leaders in this development, which was to bring American institutions of higher learning closer in organization and prestige to the universities of Europe. Furthermore, scholarship became much more departmentalized according to fields of knowledge than before, and the professor, as investigator and systematizer of knowledge, became increasingly a professional person.

During the third, 20th-century phase, the principal general change was the more complete fulfillment of goals stated in earlier periods. In elementary education this meant the achievement of almost universal literacy. Public education — though greatly varying in quality — was available from kindergarten to graduate school in all regions including the south. The high school, having spread into every part of the union, became a peculiarly American institution serving the function of social assimilation as well as teaching. With secondary education almost universal, vocational training was expanded, and at least in the larger cities there was some differentiation among high schools according to purpose,

In the Atlantic seaboard states, the idea of state universities and colleges had beginnings traceable to the 18th century. Through the 19th century such institutions were established one after another as the new territories achieved statehood, and the movement was greatly strengthened by federal favour under the Morrill act of 1862 (*see* LAND GRANT COLLEGES AND UNIVERSITIES). In the 20th century these schools continued to grow in size and importance. In conspicuous instances — for example, the University of Michigan at Ann Arbor in the old northwest, the University of California at Berkeley in the west and the University of North Carolina at Chapel Hill in the south — they became distinguished also as centres of advanced learning.

The development of many private colleges into major universities continued. With the passage of time the differences, once sharp, between these older institutions — Harvard, Yale, Columbia and Princeton, for example — and the new universities founded near the end of the 19th century, such as Johns Hopkins. Cornell university at Ithaca, N.Y., The University of Chicago and Stanford university in California, diminished considerably. However, the larger number of the older private colleges retained their character as small undergraduate, primarily liberal arts institutions and some of them, such as Amherst in Massachusetts and Oberlin in Ohio became wealthy and distinguished. During this period also new types of institutions of higher learning, devoted to training more and more students, appeared in great numbers. These included the state teachers colleges, successors to the old normal schools; state-college branches and public and private junior colleges. which brought collegiate training to many cities that previously lacked such facilities; and institutions devoted to adult education in many forms. At the other end of the scale, a few specialized institutions for advanced study beyond the Ph.D. were established. The Institute for Advanced Study at Princeton and the Center for Advanced Study in the Behavioral Sciences at Stanford, both located near major universities but not part of them, were conspicuous cases. Institutions such as the Brookings in' Washington, research libraries like the Folger at Washington, D.C., the Crerar at Chicago, and the Huntington at San Marino, Calif., and special research centres in physics and biology offered different, but parallel, opportunities for higher training.

If the first goal of a system of education in a republic is literacy, achievement in the United States was reassuring. The percentage of illiteracy in the total population, as shown by official census figures, decreased from 20.0 in 1870 to 4.3 in 1930. On the latter date only 1.5% of the native white population was illiterate and when classified by age, it appeared that practically all of this group was in the older age bracket.

The amount of schooling received by the general population also increased appreciably. Of the total population 25 years old and over in 1940, 4.6% had completed college, 14.1% had completed high school only and 34.6% had completed grade school only, while 13.5% had completed less than five years of formal school attendance. Less than 20 years later, only about 23% of males and 20% of females 25 years and older had completed less than eight years of elementary school. Approximately 39% of males and 43% of females had completed four years of high school, and the ratio of improvement for Negroes was more than twice that for the age group as a whole. Four years of college had been completed by almost 10% of males and almost 6% of females (more than 2.5% ior Negroes in both cases.)

In spite of these attainments, the post-World War II spurt in population raised some questions as to whether the educational system would be able to keep pace with the rapid increase in the number of children, and some parts of the country were experiencing serious shortages of classrooms and teachers. This, combined with the overstrained tax structures and increased financial burdens of many states and localities, raised demands from many quarters for greater federal aid to education. The question was a controversial one, for the states and localities, however strained their resources might be, were reluctant to give up any of their time-honoured prerogatives in the educational field.

At the college level, institutions of higher learning were faced not only with an absolute increase in the number of young people of college age, but with an increase in the percentage of those desiring a college education. Caught between rising costs that necessitated raises in tuition and a growing concern over the need to educate all those able to profit by advanced training, university and college administrators gave increasing attention to the possibility of more selective admissions and to scholarships, student loans and other devices for helping the needy student. Especially in the years following World War II, business corporations and foundations came into prominence as major contributors to university and college financing.

At the same time, critics of the educational system expressed concern not merely with the quantity but also with the quality of U.S. education, especially in relation to the achievements of the Russian system. Particular attention was being paid to the need for adequately training the gifted child, and the old dispute between vocational and general or liberal arts training came into prominence once more. See also ADULT EDUCATION; COEDUCATION; EDUCATION. HISTORY OF; ELEMENTARY EDUCATION; LEGAL EDUCATION; MEDICAL EDUCATION; SECONDARY EDUCATION; UNIVERSITIES; WOMEN, EDUCATION OF.

(C. A. BA.; F. E. RO.)

H. DEFENSE

1. Army.—When the second continental congress voted on June 14, 1775, to adopt the colonial militia besieging Boston, Mass., the United States army was born. Although it was still more than a year before the Declaration of Independence, the event marked the union of the forces of the 13 separate colonies under one head. When George Washington formally took command of the colonial troops on July 3, he found that they were largely militia and minutemen of local communities, given to going home whenever a particular danger was past. In Jan. 1776 the continental congress wisely decided that the troops it had directly raised and equipped should be separate in organization from those of local communities. These "Continentals" were enlisted for longer terms, mere trained more thoroughly and thereafter provided General Washington with a small but comparatively more stable nucleus with which to work, and they proved his chief reliance in the dark hours of the war. They mere the beginning of a regular army.

Washington's force varied from 8.000 troops in the operations around New York to as low as 4,000 after the winter at Valley Forge and as high as 26,000 in Nov. 1779. Other generals seldom had more than 6,000 men at their command, while some of the most important work of the war was done by bands of a few hundred under Thomas Sumter on the Catawba. Francis Marion in the Peedee swamps and George Rogers Clark in the northwest. (See AMERICAN REVOLUTION.)

When peace was declared, congress ordered the disbandment of the entire army except "t enty-five privates to guard the stores at Ft. Pitt and fifty-five to guard the stores at West Point." Indian disturbances on the frontier soon caused an increase, and, when Washington was inaugurated president, the number of men in service was 595. Until 1812 the army passed through snift periods of rise and fall, an index of national fear. From a single regiment when the constitution went into force, it changed to 3 in 1791, 6 in 1796, 9 in 1798, 6 in 1800, 3 in 1802, 11 in 1808. though the number authorized was always much higher than the number actually in service. Under stress of the War of 1812 the army increased from 21 regiments in Jan. 1812 to a paper strength of 51 regiments a year later, though it is doubtful if a sixth of the authorized 58.000 men were ever recruited. Counting militia and local combatants, possibly 60,000 men at the most served during the war.

The regular army was reduced to 6,600 by 1820, the artillery stationed largely in the coast fortifications and the infantry in the northern, western and southern frontier posts. Just before the Mexican War the army had shrunk to an actual strength of 5.300 men, occupying more than 100 posts. When war was declared the regular army was recruited to war strength, and about 20,000 volunteers responded to the call, many of whom had to be sent home again because they could not be outfitted About 20.000 troops took part in the war altogether, Gen. Winfield Scott having about 10,500 with him in the Valley of Mexico. In 1848 the troops were reduced to 8,000, scattered over the immense area to which the country had grown. The task of dealing with the Indians in the far west increased the army to a strength of 12,698 men by 1855, which it retained up to the Civil War.

Civil War to World War 1.—Enlistments in the Federal army during the Civil War numbered 2,898,304, including re-enlistments. The number in service at one time was probably a little more than 1,500,000. Estimates of the men in Confederate service varied from 700,000 to 885,000. Reduction on the usual scale in the regular army was impossible after the Civil War because of the large number of troops (about 19,000) stationed in the south to support the military governments of the Reconstruction period, because of the threat of Maximilian in Mexico which sent Gen. Philip Sheridan to the border with a large command and because of increased Indian outbreaks in the west during the Civil War and immediately afterward. The act of 1866 provided for a regular army of 54,000 men paper strength. The actual strength was 38,540 men, which decreased until in 1878 the effective strength was less than 20,000 men. The force was well trained, however, because it saw almost constant service against the Indians in the west. At the beginning of 1896 the army numbered slightly less than 25,000 men, the smallest force in proportion to the total U.S. population at any time after the Revolutionary postwar period. Calls for volunteers in the Spanish-American War increased the army to 216,029 men on Aug. 31, 1898. An act in 1899 authorized the president to keep the strength of the regular army at a maximum of 65,000, and in 1901 the allowable maximum was raised to 100,000. (X.)

Following the Spanish-American War the army launched upon a slow but increasingly accelerated struggle to bring itself up to the forefront as a military organization. To what extent this goal was achieved was demonstrated upon the entrance of the United States into World War I in the spring of 1917. While modernization of equipment and specialized training of troops had much to do with the army's progress, two radical changes in the military organization during the first 15 years of the 20th century had a lasting effect upon the defense establishment. The first was the establishment of a general staff corps in 1903 which provided for a policy-making group of officers to co-ordinate the specialized activities of infantry, artillery and other arms and services, and to act as a liaison organization between the field soldiers and the secretary of war and members of his civilian staff. (See STAFF, MILITARY.) The second, occurring in 1907, was the creation of an aeronautical division in the U.S. army signal corps. This was the beginning of the United States air force, a sister service holding comparable rank with its historic predecessors, the army and the navy (see Air Force below).

World Wars I and 11.—After the experiences gained by the concentration of a big segment of the regular army and the mobilization of the national guard for duty on the Mexican border in 1916, and in view of the threatening aspects of the war in Europe, which had been in progress from the summer of 1914, the U.S. government realized the necessity of building up its military strength as rapidly as possible. On June 3, 1916 congress passed a national defense act which raised the authorized strength of the regular army to 287,846 officers and enlisted men and provided for a reorganized military establishment which included the national guard, the organized reserve corps and a volunteer, or emergency, army.

The dress rehearsal for the army's participation in World War I started with the mobilization of the bulk of the regular establishment and the national guard in 1916. During the war the army grew from 100,000 officers and men to 4.000.000—up until then a high-water mark of U.S. military manpower. Approximately 2,000.000 soldiers went to France under the leadership of Gen. John J. Pershing and joined forces with the French, English and other Allies to crush the Central Powers in a struggle that was primarily a trench war of relatively fixed positions. (See WORLD WAR I.)

After World War I the U.S. army experienced the usual contraction that had followed in the wake of every other conflict in which it had taken part. In World War I approximately 75% of the personnel requirements of the army were met through conscription as provided by the Selective Service act of May 18, 1917. Another big percentage came from the citizen soldiers who comprised the national guard and those who enlisted "for the duration." With the advent of World War II, the army again went through the process of expanding from a force of about 200,000 regulars and a national guard of about the same size to an organization of more than 8,000,000 at peak strength. Its component parts were the army ground forces, the army air forces and the army service forces. (See WORLD WAR II.)

World War II experiences, from the outset, pointed out new lessons as well as new experiences for the American people; and the combined political, economic, industrial, diplomatic and military representatives of the nation began to make adjustments and rearrangements in the over-all defense organization even before the war drew to a close. Technological progress, electronic developments, atom- and hydrogen-bomb advancements, guided-missile inventions, aircraft perfection and other world-shaping factors contrived to "shrink" the protecting oceans on the east and the west of the United States. Previously, the army's history had been one of great expansion in time of emergency upon a mainland protected from attack by two wide water areas and supported by friendly neighbours, only to contract after each national crisis had been met and overcome. World War II emphasized the fact that homeland security could no longer depend entirely on the protection of geography, nor could national interests remain centred exclusively in its particular section of the North American continent. Moreover, the arrival of nuclear weapons brought the possibility that the issue in future wars might be decided so quickly that only those forces in being at the outbreak of hostilities would affect the outcome.

The *Army* at Mid-20th Century.—Forced into an accelerated program of implementing its revised plans and policies by the large burden assumed by the United States in the United Nations' intervention in Korea, the mission of the army at mid-20th century mas threefold in its major aspects. The first was constant preparation to maintain by timely and effective military action on land the security of the United States, its possessions abroad and other areas vital to its interests. Second was the formulation of workable plans for organizing, training and combining with allied forces for land operations. Third was the development of organization, tactics, techniques and equipment for use by army personnel in amphibious and air-borne operations. These were the missions, enumerated by the National Security act of 1947, the Key West and Newport agreements among the armed forces and the National Security act amendments of 1949.

Under the provisions of the Armed Services Unification act of July 26, 1947, the air force was established as a separate organization and was divorced from the control of the United States army. The same act created the national military establishment (later called the department of defense), in which the secretaries of the army and the navy relinquished presidential cabinet status and. along with the secretary of the air force, reported to the secretary of defense instead of directly to the president.

At mid-century the U.S. army was reorganized in accordance with the provisions of public law 581 passed by the 81st congress on June 28, 1950. This law, known as the Army Organization act of 1950, established the civilian control, the military directorate and the component elements of the nation's ground fighting service. Under the act, the army's civilian head is the secretary for the army. His immediate assistants are an undersecretary of the army and several assistant secretaries. The military head is the chief of staff. He is the chief of the general staff and reports directly to the secretary of the army. On the immediate staff of the chief are a vice-chief, four deputy chiefs and a comptroller. Each of the four deputy chiefs supervises a major element of the army organization—personnel, logistics, research and development and military operations. The deputy chief for logistics supervises the technical services, which include the chemical, medical quartermaster, ordnance, transportation, engineer and signal corps. While the signal corps and the corps of engineers are generally considered to be technical services, they are also classified as arms or combat branches, because they carry out missions as combat troops as well as engage in procurement, development and research.

Each of the three combat arms provided for under the reorganization act—infantry, artillery and armour—is especially equipped and trained for its specific type of work. Training of troops in the field is the responsibility of the chief, continental army command. In the training programs emphasis is placed on teamwork with other arms and with elements of the sister services. The results of the training are tested in combined maneuvers and exercises held at frequent intervals.

The conterminous United States at mid-20th century was divided into six army areas, plus the military district of Washington (D.C.), as follows:

1st army, with headquarters at Governors Island, N.Y., and consisting of the New England states, New York and New Jersey.

2nd army, with headquarters at Ft. George G. Meade, Md., including Delaware, Pennsylvania, Maryland, Virginia, West Virginia, Kentucky and Ohio.

3rd army, with headquarters at Ft. McPherson, Ga., and including North and South Carolina, Georgia, Florida, Tennessee, Mississippi and Alabama.

4th army, with headquarters at Ft. Sam Houston, Tex., and including Texas, New Mexico, Louisiana, Arkansas and Oklahoma.

5th army, with headquarters at Chicago, Ill., and including Illinois, Michigan, Indiana, Wisconsin, Minnesota, Iowa, Nebraska, Kansas, Missouri, Wyoming, Colorado and North and South Dakota.

6th army, with headquarters at the Presidio of San Francisco, Calif., and including California, Oregon, Washington, Montana, Idaho, Utah, Nevada and Arizona.

Overseas, the army had specific missions carried out by commands in Europe, the Pacific area and the Caribbean.

The basic combat organization in the field is the division. It is the smallest fighting team that contains representation of all the arms and most of the services and is capable of sustaining itself over an extensive period of time in combat. Divisions are of three types—infantry, air-borne and armour—depending on the type of troops that make up the main element of the organization. An infantry division, for example, consisted at mid-century of three infantry regiments (the major element) supported by five battalions of artillery, a tank battalion and an engineer combat battalion, a reconnaissance company, a signal company and the necessary service and supporting units.

The United States's strong military leadership and participation in the United Nations' action in Korea, which began in the latter part of June 1950, provided a realistic combat test for the organizational setup as well as the equipment and techniques of the country's land warfare establishment—just as the mobilization of the army along the Mexican border in 1916 provided a proving ground for the evaluation of the national strength prior to World War I. For three years after the Korean campaign ended, the structure and training doctrine of the army remained virtually unchanged, while study continued on the tactical lessons of that conflict and of the impact of atomic weapons on land forces and the form of land warfare.

The first general army-wide conference on the requirements of the future, dictated by main weapons changes, was held in 1956. One result was to popularize within the army the feeling that the greater part of its combat power should be made air transportable over strategic distance if it was to continue as an efficient instrument of national policy. This easily stated goal remained unattainable for reasons of cost and the necessity of supporting other main programs.

Within the following year, however, reform was initiated in another direction. While the division was continued as the basic self-maintaining field unit, all of its components, its weapons, methods of operation and systems for supplying and communicating were fundamentally changed. The reform was called the "pentomic" concept. Instead of a tight and mutually supporting triangle composed of three infantry regiments, the division became a much looser, but more flexibly mobile body consisting of five infantry "battle groups." Battalions were also dropped from the infantry structure. Each battle group was formed of five double-strength companies, thus eliminating one layer of command.

Not less radical was the reform of the supporting fire structure. Organic artillery within the division was cut to two battalions to make room for rocket batteries while artillery mortar batteries became integral in the rifle battle groups. The aim of this revision in gun power was to substitute atomic missiles for artillery concentrations, thereby lessening over-all weight, increasing shock and speeding the flow of force in a form of warfare certain to be operationally fluid. Logistical support for the division became centralized in a single support group, charged to move supplies for all fighting components up to the firing line. A signal battalion replaced the normal signal company serving the division because of the anticipated need for multiple lines between all echelons of command.

As a prototype for the pentomic reform, the 101st air-borne division was reactivated in Sept. 1956 to serve as the experimental laboratory. Before its first field tests could be held to determine the practicality and limits of the new design, it was announced that all air-borne and line divisions within the army would be remolded on the same general pattern. Manpower strength was scaled down slightly for all types of division.

Though the requisite reorganization was ordered. the weapons essential to the reform were still in short supply, the outlook being that the rearming would be more than 25% complete by 1962. For the fiscal year 1960 the army maintained 14 divisions: 8 of these were stationed overseas; 3 were kept in a strategic Army corps for deployment where needed; and 3 engaged in training activities in the U.S.

One other main army reform of the period sought the build-up of an adequate ready reserve and an equilization of all army training uithin the regular establishment and civilian components alike. It started with the passage of a reserve bill by congress in Aug. 1955, designed to provide an easier training option for youths otherwise subject to the draft. The bill provided that the volunteer recruits would take six months training under professional instruction and periodic drill for eight years thereafter, while remaining subject to mobilization. The program was described as the essential step toward raising a ready army reserve of 2,900.000 men within five years. Before the program was two years under way, houever, budget limitations forced a reduction of that figure to 700,000 men including 425,000 in the national guard. Under pressure from the army, the national guard in 1957 raised its level of recruit training to the standards of the regular service. This was the chief manpower advance from the army's effort to build a strong reserve. Throughout the period which followed the Korean campaign, the army was under constant and increasing political pressure to continue reduction of forces. Part of the pressure came from public feeling that because of nuclear weapons, armies mere in eclipse and the count of trained field soldiers under arms no longer decisively influenced the military poner balance between nations.

The army, like each of the other branches of the armed forces, gave increasing attention to research and development in the field of missile warfare. Its modernization program included plans for the Pershing, Sergeant, Lacrosse, Hawk, Honest John and Little John missiles. The Pershing, with an 800-mi, range, was the most powerful weapon contemplated in this area. The Hawk was an antiaircraft missile intended for use against low-flying aircraft, and both the Honest John and Little John missiles were to replace traditional field artillery weapons. Each of these weapons was designed to use ammunition with nuclear warheads, as was Davy Crockett, a short-range nuclear rocket for infantry squad use that was to replace the bazooka.

(M.B.H.; S.L.M.; F.E.Ro.; C.A.BA.)

2. Navy.—"The genesis of the United States Navy is to be found in the maritime origins and early development of the country," wrote Commodore Dudley W. Knox in *History of the U.S. Navy* (G. P. Putnam's Sons), recording that 2,342 U.S.-built vessels were included in the total of 7.694 engaged in the commerce of Great Britain in 1775. The earliest sea battles of the American Revolution were fought by small vessels armed for service by 9 of the 13 colonies. after the battle of Lexington, and intended for the protection of local water-borne commerce.

When Washington took command of the Continental army in July 1775, he found his troops without ammunition and arranged for a ship of the Rhode Island navy to sail to Bermuda for powder. Soon aftenvard, Washington fitted out seven small vessels and manned them with seagoing troops in order to interfere with British supply ships. Commodore John Manly directed this force and commanded the most successful of the vessels, capturing in one British ship a quantity of munitions equivalent to the manufacturing capacity of the colonies for about 18 months. On Oct. 13, 1775, the continental congress voted to fit out ships, and the marine committee, later appointed, sent the first Continental squadron to the Bahamas for the purpose of capturing munitions.

Congress declared all British vessels subject to capture and authorized privateering. In the aggregate, the Continental navy comprised about 60 ships and made an impressive showing. In addition to cruising against enemy merchantmen and British blockaders, the Continental vessels were required to make many voyages carrying diplomatic representatives and essential cargoes. Arrangements for the administration of the Continental vessels were not efficient, and the shortage of money imposed severe handicaps. Privateering offered much better financial inducements, and made recruiting difficult. Together the Continental navy and the privateers touched the pocketbook nerve of British merchants and each one of the many petitions to the king praying for ending of the war stressed the severe losses which the English mercantile community was suffering.

The Royal Navy enabled the British army to reduce Savannah, Ga., Charleston, S.C., and Wilmington, N.C.; it ravaged the coast of Connecticut, burned Norfolk, Va., Falmouth, Me., and other coastal towns while enabling the British army to strike at will along the seaboard. By 1778 Washington realized that he needed a superior French fleet to enable him to inflict a truly decisive defeat on the British, and thereafter he constantly urged on Benjamin Franklin in Paris the need for ships rather than French troops. In the battle of the Capes of Virginia, Sept. 5, 1781, a powerful British fleet was defeated by the comte de Grasse. The presence of the French fleet prevented the Royal Navy from rescuing the British from the Yorktown peninsula, and Washington forced the surrender of Lord Cornwallis. After the Revolution the Continental navy mas disbanded and the vessels sold. The first congress, under the constitution, provided for an army but decided that a navy was not necessary. Destruction of U.S. commerce by the Barbary states caused congress to authorize the building of six frigates in 1794 and to establish the navy department in 1798. Successes in the quasi-war with France in 1798 and in the Barbary wars gave Thomas Truxtun, Edward Preble and Stephen Decatur national reputations and provided the young navy nith experience and self-confidence.

The War of 1812 grew out of British impressment of U.S. seamen and other grievances connected with U.S. commerce. New England was not enthusiastic about the war, while the whole country was disappointed by the U.S. army's failure to occupy Canada. The overwhelming size of the British navy made possible a damaging blockade of all principal ports, enabled the British to capture and burn Washington, D.C., to attack Baltimore, Md., New Orleans, La., and various coastal towns, while driving U.S. shipping from the seas. U.S. victories in a number of frigate actions were helpful in keeping up the national spirit and added to the prestige of the navy.

Between 1815 and 1861 the U.S. navy appeared in seaports all over the world, assisted commerce, made treaties in the near east and far east, explored and surveyed unfamiliar areas, conducted many scientific expeditions and had a major share in ending piracy as well as suppressing the slave trade. The Naval academy was established in 1845 by George Bancroft, the historian, then secretary of the navy. In the Mexican war, 1846–47, the navy took over California and administered the government, besides escorting and landing the army at Veracruz for the capture of Mexico City.

When the Civil War began in 1861, the navy had about 10,000 officers and men and 90 ships. Only 42 of these ships were in commission and only 12 were in the home squadron. Many able and experienced officers "went south" and built the Confederate navy, with the assistance of about 2,000 guns and 11 ships captured with the Norfolk navy yard. On April 19, 1861, President Lincoln proclaimed a blockade of all southern ports. To many it seemed absurd to propose to blockade 3,000 mi. of seacoast with a small navy. Secretary of the Navy Gideon Welles, ably seconded by Gustavus Fox, assistant secretary, started immediately at the mouth of the James river, and before the end of Dec. 1861 more than 150 ships had been captured in attempting to evade the blockade. In November Adm. Samuel du Pont took Port Royal sound and established a base for blockading vessels. The blockade isolated the Confederate states and cut off overseas supplies of munitions. On March 8, 1862 the steam frigate "Merrimack" converted by the Confederates into an ironclad, appeared in Hampton Roads, Va., and sank two Union vessels, the "Cumberland" and the "Congress." For a time it was feared that the "Merrimack" could destroy the blockade, but on the very next day she was met by the "Monitor" in an epic fight, and she did not attack again. (See "MONITOR" AND "MERRIMACK," BATTLE OF.)

Although the Union navy had been an important element in the Civil War, it was thereafter neglected for many years. In spite of naval stagnation the U.S. Naval institute was established in 1873 for the advancement of professional, literary and scientific knowledge in the navy. The Naval War college at Newport, R.I., was established by Commodore Stephen B. Luce in 1884, and, in 1890, a member of its staff, Capt. Alfred Thayer Mahan, published The Influence of Sea Power Upon History, 1660–1783. Mahan's writings brought him academic honours at home and abroad, and the presidency of the American Historical association in 1902.

In 1883 congress appropriated money for building four steel warships and the navy took the radical step of insisting that the steel be of domestic manufacture, thus requiring the production of better steel in the United States.

The U.S. navy grew steadily in power and efficiency between 1898 and 1917. Pres. Theodore Roosevelt provided much of the impetus for the growth and aided in the national popularity of the service. He ordered a cruise around the world in 1907–08 which improved efficiency and had valuable diplomatic effects. In 1915 the office of the chief of naval operations was established, and in 1916 an important shipbuilding program, influenced largely by Japanese actions, was begun. During World War I U.S. naval vessels did not participate in any sea battles, but the navy was expanded eightfold and performed many important duties. The sea power of Great Britain, seconded by French and Italian fleets, had prevented a German victory in spite of the successes of the German armies. In April 1917, just after the U.S. entry into the war, German submarines were sinking Allied merchantmen at an alarming rate, but the assistance of U.S. destroyers, the adoption of the convoy system and a huge shipbuilding program in the U.S. overcame this threat. The navy laid an enormous antisubmarine mine field in the North sea, sent a battleship division to join the British grand fleet and a second division to Bantry bay to guard against heavy raiders, sent a naval aviation bombing squadron to France, provided a battery of heavy guns on railway cars for the western front and transported more than 1,000,000 troops to France.

World *War II.*—After the beginning of World War II in 1939 the U.S. navy began a huge building program of planes, warships, merchant ships, landing craft and various special types. A patrol was instituted in the Atlantic in 1939, Iceland was occupied in 1941 and the escort of convoys began in 1941. After the disastrous Pearl Harbor attack of Dec. 7, 1941, the U.S. navy helped seize French Morocco in Nov. 1942, and landed U.S. troops in Morocco and Algiers. It furnished sea and naval air strength for the seizure of Sicily, Salerno, Anzio and southern France. While combating German undersea warfare in the Atlantic, the navy furnished convoy escorts and special search groups including aircraft carriers, planes, destroyers and special antisubmarine vessels. In the Normandy landings of June 1944, the navy supplied large numbers of amphibious ships, landing craft, etc., as well as combat ships for fire support for troops. After the Pearl Harbor attack Japanese amphibious forces made landings in Malaya, the Philippines, South Pacific islands, New Guinea and the Netherlands Indies. Early in 1942 the Japanese were building up Rabaul as a great base and on May 8, 1942, in the battle of the Coral sea, fought by carrier planes, the U.S. navy checked the Japanese in their expansion southeastward. On June 4. 1942. the decisive battle of Midway was fought. Japanese battleships, cruisers, destroyers and submarines, as well as amphibious vessels, were in the area, and U.S. cruisers, destroyers and submarines; but the heavy blows were struck by carrier planes, and Japan lost its four best carriers together with all their planes and almost all their pilots. The U.S. navy suffered heavy casualties among carrier pilots and lost one of three carriers present, but to the Japanese the result was devastating.

Both the U.S. and Japanese navies had done far more than other navies in integrating aviation in their fleets. Japan began the war with excellent carriers and well-trained carrier pilots. The heavy losses of pilots at Coral sea and Midway were augmented in the battle of Santa Cruz and by misusing carrier pilots on shore at Rabaul later on. In consequence, Japan never replaced its "first team" of carrier pilots. In Aug. 1942 the U.S. marines landed on Guadalcanal in the Solomons, and this area became a battleground for six months. The naval battles of Savo Island, eastern Solomons, Cape Esperance, Santa Cruz, Guadalcanal and Tassafaronga were costly to the U.S. navy but even more costly to the Japanese.

Allied ground, naval and air forces under General MacArthur and Admiral Nimitz fought westward through the Solomons, Bismarck~Admiralties, Carolines and New Guinea, bypassing great bases in wide flanking envelopments, liberating and retaking the Philippines, cutting off Japan's supplies to the south and forcing the ultimate surrender. On June 15, 1944, Adm. R. A. Spruance struck the inner ring of Japanese defenses by landing marines on Saipan, and on June 19 fought the battle of the Philippine sea, which resulted in a further heavy loss of Japanese carrier pilots and planes, as well as two Japanese carriers sunk by submarines. The battle for Leyte gulf, fought Oct. 25, 1944, was one of the decisive naval victories of the war, along with Midway and the Philippine sea. Sea power was of central importance in the Pacific, destroying the Japanese merchant marine through submarine warfare, crippling its fleet and leaving great bases like Rabaul and Truk with large garrisons to die on the vine. (See WORLD WAR II: The War at Sea.)

Immediately following World War II navy development began to conform to the final lesson of that conflict, that all military forces serving the major powers must have a preponderant capability nith atomic weapons. Navy doctrine presupposed that the new age had not diminished the ancient authority of sea power but did require a radical overhaul of its floating combat structure.

World War II had proved that the main weapon of sea forces during the first half of the 20th century, the battleship, was no longer the decisive fleet element because of the ascendancy of air power, land-based and carrier-based. (See AIRCRAFT CARRIER; AVIATION. NAVAL.) The heavily armoured, heavily gunned but relatively sluggish battleship had no real utility within navy task forces and fleets which, striking at great speed over long range. were built up around the fast-moving carriers, covered by screens of cruisers and destroyers.

The essential idea controlling all navy reform mas that the fleet must be rebuilt to keep the seas under attack in any form while carrying atomic warfare against the most distant shore. The conversion program was necessarily slowed by the technical complexity of the problem and budgetary limitations. At mid-century the navy was under equal pressure to modernize and economize. While part of the fleet was being moth-balled to save money. the first experiments were run to prove that the cruiser is a suitable launching platform for guided missiles fitted with atomic warheads. Later, certain cruisers were converted into rocket ships. Of greater import was the construction of the U.S.S. "Nautilus." the first atomic-powered submarine. The "Nautilus" proved capable of cruising 50,000 mi. without refueling or overhauling. This range, more than her extraordinary speed and ability to run submerged indefinitely, infinitely extended the horizon for all sea power.

The unqualified success of the "Nautilus" established as an ultimate goal for the navy that all main fighting craft should be similarly powered. That attainment was far distant in the mid-1950's because of the costs of rebuilding. The atomic age had superinduced a trend toward supercarriers of the U.S.S. "Forrestal" class. The price of one vessel would have sufficed for a fleet in the early part of the century.

To conform with the weapons revolution, the indicated tactical change lay in a search for new dispersal systems whereby the fleet could be made more elusive under atomic attack, with its components scattering swiftly to achieve better individual concealment. All progress toward this end was perforce closely guarded by security regulations.

Being in early development, the modernization program was not importantly reflected in navy operations during the Korean conflict, 1950–53. Throughout, the navy remained unopposed by enemy sea power, and its only interference came from weak shore batteries, marine mines and occasional planes. Its vessels therefore moved with relative freedom where needed to assist land operations. One novel result was a continuing close support of the army combat line by carrier-based navy aviation.

In the decade which followed World War II, while the fundamental mission of the navy remained unaltered, the manner of its execution became transformed dramatically. This change came of U.S. leadership in the forming of the system of free-nation alliances with the object of containing Communist military power in Europe and Asia. In the pre-World War II period, navy power was based at home and its peacetime operations were in the main confined to home waters. Under the postwar policy, the preponderant parts of its striking force deployed to distant waters where they could exert, by their presence, a continuing restraining influence. One fleet became based on Formosa, another on ports of the Mediterranean and other task forces patrolled the contiguous waters. The rebuilding and resupplying of these deployed forces, toward preparation for the possibility of full-scale atomic war, continued.

After World War II the U.S. navy looked upon the attack aircraft carrier as a primary weapon in both limited and total wars. By 1960, however, a rival weapon had been developed in the area of total war. This was the large, fast nuclear-powered submarine capable of firing (even when submerged) intermediate range ballistic missiles of the Polaris type. Armed with nuclear missiles, these Polaris submarines represent a powerful weapon in modern warfare. The first three Polaris submarines were begun early in 1958. On July 20, 1960, the submarine "George Washington" successfully launched two Polaris missiles while submerged in the Atlantic ocean off Cape Canaveral, Fla.

(J. B. HN.; S. L. M.; F. E. RO.; C. A. BA.)

3. Air Force.—The antecedents of the United States air force date back to the Civil War when the balloon (*q.v.*) was used for military purposes by the U.S. armed forces. In 1892 the U.S. army signal corps established a balloon section and subsequently interested itself in aeronautical experiments with heavier-than-air flying machines. On Aug. 1, 1907, less than four years after the successful flight of the Wright brothers at Kitty Hawk, N.C., the U.S. army organized an aeronautical division, consisting of one officer and two enlisted men, under the signal corps. The U.S. army accepted its first heavier-than-air flying machine, built by the Wright brothers, on Aug. 2, 1909. In 1913 the aeronautical division had a strength of 23 officers, 83 enlisted men and 15 flying machines. Before the United States entered World War I, the 1st aero squadron participated in the expedition into Mexico in pursuit of Pancho Villa in 1916. This venture was unsuccessfu! because most of the squadron's obsolescent aircraft broke down in the early stages of the campaign.

World War I.—When the United States entered World War I in April 1917 it found itself far behind the other warring powers in the quantity and quality of its military aircraft. The aviation section (the name had been changed in 1914) had 131 officers, including 112 qualified flyers, and 1,087 enlisted men organized into 7 flying squadrons with a total inventory of 103 planes, none suitable for combat. By the end of the war, the army air arm had attained a strength of 195,000 officers and men, and had organized 45 air squadrons with a complement of 740 planes, manned by 767 pilots, 481 observers and 23 aerial gunners. Until the later stages of the war, U.S. combat squadrons in France were equipped chiefly with French and British planes. In July 1917 congress appropriated $640,000,000 for the development of U.S. aircraft production capacity. By the end of the war the U.S. army in the zone of advance in France had received 2,925 airplanes, of which 696 were manufactured in the United States.

The most important U.S. combat action of the war occurred in Sept. 1918 when Col. William Mitchell (*q.v.*) led a force of almost 1,500 U.S., British and French planes in support of the offensive which reduced the St. Mihiel salient. In all, during World War I, U.S. army aviation carried out 13,000 pursuit flights, 6,600 observation flights and 215 bombing flights, dropping a total of 275,000 lb. of explosives. Losses in combat amounted to 289 planes and 48 balloons as against confirmed enemy losses of 781 planes and 73 balloons.

In May 1918 Pres. Woodrow Wilson established the air service, U.S. army, by executive order and gave it responsibility for army aviation. Not until after the war, June 4, 1920, did congress pass legislation formally establishing the air service as a combat arm of the army, with an authorized strength of 1.516 officers and 16,000 enlisted men, including not more than 2,500 flying cadets.

Rapid demobilization after World War I was followed by further retrenchment which left the air service well below the strength authorized by the Army Reorganization act of 1920. Continued use of large numbers of planes and engines left over from World War I, although economical, saddled the air service with obsolescent equipment for almost a decade after the war. Efforts to develop better planes and engines were pushed during the 1920s, but lack of funds and facilities seriously hampered such work. One of the more notable efforts of the years immediately following World War I was the developmental work on large bombing planes which, although unsuccessful in producing an acceptable plane, added much to technical knowledge. The movement for creation of a separate air force on a par with the army and navy had its most dramatic and forceful proponent in Brigadier General Mitchell, assistant chief of the air service between 1920 and 1925. Legislative attempts to establish a separate air force met with no success and Mitchell himself resigned from the army in 1926 after being court-martialed in 1925 for disobeying orders.

The Air Corps act of July 2, 1926, replaced the air service with the army air corps and created the position of assistant secretary of war for air. The air corps retained responsibility for training and logistical support of its units, but the combat units themselves were under the control of army area commands. Advances in aircraft performance, tactics and strategic thinking during succeeding years pointed to the need for more centralized control of the army's air striking forces. This need was met by the creation of the general headquarters (G.H.Q.) air force on March 1, 1935, with headquarters at Langley field, Va. Coequal with the air corps and independently responsible to the chief of staff of the U.S. army, this new mobile air force was composed of the combat air units within the conterminous United States.

World War *II*.—On the eve of World War II in Sept. 1939 the army's air arm had a strength of less than 27,000 officers and men and approximately 1,500 tactical planes. It possessed only 13 B-17 bombers, its chief claim to leadership in military aeronautical development. In all other types of aircraft, the U.S. army air corps was inferior to the German and British air forces.

Earlier in 1939, with the support of Pres. Franklin D. Roosevelt and the help of congressional appropriations, the air corps had launched a program to expand its strength to 5,500 aircraft, including reserves, organized into 25 combat groups. This program remained in effect until May 1940 when President Roosevelt called for an air force of 50,000 planes and an annual production rate of 50,000 planes. The air corps thereupon launched a series of expansion programs which did not cease until the peak strength was reached during World War II.

During 1941 the air arm gained increased stature within the U.S. army. In June 1941 the army air forces (AAF) was created and placed over both the air corps and the air force combat command (successor to G.H.Q. air force). The next logical step was taken after the outbreak of war, in March 1942, when the air corps and the air force combat command were merged into the army air forces under a single commander, Gen. Henry H. Arnold. From its headquarters in Washington, D.C., the AAF directed expansion of the army's air arm into a powerful global weapon, composed of 16 air forces (12 of them overseas), 243 combat groups, 2,400,000 officers and men and nearly 80,000 aircraft.

The rapid build-up of U.S. air power during World War II and its effective use relatively early in the war was made possible by the prewar preparedness measures begun in June 1940. The 18-month breathing spell before Pearl Harbor permitted the United States to lay the military and industrial foundations which proved so valuable once the war began. U.S. air power played a major role, and sometimes a decisive one, in every theatre of war. The strategy adopted by the United States and Great Britain in Dec. 1941 placed first priority on the defeat of Germany. It was in Europe and North Africa, therefore, that the greater part of the combat strength of the AAF was eventually concentrated and that the earliest results were achieved. But it was not until the tide of Japanese aggression had been checked in the Pacific during the summer of 1942 that the AAF could carry on a sustained build-up of air strength against Germany.

The AAF made the first major test of its doctrine of strategic bombardment against Germany. The 8th air force in England from Aug. 1942 and the 15th air force in Italy from Nov. 1943 carried out a sustained daylight bombing offensive against Germany, its allies and the occupied countries. In conjunction with the British Royal Air Force they did much to destroy and dislocate the German economic system and to weaken the morale of the German people. The B-17 and B-24 bombers and their escort fighters, P-38s, P-47s and P-51s, secured air superiority over Germany itself early in 1944, dealing the German air force such heavy blows that it was never thereafter seriously able to dispute control of the skies over western Europe with the Anglo-American air forces.

The AAF also deployed large tactical air forces against Germany and Italy. In North Africa, the 9th air force, operating from Egypt and Libya, and the 12th air force, in Algeria and Tunisia, joined with British air units to destroy Axis air strength and to sever the lines of supply to Axis ground armies. In Sicily the 12th air force helped force a quick victory in 1943 and from then until the end of the war it assured the U.S. ground forces in Italy of air superiority over the enemy. The 9th air force moved to England in Oct. 1943 and was greatly enlarged for its vital role in the campaign for the liberation of western Europe. After helping to soften up enemy coastal defenses and destroy transportation in western Europe in the weeks before D-day—June 6, 1944—the 9th air force followed closely behind the ground armies in the sweep across France and the Low Countries into Germany. It established air supremacy over the battlefields, protecting U.S. ground forces from enemy air attack and subjecting the German armies, transportation facilities and depots to incessant blows until the end of the war in May 1945.

In the Pacific the tide began to turn against the Japanese in the summer of 1942. Beginning with the conquest of Guadalcanal in 1942 (chiefly a U.S. marine corps operation), the Pacific air force—5th, 7th and 13th—joined with the army and navy in a series of island conquests which were steppingstones to Japan. New Guinea, the Marianas, the Philippines and Okinawa—in all of these campaigns the AAF, often in conjunction with U.S. navy and marine air units, secured the control of the air which had come to be indispensable to victory on the ground. On the mainland of Asia, meanwhile, the 10th air force helped turn the Japanese back from the gates of India and spearheaded the reconquest of Burma. The 14th air force in China, supplied by the massive air lift from India over the "hump" of the Himalayas, effectively challenged the Japanese in the air in spite of great odds and lack of bases. Meanwhile, the AAF had readied an instrument which was to deal out heavy punishment to Japan. After initial operations from India and China in 1944, the B-29 superfortress bombers of the 20th air force were concentrated at giant bases on Guam and Saipan in the Marianas. From there they carried out the fire raids which severely damaged the greatest Japanese cities and destroyed a large part of Japan's industrial capacity. But it was only with the dropping of atomic bombs on Hiroshima and Nagasaki on Aug. 6 and 9, 1945, that the futility of further resistance was brought home to the Japanese.

Behind the combat forces which won the air war in every theatre of operations stood a great array of manpower which provided the many services required by modern warfare. The training command, the air technical service command, the air transport command and a number of smaller commands provided the trained men, the matériel and the air transportation essential to victory. Their success demonstrated that the AAF had attained a degree of self-sufficiency which made it ready for independent status.

Post World War *II;* the Korean War.—The swift demobilization of the postwar period severely affected the combat capability of the AAF. Its strength shrank to 303,000 men in June 1947 and it could man only 38 combat groups, of which no more than 11 were operationally effective. Meanwhile, in anticipation of becoming an independent service, the AAF applied the lessons of World War II to its organizational structure, reorganizing along lines which placed emphasis on functions rather than geographical areas. The basic pattern of unit organization, in ascending order, was established as follows: flight, squadron, group, wing, air division, air force, command. The new command structure came into being in March 1946.

The National Security act of 1947 created the department of the air force and the United States air force, effective Sept. 18, 1947. As one of the three military departments under the department of defense, the air force helped develop a series of agreements which specified the functions to be performed by each of the military services. The air force received primary responsibility for air operations, particularly in the field of strategic bombardment.

Between 1947 and 1949 the air force carried out its separation from the army, progressively assuming almost all of the functions previously performed for it by the army. The Army and Air Force Authorization act of 1949 provided the air force with a legal framework, specifying its composition, personnel strength and authority with respect to expenditure of appropriated funds, procurement and research and development activities. The Air Force Organization act of 1951 for the first time placed the internal organization of the air force on a statutory basis. From its headquarters in Washington, D.C., the air force directed the operations of about 19 major field commands. Of these, the strategic and tactical air command and the air defense command carried out the prime missions of the air force. The strategic air command, based chiefly in the United States, contained the bombardment and reconnaissance units which were responsible for the conduct of long-range operations to any corner of the world. To permit the most effective use of the strategic air command's bombers, the United States built advance bases for them in Greenland, the United Kingdom, Spain and north Africa. During most of the first decade after World War II these units were equipped with B-29, B-50 and B-36 bombers. By 1954 the B-47 six-engine jet bomber had replaced the B-29 and the B-50, and in 1955 the B-52 eight-engine jet bomber began to replace the B-36 in strategic air command units. Escort fighter units were equipped with F-84s.

The tactical air command, composed of light bombers, fighters and tactical reconnaissance units, was responsible for air operations in support of the ground forces. By the end of the Korean war most of its units were deployed in oversea areas, particularly in the far east and Europe. Its most important aircraft types after 1946 included the B-26 and B-57 light bombers and the F-80, F-84, F-86 and F-100 fighter-bombers.

The air defense command received increasing emphasis after 1949 and by 1955 had equipped all of its interceptor units with jet fighters—chiefly F-86s, F-89s and F-94s. In 1954 also it became the major component of a joint army-navy-air force command charged with defense of the conterminous United States.

Overseas, the United States air force in Europe provided the American tactical air components of the North Atlantic Treaty organization (NATO) air force. The far east air force; stationed in Japan, Korea and Okinawa, was the other major oversea GSAF combat command. The Alaskan, Northeast (Newfoundland, Labrador) and Caribbean air commands were primarily concerned with the air defense of North America,

Supporting the combat forces were a number of commands providing essential services. The air matériel command procured the billions of dollars worth of equipment and supplies required each year by the USAF and distributed and maintained them, operating depots in the United States and overseas. The air research and development command, established in 1950, supervised an extensive program for development of more advanced weapons. The air training command provided the trained men who manned the combat and service units, while the continental air command directed the reserve activities of the air force. The U.S. Air Force academy, which enrolled its first class in 1955, gave the air force an undergraduate school comparable to the U.S. military and naval academies. The extensive graduate education system continued under the control of the air university, The air force also had primary responsibility for the operation of the military air transport service, a joint air force-navy command which provided air transport for cargo and personnel of all the services.

The Berlin air lift of 1948–49 provided a severe test of air force resources when it was still recovering from the effects of the postwar demobilization. From June 26, 1948 to Sept. 30. 1949 the air force, using chiefly C-54 transports, brought almost 2,500,000 tons of food, fuel and other supplies into Berlin to sustain the 2.250.000 people there who had been cut off from land communication with western Germany by the U.S.S.R. This costly effort, carried out in conjunction with the United Kingdom and France; had its compensations in the development or' advanced techniques by the air force.

The outbreak of the Korean war in June 1950 led to an immediate expansion of the strength of the air force. The 5th air force, which fought the air war against the North Koreans and Chinese. received strong reinforcements of fighter-bomber groups enabling it to control the skies over Korea throughout the conflict. Bombardment wings of the strategic air command also joined the battle for a time in 1950 and 1951, but the war was primarily a tactical one, and the opportunities for strategic bombing were limited.

In Europe, the United States met its commitments to NATO by deployment of additional combat wings, including B-61 guided-missile units, to the United States air forces in Europe. In the U.S. the air defense command established eastern, central and western air defense forces which increased their strength several times over by 1956. The strategic air command added more bombardment, reconnaissance and escort fighter wings to its strength, and like the other commands re-equipped its units with advanced aircraft models. Starring from a strength of 48 wings and 400,000 officers and men in June 1950, the air force reached a strength of 130 wings and almost 950,000 officers and men in 1956.

The post-World War II period was marked by a constantly accelerating technological competition among the air forces of the world. Progress in the United States between 1945 and 1950 was not as great as it had been during the preceding five years because the stimulus of war was no longer present and the possession of the atomic bomb appeared to be an overriding factor. But rapid technological progress in other countries, coupled with increasing international tensions, compelled the United States to accelerate its efforts. In the six years after the beginning of the Korean conflict, the air force equipped virtually all of its units, except for its transport fleet. with advanced jet aircraft. Developments in atomic and thermonnclear energy provided not only bombs for use in strategic bombardment, but a great variety of weapons which could be used by tactical air units against ground forces and small targets. By 1956 the air force had attained a thoroughgoing capability to use atomic and thermonuclear weapons for the fulfillment of all of its combat missions.

Even before the use of the V-2 guided missile by the Germans in 1944–45 the United States air force had been working to develop a variety of missile weapons. During the course of World War II the air force used a variety of rockets and guided bombs with varying success. But the ultimate goal of postwar research and development was the use of the atomic, and later the thermonuclear warhead, with a missile which could be guided accurately to targets many thousands of miles away. Pending the development of such a weapon—generally referred to as the intercontinental ballistic missile—the air force developed a number of special purpose missiles which met other needs. The first USXF guided missile actually placed in operational units was the B-61 Matador. a jet-powered: guided aircraft with a speed of approximately 650 m.p.h. and a range reported to be up to 500 mi. This weapon was intended for short-range tactical use, and units equipped with it were stationed in Europe beginning in 1953. The first successful U.S. air force missile for air defense use was the Falcon, an electronically controlled lightweight missile for air-to-air combat.

During the latter half of the 1950s the air force made tremendous progress in developing other air-to-air and air-to-surface missiles but its most striking advances were made with long-range ballistic missiles such as the Atlas (classed as operational in 1959), Titan and Minuteman. By 1960 the launching of earth satellites with the aid of such missiles had become almost commonplace and the air force was preparing to take a further step into space by launching and recovering a man-carrying space vehicle. *See* also AIR WARFARE; KOREAN WAR; MISSILES; ROCKETS; SPACE EXPLORATIOS; WORLD WAR II. (A. GG.)

VII. THE ECONOMY

A. GROWTH OF THE AMERICAN ECONOMY

In nearly all branches of production and trade, U.S. productivity greatly exceeds that of any other country and has, accordingly, established standards by which other nations measure their own efforts. In World Wars I and II, U.S. output of military supplies and munitions played a decisive part in determining the outcome. Finally, the United States, as the country whose productive system is the most highly mechanized, presents the foremost challenge to man's attempts to readjust his way of life and social relations under the impact of the machine age, with all its attendant problems and seemingly limitless opportunities.

Economists have become increasingly aware that U.S. industry and commerce can be adequately understood only as functions of the growth of the economy.

For the purposes of the economic historian, the interrelated growth processes of innovations in industrial methods or products provide a far more suitable framework for analysis than the political events about which the conventional historian organizes his data. Characteristically, the United States has furnished leadership in the number and extent of the transformations in economic life which it has achieved. Prominent among these are the development of shipbuilding and shipping before 1860, the mechanizations of agriculture, bulk processing of iron and other metals, the refining of petroleum for fuel, the mass production of durable goods, especially automobiles. the adaptation of electricity to practical purposes and the realization of atomic energy. But it is very likely that the most strategic redirection of the U.S. economy was set in motion by the era of railroad construction. This era may be roughly dated as occupying the second half of the 19th century, even though a final, diminished wave of construction marked the years between 1900 and World War I. From its earliest days, the new mechanical mode of transportation found a powerful ally in telegraphic communication.

The redistribution in the balance of world economic power brought about in part by this revolutionary mode of transportation favoured the continental nations far more than Great Britain, the country of its origin. At the time of the introduction of the railroad, no nation stood to gain more from exploiting its potentialities than the United States. Whatever the particular advantages enjoyed by other nations, none could claim the combination of advantages represented by a national territory second to none in its natural wealth and a system of social and political institutions which eminently fitted its people for commercial enterprise and industrial resourcefulness.

With nothing more than human or animal means of overland transportation, U.S. economic activity must have remained closely restricted to the coastal belts and inland waterways. Once mechanical means of transportation were available, however, the agricultural and mineral resources of the interior not only provided the country's industrial centres with much of their food and raw materials but also supported the markets which justified economically the introduction of heavy capital equipment for mass production.

If, measured by the criteria of industrial progress, the first half of the 19th century belonged to Great Britain, world leadership in the second half was so fully appropriated by the United States that by 1900 the nation's output exceeded that of Great Britain and Germany combined. An increase in population unprecedented for any western nation was accompanied by a similarly unprecedented rise in per capita income. Between 1860 and 1910 agricultural output more than quadrupled, although the proportion of the labour force employed on farms fell from approximately 50% to less than one-third. In 1890 manufacturing for the first time exceeded agriculture in its contribution to the national income. For these reasons, the second half of the 19th century may be regarded as the principal watershed in the economic development of the United States, separating the early and the modern periods. This threefold chronological division is in keeping with a premise of growth analysis that can scarcely be overstressed: growth, in the sense of progress rather than of mere expansion along established lines, implies the presence of elements of originality. Where powerful innovational factors are absent, economic activity is likely to remain repetitive and slow. It will generally be found that the directions of greatest advance in terms of physical volume are also those marked by the highest incidence of change in methods of operation or in the nature of products. Therefore, it is in the sources of differentiation from established patterns that the keys to the understanding of the dynamic economy are to be found.

From the First Settlements to the Mid-19th Century.— For more than two centuries, American industrial and commercial expansion took place along the lines characteristic of the colonial economy. The colonial economy is generally understood as one that is primarily dependent upon agriculture and relies on its capacity to extract raw materials to exchange for the manufactured or finished goods of more highly developed countries. The early American economy can be regarded as the classic example of its kind.

From the outset, the colonies possessed immense and comparatively rare advantages. Such natural endowments of the North American continent as its unusually high proportion of arable land and other natural resources and its extensive coastal and inland waterways are well known. Less often noted is the agricultural advantage arising from the geographic situation of the United States, which not only lies entirely within the temperate zone but also coincides with the southernmost half of that zone. This situation means a high average declination of the sun, providing long, warm growing seasons favourable to many important crops. Turning to the human resources of the colonies, circumstances were also advantageous. Consequent upon the Reformation in northern Europe, the desire for religious freedom provided a motivation for permanent settlement far more effective than the lure of adventure. The accumulation of dynamic forces was gradual. Necessarily, they demonstrated an unmistakable pattern of relationship with agriculture and the extractive industries. To cite only the most prominent examples, the establishment across the free or near-free lands of farm units larger in average size than those of densely populated Europe created an order of demand, in the form of agricultural surplus, for housewares and manufactured implements quite unlike anything known before. This demand largely explains the eventual development of a number of industries. By 1850 U.S. production of farm machinery led the world in scope as well as in the pace of technological improvements. The high relative value of human effort led to the ingenious improvement of tools, foreshadowing the great power tools and precision instruments of the 20th century. Simultaneously, a market was brought into being for what later became known throughout the world as American "specialties": the stock in trade of that primarily native institution, the hardware store, and the precursors of the 20th century's household appliances. The migratory ventures of great numbers of U.S. families necessitated the continual setting up of new households, resulting in an augmented demand for hard goods. The firearms industry thrived on the needs of pioneer settlers, preparing the way for the introduction of the system of interchangeable parts in their manufacture — a system which has become a primary technique of modern manufacture.

It was in shipbuilding and shipping that the greatest triumphs of early American industry and commerce were achieved. This great enterprise, too, rested squarely on extractive industries. Production flourished as a result of the large stands of virgin timber accessible to the sea or to river estuaries. The growing demand for ships arose from the needs of the New England fishing and whaling fleets and, even more, from the coastwise and overseas trades. The country's international trade, made up largely of exports of American raw materials and the import of European manufactures and oriental luxuries, was importantly supplemented by the "triangular trade" with the West Indies and Africa in which, dried fish and rum were exchanged for slaves and molasses.

Large numbers of ships were exported to Europe. As if either accomplishment were not impressive enough in itself, the United States concurrently made the steamboat commercially successful and produced the fastest wind-propelled vessel ever devised for commercial use. The "Yankee Clipper" symbolized, in its stark functionalism aimed directly at competitive efficiency, the spirit of U.S. enterprise. In 1855 shipyards launched a documented total gross tonnage in merchant sailing ships of 505,323, a record which was never equaled by their production of steam vessels until the defense shipbuilding of World War I. Especially in Boston and the other great ports of the northeast, the sailing and shipbuilding industries became the preponderant initial sources of U.S. capital. U.S. shipping, however, was to prove no match for British competition in the age of steam.

Subsistence farming and the domestic crafts constituted the overwhelming means of livelihood for the colonists. The principal support of the export trade, however, came from the staple or cash crops. In the southern colonies these were led by tobacco, rice and indigo until after 1793, when the cotton gin provided the keystone to the south's cotton empire, destined to produce 2,000,000,000 lb. annually by 1850. Lumbering, followed by fishing, were the main resources of New England. The fur trade ran its checkered but significant course in the inland areas. In the middle colonies, wheat early became the principal staple crop. Flour milling made rapid strides in New York, Pennsylvania and Maryland, so that by the time of the Revolution the nation's exports of flour were exceeded in value only by those of tobacco. By 1850, however, the relative importance of the staple crops had changed radically from the pre-Revolutionary era. With the opening of the Northwest Territory, especially the Ohio river valley, corn (maize), utilized mainly for livestock feed, surged ahead to a value twice that of second-place wheat. Cotton, hay, oats, potatoes and tobacco followed in that order. The ascendancy of corn signaled U.S. emergence as the world's leading meat producer, foreshadowing extraordinary advances in the technology of meat processing.

Domestic coal production found difficulty in meeting the competition of British coal, upon which the colonies largely depended before the Revolution. Copper and lead were mined in very small quantities. Britain's lack of high-grade iron ores, however, provided the colonies with profitable conditions not only for the mining of ore but also for smelting. An act of 1750, partly motivated by the British government's disinclination to become dependent on the Baltic countries for the metal, admitted colonial pig iron to the mother country duty free. The stimulus to the American mines and smelters increased steadily. By mid-19th century annual production exceeded 2,000,000 long tons.

Given the state of the industrial arts in the world at large before 1850, it is clear that the country's progress at the higher levels of production would be determined by its ability to invade textile manufacturing, the original home of the British factory system. But it was just there that Britain's head start in manufacturing efficiency, coupled with labour costs as much as 50% lower, prevented U.S. producers from competing strongly not only in overseas markets but even domestically. Moreover, the widespread dispersion of the population in rural areas favoured the continuation of household output, which as late as 1830 provided more than two-thirds of the nation's supply of cloth. Meanwhile, the opposition of the southern states kept tariffs on textile imports quite low before the Civil War.

Nevertheless, as cotton fabrics came to be accepted as substitutes for those of flax and linen, after about 1800, small mills for carding and spinning yarn sprang up along the streams of the northeastern states. Significantly, the early textile entrepreneurs were supported in one direction by capital accumulated in the shipping industry and in another by espionage measures that penetrated the jealously guarded secrets of the Lancashire cotton mills. Mechanical weaving of cloth was first successfully applied to cotton and then to wool. By 1850 the volume of cotton consumed annually by the industry, destined to approach 4,000,000 bales by the end of the century. amounted to 575,000 bales. With the value of cotton goods roughly twice that of woolens, the trade by mid-century supplied the major share of the domestic market and became for a time the country's leading industry. Not until the second half of the century, however, following the improved application of steam power and the erection of higher tariff barriers, did U.S. production challenge Britain's long-standing supremacy.

In the case of metal processing or manufacture. American progress was divided. In the 18th century domestic iron rolling and forging was extremely localized. The wars between 1776 and 1815 provided the impetus and capital for some sizable foundries, of which the largest were in Pennsylvania. In the interim, however, British technology had made giant strides, principally related to the substitution of coke for charcoal which made possible better control of the properties of steel, but also including improvements in puddling and rolling. U.S. supply conditions hindered use of coke before 1840, when the Pennsylvania mills initiated methods for the employment of the state's abundant anthracite. Consequently. the industry, despite high tariff protection, remained backward before the 1850s.

To sum up, the economic growth of the United States during this period remained in the shadow of Britain's epochal advances, which are commonly regarded as having reached their peak between 1770 and 1830. With some signal exceptions, the founders of the new nation were content to consolidate their economic hold on the new continent, exporting raw materials but remaining inferior to Britain in the production of finished goods and relying on it for much of the real and money capital they required.

Building the 20th-Century Power Base, 1850–1910.—The tremendous growth of U.S. industry in the form of mass production and of U.S. domestic commerce in the form of mass marketing manifestly proceeded on rails, first of iron, then, under the prodding of Andrew Carnegie, of steel. The great gridwork of the railroad system rapidly harnessed the resources of the North American continent, attaining a mileage of 250,000 shortly after 1910, equal to more than 25% of the world total at mid-20th century. Early in the 1850s a rate of construction in excess of 2,000 mi. annually was attained; in the peak year of 1887 nearly 13,000 mi. of track were laid. Railroads both consumed and distributed unprecedented quantities of coal. Helping to bring together the twin essentials of steel manufacture, coal and iron ore, railroads became the steel industry's best customer and the prime shipper of its products. Nor should the consequences to human mobility be slighted. Later generations, conditioned to think of speed in terms of flight, forget that relative to the preceding transportation conditions, the contribution of the railroad to the speed of overland movement was at first more impressive than that of the aircraft.

In the midst of this profound economic reorganization of the country, a new industrial departure, destined to provide the impetus for the cumulative technological progress of the modem era, was set in motion. It was heralded by Carnegie when. speaking of the technical problems in steel production, he said: "Nine-tenths of the uncertainties were dispelled under the burning sun of chemical knowledge." For more than a century industry had found one of its main resources in scientific discovery, but Carnegie, taking his cue from Germany, undertook in 1873 the employment of highly trained scientists for full-time research on the properties of minerals. Applied scientific research, adopted as a department of industry, became the key to the great chemical processes that within a few decades were to derive from metals, coal, petroleum and even common clay a myriad of novel substances in the forms of elements, alloys and synthetics.

Meanwhile, almost as if by reflex action from the centralization of industrial activity which the railroad made possible, the movement toward consolidation of industrial po er got under may. The Standard Oil trust was organized in 1882 by John D. Rockefeller and his partners. In 1901 a near monopoly of the country's then greatest industry was attained when the United States Steel corporation was formed under the financial leadership of J. P. Morgan.

Except for cyclical interruptions (notably the panic years of 1857, 1873, 1893, 1907 and 1913), the era of continual accumulation of record-breaking statistics had arrived. Coal and steel production rose in close synchronization with the increase in ton-miles of freight carried by the railroads—from about 10.000,000,000 ton-miles in 1870 to nearly 150,000,000 000 in 1910. The output of coal rose from less than 10,000,000 tons in 1850 to 500,000,000 by 1910. The output of steel, less than 100,000 long tons before 1872, passed 25,000,000 by 1910. Comparable records in terms of rates of growth were established by copper, lead and zinc smelters. Although petroleum production was not to achieve its most notable expansion until the automobile boom of the 1920s, annual domestic output exceeded 200,000,000 bbl. by 1910, and this record, as Standard Oil's successful measures for gaining control of the industry demonstrated, was almost entirely keyed to rail transportation. From 1863 to 1899 manufacturing production (W. M. Persons' index of physical production of manufacturing) rose 705.3%, a greater relative increase than the 549% of the longer period of 1899 to 1947 (National Bureau of Economic Research index of physical output, all manufacturing industries).

The consequences for U.S. living standards were pronounced. Per capita income, which had risen little more than 10% during the first half of the 19th century, more than doubled during the second half. The actual increase of 105.3% was only slightly less than the 111.2% gain between 1899 and 1949. (Estimates derived from figures computed by W. S. and E. S. Woytinsky. *World Population and Production, Trends and Outlook,* p. 383, [New York, 1953], from original estimates of Robert F. Martin and, from 1929, the United States Department of Commerce. Estimates until 1859 are rough.)

The Modern Economy and the "Standard of Living."—From the outset of the 20th century the U.S. economy has led the world both in scale and in efficiency of operation. A few of the extremely large nations equal or exceed the United States in size of population or extent of territory. Only ,Australia, New Zealand and Canada come within 10% or 20% of matching its productivity as measured by the value of output per worker. The small populations of these countries and the relatively low productivity of the other larger nations have prevented any of them from remotely approximating the total output of the United States. According to the best available estimates, U.S. industrial productivity at mid-20th century was nearly two and one-half times that of any European nation and more than four times that of the Soviet Union, even with no allowance for the shorter U.S. work day. In agriculture the discrepancy was greater.

The decisive factor in the growth of U.S. industry and commerce has been the nation's successful maintenance of a unified economy of great scale. The intensive geographical and occupational specialization which has been the foundation of cost reduction mould have been possible on no other basis. Of the many directions that specialization has taken, the most fundamental has been that between agriculture and industry. The U.S. farmer forsook the domestic crafts in order to concentrate on the production of cash crops to exchange for manufactured goods. His opportunity of doing so was contingent upon the economy's ability to afford the costs of the necessary transportation. To meet these costs two conditions had to be fulfilled: first, an agricultural surplus sufficiently generous to support a large number of workers in the transportation, manufacturing and marketing trades; and, second, efficient, overland transportation. Concurrently, advances in physical mobility were augmented by increasing social mobility, an important aid to occupational differentiation. The U.S. economy has from the outset been predicated on such mobility and it is difficult to suppose that it can cease to be so except with most serious consequences.

With the establishment in the 20th century of high and steadily expanding rates of production, the American people were free, as no other people had been before, to turn their attention to the development of novel ways of disposing of the national output for purposes of consumption. Although progress in this direction has been by no means even, it has been very great and the advances have taken place on many fronts. In business it has made itself felt in the increasing stress which management has placed on marketing activities, of which advertising is the most conspicuous branch. Trade unions and social reform movements have tended to shift their emphasis away from rather intangible ideals toward more practically considered, material objectives. Above all, the aspirations of the general public have concentrated more and more intensively on that pre-eminently American goal, the "higher standard of living," which is not far from becoming the keynote of the modern socioeconomic system.

Consequently, the realization has forced itself upon economists that consumer behaviour plays a far more fundamental and positive role in the shaping of economic development than had traditionally been thought to be the case. Advancing standards of consumption are not merely a precondition of mass production. They have helped to shape the organization of industry and the structure of modern technology.

While certain aspects of the nation's greatly improved standard of living, such as the advances in conditions of health and sanitation, may meet all the tests of rational examination, many others, such as reduced working hours and higher real income, however beneficial they may be thought to be, owe a great deal to the custom-derived and comparatively unexamined impulses of the majority toward attaining the imagined gratifications of traditional wealth and privilege. It is in this area of motivation that the guiding principle underlying much of the pattern of consumer demand in the United States must be sought, especially the enormous emphasis on the acquisition of durable goods in general and mechanical household appliances in particular. The one form of gratification customarily associated with affluence which the modern economy cannot multiply—although it may offer substitutes for it—is direct personal service.

The application of assembly-line methods, classically illustrated by the automobile industry but earlier brought to a high stage of development in the manufacture of railroad rolling stock, permitted mass production of many kinds of durable articles. The widespread use of home appliances would not, however, have been feasible to anything like the same extent without the aid of electric power dispersible in minutely divisible doses. On the production side also, electricity made possible the introduction of any number of labour-saving devices ranging from the hand power tool to the elaborate computing devices which were becoming the instruments of automatic factory administration as well as of information gathering and manipulation.

Of the first five decades of the 20th century, only the fourth, disrupted as it was by the great depression, failed to show marked growth in the output of consumer durable goods. This was largely because of the sharp decline in automobile sales, particularly in the early years. All the same, unit sales of the four next most significant appliances, electric refrigerators, washing machines, vacuum cleaners and automatic ranges, rose steadily throughout the depression. Even more significant from the long-range point of view, the reorientation in social and political outlook brought about by this decade of unemployment and economic distress strengthened labour organizations and social welfare institutions to an extent which made secure earning power at increasingly high wages possible for great numbers of people. This, in turn, bolstered the purchase of durable goods in later, highly prosperous decades. Although this drive toward improvement in material possessions may be traced back to the 19th century when the sewing machine and piano were conspicuous examples, the 1920s must be recognized as the era in which the sharp rise in appliance ownership began, with enormous gains by automobiles, telephones and radios. Between 1929 and 1956 personal consumption expenditure on durable goods increased in constant dollars from $13,000,000,000 to $30,500,000,000 or 134.5%, while personal consumption expenditures as a whole rose from $107,300,000,000 to $222,500,000,000, or 107.4%. Even this statistical index greatly underestimates the growth in importance of consumer durable goods, since allowance is made neither for improvements in the ratio of quality to cost. which have been very great, nor for costs of operation, maintenance and repair. Nor are telephones and other installations not owned by the consumer included in the figures. If account is taken of the costs of household operation incurred for fuel, utilities (telephone and telegraph) and maintenance and repair of appliances and furnishing and the costs of private automobile operation and maintenance (motorists in 1959 spent more than $11,000,000,000 on gasoline and oil and nearly $6,200,000,000 for repair, insurance and other services), it will be found that consumers devote well over one-third of all personal expenditures to housing and durable goods and their upkeep.

This is a proportion unequaled by any other nation. In the case of many major mechanical household appliances, the number in U.S. ownership exceeds the total ownership of the rest of the world, and in many cases the odds in favour of the United States are manyfold. In the case of the most popular appliances—telephones, radios, television receivers, automatic ranges and washing machines—numbers in operation approximately equal or actually exceed (because of plural installations in many homes) the number of families in the nation.

This extraordinary dependence on consumer durable goods creates more than proportional problems for the stability of the economy, since the choice to buy or not to buy at a particular time is far more discretionary or easily deferrable than is the case with most perishable commodities, especially food. As the U.S. economist, J. M. Clark, pointed out at the time, the great depression which began in 1929 was severely aggravated by the disproportionate curtailment of durable goods purchases. Moreover, much of the growth of such purchases has been made possible by consumer installment credit. After 1959 consumer installment debt rose to an amount in excess of $35,000,000,000, and the majority of automobiles and major appliances were bought on the basis of time payments. Economists are not in full agreement as to whether installment credit institutions exert in the main a stabilizing or destabilizing effect on business fluctuations. Unquestionably, however, certain aspects of their activities, such as repossessions in times of mounting unemployment and reduced willingness to extend credit to poorer risks, work on the side of instability. In the great depression of the 1930s the Hoover administration, rightly recognizing the damaging effects of the collapse in speculative confidence in the commodity, real estate and securities markets, concentrated on measures to support credit, setting up the Reconstruction Finance corporation (RFC) and the Home Owners' Loan corporation (HOLC) to bolster the liquidity of firms and to prevent mortgage foreclosures, respectively.

TABLE XVIII.—*Private Gross National Product in Constant (1947) Dollars Man-hours Employed and Real Product per Man-hour by Major Sector of the United States Economy, Selected Pears, 1919–55*

	Private gross national product (in $000,000,000 of 1947 dollars)			Man-hours employed (in 000,000,000)			Real product per man hour (1947 dollars)		
Year	private	Farm	Private nonfarm	private	Farm*	Private nonfarm	Private	Farm	Private nonfarm
1919 . . .	100.9	17.3	83.6	100.1	23.6	76.5	1.008	.733	1.093
1921 . . .	88.8	15.9	[illegible]	87.1	22.1	65.0	1.020	,719	1.122
1926 . . .	133.6	17.9	115.7	108.2	23.9	81.3	1.235	.749	1.372
1929 . . .	142.3	18.6	123.7				1.254	.802	1.370
1933 . . .	95.6	18.4	77.2	1	23.2	90.2	1.169		
1937 . . .	142.1	19.8	122.3	98.0	22.6	75.9	1.450	.814	1.604
1941 . . .	181.7	21.2	160.5	1Oi.l	20.0	87.1	1.697	1.006	1.843
1915 . . .	218.0	21.1	196.9	114.0	19.1	94.9	1.912	1.105	2.075
1950 . . .	246.6	23.3	223.3	118.0	15.2	102.8	2.090	1.533	2.172
1955 . . .	298.6	25.0	273.6	127.0	14.61	112.4	2.351	11.712	2.434

*These farm man-hours represent adult equivalent man-hours rather than those actually worked. They are estimated by the department of agriculture from results of farm management studies and show the number of man-hours adult workers would need to work to produce the output of a particular year. Estimates of the actual hours worked by all farm workers, including women and children, are not available, particularly for the earlier years.

Source: *Productivity, Prices,* end *Inco nes,* material prepared for the Joint Economic Committee by the Committee Staff (Washington D.C., 19571. Data are revisions by staff, Joint Committee on the Economic Report, of estimates of John W. Kendrick in his paper: "National Productivity and Its Long-Term Projection," Conference on Research in Income and Wealth (May 1951).

The Roosevelt administration added measures to stabilize prices. provide relief payments for the unemployed and supplement private investment with public projects. It is significant. however, that neither administration succeeded in restoring the consumer durable goods industries to capacity levels of operation. The percentage distribution of personal consumption expenditure on the purchase of durables fell from 11.9 in 1929 to a low of 7.5 in 1932. and as late as 1939 it was no more than 10.

Outside of narrowly defined economic considerations, the achievement of the American standard of living raised problems of a political and sociological nature. Anything capable of producing so dynamic and unprecedented an effect on the human imagination was bound to set in motion profound social and political repercussions both within the nation and throughout the world. This magnified the increasingly thorny problems of national policy arising from the need lo maintain a viable balance between military and civilian expenditure. Cnfortunately. the existence of some unemployment and even temporary saturation of the consumer durable goods market did not prove to be inconsistent with inflationary pressures. Nor could a further question as to whether the levels of human energy devoted to the production and consumption of material goods and automatic services were not already unduly high in contrast to those expended on the expansion of knowledge and improvement of education be settled on purely economic grounds. (D. E. R.)

B. PRODUCTION

1. National Product and Income.—Gross national product (GYP) measures output of goods and services in market value and reflects the total dollar value of production. National income (*q.v.*) represents the aggregate earnings of labour and property from current production, and includes compensation of employees. income of unincorporated enterprise, rental income and net interest. (See WEALTH AND INCOME.)

The department of commerce began publication of official national product and income figures in 1929, and Simon Kuznets and his associates at the National Bureau of Economic Research developed figures for the years 1919 through 1938. Kuznets' figures indicate a post-World War I depression trough of $67,400,000,000 for GSP and $59,400,000,000 for national income (from $73,200,-000.000 and $64,200,000,000, respectively, in 1919), and a climb to $91,100,000,000 and $81,600,000,000 in 1926. The official figures indicate a peak of $104,436,000.000 for GNP in 1929, a year in which national income reached $87,814,000,000.

Statistics for the next few pears reflect the precipitous fall from the prosperity of 1929 into the deep depression of the 1933s—in 1933 GNP amounted to only $55,964,000,000 and national income to $40,159,000,000—and the steady climb, interrupted by the brief recession of 1938. until by 1941 GNP totaled $125,822,000.000 and national income $104,710,000,000. During World War II a major increase in national output occurred, together with some price advances, and GNP and national income rose substantially to $213,558,000,000 and $181,428,000,000 in 1945. A postwar readjustment occurred in 1945 and 1946, but this setback was only temporary. GNP advanced at a rapid rate in the late 1940s and the 1950s By 1957 gross national product was at an all-time high of $440,328,000,000 and national income reached $363.951.000.000.

If the aggregate earnings of labour and property from current production are classified according to the form in which they accrue—compensation of employees. profits of corporate and unincorporated enterprises, net interest and rental income of persons. employee compensation and corporate profits show marked proportional increases from 1929, with parallel declines in the other income shares.

With the shifts in distributive shares there have been important changes in the industrial origins of national income. Such changes are indicative of the way in which the allocation of economic resources has altered to meet changes in demand for the nation's output. Income originating in each industry measures the earnings of the resources—both labour and property—utilized by it. Therefore. the breakdown of national income by industrial origin provides a measure of the net contribution to national output of each industrial segment of the economy. Manufacturing, trade and government have shown a continual growth in their relative contribution to national income from 1929, while the shares from other sources have either declined or remained fairly stable, Thus, based on U.S. department of commerce figures, manufacturing accounted for about 25% of national income by industrial origin in 1929, 29% in 1945 and 31% in 1957. Agriculture, forestry and fisheries: over the same period. dropped from 9.4% in 1929 to 4.5% in 1957, while the government's share rose from 5.8% to 11.8%.

The rise in gross national product reflects the combined influence on current market value of total output exercised by greatly increased physical volume and by much higher prices. Adjusting gross national product to constant dollars indicates the increase in national production, corrected for price changes. Table XVIII shows the private gross national product in constant (1947) dollars for selected years from 1919-55. It also presents estimates of man-hours employed in the economy and real product per man-hour—a fairly accurate estimate of productivity. After 1919 the rate of expansion in the real volume of output in the private sector of the economy averaged about 3% per year. The real product per man-hour (in 1947 dollars) increased from $1.008 in 1919 to an estimated $2.360 in 1956, an increase of 134%.

2. Agriculture.—From the early colonial period to the latter part of the 19th century, farming provided the major sources of income and employment for the nation. Although the rapid rise in production of manufactured commodities, together with increases in the related activities of finance and distribution, diminished the relative economic importance of agriculture during the 20th century, farm output in the United States in 1958 was five times that in 1870. Agriculture has met the ever-increasing demand from a growing population with a rising standard of living by increased productivity and more effective use of available resources. This has been accompanied by a relative decline in agriculture's utilization of the nation's manpower.

There are several reasons for this expansion in agricultural output. Extension of total cropland was a leading factor in increasing production between the Civil War and World War I. Between 1870 and 1920 the number of acres of land in farms more than doubled. The large immigration and expanding population provided both a ready market and the manpower necessary to develop the nation's land resources. Usage of farm power—including horses, mules, machinery and equipment—was approximately five times greater in 1920 than in 1870.

Farm output continued upward between World Wars I and II. However, this increase was caused by different forces from those operating in the earlier period. Between 1920 and 1940 the total number of acres in farms increased only slightly. Mechanization of farming was a major force leading to increased output. A further result of increased mechanization was the release of nearly 60,000,000 ac. of cropland which had previously been utilized for feed for horses and mules.

The revolution in farming methods and production continued after 1940. Farm output increased by 36% between 1940 and 1956 with very little addition to the total area of land under crops and with a major reduction in the number of workers and hours of work in agriculture. Further mechanization increased productivity; average crop output per acre increased by 20%. The number of tractors on farms increased from 1,545,000 in 1940 to 4,515,000 in 1956, with other types of farm equipment showing similar or greater gains. Increased use of commercial fertilizers, insecticides and fungicides also helped stimulate production as did the development of new varieties of crops.

The history of farming in the United States has seen a gradual shift in the importance of various regions. Agriculture led the general pattern of industrialization and population migration with a steady westward movement. The older established farm regions of New England, middle Atlantic and south Atlantic have shown relative declines with increasing production in the south central, mountain and Pacific coast regions.

Number of Farms and Acreage.—By the middle of the 20th century there were more than 4,775,000 farms in the United States covering more than 1,150,000,000 ac., of which about 330,000,000 ac. were under cultivation.

The United States experienced a steady decrease in the number of farms from the high of 6,518,000 in 1920, except for a brief period of increase during the depression of the 1930s. This decline in number of farms was even more rapid in the post-World War II period.

The opening up of the western part of the continent was reflected in the large increase in land in farms and in acres under cultivation between 1850, when 15.6% of the total land area was classed as farm land, and 1920, when the percentage had risen to slightly over 50. This was followed by a gradual leveling off. The percentage of the nation's lands classed as farm land continued to show a slight but steady rise, reaching approximately 61% at mid-century. Cropland harvested, on the other hand, showed a much greater correlation with general economic conditions. After 1910 the number of acres harvested dropped below 300,000,000 only during the depression years of the 1930s, and reached peaks of more than 350,000,000 ac. in the prosperous late 1920s and during World War II. There was some decline in the postwar period, the 1954 census of agriculture showing slightly over 332,-000.000 ac. or 18% of the total land area under cultivation. A major part of the total farm land is utilized for grazing, woodland and other purposes.

Value of farm land and buildings has shown a steady increase, reaching a level of more than $97,500,000,000 at mid-century. This amount represents approximately one-fifth of the nation's total privately owned tangible assets used in production. The value of farm land and buildings increased from $34,800,000,000 and $5,470 ,average per farm in 1910 to $97,500,000,000 and $20,-405 per farm in 1954, with the average value per acre increasing from $40 to $84. The value of farm equipment and machines also increased greatly. In 1929 total shipments of farm machines and equipment for use in the United States were valued at $412,214,-000. compared to $1,398,052,000 in 1955. The number of grain combines on farms increased from 4,000 in 1920 to 1,020,000 in 1957. corn pickers from 10,000 to 715,000 and farms with milking machines from 55,000 to 720,000.

Farm Population and Employment.—In 1850 two-thirds of the people in the United States lived on farms and 64% of the nation's gainfully employed workers were engaged in agriculture. The nonfarm labour force multiplied 20 times while farm employment increased less than 2 times by 1956.

The number of persons on farms declined steadily after 1910. with the decline accelerating after 1940. In 1956 only 13 3% of the nation's population was on farms, compared with nearly 35% in 1910. Farm employment showed a similar decline, from 13,-555,000 in 1910 to 7,869,000 in 1956.

The trend of declining farm population and employment was the result of a number of factors: increased mechanization, larger yields and the combination of farms into larger, more efficient operating units permitted greater production with lower labour inputs. Employment opportunities in the rapidly expanding manufacturing and commercial sectors of the economy stimulated migration from the farms. At mid-century there were some signs that this trend was nearing its obvious limitations.

Farm Income and *Expenses*.—With the growing industrialization of the economy, agriculture has provided a declining proportion of the national income. In 1929 farming contributed 9.2% of national income compared to only 4.2% in 1957 Although farm income has shown a long-term growth, the much larger increase in other sectors has reduced the relative importance of agriculture.

Farm income fell drastically during the depressions of the 1920s and 1930s. It was not until 1942 that net farm income exceeded that of 1919. The demand for farm products during World War II caused a major increase in farm income, with continued increases in the immediate postwar period. The net income of persons on farms from agricultural sources reached a high point of $19.704,-000,000 in 1948. However, there was a steady decline after that time, with net income falling to $13,374,000,000 in 1956. Production costs of farms continued to rise while income was falling The parity ratio (ratio of prices received to prices paid by farmers) reflects this change. This ratio (1910–14 equals 100) was above 100 until the farm depression of the early 1920s. remained below 100 throughout the 1930s and then moved to a high of 115 in 1947. It declined steadily. reaching 82 in the mid-1950s.

Farm Output and Productivity.—Total farm output increased by 57% between 1930 and 1956, with livestock and products (meat. dairy products, poultry and eggs) increasing by nearly 60% and crops by 40%, while feed used by horses and mules declined by 83%. However, the number of man-hours required to produce this expanded output declined from 22,921,000,000 in 1930 to 14,177,-000,000 in 1956.

This reduction in man-hours accompanying an increasing production was the result of major advances in productivity. Output per man-hour for all farm labour increased by 152% between 1930 and 1956, while that for livestock and products increased by 62% and that of crops increased by 164%. Productivity increases on the nation's farms have been more rapid than for the private nonfarm sector of the economy.

Principal Agricultural Products—Ten years after the end of World War II, the total farm value of all crops harvested in the United States was more than $18,500,000,000 with field crops valued at over $16,000,000,000, vegetables at about $645,000,000 and fruits, nuts and horticultural specialties at more than $1,500 -000,000. Corn, the nation's major field crop, utilized about 78,-000.000 ac. of land and provided a farm value of more than $4,000,000,000. The farm value of production of cotton, wheat and hay was over $1,000,000,000 for each product with tobacco. oats and soybeans valued at nearly that amount. Milk products, cattle and calves had the largest production volume and value among livestock and products, followed by hogs, chickens and eggs

The composition of agricultural production changed substantially after the end of World War I. Shifts in the relative importance of various crops and livestock production resulted from a combination of factors including changes in demand and differences in technological progress, cost reduction and relative profitability to farmers. Livestock production increased much more than crop production after 1930. Output of poultry and eggs rose at an even faster rate, particularly after 1940. A rise of 50% to 75% in the production of many fruits and vegetables and tobacco after 1920 reflects the growth of population and the expansion in consumer demand for these products The much smaller increase in production of food grains, cotton and sugar crops was a reaction to a number of forces, including shifts in consumer demand, changes in export markets and production control programs of the federal government.

Government *Agricultural* Policies.—The maintenance of a strong agricultural sector has long been recognized as of vital importance to the health of the national economy. During the 18th and 19th centuries the agricultural policies of the government took the form of raising the prices of farm products by means of protective tariffs and of encouraging the development of the vast land resources.

The demand for food during World War I caused a major increase in the output of farm products and directly led to overproduction and the drastic break in farm prices and income following the war. In the 1920s the government attempted to help agriculture by giving aid to co-operatives, by providing farm credit and by raising import duties on many farm products. The Federal Farm board was the first formal program seeking to stabilize prices through storage. These governmental policies of the 1920s proved inadequate to meet the needs during the serious depression of the early 1930s.

With the Agricultural Adjustment act of 1933 the government took a much firmer hand to improve farm income and prices. The primary purpose of this act was to curtail production, reduce export surpluses and raise prices. This program inaugurated price supports for some products based on the parity formula. The Commodity Credit corporation, with its crop loan and storage program, was established to make price-supporting loans and purchases of specific commodities. Although these and other programs such as the soil conservation service and Farm Security administration did help raise farm prices, with parity moving from 58 in 1932 to 81 in 1940, it took the enormous demands of World War II to reduce the accumulated farm surpluses and to significantly increase farm income. With most farm prices rising above the support levels, the objective of the national farm program was changed for the war period and two years beyond to providing floors under prices to encourage expanded production.

The primary farm problem after 1952 was one of declining total farm income, a reduction in parity ratio and the build-up of surplus stocks. Net income fell from $14,802,000,000 in 1951 to $12,070,000,000 in 1956, with the parity ratio declining from 107 to 82. In spite of attempts to bring demand and supply into balance at close to the parity ratio, output continued to increase at record levels. The carry-over of war-induced expansion of production was a factor, but the main reason for the increase was the substantial growth in productivity resulting from mechanization and the adoption of improved technology. The soil bank program adopted under the Eisenhower administration limited the number of acres under production, but because of increased yields it did not substantially reduce output.

3. Forestry.—The United States was blessed with vast stands of timber which provided an important resource for building the country. By the middle of the 20th century the forests of the nation were estimated by the forest service to contain over 2.094,000,000,000 bd.ft. of lumber, enough to build a six-room house for every person in the United States, with lumber left over. However, it is estimated that the original forests contained over four times this volume. Much of this virgin timber was cleared to provide the growing need for agricultural lands and for fuel, building construction, shipbuilding, furniture manufacture, wood pulp for paper, paperboard and man-made materials and many other products. Although there has been a vast usage, often wastage, of timber, the productive capacity of the nation's forest lands should be sufficient to ensure the availability of this important resource for many generations if programs for better utilization, reforestation, sustained yield management and fire, insect and disease control proved successful.

Forest Lands and Species.—Of the 1,939,343,000 ac. of land in the Gnited States and coastal Alaska, 34% or 664,194,000 ac. are classified as forest land. Approximately one-fourth of the forest land is unsuitable for commercial forest production or has been set aside for parks or preserves, leaving 488,609,000 ac. classified as commercial forest lands.

In the Pacific northwest vast stands of Douglas fir predominate while redwood, Douglas fir and mixed conifer forests are scattered throughout California. East of these coastal forests in the west, ponderosa and white pine forests are most prevalent. In the Plains states there are river-bottom stringers of hardwoods and the pine forests of the Black hills. In the north and south the softwood and hardwood forests are intermingled and interspersed with farms and other nonforest lands. The eastern section of the nation contains three-fourths of the commercial forest land. The west has only one-fourth of the forest land area but nearly 70% of the nation's saw timber. The heaviest stands of virgin timber are along the Pacific coast with the three states Oregon, California and Washington containing 1,108,877,000,000 bd.ft. of saw timber, over half the nation's supply. The history of the forest products industries has been one of gradual westward movement where new timber supplies were available. As the virgin timberlands in the Pacific coast states are cut, however, there may be a movement back to the eastern and southern sections of the nation which are being reforested with second-growth timber.

Although nearly three-fourths of the commercial forest land area is under private ownership, the 26% held by federal, state and local governments—more than three-fifths of it in the west—contains nearly 50% of the nation's saw-timber resources. Of the 2,057,000,000,000 bd.ft. of live saw timber, 1,648,000,000,000 bd.ft. or 80% is softwood with the principal species being Douglas fir, southern yellow pine, ponderosa pine, western hemlock, sitka spruce, sugar and white pines and redwood. The major hardwoods, found primarily in the eastern section of the nation, are oak, poplar, maple, gum, beech, cottonwood, elm, birch, hickory, ash and chestnut.

Growth *Drain* in Forest.—In 1952 the forest service estimated that the net annual growth in the nation's forest was 47,397,000,000 bd.ft. of saw timber as compared to a drain of 48,840,000,000 bd.ft. In the following years this growth-cut ratio improved substantially. However, there remained a major disparity between regions, with the eastern part of the nation showing a much higher growth-to-cut ratio than the west and with hardwoods having a higher ratio than softwoods. In the west the annual cut of saw timber, 22,449,000,000 bd.ft., was twice the annual growth rate.

Production of Wood Products.—Major products from the forests are lumber, wood pulp, plywood, fuelwood, poles and posts, railroad ties, furniture and industrial woods and timbers. Lumber production had declined from a high of 44,510,000,000 bd.ft. in 1909 to 37,698,000,000 bd.ft. by 1956. However, with the reduction in lumber production, forest products shifted to different usages. Wood-pulp production increased from 3,518,000 tons in 1919 to 22,131,000 tons in 1956, stimulated by the enormous increase in demand for paper and paperboard and man-made fibres made from pulp. During this same period, paper and paperboard production rose from 5,966,000 to 31,428,000 tons. Between 1950 and 1960 the production of softwood plywood increased over three times with a production in 1956 of 5,421,170,000 sq.ft., $\frac{3}{8}$ in. basis. The production of wallboard, hardboard and many other forest products increased even more rapidly.

Outlook.—The major problem facing the U.S. forest industry at mid-20th century was the assurance of adequate timber supplies to meet growing needs. The forest service projected a very significant rise in the demand for wood products, based on increasing population and per capita consumption. The forest resources would be severely pressed to meet this demand.

In the early years of lumbering, the forests were looked upon as an inexhaustible source of timber. The fallacy of this reasoning became very apparent with the depletion of much of the original forest land, and the federal and state governments, as well as many of the private owners of forest resources. began to see the need of considering timber as a crop—one with a long growth cycle but still a renewable resource. The federal government, with its vast reserves of timber in national forests. provided for sustained yields over an indefinite period through reforestation and better forestry practices. Advances in methods for controlling forest fires, insects and diseases also helped to maintain the forests as growing reservoirs of timber. Tree farms were established in many areas as a supplement to natural reforestation, and much more efficient utilization of the total tree, together with the removal of a larger proportion of the timber from the forests, helped to improve yields. These policies of forest conservation and improved utilization resulted in a steadily improving balance between growth and drain. (*See* also FORESTS AND FORESTRY; LUMBERING.)

4. Mining. — From 1880 to just after the middle of the 20th century, the value of all mineral production in the conterminous United States multiplied 47 times. Total value in 1880 was $367,000.000; by the mid-1950s it was estimated at $17,000,000,000. In addition the value of minerals produced in Alaska was almost $23,500,000 and in Hawaii nearly $7,000.000.

From a level of $5,311,000,000 in 1926, the value of mineral production declined during the depression to a low of $2.000 000.000. It rose slowly during the 1930s, rapidly during World War II and continued to increase in the postwar period. Part of this postwar rise reflected the increasing price levels for most minerals and part reflected enlarged volume of production.

Of the mid-1950s total of $17,000,000,000, $2,000,000,000 represented the value of the production of metallic minerals and $15,000 000.000, that of nonmetallic mineral products. Of the latter figure, about $11,700,000,000 was accounted for by fuels. In 1880 the value of fuels — including coals, natural gas, gasoline and other petroleum products — made up only 33% of the total value of all mineral products; in 1956 fuels contributed 67% of the total.

In spite of the large increases in physical volume of production of most mineral products during the first half of the 20th century, there was a steady decline in the number of employees engaged in mining and related activities. This decrease was primarily the result of the increased mechanization of mining operations and the consequent increase in productivity. In 1915, 734,008 production workers were engaged in coal mining; in 1956 the figure was 238.693. In mines other than coal there were 152,118 workers in 1915 and 72,420 in 1956. In quarries and related industries the figures were 100,740 in 1915 and 78.701 in 1956. Total employment in the mineral industries in 1915 was 1,067,817, compared with a figure of only 454,950 in 1956. Using the year 1947 as 100, output per man-hour in mining increased from 62.9 in 1929 to 105.7 in 1950, with further increases after that year. Nowhere in the U.S. economy was there so dramatic an illustration of the impact of improved equipment and methods on productivity. (See also NATURAL RESOURCES: Minerals; and articles on various minerals: COAL AND COAL MINING: Coal *Mining* in the United States; IRON AND STEEL: Iron Ore; PETROLEUM: *U.S.* Petroleum Industry; etc.)

5. Fisheries. — United States fisheries have provided an important source of income, employment and food since early colonial days. These industries not only support a large fishing fleet but also provide income to such industries as boat and shipbuilding and fish-processing equipment. The primary fisheries for the nation are in the oceans surrounding the United States, including Alaska, with other areas all the way from Newfoundland to the Caribbean and from Alaska to the equator.

According to statistics compiled by the U.S. fish and wildlife service, fisheries production in the United States and Alaska in 1930 totaled 3,224,318,000 lb., with an average price per pound of 3.39 cents and a value to fishermen of $109,349,000. By 1940 the quantity had risen substantially, to 4,059,141,000 lb., although the average price in that year was only 2.44 cents per pound and the value to fishermen, $98,957,000. Following World War II, production remained well over 4,000,000,000 Ib. annually. In 1957 it was approximately 4,750,000,000 lb., with an estimated average price of 7.39 cents per pound and a value to fishermen of about $351,000,000.

In the late 1950s there was approximately 555,000 persons employed in fisheries; 142,000 fishermen, 3,000 transporters, 100,000 shore workers and 310,000 workers in allied industries such as gear manufacture, boatbuilding and processing equipment. Approximately 84,000 crafts were used for fishing with 12,000 vessels of five tons and over, 58,000 motorboats and 12,000 other boats.

The major fisheries at mid-century were along the south and Gulf states, with a value of more than $100,000,000, about three-fourths of which was accounted for by shellfish. The Pacific coast states were next in importance with a value of catch of more than $80,000.000, primarily pilchard or sardines, tuna.salmon and mackerel. California was the leading state, producing considerably more than half the west coast total. The New England states had a catch valued at close to $60,000,000 with haddock, perch, herring, cod. flounders and lobster the major species.

For the entire nation the most important fish by volume is the menhaden, used primarily for oil and fertilizer. In 1957, for example, the menhaden catch amounted to 1,684.300.000 Ib., as compared with 297,100.000 Ib. of tuna and tunalike fish, 271,900,000 lb. of herring and 257,200,000 lb. of salmon, the three species ranking next in volume. On a value basis, however, tuna and salmon were of greatest importance. Other species of importance to the fishing industry include mackerel, haddock, ocean perch, pilchard and cod. Shrimp provides the largest volume of shellfish, followed by crabs and oysters. Shrimp ranks after salmon in value for U.S. fisheries as a whole.

Of the 4,750,000,000 lb. of fish caught in 1957, approximately 1,428,000,000 lb. were sold fresh or frozen, 1,130,000,000 Ib. were canned, 88,000,000 lb. were cured and 2,104,000,000 lb. were used for the production of by-products, such as fish meal and oil. Canned fish products increased from 643,848,000 lb. in 1935 to 986,938,000 lb. in 1957 with value increasing from $74,999,000 to $334,766,000. The total value of canned and processed fishery products in 1957 was $379,656,000. According to the fish and wildlife service the major canned-fish products by species were tuna and tunalike fishes, salmon, sardines, mackerel, clam products, shrimp and oysters.

With the decline in production of many valuable fishery products, the U.S. fish and wildlife service directed its attention to the study of means for maintaining the nation's major fisheries. In line with this policy, the U.S. entered into agreements with Canada, Japan and other countries for the protection and maintenance of the nation's fishery resources.

6. Power. — From the start of the nation's industrial development, the progress made in the United States toward greater production, increased productivity and a higher standard of living can be traced by the spectacular increase in the use of energy from mineral fuels and water power. Between 1870 and 1900 the annual supply of power from mineral fuels and water power increased fivefold. With a labour force in 1956 little more than twice as large as in 1900, accompanied by more capital, better technology and with a fivefold expansion in energy use, the nation's economy produced more than five times the 1900 total volume of goods and services measured in constant dollars.

With increased energy utilization and expanding production a major shift occurred in the relative importance of various energy resources. J. Frederic Dewhurst and associates in America's Needs and Resources (1955) estimated that the percentage share of manpower as a source of energy in total work output, had declined from 13 in 1850 to 5.3 in 1900 and 0.9 in 1950. For the same years, the percentage share of animal power fell from 52.4 to 21.5 to 0.6; inanimate sources rose from 34.6 to 73.2 to 98.5.

In addition to the shift from animate to inanimate sources of energy, there have been major changes in the relative importance of the various inanimate sources. In the mid 1800s wind and water were the primary sources of energy with fuelwood and coal also of importance. By 1900 coal, anthracite and bituminous, provided 88.9% of the energy from mineral fuels and water power. Anthracite subsequently declined but bituminous increased substantially. However, because of major increases in other mineral fuels, the per cent of energy from coal had declined to 32.2 by 1957. Crude petroleum showed a major increase, providing 36.3% of the energy supply in 1957 as compared with only 4.7% in 1900. Natural gas had a similar expansion from 3.2% to 27.7%. The use of water power as a source of energy grew steadily although its proportion of total energy in 1957, 3.9%, was just slightly above the proportion in 1900.

Electrical energy provided only a minor part of the nation's total energy supply prior to 1900. In 1902, 5,969,000,000 kw.hr. of electric energy were produced in the nation. By the late 1950s more than 700,000,000,000 kw.hr. were being produced annually, an increase of 120 times. Between 1940 and 1957, kilowatt hours utilized increased by nearly 300%.

Although some of the major producers of electric power are the hydro plants located on the nation's rivers and streams, hydroelectric power made up only about 20% of the energy source for electric-power production in the late 1950s, and the proportion was declining. Coal provided slightly more than 50% of the energy source, oil about 6% and natural gas approximately 18%. The decline in electric power from hydroelectric sources resulted partly from the greater flexibility of steam plants using mineral fuels. In 1920 it took three pounds of coal (or coal equivalent in other fuels) to produce one kilowatt hour of electricity. By 1957 this had been reduced to only 0.93 lb. of coal per kilowatt hour. This increased efficiency provided a cost advantage for fuel-fired over hydroelectric power in most sections of the nation.

Vast undeveloped sources of hydroelectric energy remained as reservoirs of power for possible future needs. In 1956 the nation's hydroelectric plants had an installed capacity of 26,386,000 kw. The Federal Power commission estimated that there remained 90,102,000 kw. of undeveloped water power, located primarily in the mountain states, with a potential of 21,333,000 kw., and the Pacific states with 33,722,000 kw. However, relatively little undeveloped hydroelectric power was available in the more populated eastern section of the nation, which used over 75% of the electric energy.

The Federal Power commission estimated that future U.S. power requirements would continue to show an upward trend. It seemed probable that the major source of energy for meeting this demand would be fuel-fired plants using bituminous and lignite coals which are in plentiful supply, are located close to centres of major power usage and permit low-cost, efficient operations.

Another possibility was the production of electric power from efficient atomic power plants. In the early 1960s, more than two-thirds of the nuclear reactors in operation in the U.S. were owned by the federal government and the remainder by private industry. The majority of these were research reactors with small power output.

In the United States, where other sources of cheap power were widely available, nuclear reactors could not, at mid-century, produce power at a competitive cost. (See also ELECTRIC POWER; ATOMIC ENERGY: *Peacetime Applications*.)

7. Industries.——After the Civil War, the United States changed from an agrarian economy to one with a highly complex industrial structure. With the advent of increasingly advanced industrial technology, manufacturing grew rapidly and caused major shifts in output, income and employment as well as other basic socioeconomic changes. In 1820 only 12% of gainfully occupied persons in the U.S. were engaged in manufacturing, hand trades and construction. By 1880 this percentage had increased to 18.5. By 1899 there were about 4,502,000 production workers engaged in manufacturing who received $1,893,000,000 in wages and produced value added to products of $4,647,000,000. The mushrooming growth of industries in the nation had begun, bringing with it parallel expansion in wholesale and retail trade, financial activities and other services supported by industrial activity.

This trend of growth continued during the 20th century. Manufacturing employment by 1919 was 10,534,000 and by 1957 it was 16,800,000. Manufacturing has become the major source of income for the economy. By 1929 it provided income of $21,888,000,000, nearly 25% of total national income. By 1957 manufacturing contributed $112,517,000,000 or 31% of national income. The growth in income from manufacturing between 1929 and 1957 was over 400%.

Number of Firms and Value of Products.—Between 1899 and 1954 the number of manufacturing establishments in the United States increased from 204,754 to 286,817. The number of production workers in these establishments multiplied nearly threefold from 4,501,919 in 1899 to 13,134,683 in 1956. Value added to the products processed increased steadily over this period, except for the depression years of 1920–21 and the early 1930s. Between 1939 and 1956 value added by manufacture rose from $24,487,304,000 to $139,682,978,000, an increase of 470%.

The growth of industrial production accelerated after the end of World War I. The federal reserve board's index of industrial production increased from 100 in 1947 to 143 in 1957. This 43% increase in output was accomplished with only a 10% increase in manufacturing employment, indicating major increases in productivity. Between 1948 and 1957, output per man-hour in manufacturing rose by 30%

Major Industry Groups.—In number of establishments, those manufacturing food and kindred products led all others at mid-century. In second place were establishments manufacturing lumber and wood products, followed by printing and publishing plants.

In the same period establishments manufacturing such transportation equipment as automobiles, trucks, aircraft and ships led in number of production workers. In second place were establishments manufacturing such nonelectrical machinery as machine tools, office equipment and construction and mining equipment; and in third place were establishments manufacturing food and kindred products. Transportation equipment manufactures also led in value added by manufacture. In second place were food and kindred products manufactures followed by nonelectrical machinery. After 1939 there were notable changes in the relative positions of the various manufacturing industries as indicated by both production workers and value added. The food and kindred products, textile, apparel, leather and lumber industries declined, whereas the transportation equipment, machinery, metals and chemical industries increased in relative importance.

Location of Manufacturing Activity.—Manufacturing is concentrated in the middle Atlantic and east north central sections of the United States. These two regions provided more than 50% of the value added nationally in the mid-1950s. The Pacific states were third in importance, followed by the south Atlantic area, New England, the west north central, west south central, east south central and mountain regions in that order. In spite of the predominance of the northeastern section of the nation as the manufacturing hub, there was strong evidence of a growing dispersion of these activities to the southern and western regions of the nation. The Pacific states provided 6.3% of the national value added in 1939 and 9.9% in 1956. The west south central region's percentage increased from 3.3 in 1939 to 5.3 in 1956. By contrast the New England area had 9.9% of national value added in 1939 and only 7.5% in 1956.

At mid-20th century the manufacturing industries of the United States were continuing the basic trends that had been in evidence from the middle of the 19th century. Automation and technological improvements continued to provide the basis for further major increases in output and productivity, and the trend toward increasing productivity with a continually decreasing proportion of the nation's workers showed no signs of changing. (See ECONOMIC PRODUCTIVITY; see also under names of principal industries.) (F. E. K.)

C. TRADE AND FINANCE

1. Domestic Commerce.—Domestic commerce developed only slowly in colonial America. Foreign trade, especially with England, was quite significant in marketing certain crops and products and in supplying commodities not produced in the colonies, but in the absence of good roads, railroads or other adequate transportation, internal commerce was not extensive. Most domestic commerce was by coastwise shipping and a large portion of this was for the distribution of imported goods.

The constitution gave congress power to "regulate Commerce with foreign Nations, and among the several States," and numerous judicial decisions thereafter defined the nature and limits of interstate commerce (*q.v.*). These rulings limited the development of state barriers to commerce. In the leading case of *Gibbons* v. Ogden (1824), Chief Justice John Marshall invalidated a state restriction on steamboat navigation; this decision established national government supremacy over interstate commerce and laid the basis for later federal regulation of transportation, based upon the inclusion of transportation as commerce.

During the 19th century regional specialization—manufactures in New England and the iron and steel industry in western Pennsylvania, for example—brought with it the need for increased domestic commerce. Improvement of transportation facilities—the Cumberland road, the steamboat and its use on the Ohio, Mississippi and other rivers, the success of the Erie canal and the building of other canals and the completion of the first railroad in 1830—created arteries for commerce. As population spread westward, "Yankee peddlers" began to be supplemented and replaced by wholesale houses and the general store. Later. organized markets for staples developed and, still later, manufacturers who wished to gain the advantages of dealer distribution of branded merchandise began direct retail distribution through branch warehouses and dealer agreements.

Wholesaling began to assume greater importance and major markets for staple commodities were established, such as the wheat market in Chicago and the cotton exchanges in New York and New Orleans. Rail transportation helped make possible such developments as that of the mail-order house. Retail distribution was further modified by the development of the chain store—especially in variety goods (the five- and ten-cent store), groceries and drugs. By 1914 chain stores had begun to be significant in replacing the individually owned general store. Specialization in retailing spread as the general store began to be displaced by stores which sold only drugs, groceries, hardware or dry goods.

After World War I other developments caused further changes in the nature of domestic commerce. The supermarket began to supersede the grocery store. Decentralization and the growth of the planned shopping centre enhanced the importance of suburban retailing. Self-service and self-selection became more widespread and tendencies to circumvent the wholesaler became more significant. In many lines the trend toward specialization seemed partially to reverse itself in a trend toward "one-stop service."

Another important development was the gro th of installment selling, as the expansion of income and of sales of durable goods. especially automobiles, created needs for new types of retail financing. (See Growth of the American Economy, above.)

Wholesale Trade.—Data on wholesale establishments beginning in 1929, the year of the first official census of wholesale distribution, show a steady increase in number, volume of sales and employment. In 1929 there were 168,262 wholesale firms; in 1948 there were 216,099; and by 1954 there were 252,318. Wholesale trade accounted for 4.8% of national income by industrial origin in 1929 and for 5.5% in 1954. (Retail trade and automobile services accounted for 10.4% in 1929 and 11.3% in 1954.)

Within the wholesale trade, merchant wholesalers accounted for by far the largest number of establishments and paid employees and the greatest value of sales. Manufacturers' sales branches and sales offices were second in number of employees and sales, but followed petroleum bulk plants, terminals and liquefied petroleum (LP) gas facilities in number of establishments. Grocery, confectionery and meat wholesalers and farm products distributors accounted for almost a fourth of total sales by merchant wholesalers. and led other types of business in number of establishments and employees as well.

Wholesaling is, of course, primarily a big-city activity. In the state of Washington, for example, King county, containing the state's largest city, Seattle, and approximately a third of the state's population, accounted for over half of total wholesale trade but only about a third of total retail trade. Since more than half of the U.S. population lived in standard metropolitan statistical areas, shown in fig. 10, these are the major wholesaling centres. At mid-20th century these areas accounted for approximately 85% of the sales of merchant wholesalers and more than 95% of the sales of manufacturers' sales branches and sales offices.

Wholesaling may be considered to have reached a peak in importance toward the end of the 19th century and to have declined slightly thereafter in terms of the total value of products handled. In terms of employment, the share of the labour force employed in uholesaling did not decline relative to that in retailing.

Retail Trade.—The first complete measure of retailing for the Cnited States was contained in the 1929 census of retail distribution. For that year the total sales of retail stores (1,543,138 establishments) amounted to $49,100,000,000. The trough of the depression in retailing came in 1933 when sales dropped to $24,-500.000.000. By 1935 a total of 1,587,718 stores had sales of $32.-800,000,000 and by 1939 a total of 1,770,355 stores had sales of $42,000,000,000. Nine years later a smaller number of stores had sales of $128,800,000,000.

In both number and sales, retail food establishments far outdistanced other types of retail business, food stores and eating and drinking places together accounting for more than a third of the total number of establishments and almost a third of the dollar value of sales. The number of food stores, however, showed a tendency to decrease even though sales were rising, reflecting the continuing trend toward an increase in the volume of sales in large supermarkets.

Also high in number of establishments were gasoline service stations, apparel and accessories stores and lumber, building materials, hardware and farm equipment dealers. The leaders in sales volume included automotive dealers, general merchandise stores and the lumber and building materials group. The increasing number of retail establishments handling apparel, furniture, home furnishings and appliances reflected the growing population and high level of home building as well as the development of new products.

Retail establishments in the standard metropolitan statistical areas, accounted for more than half the total number of retail establishments and almost two-thirds of total retail sales in dollars.

Taken together, wholesale and retail trade employed an increasing percentage of the labour force after 1870. While the number of workers engaged in commodity production and construction was about three times larger in 1950 than in 1870, the number engaged in wholesale and retail trade had increased tenfold. This trend was caused in part by a relatively rapid decline in hours of work per week in wholesale and retail trade (from 66 in 1870 to 44 in 1949), in part by an expansion of the scope of wholesale and retail trade and probably to some extent by added functions. On balance, however, it was evident that productivity (output per man-hour) in distribution increased much more slowly than in manufacturing, agriculture and mining. One authority estimated the rate of growth of output per man-hour at 1.1% per year in wholesale and retail trade and 2.6% in agriculture, mining and manufacturing between 1869 and 1949. Technological innovations have been less significant in trade than in the other fields.

2. Foreign Commerce.—The United States occupies a dominant position in the world economy. Although it has only about 7% of the total world population, it produces more than 40% of the total world output of goods and services. It generates more than half of total world savings and as a result is the most important creditor country. In 1951–55 U.S. exports amounted to approximately 20% of total world exports and U.S. imports to about 15% of total world imports. The level of U.S. foreign commerce is thus of great significance to the world economy; its fluctuations have wide repercussions.

The United States foreign commerce is not as significant, however, in relation to national product and national income as is commerce in a number of other countries. U.S. merchandise exports amount to about 5% of national income and merchandise imports to about 34%. Exports of such countries as Argentina, Australia, Belgium, Canada, Great Britain and Sweden amount to about 20% of national income and exports of such countries as Denmark, the Netherlands, New Zealand and Norway amount to 30% to 40% of national income.

From these comparisons it should not be inferred that foreign commerce is of little importance to the United States. For many commodities much more than 5% of total production is exported. At mid-20th century over 40% of the rice grown was exported, over 33% of the cotton, wheat and inedible tallow, 25% of the soybeans and tobacco, over 20% of the lard, over 30% of the rolling-mill machinery and parts, over 20% of the tractors, sewing machines and textile machinery and between 10% and 20% of the printing machinery, oil-field machinery and tools, office appliances, motor trucks and coaches and agricultural machinery (other than tractors).

In certain commodities the United States is entirely dependent on imports; *e.g.,* natural rubber, tin, industrial diamonds, coffee, cocoa and tea. It imports 90% or more of its nickel, cobalt, chromite, asbestos and manganese, more than one-half of its tungsten and more than one-third of its copper, lead and zinc.

Balance of Payments.—A record of transactions with foreign areas during a given period is called a balance of payments, although the term is somewhat misleading because all transactions, whether payment is involved or not, are included. This record shows imports and exports of goods and services and unilateral transfers (gifts) (current account section) and changes in international claims such as loans, foreign bank deposits and gold movements (capital account section). Since the principles of double-entry accounting are followed, the balance of payments should balance; but because statistics are obtained from many different sources (customs reports, steamship companies, questionnaires to tourists, etc.), there is always an errors and omissions item. (See INTERNATIONAL PAYMENTS.)

Estimates of the U.S. balance of payments have been compiled by the US. department of commerce from 1919. Dollars supplied to the rest of the world by U.S. imports. payments for services and the outflow of long-term capital dropped sharply after World War I; and, after partial recovery during the 1920s there was another sharp drop from 1929 to 1933. In 1939 dollars supplied totaled less than $4,000,000,000 as compared with more than $10,000,000,000 in 1919.

Foreign trade during World War II was dominated by government wartime transactions. During the postwar period, United States exports of goods and services far exceeded imports. Foreign countries purchased much more goods and services from the U.S. than they were able to pay for from funds derived from sales of goods and services to the U.S.. and in most cases their dollar balances had been seriously depleted during the war. The resulting "dollar gap" was met (in some cases more than filled) by unilateral transfers, both private and government. In some years such transfers enabled foreign countries to add substantial amounts to their gold and dollar reserves, improving their liquidity position for international payments.

By the late 1950s the U S. was still exporting more goods than it was importing, although the margin was relatively narrow in certain years. Recovery after World War II had by this time enabied western Europe and Japan to compete more strongly with the U.S in world markets A rise in U.S. imports, relative stability of the trend in U.S. exports and a continuation of military expenditures abroad and loans and grants to foreign countries combined to create a balance of payments deficit, and hence foreign countries gained substantial amounts of gold and dollars. Relative proportions of foreign holdings of gold and of short-term dollar investments were determined by such factors as customary practices and relative levels of interest rates; in 1958 these factors combined to cause a large gold outflow, and in 1959 the gold outflow was also substantial, although smaller. An upturn in exports which began in mid-1959 reduced the deficit in the succeeding year, but gold outflow and the size of short-term dollar liabilities were still important factors influencing trade and monetary policy as the 1960s began.

Merchandise Trade.—United States merchandise exports averaged $44,000,000 annually in value in the last decade of the 18th century; by the corresponding decade of the 19th century, they averaged nearly $1,000,000,000 in value; by the middle of the 20th century they exceeded $15,000,000,000 annually; and in 1957, a peak year, they exceeded $20,000,000,000.

Imports, which averaged $56,000,000 in the last decade of the 18th century, rose to nearly $750,000,000 by the end of the 19th century and to more than $10,000,000,000 by the middle of the 20th century. With the great expansion of United States industry and commerce in the 1870s, the country developed an excess of exports over imports which continued into the second half of the 20th century (see Table XIX).

In the depression of 1929–32 exports dropped from more than $5,000,000,000 to less than $2,000,000,000; by 1940 they had recovered only to $4,000,000,000. During World War II they reached a peak of nearly $17,000,000,000 in 1944, approximately three-fourths of which was accounted for by lend-lease shipments. After World War II, in addition to ordinary exports, shipments of military goods were made under aid programs. These were not large in amount until 1951, when they totaled more than $1,000,000,000; in 1953 they totaled over $3,500,000,000, and smaller amounts in the following years. Even excluding these shipments, exports exceeded imports by large amounts.

TABLE XIX.—*U.S. Exports and Imports of Merchandise**
(in $000,000)

Yearly average or year	Total	Exports		Imports	Total exports and imports
		Domestic	Foreign		
1790–1800	44	..	..	56	100
1801–10	74	38	36	93	167
1811–20	59	46	13	81	140
1821–30	69	53	16	73	142
1831–40	103	88	15	120	223
1841–50†	123	115	8	121	244
1851–60	249	232	17	284	533
1861–65	188	170	18	255	443
1866–70	321	308	13	408	729
1871–75	502	486	16	578	1,080
1876–80	677	664	13	492	1,169
1881–85	792	775	17	667	1,459
1886–90	739	726	13	717	1,456
1891–95	892	876	16	785	1,677
1896–1900	1,157	1,136	21	742	1,899
1901–05	1,454	1,427	27	972	2,426
1906–10	1,779	1,751	28	1,345	3,124
1911–15	2,371	2,332	39	1,712	4,083
1916–20‡	6,521	6,416	105	3,358	9,879
1921–25	4,397	4,310	87	3,450	7,847
1926–30	4,777	4,688	89	4,034	8,811
1931–35§	2,025	1,989	36	1,708	3,733
1936–40	3,220	3,167	53	2,440	5,660
1941–45	10,051	9,922	129	3,469	13,520
1946–50	11,830	11,673	157	6,584	18,414
1954	15,110	14,981	129	10,240	25,350
1957	20,810	20,630	180	12,921	33,731

*Figures are for fiscal years ended Sept. 30, 1790 to 1842, and June 30, 1843 to 1915, subsequently for calendar years; gold and silver are inciuded prior to 1821. †Period beginning Oct. 1, 1841, and ending June 30, 1850. $Period July 1, 1915 to Dec 31, 1920. §Beginning with 1934 import figures are the imports for consumption; prior to that time they are general imports.

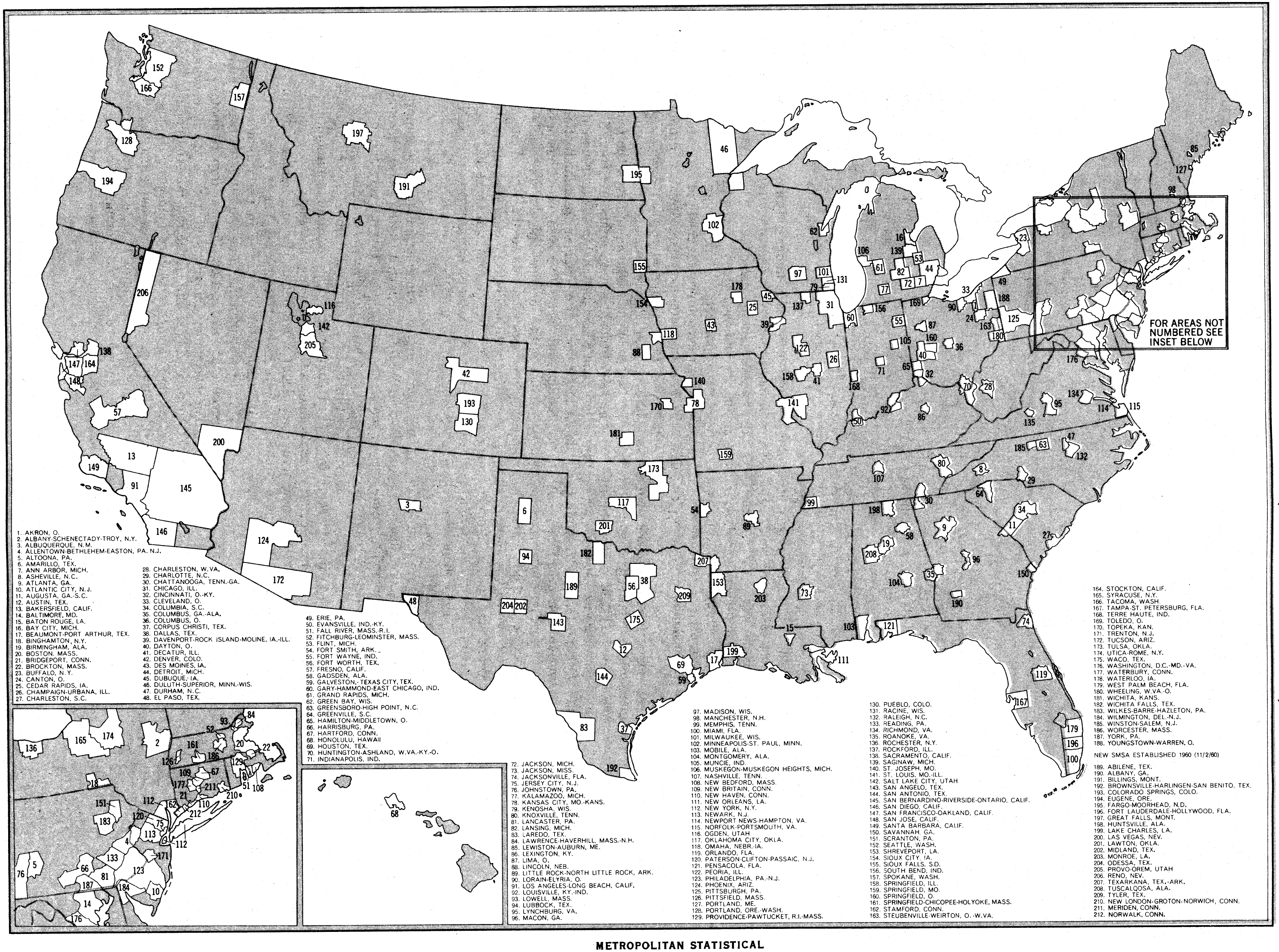
Source: U.S. Department of Commerce, Bureau of Foreign and Domestic Commerce.

Imports were even more adversely affected by the depression of 1929–32 than were exports. Imports dropped from over $4,000,000,000 to somewhat more than $1,000,000,000. A sharp drop in imports also occurred with the recession of 1937–38, from $3,000,000,000 to $2,000,000,000, and even the relatively mild recession of 1949 brought a drop in imports from $7,500,000.000 in 1948 to less than $7,000,000,000 in 1949. Fluctuations in imports in dollar terms have been greater than fluctuations in gross national product, and up to 1950 even minor business recessions resulted in substantial declines in dollars available to foreign countries from sales of goods to the United States. In the recessions after 1950 the declines were less substantial but still of some significance. In the long run there has been a decline in the ratio of imports to gross national product (GNP); this ratio dropped from over 7% of GNP in the 1870s to less than 3% in 1946–50.

Merchandise exports exceeded merchandise imports every year after World War I as reported by the census bureau, although if silver shipments are included, this was not true in 1935 and 1936.

Principal *Imported* Commodities.—More than half of the total value of United States imports at mid-20th century was accounted for by ten commodities or groups of commodities; nonferrous metals and ores, coffee, newsprint, sugar, crude rubber. raw wool, crude petroleum, wood pulp, cocoa and burlap. Imports of crude foodstuffs were higher after World War II than previously, partly because of a substantial increase in per capita consumption of coffee. Imports of manufactured foodstuffs increased much less, partly because of introduction of sugar import quotas.

Shifting consumer demand and technological developments caused changes in fibre and textile raw material imports—imports of raw silk and of burlap declined (reflecting the increased use of such substitutes as man-made fibres and paper bags) and imports of wool, which increased until 1951, dropped thereafter. On the other hand, increased demand, combined in some cases with a decline in available domestic supplies, caused an increase in imports of copper, lead, zinc, tin and crude petroleum. Imports of finished manufactures increased sharply in 1950 and 1951 after the currency devaluations of 1949 which reduced dollar prices of some of these products. Some statistical studies suggest that United States demand for finished manufactures is relatively



1. AKRON, O.
2. ALBANY-SCHENECTADY-TROY, N.Y.
3. ALBUQUERQUE, N.M.
4. ALLENTOWN-BETHLEHEM-EASTON, PA. N.J.
5. ALTOONA, PA.
6. AMARILLO, TEX.
7. ANN ARBOR, MICH.
8. ASHEVILLE, N.C.
9. ATLANTA, GA.
10. ATLANTIC CITY, N.J.
11. AUGUSTA, GA.-S.C.
12. AUSTIN, TEX.
13. BAKERSFIELD, CALIF.
14. BALTIMORE, MD.
15. BATON ROUGE, LA.
16. BAY CITY, MICH.
17. BEAUMONT-PORT ARTHUR, TEX.
18. BINGHAMTON, N.Y.
19. BIRMINGHAM, ALA.
20. BOSTON, MASS.
21. BRIDGEPORT, CONN.
22. BROCKTON, MASS.
23. BUFFALO, N.Y.
24. CANTON, O.
25. CEDAR RAPIDS, IA.
26. CHAMPAIGN-URBANA, ILL.
27. CHARLESTON, S.C.
28. CHARLESTON, W.VA.
29. CHARLOTTE, N.C.
30. CHATTANOOGA, TENN.-GA.
31. CHICAGO, ILL.
32. CINCINNATI, O.-KY.
33. CLEVELAND, O.
34. COLUMBIA, S.C.
35. COLUMBUS, GA.-ALA.
36. COLUMBUS, O.
37. CORPUS CHRISTI, TEX.
38. DALLAS, TEX.
39. DAVENPORT-ROCK ISLAND-MOLINE, IA.-ILL.
40. DAYTON, O.
41. DECATUR, ILL.
42. DENVER, COLO.
43. DES MOINES, IA.
44. DETROIT, MICH.
45. DUBUQUE, IA.
46. DULUTH-SUPERIOR, MINN.-WIS.
47. DURHAM, N.C.
48. EL PASO, TEX.
49. ERIE, PA.
50. EVANSVILLE, IND.-KY.
51. FALL RIVER, MASS.-R.I.
52. FITCHBURG-LEOMINSTER, MASS.
53. FLINT, MICH.
54. FORT SMITH, ARK.
55. FORT WAYNE, IND.
56. FORT WORTH, TEX.
57. FRESNO, CALIF.
58. GADSDEN, ALA.
59. GALVESTON,-TEXAS CITY, TEX.
60. GARY-HAMMOND-EAST CHICAGO, IND.
61. GRAND RAPIDS, MICH.
62. GREEN BAY, WIS.
63. GREENSBORO-HIGH POINT, N.C.
64. GREENVILLE, S.C.
65. HAMILTON-MIDDLETOWN, O.
66. HARRISBURG, PA.
67. HARTFORD, CONN.
68. HONOLULU, HAWAII
69. HOUSTON, TEX.
70. HUNTINGTON-ASHLAND, W.VA.-KY.-O.
71. INDIANAPOLIS, IND.
72. JACKSON, MICH.
73. JACKSON, MISS.
74. JACKSONVILLE, FLA.
75. JERSEY CITY, N.J.
76. JOHNSTOWN, PA.
77. KALAMAZOO, MICH.
78. KANSAS CITY, MO.-KANS.
79. KENOSHA, WIS.
80. KNOXVILLE, TENN.
81. LANCASTER, PA.
82. LANSING, MICH.
83. LAREDO, TEX.
84. LAWRENCE-HAVERHILL, MASS.-N.H.
85. LEWISTON-AUBURN, ME.
86. LEXINGTON, KY.
87. LIMA, O.
88. LINCOLN, NEB.
89. LITTLE ROCK-NORTH LITTLE ROCK, ARK.
90. LORAIN-ELYRIA, O.
91. LOS ANGELES-LONG BEACH, CALIF.
92. LOUISVILLE, KY.-IND.
93. LOWELL, MASS.
94. LUBBOCK, TEX.
95. LYNCHBURG, VA.
96. MACON, GA.
97. MADISON, WIS.
98. MANCHESTER, N.H.
99. MEMPHIS, TENN.
100. MIAMI, FLA.
101. MILWAUKEE, WIS.
102. MINNEAPOLIS-ST. PAUL, MINN.
103. MOBILE, ALA.
104. MONTGOMERY, ALA.
105. MUNCIE, IND.
106. MUSKEGON-MUSKEGON HEIGHTS, MICH.
107. NASHVILLE, TENN.
108. NEW BEDFORD, MASS.
109. NEW BRITAIN, CONN.
110. NEW HAVEN, CONN.
111. NEW ORLEANS, LA.
112. NEW YORK, N.Y.
113. NEWARK, N.J.
114. NEWPORT NEWS-HAMPTON, VA.
115. NORFOLK-PORTSMOUTH, VA.
116. OGDEN, UTAH
117. OKLAHOMA CITY, OKLA.
118. OMAHA, NEBR.-IA.
119. ORLANDO, FLA.
120. PATERSON-CLIFTON-PASSAIC, N.J.
121. PENSACOLA, FLA.
122. PEORIA, ILL.
123. PHILADELPHIA, PA.-N.J.
124. PHOENIX, ARIZ.
125. PITTSBURGH, PA.
126. PITTSFIELD, MASS.
127. PORTLAND, ME.
128. PORTLAND, ORE.-WASH.
129. PROVIDENCE-PAWTUCKET, R.I.-MASS.
130. PUEBLO, COLO.
131. RACINE, WIS.
132. RALEIGH, N.C.
133. READING, PA.
134. RICHMOND, VA.
135. ROANOKE, VA.
136. ROCHESTER, N.Y.
137. ROCKFORD, ILL.
138. SACRAMENTO, CALIF.
139. SAGINAW, MICH.
140. ST. JOSEPH, MO.
141. ST. LOUIS, MO.-ILL.
142. SALT LAKE CITY, UTAH
143. SAN ANGELO, TEX.
144. SAN ANTONIO, TEX.
145. SAN BERNARDINO-RIVERSIDE-ONTARIO, CALIF.
146. SAN DIEGO, CALIF.
147. SAN FRANCISCO-OAKLAND, CALIF.
148. SAN JOSE, CALIF.
149. SANTA BARBARA, CALIF.
150. SAVANNAH, GA.
151. SCRANTON, PA.
152. SEATTLE, WASH.
153. SHREVEPORT, LA.
154. SIOUX CITY, IA.
155. SIOUX FALLS, S.D.
156. SOUTH BEND, IND.
157. SPOKANE, WASH.
158. SPRINGFIELD, ILL.
159. SPRINGFIELD, MO.
160. SPRINGFIELD, O.
161. SPRINGFIELD-CHICOPEE-HOLYOKE, MASS.
162. STAMFORD, CONN.
163. STEUBENVILLE-WEIRTON, O.-W.VA.
164. STOCKTON, CALIF.
165. SYRACUSE, N.Y.
166. TACOMA, WASH.
167. TAMPA-ST. PETERSBURG, FLA.
168. TERRE HAUTE, IND.
169. TOLEDO, O.
170. TOPEKA, KAN.
171. TRENTON, N.J.
172. TUCSON, ARIZ.
173. TULSA, OKLA.
174. UTICA-ROME, N.Y.
175. WACO, TEX.
176. WASHINGTON, D.C.-MD.-VA.
177. WATERBURY, CONN.
178. WATERLOO, IA.
179. WEST PALM BEACH, FLA.
180. WHEELING, W.VA.-O.
181. WICHITA, KANS.
182. WICHITA FALLS, TEX.
183. WILKES-BARRE-HAZLETON, PA.
184. WILMINGTON, DEL.-N.J.
185. WINSTON-SALEM, N.J.
186. WORCESTER, MASS.
187. YORK, PA.
188. YOUNGSTOWN-WARREN, O.

NEW SMSA ESTABLISHED 1960 (11/2/60)

189. ABILENE, TEX.
190. ALBANY, GA.
191. BILLINGS, MONT.
192. BROWNSVILLE-HARLINGEN-SAN BENITO, TEX.
193. COLORADO SPRINGS, COLO.
194. EUGENE, ORE.
195. FARGO-MOORHEAD, N.D.
196. FORT LAUDERDALE-HOLLYWOOD, FLA.
197. GREAT FALLS, MONT.
198. HUNTSVILLE, ALA.
199. LAKE CHARLES, LA.
200. LAS VEGAS, NEV.
201. LAWTON, OKLA.
202. MIDLAND, TEX.
203. MONROE, LA.
204. ODESSA, TEX.
205. PROVO-OREM, UTAH
206. RENO, NEV.
207. TEXARKANA, TEX.-ARK.
208. TUSCALOOSA, ALA.
209. TYLER, TEX.
210. NEW LONDON-GROTON-NORWICH, CONN.
211. MERIDEN, CONN.
212. NORWALK, CONN.

METROPOLITAN STATISTICAL

elastic with respect to price; if so, increase in such imports may depend upon the extent to which foreign productivity increases and foreign monetary policies keep prices low enough to be competitive with U.S. domestic products.

Leading Export *Commodities*.—Industrial manufactured and finished products accounted for about two-thirds of the total value of U.S. exports, followed by agricultural crude materials and foodstuffs, which accounted for about 20% and manufactured foods, about 6%. Foodstuff exports rose very sharply during World War II and in the immediate postwar period.

Exports of some mineral and metal products declined as demand in the United States increased and as domestic supplies became less adequate to meet total demand. By 1956 capital equipment and producers' supplies and materials constituted three-fourths of total exports. The percentage increase in exports of capital equipment over the levels of the 1920s and 1930s was exceptional; during the postwar period large exports of capital equipment were made to such areas as Canada and Latin America.

Although values of exports of consumer goods other than foods and drugs increased from their levels of the 1920s and 1930s, these exports comprised a relatively small part of the total and showed little increase in the decade 1946–55. Partly this was because of the existence of import and exchange controls in many markets; these controls usually restrict imports of consumer goods more than other products. The percentage increase in exports of foods and drugs was not as large as that of exports of capital equipment, but such exports approximately tripled in value from 1926 to 1956 as new major markets for foodstuffs (*e.g.,* Japan) became important, especially after World War II.

Percentages of the cotton and tobacco crops exported declined markedly, accentuating the shift to nonagricultural exports. A smaller percentage of the output of passenger cars was also exported than before World War II. On the other hand, such industries as the civilian aircraft industry exported increasing percentages of total production, and a greater share of the output of machinery was exported than before World War II.

Sources *and Destinations* of *Foreign Trade*.—In the years 1876–80 more than half of U.S. imports of merchandise came from Europe, while 83% of all exports went to Europe. Other countries on the North American continent supplied 23% of all United States imports and absorbed 10% of all merchandise exports. Latin America supplied 31% of all imports and purchased nearly 9% of all exports. Asia was a source of supply of 11% of imports, but took less than 2% of exports. By 1929, however, Europe supplied only 30% of Cnited States imports and by 1937, only 27%. Exports to Europe dropped to 45% of the total in 1929, and to approximately 40% in 1937. This decline in exports to Europe was caused chiefly by a decline in the importance of the United Kingdom as a market for United States exports. Especially in the post-World War II period, because of the dollar shortage the Lnited Kingdom purchased a greater proportion of its imports from the sterling area.

World War II caused other important shifts in United States foreign commerce. Canada and the Latin-American republics, which took only one-third of U.S. exports in 1936–38 and supplied only slightly more than that proportion of imports. were the destinations of 40% of all exports in 1951–55 and the source of more than half of all imports. Exports to Asia increased much more than imports from Asia. The decline in raw silk imports, the disturbed political conditions in many parts of Asia and the increase in population (especially in Japan) which necessitated increased imports were all factors. Exports to certain areas such as Korea, Formosa and Vietnam, were financed by government aid necessitated by the economic difficulties of those areas. Some shipments to India and Pakistan were also made under special government programs, but the increasing importance of these countries as markets was also attributable to their new political status and programs of economic development.

Invisibles.—The so-called invisible items in United States foreign commerce, including receipts and payments for transportation services, travel and tourist expenditures, miscellaneous services and income on investments, are important items in the U.S. balance of payments. In 1955 these items accounted for approximately 25% of the total value of exports of goods and services and for approximately one-third of the total value of imports of goods and services. Between World Wars I and II payments generally exceeded receipts. and although this situation was reversed from 1940 to 1952, beginning in 1953 there was again an excess of payments over receipts. An important component of total payments was expenditures of United States armed forces abroad—expenditures of members of the armed forces themselves and expenditures for construction of airfields. support of troops, etc. These expenditures totaled $2,500.000.030 in 1953 and were increased in following years. In spite of heavy subsidies of the U.S. merchant marine, foreign competition was significant, and after 1951 transportation payments were not much lower than receipts Expenditure of U S tourists abroad increased much more slowly than personal disposable income from the 1920s to the 1950s, but such expenditures exceeded $1,000,000,000 in 1954. The substantial growth of U S. foreign investments resulted in an inflow of income which in 1955 reached $2,500,000,000—twice the net outflow of private U.S capital in that year.

Unilateral Transfers—Some unilateral transfers have always been made in the form of remittances and gift shipments. During World War II, however, unilateral transfers became a very substantial element in the U.S. balance of payments, exceeding $14,000,000,000 in 1944. They reached $6,700,000,000 in 1953. Lend-lease during World War II, the United Nations Relief and Rehabilitation administration (UNRRA) and other aid in the immediate postwar period and the Marshall plan and its successors after 1948 provided a flow of aid funds which totaled approximately $90,000,000,000 (net) in the 15-year period 1941–55. Private remittances amounted to approximately $500,000.000 annually.

Capital Movements—The net outflow of private capital from the U S., which had been relatively sizable during World War I and during the 1920s and uhich had reached $1,500,000,000 in 1928, dropped sharply to negligible proportions in the depression of 1929–32 and thereafter did not recover until after World War II. The international financial collapse of 1931 and the depression, together with political and military uncertainties, made potential investors hesitant. After World War II foreign investment began to revive, chiefly in the form of direct investment in branch plants and similar productive facilities rather than the purchase of foreign securities. Most of this foreign investment was made in Canada and in Latin America, with investment in the middle east (chiefly by oil companies) ranking third. Although by 1952 the outflow of private capital was almost as large in dollar terms as in 1927–28, its increase was far less than that in private domestic investment. Lack of knowledge on the part of business executives concerning foreign investment, the restrictions imposed by countries resentful of foreign influence and insufficient earnings differentials hindered the expansion of foreign investment. Thus private capital outflow financed only a small part of the export surplus; and in 1954 and 1955 repayments exceeded the outflow of government long-term capital. (See also CAPITAL. EXPORT OF.)

Commercial Policy.—The major instrument of U.S. commercial policy has been the tariff (see TARIFFS), although import quotas. subsidies to shipping and other measures have had some importance Because of the strength of the dollar vis-8-vis other currencies, the United States has never imposed the exchange controls or negotiated the clearing agreements which have been features of the commercial and international financial policies of many countries.

The first U.S. tariff act. that of 1789. was primarily for revenue, but it contained certain elements of protection. Duties on exports were prohibited by the constitution, but import duties became an important feature of United States law. Alexander Hamilton gave the classic arguments for protection in his Report on *Manufactures*, and after the War of 1812 the movement for protection grew as manufacturing interests increased in strength. From 1832 until the time of the Civil War southern influence succeeded in reducing duties, but this trend was reversed by the Morrill Tariff act of 1861. During the Civil War the tariff was used as one of many means of raising revenue; the high protective tariff was firmly established in the act of 1864.

After the election of Woodrow Wilson in 1912, the Underwood Tariff act of 1913 made some reductions in duties, although other rates were raised. After the Republican party had returned to power in 1920 upward revision of the tariff was made in an emergency act of 1921, followed by the Fordney-McCumber act of 1922. The Hawley-Smoot act of 1930 raised rates still further. These acts adopted the principle that duties should offset the lower costs of foreign producers, a principle which, if carried to its logical conclusion, would eliminate much of international commerce. The Hawley-Smoot act was followed almost immediately by tariff increases in many other countries. (See History, above.)

Reciprocal Trade *Agreements* Progrant.—No tariff act was passed by congress after 1930. The precipitous decline in world trade which accompanied the depression of 1929–32 and the spread of trade restrictions. especially after 1931, provided a basis for reconsideration of tariff policy. The Trade Agreements act of 1934 empowered the president to enter into agreements with foreign countries, reducing (or raising) U S. import duties by not more than 50% in exchange for tariff changes by foreign countries This act was renewed many times, with some modifications. The renewal in 1949 included a "peril point" provision which required the president to explain to congress any reductions below points designated by the tariff commission as likely to injure domestic industries, and that in 1951 included an "escape clause" provision which required him to withdraw concessions found by the tariff commission to be injurious or to explain to congress his reasons for not doing so. The renewal in 1955 permitted reductions of 5% of the duty a year for each of the following three years, and reduction of any duty above 50% ad valorem to that level The renewal in 1958 was for four years and permitted further gradual reductions.

Tariff reductions under the reciprocal trade agreements program resulted in reduction of. duties collected from 53% of the value of total dutiable imports in 1930–33 (under the Hawley-Smoot rates) to 13% in 1952. Calculations of average rates, however, cannot adequately measure the restrictiveness of tariffs. Many reductions are made just to the point at which substantial increases in imports might result; administrative provisions and valuation practices are often significant barriers; and reduction of a duty may have less effect than its imposition. Trade channels, once disrupted, may be difficult to re-establish. In any event, the reciprocal trade agreements program has not resulted in unusual increases in imports; although increasing absolutely, imports have declined in relation both to exports and to gross national product.

General Agreement on *Tariffs and* Trade.—In 1947 a new tariff negotiation procedure was used; concessions agreed upon by pairs of countries were incorporated in a single General Agreement on Tariffs and Trade (G.A.T.T.). Concessions in this agreement were made applicable to all signatory countries (most-favoured-nation treatment). These and subsequent concessions negotiated at Annecy, France, in 1949, Torquay, Eng., in 1951 and Geneva, Switz., in 1955 and 1956 superseded bilateral concessions; most concessions under the trade agreements program thus became embodied in the General Agreement on Tariffs and Trade. A charter for an International Trade organization (ITO), which would have provided for reduction or elimination of trade barriers, was never adopted, primarily because the U.S. congress did not ratify it; and a later proposal for an Organization for Trade Cooperation (OTC), supported by President Eisenhower, seemed to have small chance of passage. However, G.A.T.T. continued in force and periodic meetings of the contracting parties performed some functions of an international trade organization. (See TARIFFS AKD TRADE, GEKERAL AGREEMENT ON.)

Quotas.—The United States has not made extensive use of the quota (*q.v.*), but quotas have been of some importance on certain agricultural products. Sugar import quotas were introduced under the Jones-Costigan Sugar act of 1934 and quotas for such products as wheat, wheat products, flaxseed, peanuts, butter and other dairy products, fats and oils and rice were established by the secretary of agriculture under authority of sections of the Agricultural Adjustment act adopted in 1935. The conflict betneen agricultural policy and trade policy gave rise to serious problems of over-all foreign commercial policy.

Foreign Trade Zones and *Customs* Simplification.—Such things as delay and uncertainty in classification of merchandise, valuation procedure and marking requirements have been extremely important as invisible tariffs One effort to aid foreign commerce was the Foreign Trade Zones act of 1934, which provided for foreign trade zones in which goods might be sorted, graded and manipulated and then re-exported without being entered through customs. or might be entered after such handling. In 1950 manufacturing and exhibiting were authorized in such zones. Importers may eliminate damaged goods (which then need not be entered through customs), modify goods (making them subject to a lower rate of duty) or store goods in a zone pending entry. Six zones were established by 1950; in New York city, New Orleans. San Francisco, Los Angeles, Seattle and at the municipal airport at San Antonio. Tex. The San Antonio zone ceased operation in Oct. 1953, and the Los Angeles zone in Jan. 1956.

The Customs Simplification act of 1953 changed many administrative provisions so that unnecessary marking requirements, delay in entry, harsh penalties and accounting procedures might be eliminated, reduced or simplified. The Customs Simplification act of 1956 provided for use of "export value" only, for valuation of most goods subject to ad valorem duties; previously the law required the use of export value or foreign value (basically the wholesale price in the foreign country of exportation), whichever was higher. (See also PROTECTION. United States; TRADE. INTERNATIONAL)

3. Banking and Currency.—Early Developments.—In colonial America an "unfavourable" balance of trade continually drained gold and silver money out of the colonies; at times such commodities as wheat. corn and tobacco were designated legal tender in an effort to meet the shortage of currency. The currency that circulated in the colonies was a mixture of English. Spanish, French and Portuguese coins, the Spanish dollar being the commonest. A number of-the colonies issued paper money, or bills of credit. because the colonial governments felt the shortage of money acutely and desperately needed to meet defense and administrative expenses. Issues of paper money by the colonies were often termed "banks," and the money in some cases was lent to borroners who paid interest, which could be used for improvements by the colonial government.

In the colonies there were also some associations of private persons which issued bills of credit and lent them to memhers on the security of real estate mortgages. These associations performed one of the major functions of banks, that of providing a medium of exchange, but they were not an important influence on later banking development. Banking, in fact, was restrained in the colonies by the Bubble act of 1720, passed by the English parliament to prevent excesses such as those of the South Sea company (see SOUTH SEA BUBBLE) ; application of the Bubble act was expressly extended to the colonies in 1741.

Unlike banking in Europe, which originated in the'storing of gold and silver with goldsmiths who in turn made loans, banking in America began as a result of a shortage of funds. By forming banks and combining funds and by the issue of bank notes, merchants could obtain needed money. In the modern sense U.S. banking may be said to date from the incorporation of the Bank of North America, which obtained a charter from congress in 1781. Two other banks were in operation before 1789—the Bank of Massachusetts in Boston in 1784 and the Bank of New York. which began operations in 1784 although it was not incorporated until 1791.

With the establishment of the new government, the need for a better monetary system was recognized. Art. 1, sec. 8 of the constitution gave congress the power to "coin Money" and "regulate the Value thereof," and art. 1, sec. 10 stated that "No State shall . . . coin Money; emit Bills of Credit; make any Thing but gold and silver Coin a Tender in Payment of Debts. . . ."

Notes concerning a mint and coinage written by Jefferson and a report on this subject by Hamilton exercised substantial influence on the Coinage act of 1792. which provided for a bimetallic monetary system (see BIMETALLISM) based upon a dollar consisting of $24\frac{3}{4}$ gr. of pure gold or $371\frac{1}{4}$ gr. of pure silver—a ratio of 1 to 15. This act also provided for unlimited and gratuitous coinage by the mint. to be established in Philadelphia. of both metals at the option of any holder: and it designated gold and silver coins to be minted. Hamilton had argued that "to annul the use of either of the metals, as money, is to abridge the quantity of circulating medium "

It appears to have been the intention of the framers of the constitution to prohibit issuance of paper money by the federal government; the experience with paper money issued by the continental congress and by the colonies was bitter. The constitution made no reference to banks or banking; according to one authority this is probably because the subject was too controversial.

Growth of *U S* Banking.—In 1790 Hamilton submitted his plan for a bank to conduct a commercial banking business and also to aid the government in public finance and lend to the treasury. The first Bank of the United States was established by an act of congress in 1791. One-fifth of its capital was to be subscribed by the government, and the bank was given the power to issue bank notes, to accept deposits and to establish branches. It was prohibited from dealing in goods, from owning real estate other than that "requisite for its immediate accommodation in relation to the convenient transacting of its business, and such as shall have been bona fide mortgaged to it by way of security, or conveyed to it in satisfaction of debts. . . ." It was also specified that the tctal debts of the bank should not exceed the "monies then actually deposited in the bank for safe keeping" by more than $10,000,000, thus establishing the principle of fractional reserves for note issues. Deposits were exempted from similar restriction by not specifying a limit for them. because at that time deposits meant primarily deposits of specie, not deposits created in the process of lending. Hamilton's model was the Bank of England (*q.v.*), and in fact the first Bank of the United States was a kind of central bank (*q.v*), performing services for the government and exercising a stabilizing influence on banking generally. In the decade 1790–1800, about 24 banks were established, all of them in towns and cities of commercial importance.

During its 20-year life considerable controversy arose over the first Bank of the United States. Its charter was not extended when it expired in 1811, although one of the chief stockholders acquired the bank and continued a private (unincorporated) banking business. The War of 1812 and accompanying "runs" on banks, which caused bank suspensions and varying depreciation in the value of bank notes, combined with the difficulties of federal finance. resulted in a changed attitude and a desire for establishment of a second Bank of the United States to help restore a sound monetary system. Votes of southern and western senators and representatives were significant in the passage of the act to incorporate the second bank, in 1816. Although the new bank was larger, its powers were very similar to those of the first bank. Opposition to it developed on several fronts. however, and in 1832 President Jackson vetoed a bill to extend its charter, which expired in 1836. (See History, above.)

With the end of the central banking functions of the second Bank of the United States and with the growing popularity of the free banking system (under which any persons or group of persons meeting certain conditions could organize a bank), the number of banks and the amount of their note issues increased rapidly. Many of these banks did not, and could not, maintain enough reserves to redeem the quantity of notes presented for redemption. and bank notes began to circulate at varying discounts. In most sections of the country banking conditions were unsatisfactory and bank notes were of uncertain value. (Government funds were held in subtreasuries under the independent treasury system established in 1846 after an abortive attempt in 1840.) These conditions, plus the need of money by the government to finance the Civil War, led to passage of the legislation generally referred to as the National Bank act of 1863.

This act provided for incorporation of banks under federal law, for issue of bank notes on the security of government bonds and for minimum cash reserves against both notes and deposits, with permission for deposit of a portion of such reserves in major banking centres (central reserve cities and reserve cities. as they came to be known). Although it had been expected that state banks would soon convert themselves into national banks, they were slow to do so, and a heavy tax was therefore imposed on state bank notes. This resulted in a period, from about 1865 to 1893, when national banks were more numerous than state banks. However, the growing need of the country for banking services and the growth in importance of deposits as compared with bank notes resulted in the establishment of so many state banks that these became much more numerous after 1900 and remained so.

Although part of the cost of the Civil War was financed by taxation and by borrowing, these were insufficient; congress authorized issues of United States notes, or greenbacks, as legal tender. The greenbacks depreciated in value, the extent of their depreciation varying with the quantity of money in circulation, the success of the Union armies and, later, the prospects for redemption. The Resumption act of 1875 provided for gradual retirement of the notes and their redemption in specie beginning in 1879. As redemption approached. their value increased; the greenbacks are one of the few instances in which government wartime issues of paper money have been successfully restored to their face value (See *History:* From 1865 to 1910.)

Silver v. Gold.—Shortly after the establishment of a bimetallic monetary system in 1792, silver declined somewhat in value. A French coinage law of 1803 provided for bimetallism in that country, with a ratio of $15\frac{1}{2}$ to 1. The greater economic importance of France in that day and the mint overvaluation of silver combined to attract silver to the mint, while gold was driven out of use as money. Special circumstances caused silver dollars to be drained out of the country to the West Indies, where they could be exchanged for heavier-weight Spanish dollars at one to one; the Spanish dollars were then imported and sent to the mint for coinage into a larger number of United States dollars. This process could then be repeated, with profit.

In effect, these conditions resulted in a de facto silver standard until the coinage acts of 1834 and 1837 adopted a ratio of 16 to 1 (15 988 to 1 in the act of 1837). The gold dollar was defined as 23.2 gr. of fine gold (23.22 gr. in the act of 1837), resulting in increased gold coinage and a flow of silver out of circulation. New gold discoveries in the period 1845–50 made the supply of gold more plentiful, and the market value of gold in relation to silver declined accordingly. By 1853 the amount of silver in the fractional coins was reduced. making them less valuable, and bullion for coinage of these was to be purchased by the director of the mint. If the silver dollar had at that time been omitted from the list of coins to be minted. the United States would have had a de facto gold standard.

In 1873 the silver dollar—which had not been coined for some time because silver was more valuable as a commodity—was omitted from the list of coins to be minted. The volume of national bank notes was limited, state bank notes had been taxed out of existence and gold production was smaller than formerly. All of these factors combined to limit the increase in money; yet the volume of production was increasing rapidly. After the panic of 1873 a general desire for more money, combined with the attempts of silver interests to benefit themselves, resulted in legislation for purchase and coinage of silver. The Bland-Allison act of 1878 provided for the purchase of $2,000.000 to $4,000,000 of silver per month for coinage into silver dollars. The Sherman Silver Purchase act of 1890 directed the secretary of the treasury to purchase 4,500,000 oz. of silver per month and to issue treasury notes based upon it. Silver advocates gained control in the Democratic party in 1896 and William Jennings Bryan campaigned on a platform of free silver coinage in both 1896 and 1900. The defeat of Bryan in 1900 ended this effort; and earlier that year the Gold Standard act had designated the gold dollar of 25.8 gr. of gold ($\frac{9}{10}$ fine) as the standard of value. Gold production had begun to increase in 1890 and the general price level began to rise in 1896; the need for silver money was not so apparent. (See History: From *1865* to 1910, above.)

The *20th Century.*—The panic of 1907 created added interest in banking reform, and the Aldrich-Vreeland act of 1908 created a National Monetary commission. Only a year after the commission submitted its report. a bill sponsored by Rep. (later Sen.) Carter Glass and supported by President Wilson established the federal reserve system (*q.v.*), thus giving the country a central bank aiter a lapse of three-quarters of a century. The 12 iederal reserve banks serve as bankers' banks for their respective districts, serve as agents for the treasury and issue federal reserve notes, which in the mid-20th century constitute the chief form of paper money.

The banking system of the United States in the second half of the 20th century included over 14,000 banks, which at the end of 1957 had nearly 23,000 banking offices. Of these, about 4,600 were national banks. About 1,800 state banks (out of nearly 9,000) were members of the federal reserve system. The national and state member banks had about 85% of the total deposits held by all commercial banks, and were in most cases larger and more important. There were a few notable exceptions, among them the state-chartered Chase Manhattan bank, second largest in the country. There were somewhat over 500 mutual savings banks (*q.v.*) located in 17 states that had in 1958 nearly $35,000,000,000 in deposits.

This structure was strongly influenced by the banking legislation of the 1930s, especially the Banking act of 1933. This law provided for state-wide branch banking by national banks in any state in which this was permissible for state banks, required separation of commercial irom investment banking. established a system of deposit insurance and prohibited payment of interest by banks on demand deposits. The Banking act of 1935 modified and made permanent the deposit insurance plan, made changes in the organization and powers of the board of governors of the federal reserve system, giving it power to increase or decrease reserve requirements of member banks within specified limits, and made many technical changes in banking law.

Important monetary legislation also was passed in the 1930s. The depression and accompanying bank failures had created a serious demoralization of the banking system, and immediately aiter his inauguration President Roosevelt proclaimed a four-day banking holiday. Congress passed an Emergency Banking act on the last day of this holiday, and banks considered sound were permitted to reopen. A joint resolution of congress on June 5, 1933. made all obligations payable in any legal tender currency instead of in gold and an amendment to an agricultural act, enacted May 12, 1933, authorized the president to issue greenbacks, devalue the dollar, provide for free and unlimited coinage of silver and take other measures to increase the quantity of money. The objective was to raise prices as a means of restoring prosperity. This "inflation amendment" also made all coins and currencies issued "by or under the authority of the United States" legal tender.

The Gold Reserve act of 1934 transferred legal title to all gold held by federal reserve banks to the United States government, provided for withdrawal of gold coin irom circulation, prohibited redemption of currency in gold (except with authorization of the president), specified that the gold dollar should be reduced to not more than 60% and not less than 50% of its former weight, authorized a stabilization fund for the dollar from the "profit" from devaluation and made other changes. This legislation thus established a provisional international gold bullion standard. Gold did not circulate, henceforth, in the domestic monetary system, but the fact that it could be exported, subject to treasury licence, made it possible for foreign central banks and governments to maintain deposits in the United States with the assurance that these could probably be converted into gold upon demand. In some years, in fact, gold flowed out of the United States in response to such demand.

During World War II control of consumer credit was added to the margin requirements which the federal reserve had been authorized to impose in 1934 as a means of checking the use of credit for speculative purposes. War finance was aided by permitting federal reserve banks to purchase a limited amount of treasury obligations directly instead of in the open market, by exempting war loan deposits from reserve requirements and by reducing the minimum reserve requirement of the federal reserve banks to 25% of their note and deposit liabilities. The iederal reserve system supported prices of government securities and during the war maintained a fixed pattern of yields for various maturities These actions led some to refer to the iederal reserve system as "an engine of inflation." and the persistent rise in prices in the period after World War II led to fears that inflation was a continuing problem. The fear of inflation led to temporary reimposition of consumer credit control (regulation W) in 1948–49 and again in 1950–52. Similar control of credit for purchases of real estate (regulation X) was imposed in 1950–52 and a program of voluntary credit restraint (VCR) was in effect for a time.

An "accord" between the federal reserve system and the treasury in March 1951 gave the federal reserve freedom to use instruments of monetary policy without the necessity of maintaining fixed yields for government securities. Although it endeavoured to maintain "orderly conditions" in the markets for government securities. the actions of the iederal reserve in the following years were aimed at the use of monetary policy (changes in discount rates, open market operations and changes in reserve requirements) to achieve relatively full employment, reasonable stability in the general price level and long-term economic growth. Beginning in 1949 a series of hearings of congressional committees attempted to throw light on these policies and their relationship to management of the public debt and to the growth of financial institutions other than commercial banks. By 1957 there was consideration of a new national monetary commission, similar perhaps to that of 1908–12. Several factors prevented establishment of such a commission officially, but the Committee for Economic Development, a business group of some influence, announced that it would sponsor such a commission. (See also BANKING: *History of* Banking *in the United* States.)

4. National Finances. — Early History. — Under the Articles of Confederation, the federal government was empowered only to borrow and to make requisitions on the states, not to tax. Consequently. its financial position was extremely difficult. In its first two years it received little more than one-tenth of the amount requested from the states, and during its life it obtained barely enough funds to meet current expenses (and not enough to meet interest requirements on the debt). National finances finally broke down completely in 1786 Further borrowing had become virtually impossible and requisitions yielded practically nothing.

The constitution of 1789 gave the iederal government broad powers in the field of public finance, including the power to lay and collect taxes, duties (except on exports), imports and excises and to borrow money, pay debts, coin money and regulate the value thereof. States were forbidden to coin money, issue bills of credit, make anything other than gold and silver legal tender or lay any duties on imports or exports.

The treasury department was created with a single head (instead of a proposed commission). Customs duties (somewhat protective in character), excises and sale of public lands provided revenue. Funding of debt owed in France, Holland and Spain and domestically (both by the federal government and by individual states) was provided for in the Funding act of 1790. Continental currency had long since ceased to circulate as currency and had been bought and sold by speculators at from 500 to 1,000 to 1; a small amount was funded into the new debt at 100 to 1, while much of the continental currency was not presented to the government.

Until the Civil War customs duties constituted the main source of revenue of the federal government. Sales of public lands yielded some revenue. Revenue sources mere more than sufficient to provide for current expenses, and the national debt was reduced to zero in 1835—but debt was quickly incurred again as a result of the depression of 1837 and the Mexican War.

The Civil War Through World *War* I.—The Civil War created great public-finance problems. Greenbacks issued by the federal government could not be redeemed in specie and depreciated substantially in terms of gold. In spite of the introduction of internal revenue taxes and an increase in import duties, deficits were large.

Marketing of bond issues was aided by the National Bank act, which required bonds to be used as collateral for bank notes After the war national finances improved: wartime taxes were repealed and rising customs revenues helped provide budget surpluses in the years 1866–93. Specie payments were resumed by the treasury in 1879 and the public debt was reduced continually—to less than $1,000,000,000 in 1888

The history of federal expenditures has been one of gradual increase between wars and tremendous increases in wartime. Peak expenditures in 1814 reached nearly $35,000,000, in 1865 almost $1 300 000.000, in 1919 over $18,000,000,000 and in 1945 more than $95.000.000.000 The same is true of federal expenditures as a percentage of national product for the period after 1870 (for which national product estimates are available). By 1916 gradual increase had raised federal spending to a level approaching that of the Civil War peak. although per capita spending was only slightly higher than the 1870 peak (which had been followed by a sharp drop).

The 16th amendment to the constitution authorizing income taxes was ratified in 1913. By 1920 over two-thirds of federal revenue came from income and profits taxes whereas in 1910 over 96% had come from internal revenue and customs receipts

Even such revenue. however, could not meet even half the cost of World War I. and deficit financing was conducted chiefly through sale of short-term obligations to obtain funds initially, then by funding into large popular bond issues. Five such loans during the war and shortly after the Armistice raised about $21,000,000,-000. and the public debt reached a peak of over $26,000.000 000 in 1919 Thereafter, honever, it was reduced—by about $10,000,-000,000 over the next decade.

With the decline of federal spending from the wartime high, taxes also mere reduced. The excess profits taxes on corporations were repealed (although the corporation income tax was raised), individual income tax rates were reduced and a number of excise taxes were eliminated. During the 1920s further tax reductions occurred

An important fiscal development was the inauguration of an executive budget under an act of congress of 1921. A bureau of the budget was established to prepare the annual budget and other estimates At first the budget was largely an accounting document designed chiefly to secure economy in government. As the years went by. however, the budget became the chief document for presentation of the president's views on fiscal policy and expenditure programs designed to achieve goals of governmental policy. (See BUDGET, GOVERNMENTAL. *United* States)

During and immediately after World War I, the United States government made substantial loans to foreign governments for war and relief and reconstruction purposes. The principal debtor governments sought to condition their payments of interest and repayments of principal on receipt of reparations from Germany, and no satisfactory method of obtaining repayment of these loans was ever derised Ultimately all debtor nations defaulted, in whole or in part. and by the 1950s the unpaid amounts were generally regarded as uncollectible.

Depression Finance—National finances in the decade 1930–39 were influenced primarily by the world-wide depression Unemployment necessitated large outlays for relief, work programs and emergency credit institutions.

The Roosevelt administration, departing from the approaches used under Hoover, instituted monetary reform, banking reform. an industrial recovery program, agricultural subsidies, public works and relief programs, Social Security and unemployment legislation. Deficit financing, begun because of necessity, became to some extent a policy to aid in recovery. A gift tax. a group of manufacturers' excise taxes and other miscellaneous taxes were enacted in 1932 to add revenue; other taxes were added in 1933 and 1934. Rates of estate and gift taxes were increased and exemptions were decreased. Personal exemptions in the income tax were also reduced and rates of both individual income and corporate income taxes were raised. Taxes were imposed on both employers and employees to provide funds under Social Security. beginning in 1935. As a result. the national debt more than doubled from 1930 to 1939; interest payments did not rise proportionately because bank excess reserves made it possible to sell short-term government obligations at relatively low yields.

World War II and After.—During World War II there was a great rise in the national debt, a policy of supporting government obligations at an almost fixed pattern of yields and use of wartime controls (allocations, rationing, price and wage controls and credit controls). National security expenditures, which constituted less than half of budget expenditures in 1941, constituted about 85% in 1945, and although they dropped to about one-third in 1950 they climbed again to nearly two-thirds in 1955. In the budget for fiscal 1959, in the midyear review. it was estimated that major national security expenditures would total nearly $47.000,-000.000, international affairs and finance nearly $1,500,000,000 and veterans' services and benefits over $5,000,000,000—a total of $53,500,000,000 or more than 67% of the total budget of $79,223,000,000. Major receipt and expenditure items for selected years are shown in Table XX.

TABLE XX.—*Budget and Expenditures Receipts of the Federal Government by Major Function**

(in $000,000; years ending June 30)

Expenditures	1950	1953	1956	1959†
Major national security	13,009	51,830	41,825	46,845
International affairs and finance	4,671	749	662	1,441
Veterans' services and benefits	6,646	4,298	4,756	5,162
Labour and welfare	1,963	2,426	2,776	4,345
Agriculture and agricultural resources	2,783	2,936	4,913	6,392
Satural resources	1,206	1,476	1,104	1,691
Commerce and housing	1,991	2,502	2,028	3,878
General government	1,186	1,474	1,629	1,667
Interest	5,811	6,583	6,846	7,578
Allowance for contingencies	.			225
Adjustment to daily treasury statement basis	341		. .	. .
Total	39,617	74,274	66,540	79,223

Receipts	1950	1953	1956	1959†
Individual income taxes	15,745	30,108	32,188	36,000
Corporation income taxes	10,448	21,238	20,880	16,700
Excise tases	7,549	9,868	9,929	8,400
All other receipts	2,752	3,610	5,169	5,900
Total	36,495	64,825	68,165	67,000

*Because of rounding, will not necessarily add to totals. †Preliminary, from the *1959 Federal Budget Midyear Review*.

Source: Bureau of the Budget; U.S. Department of the Treasury.

After reaching a peak of over $269,000,000,000 at the end of fiscal 1946. the public debt declined somewhat to just above $250,-000.000.000 in the period 1948–1949. With the outbreak of the Korean conflict in 1950 the debt began to rise again (see Table XXI) and by the end of fiscal 1958 it exceeded $275.000.000,000. A debt limit, set by congress, had been raised to $300,000,000,000 by the end of World War II and then lowered to $275,000,000,000. Heavy expenditures, combined with the economic recession of 1957–58, necessitated raising the limit in 1958 to $288 000.000.000 as a temporary limit and $283,000,000,000 as a presumably more permanent ceiling.

Tax revenues needed for World War II and for the relatively

TABLE XXI.—*Public Debt of the United States by Type of Security*

(in $000,000,000~

June 30	Total gross debt*	Marketable					Con-vertible bonds	Nonmarketable			Special issues
		Total	Treasury bills	Certificates of indebtedness	Notes	Bonds		Total†	Savings bonds	Tax and savings notes	
1945	258.7	181.3	17.0	34.1	23.5	106.4	....	56.2	45.6	10.1	18.8
1950	257.4	155.3	13.5	18.4	20.4	102.8	....	67.5	57.5	8.5	32.4
1955	274.4	155.2	19.5	13.8	40.7	81.1	11.7	61.6	58.4	1.9	43.3
1958	276.4	166.7	22.4	32.9	20.4	90.9	8.9	52.9	52.0	....	46.2

*Includes some debt not subject to statutory debt limitation and fully guaranteed securities, not shown separately. †Includes series A investment bonds, depository bonds, armed forces leave bonds and adjusted service bonds, not shown separately.

Source: U.S. Department of the Treasury.

high level of expenditures thereafter were obtained chiefly from increased personal and corporate income taxes and corporation excess profits taxes during certain periods; some revenue was obtained from excise taxes. Some tax reduction occurred after World War II, and the corporate excess profits tax was abolished in 1946. Exemptions allowed in the personal income tax were increased, and in 1948 legislation permitting "splitting of incomes" between husband and wife reduced taxes for married persons (this "splitting" had been possible previously only in community property states). The Korean conflict necessitated an increase in taxes again; this was followed by some tax reduction in 1954. The Revenue act of 1954 included a provision termed a dividend income credit, designed to reduce, to some extent, the double taxation of corporate dividends.

The great growth of the public debt, which made government obligations the chief item of secondary reserves for banks (see Table XXII, showing ownership of government securities), and which made the government bond market an extremely important segment of the money market, caused concern over the management of the public debt. The Patman committee hearings in 1952 provided information concerning the relationship of the debt to the monetary and banking system, and later hearings also focused attention on such significant problems as the status of the board of governors of the federal reserve system. the relationship of fiscal policy (relating to public finance — taxation, budgeting, debt, management, etc.—and its effect on income distribution) to monetary policy (relating to the money supply), the effects of debt management policies and the use of fiscal and monetary policy to achieve economic growth, mitigate business cycles and at the same time maintain "reasonable" stability in the general price level. Reports of the joint economic committee of congress emphasized the importance of tax policy and expenditure policy in achievement of these goals. Necessity of adequate defense, probably requiring rising levels of defense spending, was recognized, together with the need for careful attention to the destabilizing effects of government spending at certain times. (C. N. HG.)

TABLE XXII.—*Ownership* of U.S. Government Securities, Direct and Fully *Guaranteed**
(in $000,000,000)

June 30	1940	1945	1950	1955	1958
Held by banks, total	$18.6	$106.0	$84.0	$87.1	$90.3
Commercial banks	16.1	84.2	65.7	63.5	64.9
Federal reserve banks	2.5	21.8	18.3	23.6	25.4
Held by nonbank investors, total	29.9	153.1	173.3	187.3	186.1
U.S. government agencies and trust funds	7.1	24.9	37.9	50.6	55.9
Mutual savings banks	3.1	9.6	11.6	8.7	7.4
Insurance companies	6.5	22.7	20.1	14.8	11.7
Individuals	10.1	58.9	67.1	64.8	65.7
All other investors†	3.1	37.0	36.6	48.4	45.4
Total gross debt	$48.5	$259.1	$257.3	$274.4	$276.4

*Detail will not always add to totals because of rounding. †Corporations, associations, state and local governments, foreign accounts, dealers, brokers and all others.
Source: U.S. Department of the Treasury.

D. TRANSPORTATION AND COMMUNICATIONS

It is easy to forget that 200 years after the establishment of the first English colony in 1607 virtually all important towns were on tidewater and nearly all freight was carried in small sailboats. Overland transportation was confined to unsurfaced roads and trails which were impassable to wheeled vehicles during much of the year. It is not surprising that contemporary writers believed that many centuries would be required to fill the vast territory acquired by the Louisiana Purchase. Yet within 160 years that territory, and much more, was populated to an average density greater than that of the coastal strip at the time of the Revolution. The successive revolutions in transportation had much to do with this.

1. Historical Development. — Roads were the first of three major transportation developments to follow the American Revolution. Their expansion continued for several decades in spite of increasing and soon overwhelming competition from canals and railroads for long-distance bulk carriage. All-weather surfaces of various types, including wooden planks, were installed, materially increasing the loads that could be drawn with a given number of horses.

In addition to the cost advantages of such roads, the power of the English navy provided compelling military reasons for building roads parallel to the coast that could not easily be cut off by sea. Although there were several comprehensive plans for a network of national highways, only one of any importance, the Cumberland road, was constructed with national funds. Public interest was expressed by land grants and other aids. The numerous roads built predominantly by private turnpike and plank-road companies sooner or later ran into financial difficulties and were, for the most part, turned over to local control where the obligation to keep them passable fell to abutting property owners with a private interest in their maintenance.

Interest in highways revived with the invention of the safety bicycle and became an overriding interest with the development of the automobile. Highway construction was initiated by the states; federal aid began in 1916 and a system of national highways, financed 90% by the federal government, was undertaken in 1944 and expanded in 1956. These developments, together with expansion of the state highway systems, placed the highways back in contention with the railroads as prime movers of both passengers and freight.

Technological considerations seem to explain the fortunes of the various transportation mediums. Teams of horses could move heavier loads over all-weather surfaced roads than over unsurfaced roads. The same teams could draw still heavier loads over canals. Neither could compete with the load-drawing power of the steam locomotive. Although steam could be economically applied to larger ships, the amount of useful cargo space rises rapidiy with the size of steamships, putting steam-powered canal boats at a serious disadvantage.

Some canals, like some roads, were abandoned, but characteristically, no general mode of transportation ever disappeared. Coastwise shipping, roads, canals, railroads and other forms of transportation all have some advantage. The mammoth tanker, the towboat and barge, the railroad, the pipeline, the truck, the automobile and the airplane — each provides the lowest-cost service for some type of freight or passenger movement. As technological advances occur, the type of transportation favoured by each advance expands and the others become limited to their most advantageous services.

Erich Zimmermann declared that land that is useful to man for agriculture in the United States would not be so in a country such as the China of the early 1930s. The main difference is the availability of transportation. With efficient transportation China may be able to double its area of useful land. In any nation, an area enjoying cheap transportation need not produce even its necessaries if it can produce a surplus of some product that can be sent out and exchanged for other goods and services. Thus efficient transportation makes it possible to concentrate production of the various raw materials where nature provides them most abundantly and to produce new commodities with near-maximum economies of scale.

Illustrative of this type of specialization is the concentration of iron- and steelmaking at Pittsburgh, where good coking coal, iron ore and local water transportation made possible much lower costs than could be obtained nearer the centres of population on the coast where ore and fuel were of lower quality. A more complicated structure of the industry followed the installation of locks at Sault Ste. Marie, bringing together the midwestern coal fields at the base of Lake Michigan and the rich iron deposits near Duluth, Minn. The location and efficiency of U.S. agriculture is likewise a result of changes in transport. To take a single example, the fresh-meat industry was once local by necessity. It had to be concentrated close to the final markets so that herds could be driven — in relatively small numbers — to local slaughterhouses. With the development of the railroad and particularly of the refrigerator car, ranchers on the western plains could raise cattle on the free grass of the public domain and ship great numbers with moderate weight loss to huge packing plants at the railroad centres. From there the products were distributed to major consumer markets. The modern highway brought still another change.

Farmers who own their own trucks can compare prices at several packing plants by means of frequent radio reports and transport their cattle accordingly. In this way they avoid part of the weight loss that accompanied longer shipment of livestock to central markets. The resulting reorganization of the industry reduced the importance of meat packing at the great rail junctions such as Chicago.

Some idea of the growth of various types of transportation in the U.S can be gained by a brief comparison of statistics. According to U.S. department of commerce figures. the mileage of surfaced roads rose slowly during the 19th century, from about 27,000 mi. in 1830 to 128,000 mi. in 1900. By 1940 it was 1,340.000 mi. and by the late 1950s, more than 2,000,000 mi. This increase was paralleled by the rise in the number of registered motor vehicles — from about 8.000 in 1900 to more than 70,000.000, 60 years later. The number of ton-miles of freight moved by intercity motor vehicles rose from 62.000.000.000 in 1940 to 173,000,000,000 in 1950 and to about 250,000,000,000 in the late 1950s.

Railroad mileage in operation, on the other hand, reached a peak somewhat earlier. In 1914, as the great era of railroad building drew to a close, it stood at 256,547. There was a slight increase thereafter — in 1930 the figure was somewhat more than 260.000 mi. — followed by a steady decline. Slightly more than 230,000 mi. of first-line track were in operation by the late 1950s. With some fluctuations relating to the state of the economy. the volume of railroad freight tended to hold steady or even increase, although the percentage of total freight traffic carried by rail declined from 63 in 1940 to 47 in 1958 (as compared with a rise from 9.5% to 20% for motor vehicles over the same period). Railroad passenger-miles fell from 47,370,000,000 in 1920 to 23,295,000,000 in 1958. a year in which railroads were surpassed by the 25,343,000,000 passenger-miles flown by domestic aircraft.

Airlines. while carrying less than 1% of total freight, rose in this capacity from 14,000,000 ton-miles in 1940 to more than 570,000,900 ton-miles by the late 1950s The other two principal freight carriers, inland waterways and pipelines, showed less spectacular increases. In 1940 inland waterway transport — including the Great Lakes — accounted for 118,000,000,000 ton-miles of freight or about 18% of the total. By the late 1950s the volume had risen to almost 190,000,000,000 ton-miles but the percentage had declined to 15.5%. Volume carried by oil pipelines rose from 59,000,000,000 ton-miles or almost 10% to 211,000,000,000 ton-miles or about 17% during the same period.

Communication has played a role similar to that of transportation in producing a unified nation from a far-flung, sparsely populated land. Congress recognized its importance when it established the post office in the first year of the republic. The breakthrough in modern communications came with the application of electricity to the sending of messages. The telegraph, which put the pony express out of business, was followed by the telephone, the ocean cable. radio and television. Telecommunications are an indispensable part of air and sea transportation as well as an important adjunct to nearly every business, national defense and entertainment

Telecommunication has virtually annihilated space and time. Transportation is not far behind They represent triumphs of technology which have laid the basis for a growing world consciousness that may presage a world community. It is a simple fact that from the standpoint of communication time and transportation time the globe is smaller today than was the American republic of 1803.

2. Roads. — The road system of the United States can be divided into rural farm-to-market roads, rural intercity highways and city streets. In the late 1950s there were more than 400,000 mi. of city streets and about 2,300,000 mi. of farm-to-market (locally controlled) roads, as compared with almost 750,000 mi. of state and federal highways.

Rural Roads. — Farm-to-market roads are the last to receive all-weather surfaces. primarily because of the great area to be improved and the high cost as compared with the amount of use, but by the mid-1950s more than 60% of such roads had some kind of all-weather surface. Good rural roads have increased the ability of the farmer to market his own products to greater advantage. They have also removed much of the isolation of rural life. Along with the increased use of farm machinery and the spread of rural electrification to more than 95% of U.S. farms, improved roads helped to transform farm life after 1900. greatly reducing the historic distinction between city and rural ways of living.

Intercity Roads — Until the coming of the automobile and truck, virtually no roads or streets were provided with all-weather surfaces except in the most heavily traveled parts of the cities. Hence, construction and maintenance costs were low. The national highway system began to take shape during World War I. although the initiative remained with the states. Gasoline taxes provided a ready source of revenue which could be tapped to finance high ay construction, and the growing popularity of the private automobile gave widespread acceptance to this form of governmental enterprise.

Roads built primarily for private passenger cars were available for motor trucks as well. and the amount of truck traffic rose from none in 1903. when truck production began, to 41 trillion vehicle-miles in 1930 and to 116 trillion in 1956. only 35% of which was in cities. Tonnages increased even more. The greater weight of trucks and the traffic congestion on hills occasioned by them produced controversy. It has been contended that trucks do not pay for the added highway construction and maintenance costs which their great weight and width make necessary. However, trucks have demonstrated speed and convenience, resulting from ease in packing and handling and avoidance of time lost in switching yards, sufficient to enable them to take over many of the more profitable types of shipment formerly handled by the railroads in spite of the trucks' higher ton-mile cost.

Trucks are relatively most efficient for small-lot and short-haul shipments, and it is in this field that they have cut most severely into railroad business. Local distribution of products is almost completely handled by trucks because of their flexibility.

In the late 1950s intercity bus lines using the public highway provided almost as many passenger-miles as the railways and more than two-thirds as many as the airlines. Buses fill certain transportation needs better than any rival method Because roads exist to all towns. greater coverage can be given. Operating with a seating capacity less than that of a railway coach and with only one hired operator per unit. buses can offer frequent schedules to localities where comparable railroad service might be unprofitable. Fares are often lower by bus than on any other form of transportation, and the average speed, including stops, may be as fast as that of the private automobile.

City Streets. — Transportation of passengers within and between cities was revolutionized by the automobile, but not before a prior revolution by the street railways had taken place. With the advent of the electric motor, trolley cars running on rails appeared in cities all across the nation. In many cases these streetcar systems branched out into interurban services which competed directly with the railroads for passengers on intercity runs. At its peak, street-railnay mileage exceeded that of the railways proper.

The residential sections of cities grew along the streetcar lines, the streets remaining unsurfaced in most cases, but with inexpensive sidewalks providing good footing to the houses. A tremendous incentive was thus provided toward centralization of business in the downtown sections where the trolley lines converged. Businesses a little way out were sharply penalized, since the shopper was on foot and home delivery was still a luxury.

With the advent of the automobile and surfaced roads, the spaces between the elongated residential districts filled up. The flexibility of the automobile brought business districts miles apart into competition with each other, and the great advantage of a downtown location was, at least partially, offset by the advantage of large parking lots at suburban shopping centres. Nor was delivery so much of a problem. Many shopkeepers who had built businesses based on the telephone and rapid delivery found that when women started to drive as a matter of course, they preferred to shop and carry their orders home in their own cars, saving. at least in their eyes, the delivery cost.

Street railways went into sharp decline and by the 1960s had all but disappeared in cities of less than 500,000 population. Some subways and elevated trains and many transit buses remained. All showed declining traffic and poor financial health. Many were being subsidized in one way or another in the belief that they provided an indispensable service. (See also ROADS AND STREETS: Road and Road Construction in the United States; MOTOR TRANSPORT, COMMERCIAL; ELECTRIC TRACTION.)

3. Inland Waterways. — Two major divisions of inland water transportation exist in the U.S.—shipping on the Great Lakes (*q.v.*) and shipping on the rivers and canal systems. Nearly all of this traffic is freight, although a few excursion and passenger-car ferries on the Great Lakes and numerous short ferry lines continue to operate. Although the relative importance of water traffic declined with the growth of railroads, the total volume of shipping rose to new highs, both on the Great Lakes and on the Mississippi river (*q.v.*) and other river systems. Great Lakes commerce was given additional impetus by the opening of the St. Lawrence seaway (*q.v.*) to larger ocean-going ships in 1959.

Historically, the opening of the Erie canal which connected Lake Erie (above Niagara falls) to the Hudson river and New York city, diverted much trade, particularly in grain. from the long trip down the Mississippi river system to New Orleans and then by sailing vessels to the east coast or abroad. This canal, greatly deepened and widened, continues to function as the New York State Barge canal. The shift of trade from a north-south to an east-west direction set a permanent pattern for U.S. freight traffic.

Heavy products that can be handled on a very large scale predominate in waterway movement. Iron ore, coal, grain, petroleum products, sand and gravel, cement and similar products are the principal commodities moved. On the Ohio-Mississippi river system automobiles and similar items are moved by barge, but even when placed in many layers they fail to weigh enough to be considered a full load.

The application of steam power to water transportation occurred at the most rapid rate on the Mississippi system. Prior to the river steamboat, produce was rafted down the river to New Orleans where the rafts were broken up for lumber while the crews returned north overland. With steam, upriver traffic was possible even with large loads. The combination of upstream and downstream trade served to lower costs, enabling New Orleans to hold much of the mid-continental trade. However, the growth of railroad routes to serve the river ports effectively put an end to passenger traffic and all but the heaviest freight traffic by water.

By mid-20th century virtually all inland water freight, except on the Great Lakes, was carried in barges. Towboats are lashed to groups of barges in such a manner as to make each unit virtually a single ship. River-channel depths are maintained by dredging, construction of jetties and similar devices. The day of the shallow-draft river boats is gone, and it is difficult to imagine that steamboat service at one time reached more than halfway across Montana. The Great Lakes are likewise a flourishing waterway, the locks at Sault Ste. Marie being the busiest in the world in terms of tonnage passed. There, immense but rather slender ships carry tremendous tonnages, especially of iron ore, during the ice-free months. (See also INLAND WATER TRANSPORT: United States and Canada.)

4. Railways. — The 19th century was a railway age in the United States. In the 20th century railways remained the largest carriers of freight, in spite of the rise of competitors on the land, under the land and in the air.

During the Civil War railroads proved their great military value. Not only was it difficult to keep a railroad out of operation, but railroads revolutionized the speed of movement, especially of supplies. Three decades after the Civil War, the railway network of the United States was virtually completed. At that time it was the only economical form of transportation for much of the country. A comparison made in 1873 for the period 1866–73 reported rail rates of 5.2 cents a mile per passenger — 7.3 cents below stagecoach rates — and rail freight rates at 8 cents per ton-mile — a saving of 21 cents as compared with wagon freight. The rail charges given in this comparison are higher than others reported for the period. By 1880 freight charges were about & of a cent per ton-mile and passenger fares about 2.1 cents a mile.

The railway age greatly accentuated the shift in the main flow of traffic, begun in the canal era, to an east-west rather than a north-south direction. Interregional specialization within a national market, made possible by the railroad, contributed greatly to the tremendous and sustained rise of production during the century. Finally, along with the development of telecommunications, the railroad bound the nation into greater political unity. Loyalty to localities and states began to be surpassed by loyalty to the nation as economic interdependence and the physical mobility of the population brought greater cultural homogeneity.

The rapid completion of the railway network was stimulated bv government activity at all levels. The federal government offered construction loans, later repaid with interest, and grants or parcels of land amounting all told to 131,350,534 ac. or about 9.5% of the areas of the states served along the rights of way. State and local governments gave concessions, provided land for terminals and purchased railway bonds to attract railways to their territories.

At the outset this participation was unaccompanied by restrictive regulation, but the monopolistic power of railways where not confronted by rivals. and "cutthroat" rate setting where rivals did exist brought a demand for public regulation to which both the federal government and most states responded by establishing regulatory commissions. Because of the constitutional limitation of federal power to interstate commerce, the federal Interstate Commerce commission (ICC), set up in 1887, left to state commissions the regulation of railways insofar as purely intrastate transportation was concerned. While this distinction remained valid, the scope of federal regulation was gradually widened by increasingly broad interpretation as to what could be said to "affect interstate commerce." Designed at first to prevent excessive earnings as a result of monopoly power on the one hand, and to prevent predatory competition intended to establish monopoly power where rival railway systems existed on the other, the regulation of railroads came to be primarily directed toward establishing a rate structure that would enable the railways to enjoy a "fair share" of the traffic and at least moderate financial health in the face of increasing competition. (See also RAILWAY: Railways in the United States; INTERSTATE COMMERCE.)

5. Pipelines. — In the 20th century pipelines became major carriers of fuels. Oil, natural gas and, after late 1958, coal move in quantity and for considerable distances in underground pipes. First used in the 1860s to avoid high railroad rates for oil, pipelines to gather oil from the wells and bring it to refineries or tank farms where it could be transshipped soon became common. Later, lines carrying refined petroleum products were laid. Some delivered petroleum to ocean ports for loading on tankers large enough to provide economical transportation to the east coast or elsewhere. Others penetrated areas otherwise served only by rail or road. Different products may be carried in the same line. At one time a "plug" of water separated one product from another, but experience showed this to be unnecessary since very little mixing occurs in the line.

The resulting economical handling of crude and manufactured petroleum products led to a tremendous expansion in their use, contributed greatly to the development of the private car, the truck, the bus and the farm tractor, led to the widespread use of oil in home heating and provided a cheap fuel superior for many industrial purposes in which close control of temperature and lack of ash are important.

Another spectacular achievement of the pipeline was to convert natural gas from virtual uselessness into a principal source of power. Formerly much natural gas, produced as a by-product of the petroleum industry. was vented into the air, usually burned or "flared" in the process. Although many uses for natural gas have been found, such as providing raw material for some of the man-made fibres, its basic use is as an industrial and household fuel. Natural gas is distributed almost exclusively by pipeline although some is liquefied for shipment by tanker. Pipelines built during World War II for the transmission of oil to the east coast, at a time when German submarines were taking a heavy toll of tankers between the Gulf coast and the eastern seaboard, were subsequently converted to natural gas, and new lines extending from the mid-continent as far as Seattle were built in the postwar period Thus, an enormous amount of power which formerly went largely to waste was utilized to produce benefits over a wide area. Together with oil, natural gas supplies more British thermal units of energy than any other source in the United States.

New possibilities for the pipeline industry were opened with the construction of a 108-mi. line from Cadiz, O., to Cleveland, capable of delivering coal at the rate of 1,200.000 tons annually. Small lump coal. used to produce electricity, is pumped with water through the line.

6. Transmission Lines. — Although not ordinarily classified as a form of transportation, the transmission of electricity is a direct substitute for the movement of coal, petroleum and gas since large quantities of these are converted into electricity before final use. The cost of transportation of coal, oil and gas has also affected the extent to which electricity is developed by water power rather than by coal. oil or gas-burning plants. In general, the power lost in transmitting electric power over long distances is sufficiently large to make it profitable to move fuels close to the poaer-consuming markets. However, improved methods of transporting electricity have enabled steam plants to locate at more favourable sites at moderate distance from users.

Inherent advantages exist in large monopolistic systems in which many plants can feed power into grid which serves a large area. Electricity flows toward the points of highest drain in a predictable way, and the various plants can be activated to provide overall economies not available to smaller systems. Such grids can come close to making full use of water-power resources, often using steam plants to stabilize production as demand and stream conditions vary. In the second half of the 20th century, the availability of cheaply transported power contributed to the suburban and rural relocation of industrial enterprises. This, in turn. produced the long urban strips characteristic of certain areas in the east. the midwest and the west. *(See* also *Power,* above.)

7. Shipping. — During and after World War II ocean shipping rose in significance. Discoveries abroad, more economical methods of transportation. depletion of many U.S resources and greater dependence of the free world upon U.S. investment all worked to this end. Although the U.S. continued to export uheat, cotton and other agricultural materials, it also exported large amounts of industrial materials and imported considerable quantities of basic raw materials and fuels, particularly iron ore, oil and wood pulp, shipping continued to rise in volume with world prosperity. but the gross tonnage of U.S. merchant vessels engaged in foreign trade declined from the wartime peak. *(See* SHIPPING INDUSTRY: *United States.)*

8. Air Transport. — Civil aviation, more than any other form of transportation. owes its development to military applications during World Wars I and II. It has grown most rapidly and is most significant competitively in the transportation of passengers and mail. No other form of transport must use power both to support the cargo and to move it. As a result, air transport inevitably involves high costs per ton-mile, making it impractical for shipping large quantities of heavy freight. Nevertheless, a surprising amount of heavy equipment is shipped by air. In cases where whole operations may be halted by the breakdown of a single piece of equipment and the cost of shutting down exceeds the cost of moving the part by air, or where it is less costly to use air express than to stock replacement parts in quantity when the probability of breakdown is small, air transport may actually result in savings. In sparsely settled areas! and especially where road and railroad building is expensive because of bogs, permanent frost, lack of suitable rock for ballast or rugged terrain, air transport, which saves the capital cost of extensive roads, may be more economical than its alternatives.

It was, however, in the field of passenger service that the airlines made the most startling gains, surpassing both commercial motor carriers and railroads by the late 1950s. It seemed entirely possible that in this field, at least, aviation would revolutionize U.S. transportation in the 20th century much as the railroad had revolutionized it in the 19th. One parallel was provided by the manner in which localities, looking to future economic advantages, offered inducements in the form of airport and terminal facilities to the airlines, much as they had once offered special favours to the railroads.

By the second half of the 20th century, civil aviation was itself being transformed by the rapid introduction of jet aircraft. resulting in faster airspeeds and larger craft, many of them capable of carrying well over 100 passengers. This conversion to jet service brought with it additional problems in the form of the need for larger airports situated well outside the built-up portions of cities. Thus the discrepancy between the speed of air travel and the inconvenience of terminal locations in relation to city centres became more apparent.

The use of private aircraft showed steady gains after World War II, a trend that was encouraged by the return to civilian life of many men who had learned to fly in the armed forces. In absolute terms this was a very minor part of the total transportation picture. In the late 1950s almost 90% of intercity passenger traffic was by private automobile, and the trend was upward

In overseas traffic, the jet airliner was providing formidable competition to the ocean liner. Making up in speed and frequency of scheduling what it lacked in size, a single aircraft could carry as many passengers as a large cruise ship over a year's time. Furthermore, initial costs were lower and the crew required was substantially less. *(See* also AVIATION, CIVIL: *United States.)*

9. Communications. — The size of the U.S. communications industry is impressive. The post office, the only government owned and operated communications system in the C.S., was handling more than 60,000,000,000 pieces of mail annually in the 1950s. Although domestic telegraph has declined, the number of intercity and international messages has grown substantially. In the early 1960s most of the telephones in the United States could be dialed directly and direct international connections were under active investigation. There were about 400 telephones for every 1,000 persons. More than 4,500 AM. FM and television stations mere in operation in the late 1950s, and according to the department of commerce estimates, less than 4% of U.S. homes were without radio receivers and only about 10% were without television sets. *See* also BROADCASTING: *U.S. System;* POSTAL SERVICES: *United States;* TELEGRAPH; TELEPHONE; TELEVISION.

See also Index references under "United States (of America)" in the Index volume. (D. A. Wo.)

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UNITED STATES SHIPPING BOARD: *see* MARITIME ADMINISTRATION, U S.

UNITED STATES STEEL CORPORATION is the largest steel producer in the world. Incorporated on Feb. 25, 1901, it was the first $1,000,000,000 corporation in the United States. Its chief purpose was to produce steel more efficiently and economically by including all steps in the process, from raw materials through the mills. Carnegie Steel company and Federal Steel company formed the nucleus of the corporation. They and the eight other original member companies brought into the new corporation the necessary facilities to achieve integrated operations.

The primary business of the corporation is the production of steel and its manufacture into a wide variety of steel products that are further processed by other industries, often in combination with other materials, into finished products for virtually every economic activity of the nation. To conduct its business. it operates iron ore and coal mines, limestone quarries, railroads, ore vessels, steel-producing and fabricating plants and other operating units.

UNITS, DIMENSIONS OF: *see* DIMENSIONAL ANALYSIS.

UNIVERSAL. Universal words are those which can be applied to more than one particular thing (in the widest possible sense of "thing"); *e.g.,* the word "red" applies to more than one object, and the word "prime" applies to more than one number. Such words are sometimes called "universals." But it is more usual to call them "general words" and to reserve the title "universal" for that which each member of a given class must possess if the same general word is to apply to them all. But what must they all possess? Is it something which exists in the same way that particulars exist? In one way it seems that this is how it exists, since, like a particular, it has a name which is a noun. But in other ways universals are quite unlike particulars; *e.g.,* redness, unlike red objects, cannot be picked up, and primeness, unlike prime numbers, cannot be multiplied. Then do universals exist at all? This question has been debated from the time of Plato.

Plato held that universals exist, and so was a realist (this use of the word is quite distinct from its application to those who hold that material objects exist; *see* REALISM). He called them

One of his most important arguments was that goodness stands apart from and is more perfect than any of its manifestations on earth. Another, scientific rather than ethical, was that particulars are too shifting and changeable to be objects of precise knowledge; which therefore must be concerned with universals. A third argument was logical—namely, that there must exist a universal corresponding to every general word (or any ay to most general words). It is not obvious that these three arguments, if successful, would all establish the existence of the same kind of thing. For it is impossible to attain precise knowledge about all classes of particulars. so that the scientific argument would seem to establish the existence of universals which are fewer than and perhaps different in kind from the universals of the logical argument. Also. there is nothing ethical about redness, and it is only by a metaphor that particular red objects may be said to endeavour to realize it. Furthermore, Plato did not draw the important distinction between generality and abstractness. "Red" is general, but not abstract, since particular red objects are concrete; whereas "prime" is both general and abstract, since particular prime numbers are not concrete. So generality and abstractness do not always go together. It is not clear how much of the ethical part of Plato's theory depended on the generality of "good" and how much it depended on the abstractness of "good" when it is applied to particular virtues (which are obviously not concrete). In any case it certainly relied chiefly on a third feature of goodness; viz.. that it is the ideal aim of human endeavour.

Plato's ethical approach had led him to attribute separate existence to his universals, since it seems that this is how ideals ought to exist. Aristotle used an abundance of logical arguments to prove that universals exist, not separately from particulars. but in them. This is a different variety of realism, which, as Aristotle pointed out, avoids some of the difficulties of Plato's variety. For instance, if manhood were a separate thing just like a man, then one could argue for the separate existence of a second manhood with as much justification as Plato had when he argued for the separate existence of ordinary manhood. This is the famous "third man'! argument. Again, if a universal like redness is literally a separate thing, then, since it cannot manifest its complete self in all red particulars simultaneously, it seems to follow that none of these particulars can be completely red. This argument from literal participation was cited later by hnicius Boethius against Augustine's version of Platonic realism. Plato himself was aware of these two arguments. Probably he would have moved on to Aristotle's kind of realism if his approach had been more exclusively logical. For, apart from the difficulties of its rival,, Aristotle's kind of realism is very persuasive in itself. Nobody would apply a general word to a group of particulars unless he had noticed something common to all of them.

Realism, in one of these two versions, was orthodox in the middle ages, the Aristotelian version tending to predominate after Thomas Aquinas. But meanwhile a third rival, which had been recessive in antiquity, took the field—this was nominalism (*q.v.*). Nominalists deny that universals exist, arguing that the existence of a general word does not imply the existence of a general thing named by it. The middle ages also saw the clear emergence of a fourth view, conceptualism (*q.v.*), which is sometimes regarded as a rival of nominalism and of the two varieties of realism. A conceptualist is one who holds that we have concepts or general ideas. Some conceptualists (*e.g.,* John Locke) say that we form these general ideas by abstracting a common element from each particular of a given class (hence he calls these general ideas abstract, but not for the same reason that numbers are abstract: the point is not that they are not concrete—though of course they are not—but that they are formed by abstraction). Clearly conceptualism is not incompatible with either variety of realism; Aristotle and his medieval followers, for instance, combined realism with conceptualism. Conceptualism can be regarded as a rival of realism only to this extent: a philosopher who asks the question "How is it that we are able to think and speak in general terms?" might hold that conceptualism provides the complete answer; then, if he had no other reasons for accepting realism, he would reject it.

Some would maintain that the only right approach to the problem is through the question just cited, which is a logical question (in the widest sense of "logical"). This view entails that there can be no other reason for accepting realism, so that supporters of this view would accept realism (usually the more sober, Aristotelian variety) only if they found that it was a necessary part of the answer to that question. Such an approach is characteristic of empiricism and particularly of empiricism since the time of John Locke. On the other hand, there have always been philosophers who have held that there are independent reasons for asserting or denying the existence of universals, reasons which they would call "ontological." For example, in the middle ages, while the Platonic tradition was still dominant, Platonism was associated with the immutability of moral standards, and Plato's Forms were sometimes interpreted as a limited number of fixed ideas in the mind of God.

It would be an exaggeration to say that the dividing line between these two kinds of approach to the problem is clearly marked. But philosophers have been made increasingly conscious of it by the various attempts to determine the powers and limitations of the intellect which have appeared since the Renaissance and particularly by the work of the logico-analytic school since the beginning of the 20th century. Consequently it is now more revealing to classify philosophers' treatments of this problem according to their approach rather than according to their conclusions. Those who think that ontology is partly an independent subject fit their solutions of the problem into metaphysical systems and perhaps give them connections with theological doctrines.

Those who think that the only right approach to the problem is through logic are less ambitious. The most that they would claim is that the world must contain such ieatures as recurrent similarities if we are to be able to think and speak as we do; and, if they call their inquiries ontological, this is only in order to emphasize that, though they cover far less ground than the traditional inquiries whose pattern was set by Plato, still they do cover part of the same ground. (D. F. P.)

UNIVERSALIST CHURCH, a body of religious liberals organized in the United States, and represented chiefly by parishes and churches in that country and Canada. A distinction should be noted between Cniversalism and the Universalist denomination. Universalism—the belief that the whole human race will be "saved'!—was a doctrine of some of the greatest of the church fathers, notably Clement of Alexandria and Origen, and is held by many in other communions. The Universalist denomination arose in the United States in the latter part of the 18th century.

History.—The origin of this church is commonly associated with the landing and preaching of Rev. John Murray at Good Luck, S.J., in Sept. 1770. Murray. a disciple of James Relly (1720–78), a Calvinistic Universalist of London, was seeking refuge in the new world from sorrow and trouble. Persuaded that he should be an apostle of this new faith, he became an itinerant minister in Massachusetts, New York, New Jersey, Pennsylvania and settled in Gloucester, Mass. (1774). His Universalism was a protest against the doctrine of endless punishment.

Under the leadership of Hosea Ballou (1771–1852), the most influential minister of the sect for half a century, Universalists became largely unitarian and broke with the Calvinism of Murray. The first period of the denomination's history was controversial. Religious and sectarian feeling for and against Universalism was intense. After 1820, ministers and churches began to multiply; colleges, seminaries, and newspapers were established.

Doctrine.—The fundamental tenet of Universalism may be said to be the illimitable love and goodness of God, assuring triumph over evil in society and in the life of every individual. Following its organization, the denomination officially summarized the faith of its adherents four times. These brief statements permitting the widest possible variety of interpretation within the bounds of reason and conscience were: the Articles of Faith adopted at Philadelphia in 1790; the Winchester Profession, Winchester, N.H., 1803; the Boston Declaration, Boston, Mass., 1899; and the Washington Avowal of Faith, Washington. D.C., 1935.

The Avowal of Faith adopted at Washington in 1935 restated American Cniversalism without departing in essentials from historic convictions as follows:

"The Bond of Fellowship in this church shall be a common purpose to do the Will of God as Jesus revealed it and to co-operate in establishing the Kingdom for which he lived and died.

"To that end We Avow Our Faith in God as eternal and all conquering love, in the spiritual leadership of Jesus, in the supreme worth of every human personality, in the authority of truth known or to be known, and in the power of men oi good will and sacrificial spirit to overcome all evil and progressively establish the Kingdom of God.

"Neither this nor any other statement shall be imposed as a creedal test."

Emphasis on "the authority of truth known or to be known" expresses acceptance by Universalists of the application of scientific method to the realm of values and meanings. The affirmation of "the supreme worth" of personality makes explicit the historic and continuing concern of Universalists for relations of justice and good will between individuals, races and differing religious groups. Standing within the Judeo-Christian tradition, Universalists. nevertheless, are committed to the conviction that valid religion is always universal and so not to be justly claimed as the only true revelation by any one religion. Seeking to express the universal spirit of Christianity, Universalists extend the hand of fellowship to world religionists of other historic faiths.

Polity.—Universalist churches govern themselves They formerly "acknonledged the authority" of The Universalist Church of America, houever, and in May 1960 members approved consolidation with the American Unitarian association to form the Unitarian Universalist association Before formal consolidation one year later, there were more than 70.000 Universalists in about 400 churches *See* UNITARIANISM.

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UNIVERSAL LANGUAGE. The term universal, or international, language refers commonly to an auxiliary language rather than to a superidiom replacing national languages. It is sometimes thought that an international language, by overcoming linguistic barriers, would contribute to greater understanding and peace among men. In the biblical story of the Tower of Babel, unintelligibility is indeed viewed as a calamity visited upon human beings by the wrathful deity. But not all ills can be cured by better linguistic communication: as is shown by the continued and often bloody controversies among speakers of the same tongue.

Types.—There are four basic types of international languages:

1. A philosophical, artificial idiom without conventional vocabulary and grammar, being a system of acoustic (including musical) or optic (including numerical) signs based on a philosophical classification of everything men need and wish to talk about. Francis Bacon and Descartes in the 17th century and others thereafter proposed such languages. None of the projects proved feasible, mainly because they were unsuited to oral discourse and because the intellectual demands they made were too great.

2. A revived dead language, in particular Latin. Few supported this plan, even when a simplified Latin without inflection was devised (in 1903). An attempted revival of Latin solely for scholarly purposes is equally unpromising because scholars must learn foreign languages in any event in order to read writings of the past, and translating all such writings into Latin would be impossible.

3. A constructed, semiartificial language that, uses material available in current idioms. Among these, Esperanto (*q.v.*), published by L. L. Zamenhof in 1887. is the best known; it mas followed by (among others) Ido, Volapük (*q.v.*), Novial and Interlingua. Most constructed languages derive their lexicon chiefly from Latin and the Romance languages, and their grammar is Indo-European in character, though generally simplified; consequently. speakers of the non-Indo-European languages of Africa and Asia, who constitute a large percentage of the world's population, might find such a type of speech exceedingly difficult or even repugnant. Use of these languages, restricted to a relatively small number of devotees, has penetrated only sporadically into international affairs. From the point of view of the scientific linguists (very few of whom are among the authors or champions of universal languages); the ideal constructed language should. at least [illegible]

But this severity would make the constructed language, as compared with a natural tongue, a difficult rather than an easy instrument of communication: even a slight deviation, caused by normal human shortcomings of production and perception, would, in a grammar wrought with mathematical precision and logic, impede if not prevent intelligibility.

4. A modern spoken language extended, in its current or a modified form (for example, simplified Basic English; *q* v.), to the greatest possible number of speakers. Actual developments are moving in this direction, but in such a way that several languages rather than one are obtaining increasing international currency. especially English. Russian and Chinese, for obvious reasons of political and economic prestige. Unfortunately this evolution, though in harmony with the aims of the international-language movement in that it permits a steadily growing number of persons to overcome linguistic isolation. tends to enhance rather than diminish a dangerous political and philosophical polarity.

Requirements.—The requirements usually postulated for the structure of an international language are a simple grammar; a simple spelling where each sound (phoneme) is rendered by one symbol only and each symbol represents but one sound; a limited vocabulary; and a large number of speakers. None of the four types of languages mentioned satisfies all the requirements, and any single requirement is fulfilled in various degrees by a given type. The philosophical system may be left out of consideration since it is not a language in the normal sense of the term. A revived dead language starts with few speakers, none of them native Latin. unless reshaped to the point of becoming a different language, scarcely qualifies as possessing a simple grammar (presuming that simplicity includes regular paradigms and minimal morphology). In orthography Latin would rate well. Limiting the size of the vocabulary in Latin, or in any other language, sounds helpful in theory but means little in reality since a lexicon is by nature open-ended; that is, grows larger or smaller according to the wishes and needs of the speakers. So control is possible, except perhaps that exerted by Basic English, in which, for example, "get up" stands for "rise," "get well" for "convalesce," "get low" for "decrease," "get" (and similar words) being coupled with recurrent meaningful particles to synthesize meanings. But Latin in its customary structure is not suited for this particular device. The third type, a constructed language, offers the best opportunities to satisfy the first three requirements, but the facts that it would not have a large number of speakers and would lack a literature in belles-lettres and scholarship constitute a weakness of considerable significance. Further drawbacks are the reliance on Indo-European (especially Latin and the Romance languages), and the paradox that the scientifically ideal construction would be less than humanly ideal for everyday intercourse. The fourth type, an internationalized national language, falls victim to national or ethnolinguistic prejudices even more easily than a constructed language. But it has the immeasurably great advantage of possessing numerous speakers and extensive written records. As for the requirement of grammatical simplicity, virtually all natural languages are congenitally encumbered by what. in terms of optimal design. one must call irregular and complex grammars. The requirement concerning orthography, or mode of spelling, is met variously by various idioms Russian, Spanish. Italian and languages recently reduced to writing (including Chinese in the Latin alphabet) are good; French and German are fair; English is notoriously poor.

The Outlook.—In various periods of the past some natural languages attained the status of international auxiliary languages, notably Hellenistic Greek; spoken, nonclassical Latin; Arabic; and French But none of them ever was a truly popular second language, widespread among all speakers, although some, ceasing in fact to be auxiliary languages and supplanting previous tongues, became the native idioms over extended regions (for example, Latin in countries of the Romance languages). Pidgin English and other speeches of the lingua franca type have been largely ignored by language planners as being corruptions of standard languages. Nonetheless, some have been successful [illegible] interlanguage communi[illegible]

All languages which heretofore expanded to serve as international auxiliary languages had in common that they were the languages of cultural entities or nations or empires which enjoyed cultural prestige or political supremacy or both. and that their currency grew out of the necessity and the willingness of men to co-operate. The past is of course no sure indication of future development. But since language is chiefly a tool of co-operation and only remotely and vicariously its cause, the need for the tool and the will to use it seem essential to its adoption. A universal language will come about when and if the world needs and wants it, and it will be either the natural idiom most favoured by the prestige and the social power of its native speakers or (though this is less likely) a constructed language. The role of the propagators of a universal language is in the meantime to tell the world, with insistence but without exaggeration, of the benefits resulting from an end to the confusion of tongues.

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UNIVERSAL POSTAL UNION. The first international convention governing letter mail for a significant number of countries was concluded in Berne, Switz., on Oct. 9, 1874; it created the General Union of Posts with, originally, 22 member countries. Because of the early accession of a great number of other countries, the union took in 1878 the name of Universal Postal union. It became a "specialized agency" of the Cnited Nations in 1947 In 1959 there were 100 member countries.

The Universal Postal convention contains compulsory provisions for all member countries concerning the organization of the union and the handling of international letter mail, based on unity of the postal territory of all member countries, common scales of weight and charges, freedom of transit, simplification of the sharing-out of charges between postal administrations participating in the conveyance of mail, arbitration, etc. Optimal agreements govern certain specialized aspects of the international postal service, such as insured letters and boxes, money orders, parcels. collection of payments. newspaper subscriptions and post-office savings banks.

The plenipotentiaries of the, member countries normally meet every five years in congresses to revise the acts of the union in order to adapt them to economic and technical development. An executive and liaison committee, composed of representatives of 20 member countries, meets every year in Switzerland. It maintains contact with the United Nations and other international organizations, and takes part in the supervision of the activities of the international bureau and in the appointment of the high-ranking officials of the bureau. A consultative committee for postal studies, composed also of representatives of 20 member countries, was created by the Ottawa congress in 1957 to undertake a more thorough study of economic, technical and operational problems in the postal service. The international bureau, whose seat is in Berne, is the only permanent organ of the union. It serves as a connecting link, as a centre of information and consultation for the postal administrations of the union's member countries and as a clearinghouse in the settlement of certain accounts. It serves also as a general secretariat for the higher organs of the union and plays a part in the arbitration procedure.

(FR. H.)

UNIVERSE OF DISCOURSE. in logic, is the limited sphere of reference within which an assertion is intended to hold good. Hence the alternative name. "limited universe." The expression "universe of discourse" was first introduced by A. De Morgan, who states his meaning as follows: "For the most part the objects of thought which enter into a proposition are supposed to be taken, not from the whole universe of possible objects, but from some more definite collection of them. Thus when we say 'All animals require air' . . we should understand that we are speaking of things on this earth: the planets, etc. . . . not being included" (*Formal Logic,* ch iv). Subsequently the notion was extended so as to include also merely imaginary spheres of reference. In logic the question is of some importance in connection uith the problem of the existential import of propositions, especially of categorical propositions.

UNNERSITIES. The medieval Latin term *universitas* was originally employed to denote any community or corporation, When used in its modern sense of a body devoted to learning and education. it required the addition of other words. such as *magistrorum et scholarium.* The more ancient and customary designation of such communities in medieval times (regarded as places of instruction) uas *studium* (and subsequently *studium generale).* The university appears to have started as a scholastic guild—a spontaneous combination, that is to say, of teachers or scholars. or of both combined, and formed, probably, on the analogy of the trades guilds and the guilds of aliens in foreign cities, which, in the course of the 13th and 14th centuries, sprang up in most of the great European centres.

It was a first stage of development in connection with these primary organizations when the chancellor of the cathedral or some other authority began to accord to other masters permission to open other schools than the cathedral school in the neighbourhood of his church; a further stage was reached when a licence to teach — granted only after a formal examination — empowered a master to carry on his vocation at any similar centre.

It uas a still further development uhen it began to be recognized that, without a licence from either pope, emperor or king, no *studium generale* could be formed possessing this right of conferring degrees, which originally meant nothing more than licences to teach.

Meaning of **"Studium Generale."**—In the north of Europe licences to teach were granted by the chancellor scholasticus or some other officer of a cathedral church; in the south it is probable that the guilds of masters (when these came to be formed) were at first free to grant their own licences, without any ecclesiastical or other supervision. Gradually, however, toward the end of the 12th century, a few great schools claimed, from the excellence of their teaching, to be of more than merely local importance. Practically, a doctor of Paris or Bologna would be allowed to teach anywhere; and those great schools began to be known as *studia generalia; i.e.,* places resorted to by scholars from all parts. Eventually the term came to have a more definite and technical significance. The emperor Frederick II in 1225 set the example of attempting to confer, by an authoritative bull, upon his new school at Naples the prestige which the earlier *studia* had acquired by reputation and general consent. Gregory IX did the same for Toulouse in 1229 and added to its original privileges in 1233 a bull by which anyone who had been admitted to the doctorate or mastership in that university should have the right to teach anywhere without further examination. Other *studia generalia* were subsequently founded by papal or imperial bulls, and in 1292 even the oldest universities, Paris and Bologna, found it desirable to obtain similar bulls from Nicholas IV. From this time the notion began to prevail among the jurists that the essence of the *studium generale* was the privilege of conferring the *ius ubicunque docendi,* and that no new *studium* could acquire that position without a papal or imperial bull. There were, however, a few *studia generalia* (*e.g.,* Oxford) whose position was too well established to be seriously questioned, although they had never obtained such a bull; these were held to be *studia generalia ex consuetudine. A* few Spanish universities founded by royal charter were held to be *studia generalia respectu regni.* The word *universitas* was originally applied only to the scholastic guild (or guilds) within the *studium,* and was at first not used absolutely; the phrase was always *universitas magistrorum* or *scholarium* or *magistrorum et sckolarium.* By the close of the mediaeval period, however, the distinction between the terms *studzum generale* and *universitas* was more or less lost sight of, and the term *universitas* began to be used alone.

ITALIAN UNIVERSITIES IN THE MIDDLE AGES

Rise of University of **Salerno.**—To understand why the earliest universities arose it is necessary to take account not only of their organization but also of their studies. By the 6th century the secular pagan schools of the Roman empire had been swept away. By the 12th, the cathedral and monastic schools which replaced them had attained to their highest degree of influence and reputation. But these schools taught only what was supposed to be necessary for the education of the priest and the monk. The *studia* arase out of efforts to provide instruction beyond the range of the cathedral and monastic schools. Salerno, the first great *studzum,* became known as a school of medicine as early as the 9th century. Its medical system was originally an outcome of the Graeco-Roman tradition of the old Roman world. In the first half of the 9th century the emperor at Constantinople sent to the caliph Mamoun at Baghdad a collection of Greek manuscripts. These texts were translated into Arabic by Syrian Christians, and the Arabic was later rendered into Latin for the use of teachers in the west. Of the existence of such versions we have evidence. according to C. M. G. Bréchillet-Jourdain, long before Constantine the African (d. 1087) began to lecture on medicine at Salerno. Under his teaching the fame of Salerno as a medical school became diffused all over Europe. It was distinguished by its catholic spirit; at a time when Jews were the object of religious persecution throughout Europe, they were to be found both as teachers and learners at Salerno. In 1231 it was constituted by the emperor Frederick II the only school of medicine in the kingdom of Naples. It remained a medical school only. "Nothing approaching a regular university ever existed there" (H. Rashdall, The *Universities of Europe in the Middle Ages*, vol. i, part 3, p. 82).

Bologna.—The great revival of legal studies which took place at Bologna about the year 1000 had been preceded by a corresponding activity elsewhere—at Pavia by a famous school of Lombard law and at Ravenna by a yet more important school of Roman law. In Bologna itself we have evidence that the Dzgest was known and studied before the time of Irnerius (1100–30), a certain Pepo being named as lecturing on the text about the year 1076. The secular character of this new study and its close connection with the claims and prerogatives of the western emperor aroused papal suspicion, and for a time Bologna and its civilians were regarded by the church with distrust. But the appearance of the *Decretum* of Franciscus Gratianus, about 1140, invested the studies of the canonist with fresh importance. It was quickly regarded as official canon law, and so numerous decrees of past and almost forgotten pontiffs now claimed to take their stand side by side with the enactments contained in the Corpus *Juris Civilis*. They constituted, in fact, the main basis of those new pretensions asserted by the papacy in the course of the 12th and 13th centuries. It was necessary, accordingly, that the *Decretum* should be known and studied beyond the walls of the monastery or the episcopal palace. Such a centre of instruction was found in Bologna, which became recognized as the chief school of both civil and canon law. But the statement that university degrees were instituted there as early as the pontificate of Eugenius III (1145–53) rests on no good authority. The students found their first real protector in the emperor Frederick I, Barbarossa. Finding that their grievances were real, especially against the landlords in whose houses they were domiciled, he granted the foreign students substantial protection by conferring on them certain special immunities and privileges (Nov. 1158). These privileges were embodied in the celebrated Authentzca, Habita, in the Corpus *Juris Civilis* of the empire (book iv, tit. 13), and were eventually extended to all the other universities of Italy.

Nevertheless, Bologna did not possess a university as early as 1158. Its first university was not constituted until the close of the 12th century. The "universities" at Bologna were, as H. S. Denifle has shown, really student guilds. These were originally only two in number, the Ultramontant and the Citramontani, and arose out of the absolute necessity under which residents in a foreign city found themselves of obtaining by combination that protection and those rights which they could not claim as citizens. Originally, they did not include the native student element and were composed exclusively of students in law. Denifle thinks that the "universities" at Bologna were at one time certainly more than four in number, and we know that the Italian students alone were subdivided into two—the Tuscans and the Lombards. In the centres formed by secession from the parent body a like subdivision took place. At Vercelli there were four *universitates*, composed, respectively, of Italians, English, Provençals and Germans; at Padua there were similar divisions into Italians, French (*i.e.*, Francigenae, comprising both English and Normans), Provençals (including Spaniards and Catalans). According to Odofred, in the time of the eminent jurist Azo, who lectured at Bologna about 1200, the number of the students there amounted to about 10,000, of whom the majority were foreigners. It seems, therefore, reasonable to conclude that the number of these confederations of students (societates scholarium) at Bologna was yet greater.

The Rector.—In marked resemblance to the guilds, these confederations were presided over by a common head, the rector scholarium, an obvious imitation of the rector societatunz or *artium* of the guild, but to be carefully distinguished from the rector scholarzim, or director of the studies, with whose function the former officer had, at this time, nothing in common. Like the guilds, again, the different nations were represented by their *consiliarii*, a deliberative assembly with which the rector habitually took counsel. The students at Bologna were mostly of mature years. As the civil law and the canon law were, at first, the only branches of study, the class they attracted was often composed of men already filling office in some department of the church or state—archdeacons, heads of schools, canons of cathedrals and like functionaries forming a considerable element in the aggregate.

About the year 1200 were formed the two faculties of medicine and philosophy (or the "seven liberal arts"), the former being somewhat the earlier. It was developed, as that of the civil law had been developed, by a succession of able teachers, among whom Thaddeus Alderottus was especially eminent. The faculty of arts, down to the 14th century, scarcely attained to equal eminence. The teaching of theology at Bologna remained for a long time exclusively in the hands of the Dominicans, and it was not until the year 1360 that Innocent VI recognized the university as a *studium generale* in this branch.

The term "college" at Bologna long had a different meaning from that it now ordinarily conveys. The masters formed themselves into collegia (that is, organizations), chiefly for the conferment of degrees. Places of residence for students existed at Bologna at a very early date, but it was not until the 14th century that they possessed any organization; the humble *domus*, as it was termed, was at first designed solely for necessitous students who were not natives of Bologna. A separate house, with a fund for the maintenance of a specified number of scholars, was all that was originally contemplated. Such was the character of that founded by Zoen, bishop of Avignon, in Feb. 1256 (O.S.), the same month and year, it is to be noted, in which the Sorbonne was founded in Paris. It was designed for the maintenance of eight scholars from the province of Avignon, under the supervision of three canons of the church, maintaining themselves in the university. The college of Brescia was founded in 1326 by William of Brescia, archdeacon of Bologna, for poor foreign students, without distinction as to nationality. The Spanish college was founded in 1364 for 24 Spanish scholars and two chaplains.

Other Italian Centres.—The earliest foundations in Italy after that of Bologna were the universities of Reggio nell' Emilia and Modena, both of which had flourishing schools of civil law before the close of the 12th century. Vicenza (founded 1204) and Padua (1222) both originated in migrations of students from Bologna. The University of Naples was founded by the emperor Frederick II in 1225 and was temporarily suppressed after his death. It was reconstituted in 1258. Piacenza, founded by papal charter in 1248, had little importance until 1398 when it was reconstituted by Galeazzo Visconti, duke of Milan, who caused the University of Pavia to be transferred to Piacenza. Pavia had long been famous as a school of Roman law, and for a time its fame was transferred to Piacenza. From 1404 to 1412 both universities ceased to exist. But after that date Pavia became almost as famous a school of civil law as Padua itself. Arezzo was a centre for legal study from 1215 to 1470. Rome (1303) had schools of canon and civil law for poor foreign students througho centuries. Perugia (1308) specialized in civil law, Pisa (1343) was closed from 1403 to 1476, when it was reopened by Lorenzo dei Medici. The University of Florence (1349) had a brilliant existence in the first half of the 1 jth century, but was closed in 1472. Graduates of Siena, whose importance dates from 1357 though it was nominally founded in 1241, were accorded the same privileges as those of Bologna. Ferrara was famous in the latter half of the 15th century. The University of Turin was founded about the year 1400, that of Parma not until 200 years later.

PARIS IN THE MIDDLE AGES

Origin of University of Paris.—The commencement of the University of Paris well illustrates the fact that the universities arose in response to new needs. The study of logic. which, prior to the 12th century, was founded exclusively on one or two meagre compends, received about the year 1100 a powerful stimulus on two occasions—first from the memorable controversy between Lanfranc and Berengarius, and second from the no less famous controversy between Anselm and Roscellinus. The belief arose that intelligent appreciation of spiritual truth depended upon correct use of prescribed methods of argument. Dialectic was looked upon as the "science of sciences"; and when, somewhere in the first decade of the 12th century. William of Champeaux opened in Paris a school for the more advanced study of dialectic as an art, his teaching was attended with marked success. Among his pupils was Peter Abelard, in whose hands the study made a yet more notable advance. By the middle of the century John of Salisbury could say that all learned Paris had gone well-nigh mad in its pursuit and practice. Abelard taught first at the cathedral school at Notre Dame and later at the schools on the Mont Ste. Genevieve, of which he was the founder and where he imparted to logic its new development.

The schools out of which the university arose were those attached to the cathedral on the Île de la Cité and presided over by the chancellor—a dignitary who must be carefully distinguished from the later chancellor of the university. For a long time the teachers lived in separate houses on the island, and it was only by degrees that they combined themselves into a society and that special buildings were constructed for their classwork. The flame which Abelard's teaching had kindled was not destined to expire. Among his pupils was Peter Lombard, who was bishop of Paris in 1159 and widely known to posterity as the compiler of the famous volume of the *Sentences*. The design of this work was to place before the student, in as strictly logical a form as practicable, the views (sententiae) of the fathers and all the great doctors of the church upon the chief and most difficult points in the Christian belief. The logicians seized upon it as a great storehouse of indisputable major premises, on which they argued with renewed energy and with endless ingenuity of dialectical refinement. It was probably this development of new methods of instruction concurrently with new material upon which to exercise them which finally distinguished the university from the cathedral schools.

Early Organization.—The University of Paris, as already stated, took its rise entirely out of the movement carried on by teachers on the island, who taught by virtue of the licence conferred by the chancellor of the cathedral. In the second decade of the 13th century, it is true, we find masters repairing to the left bank of the Seine and placing themselves under the jurisdiction of the abbot of the monastery of Ste. Genevieve; but it was around the bestowal of this licence by the chancellor of Notre Dame, on the Île de la Cité, that the university grew up. It is in this licence that the whole significance of the master of arts degree is contained; for what is technically known as admission to that degree was really nothing more nor less than receiving the chancellor's permission to "incept," and by "inception" was implied the master's formal entrance upon, and commencement of, the functions of a duly licensed teacher and his recognition as such by his brethren in the profession. The previous stage of his academic career, that of bachelordom, had been one of apprenticeship for the mastership; and his emancipation from this state was symbolized by placing the magisterial cap (biretta) upon his head, a ceremony which, in imitation of the old Roman ceremony of manumission, was performed by his former instructor. He gave a formal inaugural lecture, and was then welcomed into the society of his professional brethren with set speeches and took his seat in his master's chair.

Some time between the years 1150 and 1170 the University of Paris came formally into being. Its first written statutes were not, however, compiled until about the year 1208, and it was not until long after that date that it possessed a "rector." Its earliest recognition as a legal corporation belongs to about the year 1211, when a brief of Innocent III empowered it to elect a proctor to be its representative at the papal court. By this permission it obtained the right to sue or to be sued in a court of justice as a corporate body. Papal recognition did not imply episcopal recognition, but with papal support Paris became the great transalpine centre of orthodox theological teaching. Successive pontiffs, down to the great schism of 1378, cultivated friendly relations with the university and systematically discouraged the formation of theological faculties at other centres. In 1231 Gregory IX, in the bull *Parens Scientiarum* (which has been called the Magna Carta of the university), gave full recognition to the right of the several faculties to regulate and modify the constitution of the university. The fully developed university was divided into four faculties: three "superior," those of theology, canon law and medicine; and one "inferior," that of arts, which was divided into four "nations." These nations, which included both professors and scholars, were: (1) the French, composed, in addition to the native element, of Spaniards, Italians and Greeks; (2) the Picard, representing the students from the northeast and the Netherlands; (3) the Norman; (4) the English, comprising, besides students from the provinces under English rule, those from England, Ireland, Scotland and Germany. The head of each faculty was the dean, of each nation the proctor. The rector, in the first instance, was head of the faculty of arts. Eventually he became the head of the collective university, by the incorporation under him, first, of the students of the canon law and of medicine (which took place about the end of the 13th century), and, second, of the theologians, which took place about half a century later.

In the course of the 16th and 17th centuries this democratic constitution of. the middle ages was largely superseded by the growth of a small oligarchy of officials. The tribunal of the university—the rector, deans and proctors—came to occupy a somewhat similar position to the old "Hebdomadal board" of heads of colleges at Oxford and the caput at Cambridge. Moreover, the teaching functions of the university, or rather of the faculty of arts, chiefly because of the absence of any endowment for the regents or teaching graduates, practically passed to the colleges. Almost as much as the English universities, Paris came to be virtually reduced to a federation of colleges, though the colleges were at Paris less independent of university authority, while the smaller colleges sent their members to receive instruction in the larger ones (*collèges* de *plein* exercice), which received large numbers of nonfoundation members. This state of things lasted till the French Revolution swept away the whole university system of the middle ages. It may be noted that the famous Sorbonne (see PARIS UNIVERSITY) was really the most celebrated college of Paris—founded by Robert de Sorbon in 1257—but as this college and the College of Navarre were the only college foundations which provided for students in theology, the close connection of the former with the faculty, and the use of its hall for the disputations of that body, led to the word Sorbonne becoming a popular term for the theological faculty of Paris.

In the 14th century the University of Paris had 40 colleges, governed either by secular or religious communities, and numbered among its students representatives of every country in Europe. The university became known as the great school where theology was studied in its most scientific spirit, and the decisions of its doctors upon those abstruse questions which absorbed so much of the highest intellectual activity of the middle ages were regarded as almost final. The popes, as already stated, discouraged the creation of faculties of theology elsewhere. The apparent exceptions to this policy are easily explained: the four faculties of theology which they sanctioned in Italy—Pisa (1343), Florence (1349), Bologna (1362) and Padua (1363)—were designed to benefit the Italian monasteries, by saving the monks the expense and dangers of a long journey beyond the Alps; while that at Toulouse (1229) took its rise under circumstances entirely exceptional, being designed as a bulwark against the heresy of the Albigenses. The popes, on the other hand, favoured the creation of new faculties of law, and especially of the canon law, as the latter represented the source from which Rome derived its most warmly contested powers and prerogatives.

ENGLISH MEDIAEVAL UNIVERSITIES

Oxford.—The University of Paris became the model for French universities north of the Loire and for those of central Europe and England. Of the universities modelled on that of Paris, Oxford would appear to have been the earliest. Certain schools, opened within the precincts of the dissolved nunnery of St. Frideswyde and of Oseney abbey, are supposed to have been the nucleus round which it grew up. In the year 1133 one Robert Pullen, a theologian of considerable eminence (but whether an Englishman or a Breton is uncertain), arrived from Paris and delivered lectures on the Bible. Denifle maintains that there is, at best, only presumptive evidence of a studium generale at Oxford in the 12th century. Rashdall inclines to find the beginning in a migration of English students from Paris about 1167 or

1168. In the first-mentioned year we are told by John of Salisbury that "France, the mildest and most civil of nations," has "expelled her foreign scholars" *(Materials for the History of Thomas Becket,* ed. by Robertson, vi, pp. 235–236). At about the same time we hear of an edict of Henry II, during the quarrel with Becket. recalling all clerks holding benefices in England (as they loved their beneficesj and forbidding all clerks in England to cross the channel *(ihid.,* i, pp. 53–54). Paris was at this time the great place of higher education for English students. Immediately after 1168 allusions to Oxford as a *studium* and a *studium generale* begin to multiply. The natural inference is that the breaking off of relations between England and Paris, in 1167 or 1168, led to the growth of a *studium generale* in Oxford, formed, no doubt, in the first instance of seceders from Paris. In the 13th century mention first occurs of university "chests," especially the Fridesmyde chest, which were benefactions designed as funds for the assistance of poor students. Hall, or places of licensed residence for students. also began to be established. In the year 1257, when the bishop of Lincoln, as diocesan, had trenched too closely on the liberties of the community, the deputies from Oxford, when preferring their appeal to the king at St. Albans, could venture to speak of the university as *schola secunda ecclesiae,* or second only to Paris. Its numbers about this time were probably about 3.000; but whenever plague or tumult led to a temporary dispersion, a serious diminution in its numerical strength generally ensued for some time after. Against such vicissitudes the foundation of colleges proved the most effectual remedy. Of these the three earliest were University college, founded in 1249 by William of Durham; Balliol college, founded about 1263 by John Balliol, the father of the king of Scotland of the same name; and Merton college, founded in 1264. The last-named is especially notable as associated with a new conception of university education; viz., that of collegiate discipline for the secular clergy, instead of for any one of the religious orders, for whose sole benefit all similar foundations had previously been designed. The statutes given to the society by Walter de Merton are not less noteworthy, being characterized not only by breadth of conception but also by a careful and discriminating attention to detail, which led to their adoption as the model for later colleges not only at Oxford but at Cambridge.

Cambridge. — The University of Cambridge, although it rose into existence somewhat later than Oxford. may reasonably be held to have had its origin in the same century. There was probably a certain amount of educational work carried on by the canons of the church of St. Giles, which gradually developed into the instruction belonging to a regular *studium.* In the year 1112 the canons crossed the river and took up their residence in the new priory in Barnwell, and their work of instruction acquired additional importance. In 1209 a body of students migrated there from Oxford. Then, as early as the year 1224, the Franciscans established themselves in the town and, somewhat less than half a century later: were followed by the Dominicans. At both the English universities. as at Paris, the mendicants and other religious orders were admitted to degrees, a privilege which, until the year 1337, was extended to them at no other university. Their interest in and influence at these three centres were consequently proportionably great. In the years 1231 and 1233 certain royal and papal letters afford satisfactory proof that by that time the University of Cambridge was already an organized body, with a chancellor at its head. In 1229 and 1231 the numbers were largely augmented by migrations from Paris and from Oxford. Cambridge, however, in its turn suffered from emigration; while in the year 1261, and again in 1381, the records of the university were wantonly burned by the townsmen. Throughout the 13th century, indeed, the university was still only a very slightly and imperfectly organized community. Its endowments were of the most slender kind; it had no systematic code for the government of its members; the supervision of the students was very imperfectly provided for. Although both Oxford and Cambridge were modelled on Paris, their higher faculties never developed the same distinct organization; and while the two proctors at Cambridge originally represented "north" and "south," the "nations" are scarcely to be discerned. An important step in the direction of discipline was, however, made in the year 1276, when an ordinance was passed requiring that everyone who claimed to be recognized as a scholar should have a fixed master aithin 15 days after his entry into the university. The traditional constitution of the English universities was, in its origin, an imitation of the Parisian, modified by the absence of the cathedral chancellor. But the feature which most served to give permanence and cohesion to the entire community at Cambridge was, as at Oxford, the institution of colleges. The earliest of these was Peterhouse, first founded as a separate institution by Hugh Balsham, bishop of Ely, in the year 1284. In 1324 was founded Michaelhouse, and two years later, in 1326, Edward II instituted his foundation of "king's scholars," afterward forming the community of King's hall. Both these societies, in the 16th century, were merged in Trinity college. To these succeeded Pembroke hall (1347) and Gonville hall (1348). All these colleges were expressly designed for the benefit of the secular clergy. The foundation of Trinity hall *(Aula)* in 1350 by Bishop William Bateman. on the other hand, as a school of civil and canon law was probably designed to further ultramontane interests. That of Corpus Christi (1352), the outcome of the liberality of a guild of Cambridge townsmen, was conceived with the combined object of providing a house of education for the clergy, and at the same time securing the regular performance of masses for the benefit of the souls of departed members of the guild. But both Trinity hall and Corpus Christi college were, to a great extent, indebted for their origin to the ravages caused among the clergy by the great plague of 1349.

FRENCH AND SPANISH MEDIAEVAL STUDIA

France.—Montpellier was a recognized school of medicine as early as the 12th century Before the end of the century it possessed also a faculty of jurisprudence. The university of medicine and that of law continued, however. to be totally distinct bodies, with different constitutions. On Oct 26. 1289. Montpellier was raised by Nicholas IV to the rank of a *studium generale.*

The University of Toulouse is to be noted as the first founded in any country by virtue of a papal charter. It took its rise in the efforts of Rome for the suppression of the Albigensian heresy. and its foundation formed one of the articles of the conditions of peace imposed by Louis IX on Count Raymund of Toulouse. In the year 1233 it first acquired its full privileges as a *studium generale* by virtue of a charter given by Gregory IX. The University of Orléans had a virtual existence as a *studium generale* as early as the first half of the 13th century, but in the year 1305 Clement V endowed it with new privileges and gave its teachers permission to form themselves into a corporation. The schools of the city had an existence long before — as early, it is said. as the 6th century. In the 14th century its fame as a school of law was surpassed by no other university in Europe. Before the 13th century it had been famed for its classical learning.

The other French universities famous in the middle ages were Angers, Avignon, Cahors (1331) and Grenoble (1339). At Perpignan and Orange there were schools of small note.

Spain.—Valladolid, which received its charter from Pope Clement VI in 1346, attained great celebrity. In 1418, at the Council of Constance, Martin V decreed that Valladolid should take rank not only as a *studium generale* but also as a *universitas tkeologiae.* From this time, accordingly, the advance of the university in numbers was steady and continuous throughout the 15th century, and. along with Salamanca, it served as the model for Alcalá in 1409.

Seville aas founded in 1253 by Alphonso the Wise, simply for the study of Latin and of the Semitic languages, especially Arabic. Salamanca had been founded in 1243 by Ferdinand III of Castile as a *studium generale* in the three faculties of jurisprudence, the arts and medicine. But the main stress of its activity. as was the case with all the earlier Spanish universities, was laid on the civil and the canon law. In the early part of the

15th century, however, the efforts of Martin V established a school of theology which was afterward regarded almost as an oracle by Catholic Europe. About the year 1600 the students are shown by the matriculation books to have numbered more than 5,000. According to Cervantes they were noted for their lawlessness. The earliest of the numerous colleges founded at Salamanca was that of St. Bartholomew, long noted for its ancient library and valuable collection of manuscripts.

The only Portuguese university in mediaeval times was founded at Lisbon in 1290 and had its seat alternately there and in Coimbra, until, in the year 1537, it was permanently attached to Coimbra. It had received from King Dinis a charter, the provisions of which were mainly taken from those of the charter given to Salamanca. In 1772 the university was entirely reconstituted.

MEDIAEVAL UNIVERSITIES IN CENTRAL EUROPE

Prague. — Of the mediaeval universities in central Europe, Prague, which existed as a *studium* in the 13th century, was the earliest. It mas at first frequented mainly by students from Styria and Austria, countries at that time ruled by the emperor Charles IV, who was also king of Bohemia, and at whose request Pope Clement VI, on Jan. 26, 1347, promulgated a bull authorizing the foundation of a *studium generale* in all the faculties. In the following year Charles himself issued a charter for the foundation. Charles had been a student in Paris, and the organization of his new foundation was modelled on that university, a like division into four "nations" (although with different names) constituting one of the most marked features of imitation. The numerous students — and none of the mediaeval universities attracted in its earlier history a larger concourse — were drawn from a gradually widening area, which at length included not only all parts of Germany but also England, France, Lombardy, Hungary and Poland.

Cracow.—The University of Cracow, in Poland: was founded in May 1364 by virtue of a charter given by King Casimir III the Great, but its real commencement must be considered to belong to the year 1400, when it was reconstituted. Toward the close of the 15th century the university is said to have been in high repute as a school of both astronomical and humanistic studies.

Vienna. — The Avignonese popes appear to have regarded the establishment of new faculties of theology with special jealousy; and when, in 1365, Duke Rudolph IV founded the University of Vienna. with the design of constituting it a *studium generale* in all the faculties. Urban V refused his assent to the foundation of a theological school. Because of the sudden death of Duke Rudolph, the university languished for the next 20 years, but after the accession of Duke Albert III, who may be regarded as its real founder, it acquired additional privileges.

Heidelberg. — The University of Heidelberg (the oldest of those of the German'realm) received its charter (Oct. 23, 1385) from Urban VI as a *studium generale* in all the recognized faculties save that of the civil law. It was granted at the request of the elector palatine, Rupert I. But the real founder, as he was also the organizer and teacher, of the university was Marsilius of Inghen, to whose ability and energy Heidelberg was indebted for no little of its early reputation and success. In spite of the omission of the civil law in the original charter, this was included among its faculties almost from its first creation. No mediaeval university achieved a more rapid and permanent success.

Cologne. — As a result of the labours of the Dominicans, Cologne had gained a reputation as a seat of learning long before the founding of its university; and it was through the advocacy of some leading members of the mendicant orders that, at the desire of the city council, its charter as a *studium generale* (May 21, 1385) was obtained from Urban YI. It was organized on the model of the University of Paris, as a school of theology and canon law and "any other recognized faculty," the civil law being incorporated as a faculty soon after the promulgation of the charter. In common with the other early universities of Germany—Prague, Yienna and Heidelberg — Cologne owed nothing to imperial patronage, while it would appear to have been, from the first, the object of special favour with Rome. This circumstance serves to account for its distinctly ultramontane sympathies in mediaeval times, and even far into the 16th century.

Erfurt.—Erfurt, no less noted as a centre of Franciscan than was Cologne of Dominican influence, received its charter (Sept. 16, 1379) from the antipope Clement VII, as a *studium generale* in all the faculties. Ten years later it was founded afresh by Urban VI. In the 15th century the number of its students was larger than that at any other German university — a fact attributable partly to the reputation it had acquired as a school of jurisprudence and partly to the ardour with which the nominalist and realist controversies of the time were debated in its midst; its readiness in according a hearing to novel theories caused it to be known as *novorum omnium portus*.

Leipzig.—The conditions connected with the rise of the University of Leipzig are especially noteworthy, it having been the result of the migration of almost the entire German element from the University of Prague. This element comprised: (1) Bavarians, (2) Saxons. (3) Poles (this last-named division being drawn from a wide area which included Meissen, Lusatia, Silesia and Prussia), and, being represented by three votes in the assemblies of the university, while the Bohemians possessed but one, had acquired a preponderance in the direction of affairs to which the latter could no longer submit. Religious differences, again, evoked mainly by the preaching of John Huss, further intensified the existing disagreements; and eventually, in the year 1409, King Wenceslaus, at the prayer of his Bohemian subjects, issued a decree which exactly reversed the previous distribution of votes — three votes being assigned to the Bohemian nation and only one to all the rest. The Germans took deep umbrage and seceded to Leipzig. where, a bull having been obtained from Alexander V (Sept. 9, 1409), a new *studium generale* was founded by the landgrave of Thuringia and the margraves of Meissen. The members were divided into four nations composed of natives of Meissen, Saxony, Bavaria and Poland.

Restock.-At Rostock, in the north, the dukes John and Albert of Mecklenburg conceived the design of founding a university from which the faculty of theology should be excluded. The university was accordingly founded as proposed in 1419, but in 1431 Eugenius IV instituted a faculty of theology. Six years later, the whole academic community having incurred the papal ban, was fain to migrate to Greifswald, returning, however, to Rostock in 1443, but with one important exception, that of a master of arts named Henry Rubenow, who remained to become burgomaster of the former city and succeeded in persuading Duke Wratislaw of Pommern to make it the seat of a university. Calixtus III granted a bull in 1456, but it was stipulated that the rector should be a bishop, and the professorial chairs were also made partially dependent for endowment on canonries. Greifswald thus became exposed to the full brunt of the struggle which had ensued when the endeavour to nationalize the German church was terminated by the Concordat of Vienna (1448).

Freiburg.—The universities of Freiburg, in Baden, and Tübingen, in Wiirttemberg, alike owed their foundation to the countess Matilda, by whose persuasion her husband, the archduke of Austria, known as Albrecht VI, was induced to found Freiburg in 1455, and Count Eberhard (her son by a former marriage) to found Tübingen in 1477. At Freiburg, under the supervision of its first rector, Matthew Hummel of Villingen, the numbers were soon largely augmented by migrations of students from Vienna and from Heidelberg, while its resources, which originally were chiefly an annual grant from the city council, were increased by the bestowal of canonries and prebends. Erasmus made Freiburg his residence from 1529 to 1535, during which time he may have originated the tradition of liberal learning, but in 1620, under the rule of the archduke Maximilian. the control of the humanistic studies and of the entire faculty of philosophy was handed over to the Jesuits, who also gained possession of two of the chairs of theology.

Tübingen.—The University of Tiibingen was founded in 1477 with the usual four faculties. and numbered Johann Reuchlin and Philipp Melanchthon among its teachers.

Louvain.—In the Netherlands the growing wealth and prosperity of the different states especially favoured the formation of new centres of learning. In the flourishing duchy of Brabant the University of Louvain (1426) was to a great extent controlled by the municipality; and its patronage, although ultimately attended with detrimental results, long enabled Louvain to outbid all the other universities of Europe in the munificence with which it rewarded its professors. In the course of the next century the "Belgian Athens," as styled by Justus Lipsius, ranked second only to Paris in numbers and reputation. It possessed no fewer than 28 colleges, while its active press afforded facilities to the author and the controversialist of which both Cambridge and Oxford were at that time almost destitute. It embraced all the faculties, and no degrees in Europe stood so high as guarantees of general requirements. Erasmus recorded it as a common saying that "no one could graduate at Louvain without knowledge, manners and age."

Budapest.—In Hungary, Matthias I, Hunyadi, obtained permission in 1465 to found a university where he thought best in his realm. The university at Ofen (Hungarian Buda) was founded in 1475. It had a school of law at Pressburg, the sole remains of the university there founded by Matthias in 1465.

THE PASSING OF MEDIAEVALISM

France.—The earliest 15th-century university in France was that of Aix in Provence. It had originally been nothing more than a school of theology and law, but in 1409 it was reorganized as a studium generale on the model of Paris. Its students were divided into Burgundians, Provençals and Catalans.

The University of Poitiers was instituted by Charles VII in 1431 with the design of creating a centre of learning less favourable to English interests than Paris had at that time shown itself to be. He conferred on Poitiers all the privileges collectively possessed by Paris, Toulouse, Montpellier, Angers and Orléans, and at the same time placed the university under special royal protection.

The University of Caen was founded under English auspices during the short period of the supremacy of the English arms in Normandy in the 15th century. Its charter (May 1437) was given by Eugenius IV, and the bishop of Bayeux was appointed its chancellor. After the expulsion of the English from France, it received a new charter. From this time the University of Caen was distinguished by its loyal spirit and firm resistance to ultramontane pretensions; and, although swept away at the French Revolution, it was afterward restored, owing to the sense of the services it had thus once rendered to the national cause. Other French 15th-century foundations are Bordeaux (1441), Valence (1452), Nantes (1463) and Bourges (1465).

Central and Northern Europe.—The University of Basle was opened in 1460, under the auspices of its own citizens, and Pius II (Aeneas Sylvius) granted the charter (Nov. 12, 1459). During the first' 70 years of its existence the university prospered, and its chairs were held by eminent professors. among them historical scholars such as Sebastian Brant and Jacob Wimpheling. But with the Reformation Basle became the arena of contests which menaced the very existence of the university itself, the professors being, for the most part, opposed to the new movement with which the burghers warmly sympathized. Eventually the statutes were revised, and in the latter half of the 16th century the university may be said to have attained its apogee.

The University of Ingolstadt was founded on April 7, 1459. But it was not until 1472 that the work of teaching was actually commenced there. Some long-existing prebends, founded by former dukes of Bavaria, were appropriated to the endowment. Nowhere did the Reformation meet with more stubborn resistance, and it was at Ingolstadt that the Counter Reformation commenced. In 1556 the Jesuits made their first settlement in the university.

At Trier and Mainz universities were established in the second half of the 15th century. Trier received its charter as early as 1450, but the first academical session did not commence until 1473. Sixtus IV granted the charter to Mainz (Nov. 23, 1476) at the request of Archbishop Diether, who was himself a great humanist.

Other foundations were those of Uppsala (1477) and Copenhagen (1479), which, although lying outside the political boundaries of Germany, reflected its influence. The charter for Copenhagen was given by Sixtus IV a5 early as 1475.

The university founded at Wittenberg by Maximilian I (July 6, 1502) was the first established in Germany by imperial decree. Its charter is, however, drawn up with the traditional phraseology of the pontifical bulls and is evidently not conceived in any spirit of antagonism to Rome. Wittenberg was constituted a studium generale in all the four faculties, the right to confer degrees in theology and canon law having been sanctioned by the papal legate several months before, on Feb. 2, 1502. Wittenberg was the first academic centre north of the Alps where the Latinity and antiquated methods of the scholastic era were overthrown.

Frankfurt-on-Oder received its charter in 1506.

Scotland.—The first Scottish foundation was at St. Andrews, founded in 1411 by Henry Wardlaw, bishop of that see, and modelled chiefly on the constitution of the University of Paris. It acquired all its three colleges—St. Salvator's, St. Leonard's and St. Mary's—before the Reformation. The most ancient of the universities of Scotland, with its three colleges. was thus reared in an atmosphere of mediaeval theology, and undoubtedly designed as a bulwark against heresy and schism. But "by a strange irony of fate, two of these colleges became, almost from the first, the foremost agents in working the overthrow of that Church which they were founded to defend." St. Leonard's more especially became a noted centre of intellectual life and Reformation principles.

The University of Glasgow was founded as a studium generale in 1453. Among its objects also was "the extension of the Catholic faith"; but it was to produce John Knox. It was founded on the model of Bologna, but in its customs largely imitated Louvain, whose rector at the time was a Scotsman. Though founded to "flourish in theology, canon and civil law, and in any other lawful Faculty," for long only the faculty of arts had a constitution. Throughout the 15th century this faculty flourished exceedingly.

The Cniversity of Aberdeen was founded in 1494, mainly through the efforts of Bishop William Elphinstone, who had earlier been successively dean of the faculty of arts and rector of Glasgow university. He avoided two defects in the constitutions of St. Andrews and Glasgow by providing salaries for teachers in the higher faculties and establishing a visitorial power.

The fourth Scottish university, Edinburgh, was a post-Reformation foundation.

General Aspects.—Generally speaking, the mediaeval universities were conservative. Alexander Hegius, Johan Wessel and Rodolphus Agricola carried on their work as reformers at places like Deventer, remote from university influences. That there was a considerable amount of mental activity going on in the universities themselves is not to be denied; but it was mostly of that unprofitable kind which, while giving rise to endless controversy, turned upon questions in connection with mhich the implied postulates and the terminology employed rendered all scientific investigation hopeless. At almost every university—Leipzig, Greifswald and Prague (after 1409) being the principal exceptions—the so-called Realists and Nominalists represented two great parties occupied with an internecine struggle. At Paris, because of the overwhelming strength of the theologians, the Nominalists were. indeed, under a kind of ban; but at Heidelberg they had altogether expelled their antagonists. It was much the same at Vienna and at Erfurt. At Basle, under the leadership of the eminent Johannes a Lapide. the Realists with difficulty maintained their ground. Freiburg, Tübingen and Ingolstadt, in the hope of diminishing controversy, arrived at a kind of compromise, each party having its own professor and representing a distinct "nation." At Mainz the authorities adopted a manual of logic which was essentially an embodiment of nominalistic principles.

In Italian universities. it was decided that these controversies were endless and that their effects mere pernicious. It was resolved, accordingly, to expel logic and allow its place to be filled by rhetoric, thereby effecting that important revolution in academic studies which constituted a new era in university learning and largely helped to pave the way for the Reformation. Hence the Italian universities enjoyed a fortunate immunity from dissensions such as those which distracted the centres of learning in Germany.

The professorial body in the great Italian universities attained an almost unrivalled reputation throughout Europe. For each subject of importance there were always two, and sometimes three, rival chairs and a powerful and continuous emulation was thus maintained among the teachers. "The call to a Paduan or Pisan chair was deemed the highest of all literary honours. The status of professor was, in Italy, elevated to a dignity which in other countries it has never reached; and not a few of the most illustrious teachers in the Italian seminaries were of the proudest nobility of the land. While the universities of other countries had fallen from Christian and cosmopolite to sectarian and local schools. it is the peculiar glory of the Italian that, under the enlightened liberality of their patrons, they still continued to assert their European universality. Creed and country mere, in them, no bar—the latter not even a reason of preference. Foreigners of every nation are to be found among their professors; and the most learned man in Scotland. Thomas Dempster, sought in a Pisan chair that theatre for his abilities which he could not find at home."

Spain. — To such catholicity of sentiment the Spanish universities of this period offer a complete contrast, their history being strongly modified by political and religious movements. Valencia, founded in 1501, and Seville, sanctioned by Julius II in 1505, appear both to have been regarded without mistrust at Rome. Julius had approved the foundation of the University of Santiago as early as 1504, but the bull for its creation was not granted by Clement VII until 1526. The design of establishing a university at Granada was deferred until 1531. Little, indeed, is to be learned respecting the new society until the foundation of the liberally endowed College de Sacro Monte by the archbishop of the province in 1605. Under the direction of the Jesuits the scholastic philosophy, together with a certain attention to Greek and Hebrew, became the dominant study. Gregory XIII in 1574 authorized the foundation of the University of Oviedo; but this was not opened until 1608, and then only with a faculty of law. After this time the universities in Spain shared in the general decline of the country; and. even after the expulsion of the Jesuits in 1769, no marked improvement is discernible in their schools until the second half of the 19th century.

Mention should be made, however, of the foundations in Spanish America, nhich went on for more than two centuries. They included the University of Lima, Peru (now Universidad Nacional Mayor de San Marcos and claimed as the oldest university in the new world), set up as a Dominican seminary in 1551 and secularized in 1571 with faculties in philosophy and theology; Mexico City, opened in 1553, Bogota, Colom (1572); Cuzco, Peru (1696); Havana, Cuba (1728); and Santiago, Chile (1747).

THE REFORMATION

The Reformation represents the first great boundary line in the history of European universities. Even in Roman Catholic countries its effects found expression in connection with the Counter Reformation. The influence of the humanists, and the special character which the Reformation assumed in Germany through the labours of scholars like Erasmus, Reuchlin and Melanchthon, augured well for the future. German university teaching was free from the frivolity, pedantry and scepticism which characterized so much of the corresponding culture in Italy. It gave promise of resulting at once in a critical and enlightened study of the masterpieces of classical antiquity, and in a reverent and yet rational interpretation of the Scriptures and the Fathers. The bigoted and ceaseless controversies evoked by the promulgation of Lutheran or Calvinistic doctrine dispelled, however, this prospect, and converted the universities into gloomy fortresses of sectarianism. For a century after the Reformation the history of Lutheran theology became almost identified with that of the German universities.

Marburg. — The first Protestant university was that of Marburg, founded by Philip the Magnanimous, landgrave of Hesse, May 30, 1527, and mainly built up out of the confiscation of the property of the religious orders in the Hessian capital. It rapidly became famous and attracted students from remote countries. After 1605, when, by the decree of Count Maurice, its formulary of faith was changed from Lutheran to Calvinistic, its numbers greatly declined. This dictation by the temporal power now becomes one of the most notable features in academic history in Protestant Germany.

Königsberg.—The Lutheran University of Konigsberg was founded Aug. 17, 1544, by Albert III, margrave of Brandenburg and the first duke of Prussia, and his wife Dorothea, a Danish princess. King Sigismund of Poland gave the charter (Sept. 29, 1561), and students who graduated as masters in the faculty of philosophy ranked as nobles of the Polish kingdom. When Prussia was raised to the rank of a kingdom (1701) the university was made a royal foundation, and the *collegium Fridericianum,* which was then erected, received corresponding privileges. Konigsberg will always be remembered as the university of Kant.

Jena.—The Lutheran University of Jena was opened on Feb. 2, 1558. Distinguished for its vehement assertion of Lutheran doctrine, its hostility to the teaching of Wittenberg was hardly less pronounced than that with which both centres regarded Roman Catholicism. For a long time it was chiefly noted as a school of medicine, and in the 17th and 18th centuries was in bad repute for the lawlessness of its students, among whom duelling prevailed to a scandalous extent.

Helmstedt.—The Lutheran University of Helmstedt, founded by Duke Julius (of the house of Brunswick-Wolfenbiittel), received its charter May 8, 1575, from the emperor Maximilian II. It was munificently endowed by the founder and by his son, and its *Convictorium,* or college for poor students, expended in the course of 30 years no less than 100,000 thalers, an extraordinary expenditure for an institution of such a character in those days. Distinguished by its comparatively temperate maintenance of the Lutheran tenets, it attracted a considerable concourse of students, especially from the upper classes. Until suppressed in 1809, Helmstedt enjoyed the special and powerful patronage of the dukes of Saxony.

Altdorf.—The *Gymnasium Aegidianum* of Nuremberg, founded in 1526 and moved in 1575 to Altdorf, represents the origin of the University of Altdorf. Altdorf was about the poorest university in Germany, yet long one of the most eminent. Its whole endowment never rose above £800 a year.

17TH- AND 18TH-CENTURY GERMAN FOUNDATIONS

Giessen.—The conversion of Marburg into a school of Calvinistic doctrine gave occasion to the foundation of the universities of Giessen and of Rinteln. Giessen, founded by the margrave of Hesse-Darmstadt, Louis V, as a kind of refuge for the Lutheran professors from Marburg, received its charter from the emperor Rudolph II (May 19, 1607). In 1625 the university was transferred to Marburg; in 16jo it was moved back again to Giessen.

Strasbourg.—The University of Strasbourg was founded in 1621 on the basis of an already existing academy which, under the direction of John Sturm, had attracted students from all parts of Europe and especially from Portugal, Poland, Denmark, France and England. The method of Sturm's teaching became the basis of that of the Jesuits, and, through them, of the public schools in England. In 1621 Ferdinand II conferred on this academy full privileges as a university. In 1681 Strasbourg became French. It was refounded by the emperor William I and before the close of the century numbered more than 1,100 students. At the end of the 18th century, after its reversion to Germany, it was distinguished by an intellectual activity with which the name of Goethe is connected.

Kiel.—The royal university of Kiel was founded in 1665 by Duke Christian Albrecht of Holstein (who himself assumed the office of rector), with faculties of theology, law, medicine and philosophy. After the incorporation of Schleswig-Holstein with the kingdom of Prussia it made a marked advance.

Halle and Pietism.—The year 1693 saw the foundation of the University of Halle, which has been described as the "first real modern university." It originated in a *Ritterschule* for the sons of the nobility. Leopold I granted (Oct. 19, 1693) the requisite charter. The primary object in founding a university in Halle was to create a centre for the Lutheran party; but its character, under the influence of its two most notable teachers, Christian Thomasius and A. H. Francke, soon expanded beyond the limits of this conception. Thomasius and Francke had both been driven from Leipzig because of their liberal and progressive tendencies. Thomasius was the first to set the example, soon after followed by all the universities of Germany, of lecturing in the vernacular instead of in the customary Latin. Francke, as the founder of that Pietistic school, exercised great influence. Christian Wolff, who followed Thomasius as an assertor of the new culture, was driven from Halle by the accusations of the Pietists. In 1740, however, he was recalled by Frederick II and reinstated. Throughout the whole of the 18th century Halle was the leader of academic thought and advanced theology in Protestant Germany, although sharing that leadership, after the middle of the century, with Gottingen.

Göttingen.—The University of Gottingen (named after its founder, "Georgia Augusta"), was endowed with the amplest privileges as a university by George II of England, elector of Hanover, Dec. 7, 1736. The university included all the faculties, and two of its first professors—J. L. von Mosheim, the eminent theologian from Helmstedt, and G. L. Bohmer, the no less distinguished jurist from Halle—together with Johann Gesner, the man of letters, at once established its reputation. Not least among its attractions was also its splendid library, located in an ancient monastery. The Gottingen school of history became famous. The labours of the professors at Gottingen, especially J. S. Putter, J. C. Gatterer, A. L. von Schlozer and L. T. von Spittler, combined with those of J. J. Mascov at Leipzig, did much to promote both a more catholic treatment and a wider scope. The method of appointment of professors was reformed by the chief curator, G. A. von Miinchhausen, on lines similar to those already instituted in the universities of the Netherlands by Janus Dousa.

Erlangen.—The University of Erlangen, a Lutheran centre, was founded by Frederick, margrave of Bayreuth. Its charter was granted by the emperor Charles VII in 1743. In 1791, Ansbach and Bayreuth having passed into the possession of Prussia, Erlangen also became subject to the Prussian government.

NORTHERN EUROPE

The earliest Dutch university, Leyden, founded in 1575, commemorated the successful resistance of the citizens to the Spanish. Throughout the 17th century Leyden was distinguished by its learning, the ability of its professors and the shelter it afforded to the more liberal thought associated at that period with Arminianism. Much of its early success was a result of the wise provisions and the influence of the celebrated Janus Dousa. Dousa, in fact, did for Leyden and the Dutch what Miinchhausen afterward did for Gottingen and the German universities. The appointment of the professors at Leyden was vested in three (afterward five) curators, one of whom was selected from the body of the nobles, while the other two were appointed by the states of the province, the office being held for nine years and eventually for life. With these was associated the mayor of Leyden for the time being. Leyden secured and maintained a very high reputation for scientific work. Other Dutch universities with a famous history are Franeker (1585), Harderwyk (1600), Groningen (1614) and Utrecht (1634), the last being a great resort in the 18th century for English students.

The Royal University of Uppsala, whose foundation as a *studium generale* was sanctioned by Pope Sixtus IV in 1477, despite a checkered history remained the chief centre of higher education in Sweden. In the 18th century lectures began to be delivered in Swedish, but the mediaeval division of the students into "nations" continued, as at Lund (1666), until the second quarter of the 19th.

REFORMATION AND POST-REFORMATION IN BRITAIN

Oxford and Cambridge.—The influence of the Renaissance and the teaching of Erasmus, who resided at both universities, exercised a notable effect alike at Oxford and Cambridge. The names of John Colet, William Grocyn and Thomas Linacre illustrate this influence at the former centre; those of Bishop John Fisher, Sir John Cheke and Sir Thomas Smith at the latter. The labours of Erasmus at Cambridge, as the author of a new Latin version of the New Testament, with the design of placing in the hands of students a text free from the errors of the Vulgate, were productive of important effects, and the university became a centre of Reformation doctrine several years before the writings of Luther became known in England. The foundation of Christ's college (1505) and St. John's college (1511), through the influence of Fisher with the countess of Richmond, also materially aided the general progress of learning at Cambridge. The Royal Injunctions of 1535, embodying the views and desigcs of Thomas Cromwell. mark the downfall of the old scholastic methods of study at both universities; and the foundation of Trinity cellege, Cambridge, in 1547 (partly by an amalgamation of two older societies), represents the earliest conception of such an institution in England in complete independence of Roman Catholic traditions. Trinity (1554) and St. John's (1555) at Oxford, on the other hand. founded during the reactionary reign of Mary, serve rather as examples of a transitional period.

Puritanism at Cambridge.—In the reign of Elizabeth, Cambridge became the centre of another great movement, that of the earlier Puritanism, St. John's and Queens' being the strongholds of the party led by Thomas Cartwright, Walter Travers and others. The movement continued to gather strength, and Emmanuel college. founded in 1584, owed much of its early prosperity to the fact that it was a known school of Puritan doctrine. Most of the Puritans objected to the discipline enforced by the university and ordinary college statutes, especially the wearing of the cap and the surplice and the conferring of degrees in divinity. The Anglican party, headed by such men as archbishops John Whitgift and Richard Bancroft. resorted in defense to a repressive policy, of which subscription to the Acts of Supremacy and Uniformity and the Elizabethan statutes of 1570 (investing the *caput* with larger powers and thereby creating a more oligarchical form of government) were the most notable results. Oxford, although the Puritans were there headed by Leicester, the chancellor, devised at the same time a similar scheme. the rigid discipline of which was further developed in the Laudian or Caroline statutes of 1636. It was under these respective codes—the Elizabethan statutes of 1570 and the Laudian statutes of 1636—that the two universities were governed until the introductian of new codes in 1858. The fidelity with which both universities adhered to the royal cause in the Civil War caused them to be regarded with suspicion by the Puritan party. and under the Commonwealth both Oxford and Cambridge were, for a brief period, in great danger because of the distrust. which reached its highest point among the members of the "nominated parliament" (July-December 1653), of university education generally. as tending to foster contentiousness with respect to religious belief. It was even proposed by William Dell—himself the master of Caius college—to abolish the two universities altogether, as hopelessly pledged to antiquated and obsolete methods. and to establish in their place schools for higher instruction throughout the country. They were saved, however, by the firmness of Cromwell, at that time chancellor of Oxford, and, although Aristotle and the scholastic philosophy no longer held their ground, a marked improvement was observable both in discipline and morality among the students. At Oxford, under the influence and teaching of John Wilkins, Seth Ward and John Wallis, a flourishing school of mathematics was formed.

The Cambridge Platonist Movement.—In the 17th century Cambridge became the centre of a further movement (a reflex of the influence of the Cartesian philosophy), nhich attracted for a time considerable attention. Its leaders. known as the Cambridge Platonists, among whom Henry More and Ralph Cudworth were especially conspicuous, were men of high character and great learning, although much under the influence of an ill-restrained enthusiasm and purely speculative doctrines. The spread of the Baconian philosophy, and the example of a succession of eminent scientific thinkers, among whom were Isaac Barrow, master of Trinity (1673–77), the two Lucasian professors Isaac Newton (professor 1669–1702) and his successor William Whiston (professor 1702–11), and Roger Cotes (Plumian professor 1707–16), began to render the exact sciences more and more an object of study, and the institution of the tripos examinations in the course of the first half of the 18th century established the reputation of Cambridge as a school of mathematical science. At Oxford, where the study had, in turn, declined, and where the statutable requirements with respect to lectures and exercises were suffered to fall into neglect, academic culture declined.

Edinburgh. — The "College of Edinburgh" was founded by charter of James VI, dated April 14, 1582. This made no mention of a *studium generale* or of any of the privileges associated with a university, and not until 1685 was the college referred to as a university in municipal records. But the charter gave the town council the right to provide for the teaching of all the subjects usual in a university, and from 1587 the college conferred degrees.

Trinity College, Dublin. — Trinity college, Dublin, was founded in 1591. A royal charter nominated a provost and a minimum number of three fellows and three scholars as a body corporate. The first five provosts of Trinity college were all Cambridge men, and under the influence of Archbishop Adam Loftus, the first provost, and his successors, the foundation received a strongly Puritan bias, but the policy of Laud and Wentworth was to make the college more distinctly Anglican as regards its tone and belief. At the Restoration its condition was found to be that of a well-ordered home of learning and piety, with its estates well secured and its privileges unimpaired. Under Bishop Jeremy Taylor, who succeeded to the vice-chancellorship, its progress in learning was considerable.

THE COUNTER REFORMATION

Barnberg. — The earliest university whose charter represented the Counter Reformation was that of Bamberg, founded by the prince-bishop and opened Sept. 1, 1648. At first, however, it comprised only the faculties of arts and of theology; to these were added in 1729 that of jurisprudence and in 1764 that of medicine. The university library was enriched by a collection of manuscripts from about 30 suppressed monasteries, convents and religious institutions at the time of the "secularization."

Innsbruck.—The University of Innsbruck was founded in 1672 by the emperor Leopold I. In the following century, under the patronage of the empress Maria Theresa, it made considerable progress, and received from her its ancient library and bookshelves in 1745. In 1782 the university was reduced by the emperor Joseph II from the status of a university to that of a lyceum, although retaining in the theological faculty the right of conferring degrees. In 1791 it was restored to its privileges by the emperor Leopold II.

Breslau.—The University of Breslau was founded by the emperor Leopold I in 1702. When Frederick the Great conquered Silesia in 1741, he took both the university and the Jesuits in Breslau under his protection, and when, in 1774, the order was suppressed by Clement XIV he established them as priests in the Royal Scholastic institute, at the same time giving new statutes to the university.

Jesuit Influence in France. — In no country was the influence of the Jesuits on the universities more marked than in France. The civil wars in that country during the 30 years which preceded the close of the 16th century told with disastrous effects upon the condition of the University of Paris, and with the commencement of the 17th century its collegiate life seemed at an end and its 40 colleges stood absolutely deserted. To this state of affairs the obstinate conservatism of the academic authorities contributed not a little. The Jesuits did not fail to profit by this excessive conservatism on the part of the university. and during the second half of the 16th century and the whole of the 17th they contrived to gain almost a complete monopoly of both the higher and the lower education of provincial France. Their schools rose at Toulouse and Bordeaux. at Auch, Agen, Rhodez, Périgueux, Limoges, Le Puy, Aubenas, Béziers, Tournon, in the colleges of Flanders and Lorraine, Douai and Pont-à-Mousson—places beyond the jurisdiction of the *parlement* of Paris or even of the crown of France. Their banishment from Paris itself had been by the decree of the *parlement* alone and had never been confirmed by the crown. "Lyons," says Mark Pattison, "loudly demanded a Jesuit college," and even the Huguenot duke of Lesdiguitres, almost king in Dauphiné, was prepared to erect one at Grenoble. The university was rescued from the fate which seemed to threaten it only by the excellent statutes given by Edmond Richer in 1598 and by the discerning protection extended by Henry IV.

Nevertheless, the University of Paris remained distracted throughout the 17th century by theological dissensions — in the first instance as a result of the struggle that ensued after the Jesuits had effected a footing at the Collège de Clermont, and subsequently by the strife occasioned by the teaching of the Jansenists. Toward the close of the century a certain revival took place, and a succession of illustrious names — E. Pourchot, Charles Rollin, Bénigne Grenan, Charles Coffin, Jean-Gabriel Demontempuis, J. B. L. Crevier, Charles Le Beau — appear on the roll of its teachers. But this improvement was soon interrupted by the controversies excited by the promulgation of the bull *Unigenitus* in 1713, condemning the tenets of Pasquier Quesnel. At last. in 1762, the *parlement* of Paris issued a decree (Aug. 6) placing the colleges of the Jesuits at the disposal of the university, and this was immediately followed by another for the expulsion of the order from Paris, the university being installed in possession of its vacated premises. Concurrently with this measure, both history and natural science began to be cultivated with a certain success. Then came the French Revolution.

19TH AND EARLY 20TH CENTURIES

The United Kingdom. — The Reformation marked the first great turning point in the history of the universities; the 19th century can lay good claim to having marked the second. It saw the foundation of numerous new universities, many in parts of the world previously unprovided with facilities for higher education; it saw also the reconstitution of numerous ancient universities. Neither process was the result of chance; new and reconstituted universities alike arose to meet new needs, the needs of an expanding world and an increasingly industrialized age.

Oxford and Cambridge.—In the United Kingdom of Great Britain and Ireland both processes took place. At the beginning of the 19th century Oxford and Cambridge nere "the endowed preserve of a class" (Sir Charles Grant Robertson, The *British Universities*); by the end of it the "privileges and monopoly" of this class hacl been almost completely swept away. Much of the reform came from within. hut two royal commissions, in 1858 and 1877, investigated the affairs of the universities and recornrnendetl drastic and far-reaching changes. During the century the range of studies n-as enormously extended. Exacting written examinations took the place of the often merely formal oral ceremonies. The professoriate was increased. reorganized and re-endowed, so that it became a resident, university hody.

General and uniform regulations were enforced for the selection. duties and salaries of professors. lecturers and examiners. Fellowships were thrown open to merit. The colleges were emancipated from their mediaeval statutes. invested with new constitutions and granted new legislative powers, while at the same time a proportion of their revenues was diverted to the uses of the university. A great mass of vexatious and obsolete oaths was swept away; in 1858 dissenters were admitted to matriculation and the B.A., and in 1871 all religious tests were abolished.

In 1863 noncollegiate students were admitted to Oxford and in 1869 to Cambridge. Women's colleges were also established. Girton (1869) and Newnham (1871–75) at Cambridge, Somerville (1879) and Lady Margaret Hall (1878), the latter being followed by St. Hugh'. (1886) and St. Hilda's (1893) at Oxford.

Women had to wait, however, until the 20th century before the ancient English universities would admit them to degrees.

London.—London. the first of Britain's modern universities, mas born out of religious differences, which gave it a unique and unhappy start It originated in a movement begun in 1825 by the poet Thomas Campbell. Henry (later Lord) Brougham and influential dissenters, nhose aim was to set up an institution of university status for students excluded from Oxford and Cambridge by religious belief or lack of means. In 1828 the University of London was opened. But the project brought into being a rival group, equally influential, nhich in 1829 opened King's college, London, mhose curriculum was similar except that it included instruction in "the doctrines and duties of Christianity, as the same are inculcated by the United Church of England and Ireland." The result was that neither college received a university charter. In 1836 a nonteaching body, called London university, was created, authorized to hold examinations and confer degrees, not only, it is important to note, upon students of its two incorporated colleges, University and King's, but also upon students of such other institutions in the United Kingdom and the British colonies as it might affiliate.

In 1858 the degrees of London university (except in medicine) were made available to all. Since that date London has awarded two kinds of degrees. *internal* to members of the university and *external* to anyone else passing its examinations, whether members of an educational institution or private students. This extraordinary constitution caused the University of London embarrassment for many years but later the external degrees were to prove of inestimable value in assisting university colleges in England and throughout the British Commonnealth to qualify for full university status The colleges prepare their students for the London degrees until such time as their academic standards, their teaching staff and their financial resources are sufficiently good to justify application for a university charter.

Attempt after attempt was made to reorganize the university until in 1900 it was reconstituted so that only institutions within the county of London could become recognized as "schools of the university."

Durham and Newcastle.—The London colleges were designed for students of limited means. So was the University of Durham. A residential. collegiate university. modelled on Oxford. it nas founded by act of parliament in 1832 and received its charter in 1837. It was endowed from the revenues of Durham cathedral and diocese. With it was associated in 1852, and more closely in 1870, the Newcastle College of Medicine.

In 1871 the Durham College of Physical Science was founded (in Newcastle: later called Armstrong college) and incorporated into the university. In 1908 the university was reconstituted in two divisions—Durham and Newcastle—under a single vice-chancellor but with separate teaching staffs. A further reconstitution in 1937 established a central financial control and merged the tno Nencastle colleges into King's college, Newcastle upon Tyne.

Other Provincial Universities.—Forty-four years nere to elapse before another English university was founded. but nithin that period the progenitors of at least three others were born, and before the end of the century an additional five. In 1851 Owens college, Jlanchester, was established to teach "such branches of learning and science as nere then or might hereafter be usually taught in English universities."

In 1874, at Leeds, arose the Yorkshire College of Science; in 1876 the University college. Bristol; both absorbed earlier medical schools. Within the next 20 years there were similar colleges at Birmingham, Liverpool, Nottingham. Reading and Sheffield In 1880 Owens college became the Victoria University of Manchester, in which were shortly federated the university colleges of Leeds and Liverpool.

"*Redbrick*" Universities.—The university college movement produced a rich harvest in the first decade of the 20th century. Mason college became Birmingham university in 1900. Liverpool and Leeds broke away from Manchester to obtain their own charters in 1903 and 1904, respectively The University of Sheffield followed in 1905 and that of Bristol in 1909. These five, with Manchester, established a new tradition in English university education. Each was the product of a large industrial city. endowed by its citizens (who justly claimed a share in its government) and linked closely with its occupations. Each had a strong scientific and technological side. Each catered mainly though never exclusively, for local students and was consequently nonresidential. All were completely free of religious tests; in some the teaching of religion was forbidden. In all the fees and other expenses were low. The sobriquet "Redbrick" given them later by an English writer referred primarily to their buildings but also characterized them as a homogeneous group. Reading became a university in 1926; later followed Nottingham (1948). Southampton (1952), Hull (1954), Exeter (1955) and Leicester (1957).

Scotland.—In the 19th century three royal commissions wrestled with the affairs of the Scottish universities. The first, which reported in 1830, produced no tangible results, the opposition to its proposals proving too strong. But it stimulated thought about reform and paved the way for the commission of 1558, mhose recommendations. embodied in the Universities (Scotland) act, 1858. remodelled the Scottish universities and assimilated their constitutions and conditions of graduation. The teaching and administrative functions were differentiated by the setting up at each university of a university court whose duty was to review all decisions taken by the *Senatus Academicus*. Also, each university was given a general council, which was to meet twice yearly to consider "questions affecting the well-being and prosperity of the university." The two independent degree-conferring colleges at Aberdeen, King's and Marischal, were amalgamated.

The Universities (Scotland) act. 1889, introduced further drastic changes. It set up a Scottish universities committee of the privy council, to which all ordinances and petitions from the universities had to be referred. (This procedure was abandoned 20 years later because of the delays and difficulties it caused.) It increased the membership and powers of the uni ersity courts. adding to them representatives of the senate, the general council and the municipality within which the university was situated. and vesting in them responsibility for the business management of the university property and finances. leaving the control of education and discipline only to the *senatus*. It gave statutory recognition to the Students' Representative council (which had come into being in 1884) and empowered it to petition the *senatus* or the university court about any matter affecting the students' interests. It reorganized the curriculums of all the faculties except divinity; greatly broadening them and ending the compulsion to take the "sacred six" subjects in arts (Latin. Greek. mathematics, natural philosophy, logic and moral philosophy). It reduced the period of required residence from four to three years, established a new system of honours degrees and empowered the courts to admit women to lectures and degrees in all faculties. Most of these changes were effected by the executive commission set up under the act; they took eight years to complete.

Wales.—The principality of Wales played a notable part in the university college movement and because of a strong national feeling and an earlier development of secondary education than in England, secured its university in 1893, when the university colleges of Aberystwyth (1872). Cardiff (1883) and Bangor (1885) were federated. St. David's college; Lampeter (1827), a theological college, was not included, but retained its right to confer the degrees of bachelor of arts and of divinity.

Ireland.—Religious difficulties gravely impeded university education. In 1845 three state-endowed university colleges were set up by act of parliament at Belfast, Cork and Galway, and in 1850 they were federated as the Queen's university. As no provision was made for theological teaching they were boycotted by Roman Catholics. In 1850 John Henry (later Cardinal) Newman founded a Roman Catholic university at Dublin, but this was refused the right to grant degrees. In 1879 the Queen's university was displaced by the Royal university, a nonteaching body empowered to hold examinations and grant degrees, which Catholics could take.

In 1909 university education in Ireland was reorganized. Two new universities were created: the National University of Ireland at Dublin, which incorporated the Queen's colleges at Cork and

Galway and set up a third college in Dublin; and the Queen's university at Belfast (formerly the Queen's college). Both universities nere given nominated senates with a Roman Catholic majority in Dublin and a Protestant one in Belfast. Trinity college, Dublin. was left intact. In all three universities there were to be no religious tests for teachers or students.

COMMONWEALTH OF NATIONS

India. — Though there were previously institutions of university status, the foundation of universities as such in India was the outcome of the parliamentary inquiry which preceded the confirmation of the East India company's charter in 1853, and of Sir Charles Wood's dispatch to its court of directors in 1854. In 1857 three universities — Calcutta (Jan. 24), Bombay (July 18) and Madras (Sept. 5)—were founded on the London model as examining bodies with power to affiliate. The framers of this policy did not intend the universities to have no teaching functions, but not until the 20th century did they become fully teaching institutions. Proposals made in 1865–67 for an oriental university in the Punjab resulted in the foundation of a university college at Lahore which became a university in 1882, and in 1887 Allahabad university followed. Both of these were London-model examining and affiliating bodies, though the University of the Punjab was also authorized to appoint teachers.

In 1902 a universities' commission recommended, and in 1904 an act provided. that the older universities should become teaching bodies. The conditions for affiliation were stiffened. In 1913 a government resolution proposed the establishment of residential universities at Dacca, Aligarh and Benares and the creation of new universities at Rangoon. Patna and Nagpur; but the outbreak of World War I delayed these developments.

Canada. — The history of the universities of Canada is highly complex, reflecting the varied religious and political influences in the making of the nation. All the older universities except two were founded by religious bodies, among whom the Roman Catholics, Anglicans, Presbyterians, Methodists and Baptists were prominent. Broadly speaking, these copied three models, Paris, Oxford and Edinburgh, according to the nationality of the founders. Later, after efforts, largely unsuccessful, to overcome the denominational problem by founding universities on the London style, there came the evolution of a distinctively Canadian type of federated university. Finally, the 20th century saw, in the western provinces, the foundation of fully state-provided universities.

The French Laval university, Quebec, was founded as late as 1852, but the Seminary of Quebec, from which it sprang, dates from 1633. The University of Montreal was founded in 1878 as a branch of Laval, from which it was finally separated in 1920. Other Roman Catholic foundations were Ottawa (1849) and St. Francis Xavier, Antigonish, N.S. (1853), the latter with no religious tests for entrance or degrees. Three colleges, each called King's college and each a Church of England establishment, were early founded by the immigrant American loyalists and received royal charters: at Windsor, N.S. (1802; later moved to Halifax), Toronto (1827) — later the University of Toronto — and Fredericton, N.B. (1828). which in 1859 was secularized as the University of New Brunswick. All three were modelled upon Oxford. Later Anglican foundations included the University of Bishop's College, Lennoxville, Que. (1853), and Western university (1878); the latter became nondenominational in 1908 and later changed its name to Western Ontario. The Baptists founded Acadia, Wolfville. N.S. (1838), and in 1887 amalgamated two colleges to form McMaster, now located in Hamilton, Ont. The Presbyterians founded Queen's, Kingston, Ont. (1841), modelling it on Edinburgh; it became nondenominational in 1912. The Methodists founded Mount Allison academy at Sackville, N.B., which was given a university charter in 1858 and later also became nondenominational.

The two private foundations, Dalhousie (Halifax, N.S.) and McGill (Montreal, Que.), were both from the start nonsectarian, Both were Scottish-type universities. Each had a precarious early existence; Dalhousie, though founded in 1818, did not open until 1838, and was closed again between 1843 and 1863. The reopening was made possible by the closing of various Presbyterian and Congregational colleges. In 1868 the government withdrew grants from denominational colleges, and this, with the increasing cost of maintenance, compelled them to think seriously about federation. In 1887 a scheme was approved for a university of Toronto consisting essentially of "a group of arts or divinity colleges gathered about a central university, supported and controlled by the State, the University conducting examinations, conferring degrees (except in Divinity), and giving the instruction in those branches of learning which are costly to conduct, or are taken by only a few students, or are professional in character." *(Yearbook of the Universities of the Commonwealth, 1949–50, p. 547).* This scheme became archetypal.

For nearly 20 years Toronto university was administered by a government department. In 1906 it was granted an independent board of governors, nominated by the lieutenant governor in council, and the right of nominating to academic appointments was vested in the president of the university. In 1907 Manitoba university was reconstituted on the same lines. In 1906 and 1907 provincial universities, modelled on Toronto, were founded in Alberta at Edmonton and in Saskatchewan at Saskatoon.

Australia. — The earliest Australian universities successfully combined mediaeval and modern features. Each was established by the state legislature, yet constituted a self-governing corporation. Each relied for support upon both public money and private benefactions. Each was nonresidential. nondenominational and secular, yet each made provision for including residential denominational colleges on religious foundations. Geography dictated their location in capital cities. The first to be founded was Sydney (1850), closely followed by Melbourne (1853). Each of these had, before the end of the 19th century, three colleges for men and residential accommodation for women. Adelaide was similarly established in 1874 but did not incorporate any colleges until the 20th century. When the University of Queensland was founded in 1909 it was made wholly residential, and four colleges, including one for women, were established within four years. Living at home was recognized as residence. The universities of Tasmania, Hobart (founded 1890, charter 191jj, and Western Australia, Perth (1911), had no such provision.

New Zealand. — In 1869 the University of Otago, Dunedin, was founded by provincial ordinance, with power to grant degrees in arts, law and medicine. But the next year the University of New Zealand, Wellington, a purely examining body, was established, and in 1874 Otago agreed to affiliate with it and to hold in abeyance its own right to grant degrees. Canterbury University college. Christchurch (founded 1873), also affiliated, as did later Auckland (1882) and Victoria (1897). In the early days New Zealand maintained academic standards by appointing external examiners from England.

Union of South Africa. — The development of university education in South Africa aptly illustrates the truth that universities are born to meet new needs. Higher education began with the founding in 1829 of South African college, Capetown, a proprietary institution which for 20 years had no competitors. Then within six years appeared the Diocesan college, Capetown (1849), St. Andrew's, Grahamstown (1855), and Grey college, Bloemfontein (1855). In 1858 there was established, primarily to examine candidates for public appointments, a board of examiners in literature and science, which shortly began to conduct examinations not unlike those for university degrees. This greatly stimulated the work of the colleges, and by a natural sequence the University of the Cape of Good Hope, an examining and degree-granting body, took the place of the board in 1873 Almost simultaneously the Cape parliament passed a higher education act providing for salary grants to professors at recognized colleges. This further stimulated progress and incited other college foundations, including Stellenbosch (1874), which was raised to university status in 1916. Later came the Kimberley School of Mines (1896). Pretoria University college (1908) and Natal University college (1909), all destined eventually to graduate into universities.

CONTINENTAL EUROPE

France. — On Sept. 15, 1793, the universities and colleges throughout France, together with the faculties of theology, medicine, jurisprudence and arts, had been abolished by a decree of the convention. and the whole system of national education may be said to have remained in abeyance until 1808, when Napoleon I promulgated the scheme which in many essential features obtains today. The whole system of education, primary, secondary and higher, was made subject to the control and direction of the state. France was divided into 17 districts, designated "academies," each administered by its own rector and council, but subject to the supreme authority of the minister of public instruction, and representing certain faculties which varied at different centres, in conformity with the new scheme of distribution for the entire country. The "University of France." as it was styled, became little more than an abstract term signifying collectively the various centres of professional education in their new relations to the state. While three new "academies" — those of Lille, Lyons and Rennes — were formed in 1808, many of the pre-existing centres were completely suppressed. In some cases, however, the effacement of an ancient institution was avoided by investing it with new importance, as at Grenoble; in others, the vacated premises were appropriated to new uses connected with the department, as at Avignon, Cahors and Perpignan. Each rector of an "academy" was also constituted president of a local *conseil d'enseignement*, in conjunction with which he nominated the teachers in elementary and secondary schools. The appointments were ratified by a promotion committee in Paris.

"Free Faculties." — In 1895 the government was prevailed upon to sanction the institution of certain "free faculties," as they were termed, to be placed under the direction of the bishop, depending for support upon voluntary contributions and each including a faculty of theology, the best known being those of Paris and Lille. The faculty at Marseilles was called upon to unite with the academy of Aix, its faculties being restricted to mathematics and natural science (including a medical school), while faculties of law and philosophy were fixed at Aix, which possessed also the university library. In the capital itself, the University of Paris and the École Pratique des Hautes Études carried on the work of higher instruction independently of each other — the former with faculties of Protestant theology, law, medicine. science, letters and chemistry, distributed over the Quartier Latin; the latter with schools of mathematics, natural science. history, philology and history of religions centred at the Sorbonne.

In 1896 the higher education of France was decentralized and the existing academies, consisting of isolated faculties, were converted into regional universities, while the Sorbonne. from being the University of France, became the University of Paris. The total number of universities, including that of Algiers, was 16.

Germany. — The political storms which marked the close of the 18th and the beginning of the 19th century gave the deathblow to not a few of the ancient universities of Germany. Mainz and Cologne ceased to exist in 1798, Bamberg, Dillingen and Duisburg in 1804, Rinteln and Helmstedt in 1809, Salzburg in 1810 and Erfurt in 1816. Altdorf was united to Erlangen in 1807, Frankfurt-on-Oder to Breslau in 1809 and Wittenberg to Halle in 1815. The University of Ingolstadt was first moved in 1802 to Landshut and from there, in 1826, to Munich, where it was united to the academy of sciences which had been founded in the Bavarian capital in 1759. Miinster, in Prussia, which had been constituted a university by Maximilian Frederick (elector and archbishop) in 1771, was abolished in the year 1818; but two faculties, those of theology and philosophy. continued to exist, and in 1843 it received the full privileges of a Prussian university, together with the designation of a royal foundation. Of those of the above centres which altogether ceased to exist, few were much missed or regretted, that at Mainz, which had numbered about 600 students, being the one notable exception. The others had, for the most part, fallen into a perfunctory and lifeless mode of teaching, and, with wasted or diminished revenues and declining numbers, had long ceased worthily to represent the functions of a university. Whatever loss may have attended their suppression was more than compensated by the activity and influence of the three great German universities which were born in the 19th century.

Munich, after having been completely reorganized, soon became a distinguished centre of study in all the faculties, and its numbers, allowing for the wars of 1866 and 1870, continuously increased. The eminence of its professoriate, among whom were J. J. I. von Döllinger, Justus von Liebig, Friedrich von Schelling, K. Zeuss and W. von Giesebrecht, attracted students from all parts of Europe.

The University of Berlin, known as the Royal Friedrich Wilhelm university, was founded in 1809, immediately after the peace of Tilsit, when Prussia had been reduced to the level of a third-rate power. It incorporated the famous academy of sciences. Wilhelm von Humboldt, supported by Frederick William III, adopted for it principles which not only raised it to a foremost place among the universities of Europe but also largely conduced to the regeneration of Germany. Attachment to any particular creed or school of thought was expressly repudiated in favour of complete Lehrfreiheit ("teaching freedom"). Each teacher presented freely his own views. The growth of the university was astonishing: before the end of the 19th century it had more matriculated students than any university except Vienna

The University of Bonn, founded in 1818, also by Frederick William III, became known as the Rhenish Friedrich Wilhelm university. It was the king's design to introduce into the Rhine provinces the classic literature and the newly developed scientific knowledge of Germany proper. Accordingly, he summoned to his aid the best available talent, including B. G. Niebuhr and A. W. von Schlegel, with C. F. Nasse in medicine and Georg Hermes in theology. In the last-named faculty Bonn combined the opposed schools of theological doctrine of the Evangelical (or Lutheran) and of the Roman Catholic churches.

The German universities underwent considerable changes as a result of the compulsory military service required by the law of 1867, and the events of 1870 were not unconnected with the martial spirit that had been evoked in the student world.

The Low Countries. — The settlement of Europe in 1814–15 created the "Kingdom of the Netherlands" comprising Holland and Belgium. The universities of Franeker and Harderwijk were suppressed and those of Ghent and Liege created in 1815, and a uniform constitution was given to Dutch and Belgian universities. It was provided that there should be attached to each a board of curators, consisting of five persons "distinguished by their love of literature and science and by their rank in society," to be nominated by the king. At least three had to come from the province in which the university was situated. When in 1830 Belgium was created as a separate kingdom, further changes took place there. From Louvain, the chief Catholic centre, the faculties of law, medicine and philosophy had already, in 1788, been moved to Brussels; in 1834 Brussels was constituted a free and independent university with a new fourth faculty of natural science. Having, however, no charter, it continued incapable by law of possessing property. Louvain and Brussels came to represent the two chief political parties in the realm, while the universities of Ghent and Liege recruited their students mainly from the two chief language groups, the Flemish and the Walloon. In Holland, where no such marked differences existed, the universities of Groningen, Leyden and Utrecht were in 1876 assimilated in constitution, each being administered by a consistory of five rectors with a senate composed of the professors in the respective faculties. The opening of the Free University of Amsterdam in 1880 more than repaired the loss of Franeker and Harderwijk, particularly as the progress of this new centre during its first ten years was remarkably rapid.

Scandinavia and Iceland. — The University of Christiania (now Oslo) in Norway was founded in 1811 as a state institution yet given self-government by a collegium academicum. It had at first four faculties, theology, law, medicine and philosophy; in 1860 the last was divided into the faculties of letters and science. Women gained admittance in 1882, and the first woman professor was appointed in 1912. In 1910 the Norwegian Institute of Technology was opened at Trondheim. No new universities were founded in Sweden, though institutions at Göteborg (1887) and Stockholm (1877) achieved something of university status. In Finland, the University of Abo was moved to Helsingfors (Helsinki) in 1828. In 1911 the University of Iceland was created by bringing together schools of theology (1847), medicine (1876) and law (1908). The university is probably unique in having been conducted for the first 29 years of its life in the parliament building (*Altingishus*).

Switzerland.—In Switzerland the universities shared in the conflicts handed down from the days when the Helvetic republic was first created. In 1832, Basle having joined the League of the Catholic Cantons, the Confederates divided the canton into two and agreed to raise the flourishing Hochschule, which already existed at Ziirich, to the rank of a university—a measure which may be said to mark a turning point and a new epoch in the history of higher education in the republic. The gymnasium of Berne, originally established under the teaching of Ulrich Zwingli, developed, in 1834, into a university with all the faculties. As early as 1586 Lausanne had been a noted school for the education of Protestant ministers, but it was not until 1806 that chairs of philosophy and law were established, to which those of natural science and literature were added in 1836 and, somewhat later, that of medicine. Not, however, until 1891 was Lausanne formally constituted a university. At Geneva the famous academy of the 16th and 17th centuries, long distinguished as a centre of Calvinistic teaching, became merged in 1876 in a university, where the instruction was given mainly in the French language. With this was also incorporated an earlier school of science in which H. B. de Saussure and A. P. de Candolle had once been teachers. Fribourg, founded in 1889, began with only two faculties, those of law and philosophy, to which one of theology was added in the following year. At Ziirich in 1872, and later at Geneva and Berne, women were admitted to lectures, and in 1892 were permitted to lecture.

Austria-Hungary.—The Austrian universities declined rather than advanced during the 19th century. Salzburg, founded in 1623, was suppressed in 1810. Throughout the first half of the century Vienna was in a depressed state; though its medical school attained an unrivalled reputation. its other faculties languished. Olmütz (Olomouc), founded in 1581, was closed in 1853. Lemberg. founded in 1774 by the emperor Joseph II, was in 1805 moved to Cracow, but in 1816 opened on an independent basis. In 1848 it lost by bombardment its buildings, library and natural history museum. Graz (1586) alone flourished. In 1875 Czernowitz university was founded. three years after that of Klausenburg (Cluj), the chief Magyar centre in Hungary. Zagreb, in Croatia, originally founded in 1669, was reopened in 1874.

Russia.—At the beginning of the 19th century Russia possessed only three universities: Moscow (1755), founded by the empress Elizabeth; Vilnius (1578), which was Polish; and Dorpat (Tartu) (1632), which was virtually German. Under the enlightened policy of Alexander I were founded the universities of Kharkov (1804) for New Russia, Kazan (1804) for the countries about the Volga but designed also for the populations of Finland and Siberia, and St. Petersburg (1819). Each of the foregoing six universities had a definite district assigned to it, and, as a further incentive to the pursuit of academic studies, a ukase promulgated in 1809 proclaimed that in all appointments to official posts throughout the empire the holders of university degrees would receive the first consideration. In 1835 the foundation of the St. Vladimir university of Kiev absorbed the university at Vilnius. Odessa, founded in 1865, was designed to be the university of New Russia. Although at St. Petersburg considerable attention was regularly given to the teaching of languages, especially those of Armenia, Georgia and Tartary, the general status of the Russian universities continued, throughout the greater part of the century, exceptionally low. In 1884 they were all reconstituted by the promulgation of a "universal code"; with this the statutes of the universities at Dorpat (1632) and Warsaw (1816) were essentially in agreement. The study of the Slavonic languages received a considerable stimulus, especially when, by a decree in May 1887, the use of the Russian language was made obligatory in all places of instruction throughout the Baltic provinces. During the ensuing 20 years the general influence of Dorpat rapidly spread far beyond the Baltic provinces. In 1889 the Russification of the university went far to deprive it of its claim to be considered German.

The University of Tomsk in western Siberia, founded in 1888, depended chiefly on a grant from the state, aided by private liberality.

Greece.—The University of Otho at Athens, founded by King Otho (Otto) in 1837, was modelled on the university systems of northern Germany. It originally included only four faculties, theology, jurisprudence, medicine and philosophy, to which one of applied mathematics was subsequently added. It was later renamed the National University of Athens.

Rumania, Bulgaria and Turkey.—The University of Jassy (1860) was founded by Prince Cuza of Rumania, and together with the newly founded University of Bucharest received its completed organization in 1864. Both were constituted state institutions and were represented in the senate, although not receiving any fixed revenues from the government. In the Kliment Ochridski university of Sofia (1888) in Bulgaria, faculties were established of history, philology, physics, mathematics and jurisprudence, the main object in view being the training of competent schoolteachers and lawyers and affording them the means of gaining an intelligent insight into the real wants of the native population. The University of Istanbul, founded 1453, was until the 19th century a religious school.

Mediterranean Lands.—The distracted state of Italy long prevented advance. In 1875, when the educational system was reformed, an attempt was made to assimilate the universities to the German pattern, but this policy was quickly reversed In 1890 four "free universities," Camerino. Ferrara, Perugia and Urbino, were created, and women were admitted. In Sicily the University of Palermo, founded 1779, was closed in 1805 but reopened in 1850 and became of considerable importance and size. The Sardinian universities, Cagliari (1596) and Sassari (1617) were similarly closed and reopened, but attained little eminence.

Spain.—Lifeless routine and unreasoning tradition characterized the Spanish universities until the second half of the 19th century. In 1857 the entire system of education was placed, as in France, under the control of the minister for public instruction. The kingdom was divided into ten university districts, each in the charge of a rector, and a precise plan of instruction was prescribed in which every hour had its appointed lecturer and subject. At every university philosophy, natural science, law and medicine were to be studied, but no provision was made for theology, this being transferred to the seminaries in the episcopal cities. In the same year the University of Manila in the Philippines was formally founded; it had been in existence for 250 years.

(J. B. Mu.; C. Br.; H. C. D.)

THE UNITED STATES

The origins of the universities in the U.S. are to be found in the colleges established in the colonies before the nation was formed. Nine such colleges were founded: Harvard college, 1636; College of William and Mary, 1693; Yale college, 1701; College of New Jersey, 1736; King's college, 1754; College and Academy of Philadelphia, 1755 (originated in a charity school trust created in 1740); Khode Island college, 1764; Queen's college, 1766; and Dartmouth college, 1770. In general, these institutions represented the arts course provided in the colleges of the universities of England, particularly at Cambridge and Oxford. The principal purpose of the colonial colleges was to train a class of learned men specifically ior the Christian ministry. although some of them aimed also at training a body of men in culture and knowledge for service in the state. The College and Academy of Philadelphia. in contrast with the other colleges, was founded on a broad plan of education. which included a considerable amount of mathematics, science, government and law. It established a medical department in 1765—the first in the country. Two years later King's college in New York city also opened a medical department.

From the American Revolution to the Civil War there was a spectacular increase in the number of new colleges established. During this period some of the older colleges came to be known as universities, and new institutions bearing the name were founded. The constitution of hfassachusetts adopted in 1780 refers to Harvard college as the "University at Cambridge." The College and Academy of Philadelphia, through legislative action, became the University of Pennsylvania in 1791, and in 1804 Rhode Island college was named Brown university. The names of three other colonial colleges were officially changed at later dates—Yale college to Yale university, 1887; the College of New Jersey to Princeton university, 1896; King's college to Columbia college, 1784. and to Columbia university, 191a—although all three operated as universities before these dates. Queen's college became Rutgers college in 182j and Rutgers university in 1924. The legislature of New Hampshire attempted in 1816 to take over Dartmouth college and make of it a state university, but a decision of the United States supreme court in 1819 stopped this action.

The state university, destined to become one of the important and characteristic types of U.S. higher education institutions, had its origin in the latter part of the 18th century: the University of North Carolina was provided for in the state constitution of 1776, chartered in 1789 and opened in 1795; the University of Georgia was chartered in 1785 and opened in 1801. The Indiana constitution of 1816 made it the duty of the general assembly "to provide by law for a general system of education, ascending in a regular gradation from township schools to a state university, wherein tuition shall be gratis, and equaily open to all." This statement represents the ideal of the state university—the capstone of the system of public education.

The most notable early example of the state university was the University of Virginia. which, through the influence of Thomas Jefferson, was established by legislative act in 1819 and opened in 1825. The model for the state universities, however, particularly those in the western states, was the University of Michigan, opened in 1841 and reorganized in 1850. The establishment of the state universities in the states carved out of the public lands in the west was greatly aided by grants of land from the federal government, beginning with the admission of Ohio into the union in 1803. The State University of New York, created by the legislature in 1948, was, at mid-20th century, the most recently established state university. It consisted of a number of state-owned institutions of higher education located at various places and of such new ones as might be established.

By the 1950s, all states except Pennsylvania maintained one or more state universities. Pennsylvania supports Pennsylvania State university, a privately controlled institution, and it gives also some financial assistance to several privately controlled universities, including the University of Pennsylvania. In addition, there are territorial universities. Distinguishing characteristics of the typical state university are: (1) creation and direct support by the state government; (2) control by a publicly appointed or elected board; (3) free or low tuition to students who reside in the state; and (4) provision for numerous educational services to the state in addition to instruction on the campus.

Thirteen municipal colleges and universities were established by mid-20th century: College of Charleston (S.C.); College of the City of New York, comprising four colleges; the universities of Akron, Cincinnati, Houston (district). Louisville, Omaha, Toledo and Wichita; and Washburn Municipal university of Topeka, Kan. These institutions are controlled and supported by the municipalities in which they are located.

A group of institutions which became a prominent feature of higher education in the United States are the land-grant colleges and universities. which numbered 68 in 1957. About 200 colleges for aomen had also been established by mid-century. (See WOMEN. EDUCATION OF.)

As large personal fortunes were amassed in the United States another type of university was established—that endowed by individual munificence. Among these universities (with date of original founding) were: Tulane (1834). Emory (1836), Duke (1838), Cornell (186j). Vanderbilt (1873), Johns Hopkins (1876), Stanford (1885) and Chicago (1890). Other highly endowed institutions were the Massachusetts Institute of Technology, founded in 1861 and opened in 1865; Rice institute, 1912; Carnegie Institute of Technology, 1900; and California Institute of Technology, 1891. A number of the older universities also became the recipients of large endowments, among them Columbia, Brown, Dartmouth (college), Harvard, New York, Northwestern, Pennsylvania, Princeton, Rochester. Washington, Western Reserve and Yale. A few state universities likewise acquired large endowments, some from private and some from public sources, among them California. Michigan, Minnesota, Texas, Virginia and Washington. The endowments of these 30 institutions at mid-century ranged from $24,784,000 (Brown) to $450,461,000 (Harvard), the average being $88,123,408. When the federal government was organized, some leaders of the nation desired the establishment of a national university, and subsequently numerous proposals for such an institution were placed before congress, but none was enacted into law. Some of the federal interests are served through institutions maintained by the federal government, such as the United States Military academy; other federal interests are served through certain relationships established with higher education institutions through grants-in-aid, payment for contracted services and loans for the construction of housing for students and faculty members.

Control and Organization.—Some universities are publicly controlled—by a state, a municipality or a district. Others are controlled by private organizations, which usually receive their charters from the states in which they are located. In general, each university is under direct control of a lay board, usually known as a board of trustees, although other titles, such as board of regents and board of directors, are also used. Boards of publicly controlled universities are elected by the voters of the state or the municipality which maintains the institution, or they are chosen by a governmental official or agency. In a few states all the state institutions of higher education are controlled by one board. as in Georgia and Oregon. The members of the boards of privately controlled universities elect persons to fill vacancies; such boards are known as self-perpetuating. The members of the boards that control church-related universities are, in many instances, elected by the religious organizations which maintain the institutions. For many universities the alumni elect some members of the boards of trustees. Most of the Roman Catholic institutions are controlled by the religious orders, though some are under diocesan control.

The actual administration of a university is assigned to administrative officers employed by the board of trustees. Usually the principal officer is called president or sometimes chancellor. He has a heavy responsibility and large authority in the direction and management of the institution. Among his principal assistants are vice-presidents, directors, deans and business managers. The various colleges and schools of the university are in charge of deans, who have large responsibility for such matters as selection of faculty members, leadership in development of the curriculum and improvement of the quality of instruction. Each college or school is organized in departments or divisions, or both, the division being the larger unit. In most universities the faculties have considerable control over educational policy, especially matters relating to admission requirements, organization of the curriculum and requirements for degrees; in the larger universities this control is usually delegated to a smaller group selected entirely or partly by the faculty or by instructional staff members holding certain positions. In the universities the academic year of approximately nine months usually begins in September or early October and ends the latter part of May or early June. The academic calendar is arranged on the semester plan under which the academic year is divided into two equal parts, each of which is called a semester; or it is arranged on the quarter plan under which the academic year is divided into three equal parts, providing terms or "quarters" of about three months in length. Most universities are open also for summer sessions. Some of these students in the summer sessions attend the universities during the academic year; others are teachers of elementary and secondary schools and colleges who are employed and attend only during the summer.

Educational Programs. — Admission to the university generally presupposes the completion of 12 years of elementary and secondary education or the equivalent of such education as measured by some form of entrance examination. Admission is by an examination or by a certificate which attests the satisfactory completion of an educational program in an approved secondary school. In addition to these two means of selection most institutions use also a number of others, among them psychological tests, personal interviews, and confidential information about the applicant's character and moral qualities. At the centre of the typical university in the United States is the college of arts and sciences. Students enter it upon completion of secondary education. The curriculum, which is four years long, leads to the bachelor's degree — bachelor of arts or bachelor of science. The college of arts and sciences offers a program of education for students who take all their nork in the arts and sciences, and provides a considerable amount of instruction to students who are registered in the professional schools of the university. The curriculum is usually so arranged as to require the student to obtain a general knowledge of a number of fields and more highly specialized and advanced knowledge in one or two fields.

Most of the formal professional education in the United States is acquired in the universities, where it is organized in various patterns. Much of it consists of four-year programs which students enter upon completion of secondary education and which end with attainment of the bachelor's degree. Examples are agriculture, business administration, education (preparation of teachers of elementary and secondary schools), engineering, fine arts, forestry. journalism and pharmacy. The degrees conferred for the completion of study in special fields frequently carry designation of those fields, as bachelor of education, bachelor of fine arts and bachelor of business administration; or as bachelor of science in education. bachelor of science in engineering, bachelor of science in pharmacy; or as bachelor of arts in education, bachelor of arts in business administration.

There is a tendency to lengthen programs of education for the professions. This is usually done by including, as an entrance requirement of the professional college or school, the completion of a specified amount of study in a college of liberal arts or a college of arts and sciences. As an example, three years of college work constitute a minimum for admission to the study of medicine. The medical curriculum is four years long. The educational patterns in some other fields are: dentistry, two years in college and four years in the school of dentistry; veterinary medicine. two and four; law. three and three or two and four. For admission to professional training in several fields, possession of a bachelor's degree is a prerequisite, and the professional curriculums range in length from one to three years; examples are hospital administration, public health, social work and theology. The first degrees conferred for the completion of curriculums in these professional fields are doctor of medicine, doctor of dental surgery or doctor of dental medicine, bachelor of laws, doctor of veterinary medicine, master of hospital administration (master of business administration, master of science in some schools), master of public health and doctor of public health, master of social work and bachelor of divinity.

All universities, except those that are universities in name only, provide programs of advanced study leading to graduate degrees. Such study is usually supervised by an administrative division known as a graduate school, which establishes and enforces policies and standards for advanced work. The instruction. however, is usually carried on by the regular departments of the university. In some universities the graduate work in professional studies is carried on by the professional schools independent of the graduate school. As a prerequisite for admission to graduate study a student must present a bachelor's or a first professional degree or the equivalent.

The principal purposes of graduate education are: to prepare college and university teachers; to prepare specialists in the various professions; and to prepare students to carry on research. Graduate study also prepares teachers of elementary and secondary schools for better service. Programs of graduate study consist of (1) specialized and advanced courses aimed at broadening and deepening the student's knowledge in one or a few fields and (2) independent study and research, largely original in character, intended to develop ability to do research in a particular field. The degrees conferred for graduate study are the master's degree, usually master of arts or master of science, and the degree of doctor of philosophy. The master's degree is usually obtained for one academic year of graduate work as a minimum; three or more years of study are required for the doctor of philosophy degree. Other types of doctoral degrees comparable with the doctor of philosophy are the doctor of science and the doctor of education. These degrees should not be confused with the doctor of laws (LL.D.), doctor of humane letters (L.H.D.), doctor of letters or doctor of literature (Litt.D.), doctor of divinity (D.D.) and other doctoral degrees which are conferred by colleges and universities as purely honorary distinctions.

Other Services. — Research is an important part of the work of the universities. Some of it is carried on by individual faculty members as a part of their effort to improve themselves and gain professional recognition and advancement. 4 considerable part of the research, however, is organized in projects for ahich funds are appropriated to pay the costs. The land-grant colleges and universities maintain agricultural experiment stations, and many colleges of engineering carry on research through their engineering experiment stations. Within a number of universities research institutes have been organized to promote specific types of investigations.

Research in universities is supported from university funds and from funds supplied by foundations, scholarly and professional societies, commercial concerns, state agencies, the federal government and individual donors. The financial assistance takes the form of fellowships and grants-in-aid to mature students and faculty members. and grants and contract payments to the universities. During the year 1953–54 (as an example). $372,643,000 was spent in organized research by higher education institutions.

Research in universities results in the preparation of many scholarly and scientific articles, monographs and books. To facilitate publication of such materials a number of institutions, beginning with Cornell university in 1869, established university presses. In addition to books, these presses publish a number of scholarly periodicals.

Many universities extend their educational services to persons who cannot go to the institution for regular residence instruction. These services are usually grouped under the category of extension work (see UNIVERSITY EXTENSION), which includes home-study or correspondence courses. extension classes, short courses and various minor activities. The co-operative agricultural and home economics extension work carried on by the land-grant colleges and universities is supported partly by the federal government.

Statistical Data. — The *Education Directory* for 1956–57 published by the United States office of education of the department of health, education and welfare, listed 1,886 institutions of higher education in the United States. Of this number, 228 bore the name university, but perhaps one-third of these were universities in name only and should more appropriately be called colleges.

In the fall of 1955 the enrolment in institutions of higher education was 2,720,929. Of this number 1,241,101 students were enrolled in 141 universities. (Universities, as defined by the office of education for statistical purposes. are "those institutions of large and complex organization in which several professional schools and colleges, not exclusively technical, are incorporated within the administrative framework of the institution.") The other 1,479,828 students were enrolled in smaller universities and liberal arts colleges, teachers colleges. institutes of technology, technical institutes and other institutions. The largest enrolment in one institution was 38,594; 44 universities and colleges enrolled more than 10,000 each. Graduate students comprised approximately 9% of the enrolment. The numbers of earned degrees conferred by all higher education institutions during the academic year 1954–55 were: bachelor's and first professional. 287,401; master's and second professional, 58,204; doctor's, 8,840.

The amount expended in 1953–54 by all higher education institutions for educational and general purposes, including research but not including expenditures for plant expansion and for noneducational purposes. was $2,271,296,000. At many of the institutions the expenditures ran into millions of dollars; as examples: the University of Illinois $46,946,000; The University of Chicago, $48,819,000; the University of Minnesota. $37,089,000.

The funds which the institutions of higher education received for educational and general purposes during the year 1951–52 were from the following sources: state governments, 32%; student fees, 24%; federal government, 18%; private benefactions, 8%; endowment earnings, 5%; local governments, 4%; others, 9%.

The universities, particularly the larger ones, possess extensive libraries. The book collections of 18 run to more than 1,000,000 volumes each. Some of the largest are: Harvard, 5,956,000; Yale, 4,280,000; Illinois, 2,889,000; Michigan, 2,325,000; Columbia, 2,117,000. (L. E. BH.)

SOUTH AND CENTRAL AMERICA

The achievement of independence by the Latin-American states was. in some instances at least, accompanied by measures of educational reform. Betn een 1821 and 1832 nine universities were founded or refounded and survived the many and grievous troubles which wracked the continent throughout the 19th century.

In Peru. Trujillo (1824), founded by Simón Bolivar; Arequipa, raised in 1827 from academy to university status; and Cuzco (founded 1696), uhich was in the same year transformed from an ecclesiastical to a lay foundation and made open to all, became centres of considerable intellectual activity. In Colombia the foundation of the University of Xntioquia at Medellín in 1822 nas folloned by those of Cartagena (1824) and Popayán (1827). In Argentina arose Buenos Aires (1821). and in Bolivia. La Paz (1831) and Cochabamba (1832). Round the mid-19th century there was a second cluster of foundations. The University of Montevideo in Uruguay dates from 1849. though it became important only when a medical school was added in 1876. In 1843 the University of Costa Rica was founded at San José, and in 1867 the University of Cuenca in Ecuador. In 1842 the century-old University of Havana was reorganized; its subsequent history for 60 years was unhappy. until in 1900 it was refounded with U.S. aid. In 1843 the University of Santiago in Chile (1738) was nationalized, as was also in 18j6 that of Cordoba in Argentina (1613). The closing years of the century were also marked by new foundations: La Plata (1890) in Argentina (to be reopened in 1905–08 under the auspices of the University of Philadelphia). the Catholic University of Chile in Santiago (1888), the National University of Paraguay at Asunción (1889) and the University of Guayaquil in Ecuador (1867) among others.

THE FAR EAST

China.—Until nearly the end of the 19th century public education in China consisted almost entirely of study of the classical texts. But some education on western lines had been introduced nearly half a century previously. In 1852 Roman Catholic missionaries founded a college to train Chinese as priests. Protestant missions followed suit, and Americans in particular began to found institutions of university status which were open to all. Meannhile, in 1861, the government opened two colleges. at Peking and Canton, for the study of foreign languages, and about 25 years later began to send young Chinese abroad to foreign universities. In 1902, after the Boxer rising, the government embarked on thoroughgoing educational reform and in the same year founded the National University of Peking. incorporating in it the foreign-language colleges. By 1910 an imperial university had been established, in name at least, in every one of the 18 provinces.

Japan. — On the reopening of communication with the west Japan began eagerly to absorb western learning. In 18j7 the government founded "a place for studying foreign books" and a "school for acquiring foreign medical art." To these in 1862 a college for the study of European science mas added. In 1871 a system of compulsory education was introduced, and in 1877 the Imperial University of Tokyo was founded. By 1910 three other universities (all much smaller) had been established: Kyoto (1897), Tohoku (1907) and Kyushu (1910).

WORLD WARS I AND II AND AFTER

The pears following 1914 saw a huge increase in the number of universities. Excluding the U.S.. about 250 new foundations had been recorded by the late 1950s, or rather more than one for every two universities functioning in 1914. During the same period new faculties, schools and research institutes were added in profusion at both old and modern universities. and the numbers of students and staff multiplied at an unprecedented rate. Yet the demand for admission was hardly anywhere satisfied.

It would be wrong to attribute this amazing growth solely, or even largely, to the effect of two world nars, though each proved a powerful stimulant. The growth derived from forces set in motion long before the outbreak of World War I. forces which were working themselves out in a world-wide social and economic revolution.

ASIA

China. — By far the largest increase in the number of universities took place in Asia. Including those in the U.S S.R., there were about 150 new foundations. Of these, a quarter or more took place in China. There, in 1912, a universities law was passed making the college of liberal arts and sciences the nucleus of the university. whose purpose was declared to be "to cultivate scholars and prepare men for the service of the state." By 1925 there were said to be 47 institutions of university status in China, and by 1937 (when Japan attacked China). 108. Probably fewer than half would have qualified as universities in the western sense.

Between 1937 and 1945 China wrote an immortal chapter in university history. Many of the major institutions, situated in coastal areas. were early exposed to the iull blast of invasion. Their buildings destroyed, damaged or occupied. staffs and students migrated westward, carrying with them what they could of books and equipment. More than 80 institutions are said to have thus sought security during the first year of the war; during the following seven, many universities nere compelled to move again and again. usually on foot and often across mountainous territory. They suffered terrible privations and had to pursue their studies with little or nothing even of essential materials; but they held on. Academic standards inevitably deteriorated. When hostilities ended, arrangements were made for the universities to return home, and between May and October 1946 about 60 institutions. with more than 60.000 students, nere moved back. Scarcely had this happened before the tide of war began to flow over them again. to culminate in 1949 in the complete occupation of continental China by the Communists. Within three years all universities and colleges onned or administered by foreigners had been closed or absorbed into a reorganized and nationalized system of higher education comprising some 20 universities and a large number of institutions for advanced technical education.

Japan.—Between 1920 and 1945 about 35 universities were founded in Japan. These were of three kinds: imperial; other state universities; and private. The imperial universities had several faculties, the government universities one only. The private universities, about 25 in all. were about half and half multiple- and single-faculty institutions; most of them maintained their own preparatory schools to ensure a steady flow of entrants.

During World War II the buildings of tno-thirds of the universities were destroyed or badly damaged. In 1947, following advice from a U.S. education mission, the diet passed a school education law which provided for a four-year university system after the U.S. pattern. Under this all institutions for higher education which could .satisfy the University Accreditation association (founded for the purpose) nere to be organized into about 220 "new-type" universities — jo government. 20 public and 130 private.

Indonesia. — Following the attainment of independence, there were founded the universities of Gadjah Mada in Jokjakarta (1948), the Islam university of Medan (1952) and the private North Sumatra medical university (1952).

India.——In India. follow ing the government's 1913 resolution, universities were founded at Benares (1915) and Patna (1917), the former specifically to develop Hindu culture. Almost simultaneously two universities were started in Indian states, at Mysore (1916) and Hyderabad (1919), the latter, Osmania university adopting Urdu. the official language of the state, as the medium of instruction. Between 1917 and 1919 the organization of higher education in India was examined by the government's Calcutta University commission. Little change ensued at Calcutta, but from the recommendations sprang eight new universities: the Moslem university of Aligarh (1920); Rangoon (1920); Lucknow (1921); Delhi (1922); Nagpur (1923); Andhra (1926); Agra (1927); and Annamalai (1929). During these years Bombay, Madras and Allahabad were reconstituted. During the 1930s one university was founded, at Travancore (1937), but in 1943 another succession began which produced Utkal (1943), Saugar (1946) and Rajputana (1947).

After India's attainment of independence in 1947 foundations multiplied; they included Gauhati (1948), Jammu and Kashmir (1948), Indore (Madhya Bharat, 1948), Poona (1948), Baroda (1949), Roorkee (1949), Shrimati Nathibai Damoda Thackersey Women's university (1949), Karnatak (19jo). Gujarat (19jo), Santinekatan (Visva-Bharati, founded by Rabindranath Tagore in 1921 and given university status in 1951), Bihar (1952) and Andhra State university (Sri Venkateswara, 1954). The University of the Panjab was divided in 1947 after the partition of the Punjab. The Indian Panjab university was established at Solan.

Pakistan. — On the creation in 1947 of the dominion of Pakistan, the University of Panjab (1882) became two universities: West Panjab in Pakistan and East Panjab in India. The former became the University of the Panjab. The University of Dacca (1921), previously unitary, became affiliating. The University of Sind (1947) founded just before partition, was in 1951 moved to Hyderabad. New universities mere established at Peshawar (1950), Karachi (1950) and Rajshahi, in East Pakistan (1953).

Ceylon. — In Ceylon the Cniversity college (1921) and the Medical college (1870) amalgamated to become in 1942 the University of Ceylon, which in 1952 began to move into new buildings near Kandy.

Other.;. — Following the reports of commissions sent from England, the University of Malaya was founded in 1949 by the amalgamation of Raffles college (1928) and the King Edward VII college of Medicine (1905), and university colleges were established in the West Indies (in Jamaica, 1946), Gold Coast (Achimota, 1948), Nigeria (Ibadan, 1948), East Africa (Makerere in Uganda, 1949) and the Federation of Rhodesia and Nyasaland (Salisbury. 1952). In the Sudan, Gordon college, Khartoum. was raised to university status in 1951. All these institutions were largely financed by the British government. During the years after 1914 universities were also founded in Afghanistan (1946), Java (1947), Iran (1934), the Philippines (seven between 1921 and 1948), Siam (four between 1917 and 1943).

The Hebrew University of Jerusalem, begun in 1918 and formally opened by Lord Balfour in 1925, became the world centre of Jewish culture. Bar-Ilan university, the first after the establishment of Israel in 1948, opened in 1955.

U.S.S.R.—During the revolutionary period (1917–20), many of the republics founded national universities. Between 1922 and 1932 the Russian S.F.S.R. and other republics broke up their universities into separate specialist institutes, but the sharp lowering of standards of general culture led in 1932 to a reversal of this policy. The universities were reconstituted, at first with scientific faculties only, to which between 1934 and 1948 the humanities and law were added. During World War II many universities in the west were destroyed or seriously damaged; as they were freed from German occupation they were restored. In 195j, 34 state universities and numerous institutions for advanced technical instruction were listed in the U.S.S.R.

EUROPE

Both World Wars I and II temporarily checked university development. During World War II it was German policy in all the occupied countries to transform the universities into purely nazi institutions. Everywhere the policy met with determined resistance. open or underground. The Poles formed a secret department of education and culture and organized in Warsaw a "free Polish university" nhich enabled students to study and sit for degrees. By 1943–44 this had 2,000 registered students and was providing instruction in a score of subjects. In the Netherlands, where the universities of Leyden. Amsterdam and Nijmegen were closed, 80% of the students refused to sign a declaration of compliance with nazi desires. and uent underground. In Norway the University of Oslo nas closed in 1942, when 700 students mere arrested and deported. Many escaped into Sweden, which received refugees also from Denmark. Finland and the Baltic states and organized courses and examinations for them.

There was considerable similarity between processes of recovery after World Wars I and II, though that after the latter, having to rise from far greater depths of desolation, was on a much larger and more heroic scale. First, both mars, especially the second, stimulated the desire for increased facilities for secondary and higher education. As a result, universities everyahere were overcrowded to the breaking point. Second, both wars, but again especially the second, impressed upon the nations the necessity for widespread technological and administrative proficiency; consequently there was a rapid development of specialist institutes, for both teaching and research, mainly within or attached to universities. New faculties and schools arose in equal profusion: in the applied and social sciences. agriculture, commerce and the fine arts. Third the wars emphasized the urgent need for international co-operation at university level. Cultural conventions between nations facilitated the exchange of teachers and students. This development was particularly widespread after World War II, being stimulated not least by the Fulbright agreements. International conferences, courses and summer schools proliferated, being encouraged after World War I by the League of Nations and organized by such bodies as the Institute of International Education in New York city. and after World War II by the United Nations Educational. Scientific and Cultural organization and, for example, the Association of Universities of the British Commonwealth and the British council.

After World War I. several new universities were set up in the newly established states of Czechoslovakia. Finland, Poland, Rumania, Yugoslavia and the Baltic republics; elsewhere, except in Italy under *Benito Mussolini*, only an evolutionary development took place, illustrated, for example. by the promotion of Reading (1926) in England and the foundation of Hamburg (1919) in Germany. After World War II there was a similar outcrop in the east, chiefly in Poland and Rumania, in Turkey the University of Ankara was founded (1946) and Istanbul (1944), the latter a technical university. For political reasons Berlin acquired three new universities: the British raised the famous Charlottenberg Institute of Technology to university rank (1946). the Americans founded the Free University of Berlin (1948) and the Russians the University of Potsdam (1948). The French reopened the ancient University of Mainz (1946), closed for a century and a half. Other foundations in western Europe were Nottingham (1948), Southhampton (1952), Hull (1954), Exeter (195j) and Leicester (1957) in England and Bergen (1948) in Norway, all elevations of long-established institutions. In England the experimental University College of North Staffordshire was founded in 1949 with a four-year first degree course including an initial year of general studies and less intense specialization thereafter than normally occurs in English universities.

LATIN AMERICA

Brazil. — Brazil and Mexico contributed almost half of the new universities, about 50 in number. founded in South and Central America between 1914 and the mid-1950s.. Brazil's first university, at Parana. was set up in 1912; 40 years later the country had 11. By a law passed in 1931, every university must have a law school, a medical school and either a school of engineering or philosophy.

Mexico. — The rapid growth of universities in Mexico refleeted the intensive attention given to public education after the 1910 revolution. In May of that year the ancient Royal and Pontifical University of Mexico (founded 1551) was reorganized as the National University of Mexico. In 1929 it was granted virtual autonomy and became the model for all the state universities, of which there were 11 in the mid-1950s. In 1933, the students at the state university of Guadalajara went on strike against state control and after several months forced the government to agree to found autonomous universities. Thereupon they organized the Autonomous University of Guadalajara, inducing teachers to serve without pay, until the university was recognized in May 1935. In 1943 a private women's university was founded in Mexico City providing courses in letters, law, science and special subjects.

Colombia.—In Colombia as in Mexico there was a determined effort to raise the general standard of education. A law passed in 1934 decreed that not less than 10% of the government's revenue was to be expended on education. Within the next six years four new universities had been set up, and by 1955 there were altogether ten in the country. All enjoy considerable autonomy, though all must conform to the statutes of the National university at Bogotá.

Other Countries.—Universities were also founded after 1914 in Argentina, Bolivia, Chile, Costa Rica, Ecuador, Panamá and Peru.

Cuba.—Between 1946 and 1948 Cuba increased the number of its universities from one to five: in 1946 the Catholic university, Havana, the first private university in the republic, was approved by the church; in 1947 and 1948, respectively, the universities of Oriente and Santa Clara were founded; and in 1947 the Junior college of the private Havana Business academy became an independent university.

AFRICA

Union of South Africa.—After long discussions on the replacement of examining by universities by teaching ones, the South African parliament in 1916 passed three acts whereby the University of the Cape of Good Hope became the University of South Africa, with headquarters at Pretoria; the South African college became the University of Capetown; and the Victoria college, Stellenbosch, became the University of Stellenbosch. In 1922 the University college, Johannesburg (formerly the Kimberley School of Mines), became the University of the Witwatersrand; in 1930 Transvaal University college became the University of Pretoria; and in 1948 Natal University college the University of Natal. In 1945 the Pius XII Catholic University college at Roma in Basutoland was founded, the first Roman Catholic university establishment for Negroes in the world. In the 1950s it became the government's policy to enforce *apartheid* by excluding coloured students from white universities. In 1957 a bill was approved in parliament to this end.

AUSTRALASIA

Australia.—In 1930 Canberra University college was constituted, "pending the establishment of a teaching university in Canberra." Its function was to provide courses for degrees in co-operation with one or more of the existing universities. In 1946 the commonwealth parliament passed the Australian National University act to establish at Canberra a university providing especially for postgraduate study and research. Building began in 1949. By 1952 all its four research schools (medicine, physical sciences, social sciences and Pacific studies) were at work.

In 1947 the New South Wales government set up a development council to create a university providing facilities for undergraduate, graduate and research study in technical subjects. The New South Wales University of Technology began work in March 1948 and was incorporated by the state parliament in April 1949. In 1954 the university college at Armidale, N.S.W., was detached from Sydney university to become the University of New England.

New Zealand.—In 1926 the University of New Zealand became a federal body including four constituent colleges (Otago, Canterbury, Auckland, Victoria) and two associated agricultural colleges.

(J. B. Mu.; C. Br.; H. C. D.)

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(H. C. D.)

UNIVERSITY ARCHITECTURE: *see* Educational Architecture.

UNIVERSITY CITY, a suburb of St. Louis, Mo., U.S.: *see* St. Louis.

UNIVERSITY COLLEGES. A characteristically British invention, university colleges are chartered institutions organized like universities and doing university work but (with two exceptions) lacking the power to grant degrees. The term was first given exact significance in 1889, when the British parliament made grants to various colleges on condition that they did work of university standard. University colleges are usually regarded as undergoing apprenticeship for promotion to university rank.

In the mid-19th century desire to promote higher education in industrial areas stimulated civic effort and private benefaction, and the unique constitution of the University of London as a body empowered to examine degree candidates anywhere provided the opportunity for university studies. If King's college, London (1829), and University college, London (1826)—originally the only institutions qualified to prepare students for London degrees—be excepted, the first university college was Owens college, Manchester, opened in 1851. It accepted students to read for London degrees. In 1880 it became a college of the newly created Victoria University of Manchester, which affiliated in 1884 Liverpool university college (founded in 1881 by the citizens of Liverpool) and in 1887 the Yorkshire college, Leeds. The federation lasted less than 20 years, all three colleges then becoming independent universities.

Growth to university college status—only to be achieved by royal charter—was in the earlier days usually by amalgamation or adaptation of earlier institutions. Mark Firth, a Sheffield steel manufacturer, founded Firth college (1879), which united in 1897 with the local medical and technical school to form University college, Sheffield. Firth's interest had been quickened by Cambridge university extension lectures held in Sheffield. The university colleges at Bristol (1876), Nottingham (1881), Reading (1892) and Exeter (1901) also originated from extension lectures. Leeds and Birmingham began as exclusively scientific institutions, the former as the Yorkshire College of Science (1874), the latter as Mason college (1880). Southampton, opened in 1862 as the Hartley institution, experienced chequered fortunes before becoming 40 years later the Hartley University college (became University of Southampton in 1952). Hull, on the other hand, came full-fledged from birth (1927) on a magnificent donation of £250,000 from T. R. Ferens. The University College of Wales, Aberystwyth, was created in 1872 by an enthusiastic national movement, and Welsh patriotism later added university colleges at Bangor and Cardiff. The three colleges were federated in 1893 as the University of Wales. In 1920 a college at Swansea was added to the university. A much earlier Welsh foundation. St. David's college, Lampeter (opened in 182j), is still outside the university though it has since 1852 been empowered to grant first degrees.

The only recognized university college having this right is the University College of North Staffordshire, near Stoke-on-Trent, founded in 1949. This college offers a four-year course. The first year is occupied by "foundation studies" surveying western civilization, society and science. Thereafter students must study at least five subjects. As this original scheme did not fit the regulations for London degrees, the college was empowered to award B.A. degrees.

By 1957 all university colleges in England had attained university status, except North Staffordshire, and their dependence on London university for their degrees ceased. In Northern Ireland, Magee University college, Londonderry (186j), is affiliated to the University of Dublin (Trinity college) for the award of degrees (although a few of its students read for those of Belfast).

The University of Ceylon (1942) spent 20 years as a university college. Canberra University college, Australia (1930), prepares students for the University of Melbourne degrees. Until 1954, when it became a university, the New England University college, at Armidale, New South Wales, was an outlier of the University of Sydney. After World War II the British government promoted six university colleges in colonial territories: Gold Coast, at Achimota (1948); Ibadan, Nigeria (1948); East Africa (Makerere college) at Kampala, Uganda (as university institution 1950); West Indies, in Jamaica (1946); Southern Rhodesia, at Salisbury (1953); and Anglo-Egyptian Sudan, at Khartoum (1951). All are in a special sponsoring relationship with the University of London, whose degrees their students take. Other autonomous colleges mainly or wholly devoted to university work but dependent upon another university for their degrees are bhe University College of Fort Hare. South Africa (1916), which prepares students for the degrees of Rhodes university, Grahamstown, S. Afr.; and Pius XII Catholic University college, Roma. Basutoland (1945), whose students take University of South Africa degrees. Both are for Africans. (H. C. D.)

United States.—In the United States, this term is used by a number of the larger universities as a name for their evening divisions for adult students. (See UNIVERSITY EXTENSION.) University colleges are typically in large cities and have varied curriculums including both degree-granting and noncredit programs. Their nearest approximation in the United Kingdom is Birkbeck college of the University of London. (H. G. RY.)

UNIVERSITY COURTS, in the English universities of Oxford and Cambridge, courts of inferior jurisdiction, administering the form and procedure of the canon lam.

At Oxford the chancellor, in 1244, acquired jurisdiction over actions of debt and actions affecting movables in which one party was a clerk; in 1275 over all personal actions in which either party was a member of the university, and in 1290 over all crimes, except homicide and mayhem. The chancellor. vice-chancellor and the vice-chancellor's deputy are justices of the peace for Oxford, Oxfordshire and Berkshire, where scholars are concerned. and so exercise jurisdiction under the Summary Jurisdiction acts. By the Oxford University act 1854, the procedure of the common Iaw was substituted for that of the canon law.

At Cambridge the chancellor enjoyed a jurisdiction similar to that of the Oxford chancellor, but limited to cases arising in the town and suburbs of the university. Previous to 1891, women of light character, who had been convicted of consorting with or soliciting members of the university *in statu pupillari,* were detained in a house of correction called the "spinning house." but in that year a conviction was held had (*ex parte Hopkins* [1891]), with the result that the clause in Elizabeth I's charter of 1561 giving power to imprison women was repealed.

See H Rashdall, *Universities of Europe in the Middle Ages (189;)*; D. S. Holdsworth, *Hist. Eng. Law* (1921). (H. H. L. B.)

UNIVERSITY EXTENSION, in its broadest meaning, includes all educational activities sponsored by an institution of higher learning for those persons (usually adults) who are not full-time students. As illustrated below, varying national practice sometimes causes the term to be given a more limited definition.

United States.—Throughout the 19th century, the many efforts by individual professors to carry knowledge to the general public were usually independent ventures not sponsored by the universities themselves. More sustained and systematic efforts did not begin until about 1885, when U.S. university leaders (most notably Herbert Baxter Adams, a historian of Johns Hopkins) became aware of the programs at Cambridge and Oxford. Several widely publicized and initially successful ventures were undertaken and soon many universities and colleges established extension committees and departments. In imitation of the English models. the early activities consisted chiefly of regular university lectures offered away from the campus. Since there was little adaptation to the needs and interests of mature students, interest soon palled; before long, many extension departments became little more than entries in university catalogues. Fortunately, however, much thought was being given to the expansion of higher education and some of the new institutional plans incorporated the idea of university extension. The most significant recognition came at The University of Chicago, whose first president, William Rainey Harper, had been an active leader in the earlier movements and in the Chautauqua institution. He included extension as an integral part of his design for the new university, incorporating provisions for off-campus centres, correspondence instruction and various other programs. In essence, the original Chicago plan represented a consolidation of the best elements of past experience. preserving it as a model for much of the widespread development which occurred later.

Soon after the beginning of the 20th century, a new interest in university extension began to be manifested, chiefly at the state institutions and most notably at the University of Wisconsin. In the same decade, Seaman Knapp and others demonstrated ways in which knowledge about scientific agriculture could be carried to farmers. The methods thus developed were incorporated into the Co-operative Extension service which, from 1914, became a distinctive function of the land-grant colleges. Somewhat later the urban universities, under both public and private auspices, began to offer educational programs for their communities. As a result of these and other influences, university extension gradually broadened in scope and function so that its services became myriad and the persons it influenced legion.

The core of extension remained the provision of group instruction. Formal lectures continued to play an important part but were supplemented by discussion groups, seminars, workshops and countiess other arrangements, both formal and informal, in which teachers or leaders worked with students. Sometimes groups mere widely scattered over a city, a state or a region, but often they were clustered together within centres. There was a marked growth of integrated programs designed to achieve goals far broader and deeper than could be accomplished in a single course.

Many other services also developed. Correspondence courses were provided in a great variety of subjects. Intensive short courses and conferences increased in number; some universities have special buildings designed to house them. Books, pamphlets, phonograph records, films and other communications materials were provided. Use of mass media (especially radio, the press and television) became widespread and some universities had film production units. Various institutions assumed other special functions such as the arrangement and judging of contests, the operation of lecture and concert bureaus, the administration of tests, the sponsorship of program planning services and the provision of assistance to communities to aid them in analyzing and solving their problems. Sometimes various methods mere combined to provide integrated services for special groups, among which are management, labour and the professions.

While university extension is an omnibus term covering all of the foregoing activities. it is sometimes used in more restricted senses: (1) Many institutions have developed special divisions to undertake this work and university extension sometimes refers only to the activities of such divisions, even though other parts of the institution may also sponsor similar activities. (2) University extension sometimes is used only in connection with those institutions of higher learning that have the word university in their titles. (3) The term occasionally refers only to large-scale and complex programs; efforts centred on a single kind of activity or organization, such as an evening college, may be excluded.

Because of these and other problems of definition and because most of the services concerned are provided for people who have reached their maturity. university adult education and continuing education mere being used in the second half of the 20th century increasingly instead of the older term university extension.

The National University Extension association is the most broadly based organization of extension workers. There are various other groupings of persons interested in special kinds of service; of these perhaps the Association of University Evening Colleges is the most active and best known.

In the United States there is no special organization of adult students corresponding to the Workers' Educational association in England. Universities in the United States usually accept full responsibility for scheduling activities and recruiting students, although sometimes they collaborate with other institutions and groups. Statistics as to the total number of persons served are largely meaningless because of the differences in length and intensity of contact of the various services. At many universities, however. the number of adults engaged in programs of instruction in the second half of the 20th century was already greater than the number of young people enrolled for full-time study on campus. The continuing increase in the scope and size of extension services seemed certain to cause fundamental changes in the conception and structure of U.S. universities.

Great Britain. — In the middle of the 19th century, the term university extension was used to designate the many current proposals to make Oxford and Cambridge more accessible to all classes of society. Included, for example, were the struggles to remove religious tests for admission and to grant entry to women. In the last quarter of the century, however, the English universities developed programs of lectures for adult audiences that aroused world-wide attention, and the term "university extension" gradually narrowed to designate only these efforts.

The first such program was established at Cambridge. James Stuart, a fellow of Trinity college, became convinced that scholars should go outside the jealously guarded walls of the universities to teach the men and women who had hitherto been denied an education. On his own initiative, he began in 1867 to offer courses on scientific subjects in northern and midland towns. Heartened by the success of his efforts and realizing the need for institutional sponsorship. he succeeded in 1873 in persuading Cambridge to accept responsibility for the provision of extension courses. The other universities soon followed this lead and, by the 1880s, extension mas flourishing in centres throughout England

The work developed on a lecture-course pattern. There were usually from 6 to 12 lectures in a series and they were delivered to audiences that averaged somewhat more than 100 persons but that were, on occasion, very much larger. The subjects principally taught were history, literature, music, economics and science. Classes for smaller groups were held after the lectures and the members of these classes were expected to do supplementary reading and to write papers. Most of the cost was met from fees or voluntary local contributions, but the universities paid part of the administrative expense.

In addition to its basic contribution of providing education for a large number of men and women, the university extension movement had other important consequences. It helped to establish higher education for women. The activities of several of the extension centres became the nuclei around which universities were developed. The program was studied by educational leaders in other parts of the world, particularly the United States, and served as a model for many similar efforts elsewhere.

The pattern of activities that was developed, however, proved to be chiefly suited to the middle class and not to the labouring people who were most in need of education. Both for this reason and because of the passing of the original leaders, the zeal and enthusiasm that had characterized the early days of the movement tended to disappear, and, by 1900, the work was settling into a rigidity of conception and form that made it less and less attractive to those concerned with adult education.

The failure of university extension to reach working-class audiences prompted Albert Mansbridge, a young clerk, to found the Workers' Educational association (W.E.A.) in 1903. His original hope was to instill new vitality into the extension movement by putting it more closely in touch with a strong and sympathetic organization of workers. In 1908, however, a new educational format, the tutorial class, was developed as a means of liberal education for adults. It is, in essence. a three-year program of close study on a single subject led by a tutor for a relatively small group of students who are expected to read extensively and to do written work. This pattern of activity became the focus of future university-W.E.A. relationships and soon achieved a dominant position in university adult education, although extension courses continued to be provided. The term extra-mural studies was used to describe both programs, and, as more and more universities developed organized units to handle the work, they were called extra-mural departments. After World War I, these departments developed rapidly and are now to be found in almost all British universities. Their work is in some measure co-ordinated by the Universities Council for Adult Education.

The tutorial course pattern has been modified in various mays, chiefly by the development of shorter courses, but its essential nature has been carefully preserved. Since new times bring new needs, the extra-mural departments at some universities, from 1945, experimented with new types of work that have been carried out under the name of extension. The old pattern of lectures to audiences continued but it was supplemented by a variety of other provisions, including diploma. certificate and study courses. These activities carried out independently of the W.E.A., were directed largely at professional people and others with a good general education. An increasing amount of work was in technologies and other subjects having a largely vocational interest.

Other **Countries.**—Elsewhere in the world, university extension has developed most fully in English-speaking countries, particularly Australia. Canada. Ghana. the Federation of the West Indies, New Zealand and the Union of South Africa. In some instances, following British practice, the term extra-mural studies is used. In every case, significant variations on the British or U.S. pattern have occurred as a result of the necessary adjustment to local conditions.

In the Scandinavian countries, adult educational programs developed in connection with several universities but with no organic relationship to them. Customarily these programs were operated and taught by university students. The popular (or people's) universities organized in some countries (notably Belgium, the German Federal Republic and the Netherlands) are not really universities at all but adult educational centres and therefore are not examples of university extension.

In the rest of the world, universities vary greatly in their provision for extension. In most of them, in the second half of the 20th century it was still related to the specific interests and concerns of individual professors or to the conduct of special programs and campaigns.

See also ADULT EDUCATION; CORRESPONDENCE INSTRUCTION.

See John R. Morton, *University Extension in the United States* (1953); Robert Peers, *Adult Education* (1958); *UNESCO, International Directory of Adult Education* (1953), *Universities in Adult Education* (1952). (C. O. H.)

UNIVERSITY PARK, a city of Dallas county, Tex., U.S., wholly surrounded by the city of Dallas (*q.v.*). University Park grew up around Southern Methodist university, chartered in 1911 and located on what was then a country knoll north of Dallas; instruction began in 1915. At first the school allowed houses around it to tie onto its artesian water supply and to the sewerage system which connected it with Dallas. By 1924 the community had outgrown these arrangements and in that year was incorporated as a city. The university's Georgian buildings occupy 150 ac. in the city's southeast quadrant. It includes a college of arts and sciences and schools of graduate studies, theology, music. law. engineering and business administration. Its downtown night college is one of the larger adult education projects in the United States. Its legal centre houses the Law Institute of the Americas. For comparative population figures *see* table in TEXAS: *Population.* (E. P. CR.)

UNRUH, FRITZ VON (1885–), German writer, was born in Coblenz of an aristocratic Prussian family. He joined the Prussian guard hut resigned his commission in 1912 when his first play *Offiziere* met with great success. His prose epic *Opfergang* (1916; English trans. *Way of Sacrifice,* 1928), which is the first written description of the battle of Verdun, expressed his revolt against militarism. His verse drama *Ein Geschlecht* (1917) dealt with passion and crime unleashed by the upheaval caused by the war; the sequel *Platz* (1920) preached a return to nature and expressionist ethics as the only cure. Unruh was regarded as one of the leaders of Expressionism. Later works include *Rosengarten* (1921), *Flügel der Nike* (1925), *Gandha* (1936), *Dcr nie verlor* (1945; English trans. *The End Is Not Yet,* 1947), *Der Heilige* (1950; English trans. *The Saint,* 1950). Unruh moved to France in 1933 and to the United States in 1940. In 1952 he returned to Germany. (A. GS.)

UNTERMYER, SAMUEL (1858–1940), U.S. lawyer, was born at Lynchburg, Va., on June 6, 1858. He was educated at the College of the City of New York and at the Columbia law school, and was admitted to the bar in 1879, practising thereafter in New York city. He was counsel in many celebrated cases covering almost every phase of corporate. civil, criminal and international law. As counsel for H. Clay Pierce he prevented the Standard Oil Co., after its dissolution in 1910, from dominating the Water-Pierce Co. In the same year he effected the merger of the Utah Copper Co. with the Boston Consolidated and the Nevada Consolidated companies. involving more than $100,000,000. In 1903 he undertook the first judicial exposure of "high finance" in connection with the failure of the U.S. Shipbuilding Co.. organized as a consolidation of the larger shipbuilding companies in the U.S. After this he conducted a number of similar exposures. In 1911 he delivered an address entitled, "Is There a Money Trust?" which led to the so-called Pujo money trust investigation by the committee on banking and currency of the house of representatives in 1912. Untermyer urged measures like the compulsory regulation of stock exchanges, reform of the criminal laws and the regulation of trusts and combinations. He took part in preparing the federal reserve bank law, the Clayton bill, the Federal Trade Commission bill and other legislation curbing trusts. He was a delegate to Democratic conventions and a strong supporter of Pres. Woodrow Wilson. who appointed him to serve on the commission which sat at Buenos Aires in 1916 to frame uniform laws for the Pan-American countries.

Untermyer acted for Gov. Alfred E. Smith in a water-power controversy over the Niagara, St. Lawrence river, Adirondack forest reserve and other hydroelectric power rights, resulting in the defeat of the grant of the water-power rights of the state to private interests. Untermyer died in Palm Springs, Calif., on March 16, 1940.

UNTERWALDEN, a canton of Switzerland, consisting of the basins of two streams, both called Aa, flowing into the Lake of Lucerne and divided into Obwalden and Nidwalden. The area of the canton is 296.4 sq.mi. Forests cover about 85 sq.mi. and glaciers occupy over 5 sq.mi. The highest point is the Titlis—10,627 ft.—south of Engelberg. As Obwalden includes this region, it is generally more mountainous than Nidwalden. The latter includes much more lake surface than Obwalden. The inhabitants are devoted to pastoral and, in a much less degree, to agricultural pursuits. In 1941 the total population was 20,110 in Obwalden and 17,346 in Nidwalden. and in 1950, 22,125 and 19.389, respectively, mainly German-speaking Catholics. The capital of Obwalden is Sarnen (pop., 1950, 6,199); and of Nidwalden. Stans (3,992).

A light railway was built from Lucerne to Briinig pass via the Sarner-Aa valley; an electric railway from Stansstad ascends the other main valley as far as Engelberg; and the mountain railways give access to the summits of Pilatus, Stanserhorn, Burgenstock and Seelisberg. Each area was organized as a single administrative district, with its own independent local institutions. In each "half" canton the legislature was composed of members elected by all male citizens of voting age.

In the church of Sachseln, on the Sarnsee were preserved the bones of the holy hermit, h'icholas Lowenbrugger (1417–87), known as Nicholas von der Flue, or "Bruder Klaus," while at Sarnen, nearby, several convents were established; the most famous of all the monasteries in the canton is the great Benedictine house of Engelberg (founded about 1120). Another site of historical interest is Stans, the birthplace of Arnold von Winkelried, the real or legendary hero of Sempach (1386).

History. — Historically, both Obwalden (save a small area in the Aargau) and Nidwalden were included in the Zurichgau. In both there were many great landowners (especially the abbey of Murbach and the Habsburgs) and few free men; while the fact that the Habsburgs were counts of the Aargau and the Zurichgau further delayed the development of political freedom. Both took part in the risings of 1245–47, and in 1247 Sarnen was threatened by the pope with excommunication for opposing its hereditary lord, the count of Habsburg. The alleged cruelties committed by the Habsburgs do not, however, appear in history until Justinger's *Chronicle,* 1420. On April 16, 1291, Rudolph, the future emperor, bought from Murbach all its estates in Unterwalden, and thus ruled this district as the chief landowner, as count and as emperor. On Aug. 1, 1291, Nidwalden (Obwalden is not named in the text of the document, though it is named on the seal appended to it) formed the "Everlasting League" with Uri and Schwyz (this being the first known case in which its common seal is used). In 1304 the two valleys were joined together. and in 1309 Henry VII confirmed to them all the liberties granted by his predecessor. This placed Unterwalden on an equal political footing with Uri and Schwyz, and as such it took part (1315) in Morgarten fight, in the renewal of the Everlasting League at Brunnen (1315), at Sempach (1386), and in driving back the Gugler or English free-booters (1375).

For physical reasons, it was difficult for Unterwalden to enlarge its territories. Yet in 1368 it acquired Alpnach and in 1378 Hergiswil. Also Obwalden shared with Uri in the conquest of the Val Leventina (1403) and in the purchase of Bellinzona (1419), as well as in the loss of both (1422). It was Nidwalden that, with Schwyz and Uri, finally won (1500) and ruled (until 1798) Bellinzona, the Riviera and the Val Blernio; while both shared in the conquests of the Aargau (1415), the Thurgau (1460) and Locarno, etc. (1512), and in the temporary occupation of the Val d' Ossola. In the Burgundian war Unterwalden, like the other Forest cantons, long hung back through jealousy of Bern but came to the rescue in time of need. In 1481 it was at Stans that the confederates nearly broke up the league for various reasons; and it was only by the intervention of the holy hermit, Nicholas von der Flüe, that peace was restored and the great federal agreement known as the compact of Stans concluded. Like the other Forest cantons, Unterwalden clung to the old faith at the time of the Reformation, being a member of the "Christliche Vereinigung" (1529) and of the Golden league (1586).

In 1798 Unterwalden resisted the Helvetic republic. but, having formed part of the short-lived Tellgau, became a district of the canton of the Waldstätten. Obwalden submitted at an early date, but Nidwalden, refusing to accept the oath of fidelity to the constitution, rose in revolt (Sept. 1798) and was only put down by the arrival of 16,000 armed men. In 1803 its independence as a canton was restored. but in 1815 the refusal of Nidwalden to accept the new constitution resulted in the transfer (1816) to Obwalden of the abbey lands of Engelberg.

UNTOUCHABLES, members of certain Indian castes which, though reckoned as Hindus, were excluded from the ordinary social and religious privileges of Hinduism. Under the constitution adopted by the Indian constituent assembly Nov. 26. 1949, "untouchability" was outlawed and persecution of untouchables made punishable by law. In Pakistan the constituent assembly accepted a similar statement in 1950.

How this caste came to be pushed out of, or never admitted within, the pale is obscure. Probably in the main they represented Dravidians of the lower orders, relegated to menial or unsavoury occupations; they must not be confused with the non-Hindu animists. the wandering and criminal tribes and the pre-Dravidians of the hills and forests. A mistaken aggregation with these latter sometimes led to their numbers being taken at 60,000,000. The population of untouchables proper seems to have been nearer 40,000,000. They are best defined as Hindus who were not allowed to enter ordinary Hindu temples and who supposedly caused pollution to ordinary Hindus either by touch or by proximity. The Brahman would not officiate at the events in life at which, in the case of other castes, his attendance was essential. The untouchables were compelled to live either in hamlets or wards of their own or in separate quarters. generally the unsanitary outskirts. of the villages. They could not use the village well, and there was always opposition to their children attending the village school. The indignities they suffered varied in different parts of India, being the worst in the south. where a fantastic code regulated the distance an untouchable must maintain from a high-caste Hindu on the public roads and the warning he must give of his approach. During their persecution, large numbers of untouchables adopted the religions of Islam or Christianity. (ME.; X.)

UPDIKE, DANIEL BERKELEY (1860–1941), U.S. printer and leader in the revival of traditional printing type faces in the United States, was born in Providence. R.I., on Feb. 24, 1860. In 1893 he established the Merrymount Press. In 1895 he revived the Scotch cut type produced by Alexander Wilson about 1835. He later acquired the 17th-century Dutch fonts of Janson and the matrices of the Mountjoy type, and he led in the revival of classical typography in the U.S. Special types, among them the Merrymount type, were designed by Bertram G. Goodhue and Herbert Horne. From 1910 to 1917 he was lecturer on printing in Harvard university. He was selected to print the Book *of Common Prayer* in the revision of 1928. His published works include: *On the Dedication* of *American Churches* (with Harold Brown; 1891); *Printing Types—Their History, Forms, and Use* (1922): In *the Day's Work* (1924). Also he edited: *A Dissertation Upon English Typographical Founders and Foundries* by Edward Rowe Mores; appendix by J. Nichols (1924), and *Notes* on *the Merrymount Press* (1934). Updike died Dec. 28, 1941.

UPHOLSTERY: *see* FURNITURE.

UPJOHN, RICHARD (1802–1878), U.S. architect and founder of the American Institute of Architects, was born in Shaftesbury, Eng., on Jan. 22, 1802. He came to America in 1829, settling first in New Bedford. Mass. (1833), and later in Boston (1834) and New York (1839). His first churches illustrate the early phase of the Gothic revival. His mature style began with Trinity church, New York (1839–46), whose significance lies in the purity of its Perpendicular Gothic style and even more in the deep liturgical chancel advocated by the Oxford movement. Thereafter, his many Episcopal churches were either Early English or Decorated in style. For poor parishes he published in *Upjohn's Rural Architecture* (1852) an unpretentious design in wood remarkable for its structural honesty and its liturgical character. He chose a modified Italian Renaissance style for secular buildings, In 1857 Upjohn founded the American Institute of Architects and served as its president until 1876. He died on Aug. 1:. 1878, in Garrison, N.Y.

See E. M. Upjohn, *Richard Upjohn, Architect and Churchman* (1939). (E. M. Us.)

UPPER AIR SOUNDINGS. In meteorology and upper-air physics, kites, aircraft, balloons and rockets are used to carry instruments aloft to put them into direct contact with the phenomena to be studied. The term soundings distinguishes these direct measurements of atmospheric phenomena from the more indirect observations made entirely with ground-based equipment.

Investigation of the upper air began in 1749 when Alexander Wilson attached a thermometer to a kite. With the development of the balloon in the late 18th century, scientific ballooning began with manned flights. Extensive application to research started in 1892 when Gustave Hermite and Georges Besançon began to use small unmanned balloons *(ballons-sondes)* carrying instruments. In 1894 Albert Rotch used large kites tethered by steel wire. but meteorological kite flying subsequently was virtually abandoned.

Between 1899 and 1902 balloon experiments led Richard Assmann and L. P. Teisserenc de Bort to the discovery of the stratosphere, and the first two decades of the 20th century saw an immense development of the balloon-sounding technique, yielding considerable information about the lowest 60,000 ft. of the atmosphere, In the period 1927–36 advances in radio techniques made possible the development of the radiosonde. This instrument, attached to a free balloon. sends radio signals that can be translated into numerical values of temperature, humidity and pressure. The results are immediately available to weather forecasters. an advantage that resulted in the adoption of the radiosonde to the practical exclusion of earlier methods, which depended on subsequent recovery of instruments dropped from balloons by parachute. During World War II and the decade immediately following, radiosonde techniques were further developed, radar was applied to wind measurements, meteorological instrumentation for aircraft was greatly advanced and the sounding rocket came into use.

Aircraft.—Aircraft are used extensively for weather reconnaissance, including hurricane patrol. Much of the data are measured and recorded automatically. The airplane aerograph used in some G.S. navy aircraft continuously presents on digital indicators ternperature, pressure. humidity and time data.

Balloons and Balloon-borne Instruments.— The usual neoprene meteorological balloons weigh from one-half to three pounds, are inflated with hydrogen or helium and carry pay loads of only a few pounds. Altitudes of 120,000 ft. can be reached, although a more representative height is about 90,000 ft. For special purposes there are giant balloons that displace hundreds of thousands or even millions of cubic feet and can carry instruments weighing hundreds of pounds to altitudes over 100,000 ft. An example is the "Skyhook" balloon, made of polyethylene plastic .001 to .002 in. thick.

The balloon-borne radiosondes are all basically the same. weigh two pounds or less and consist of a radio transmitter and antenna;

modulator; pressure, temperature and humidity-sensing elements; and battery power supply. The transmitter operates on a frequency of either 403 or 1,680 mc. and its carrier is pulsed at an audio-frequency rate determined by the electrical resistance of either the temperature or humidity-sensing element. These sensing elements. together with fixed-reference resistors, are sequentially switched into the modulator circuit. An aneroid pressure cell changes the sequencing of the sensing elements and resistors as the pressure changes, and the changes in the signal thus produced provide a means of determining the air pressure.

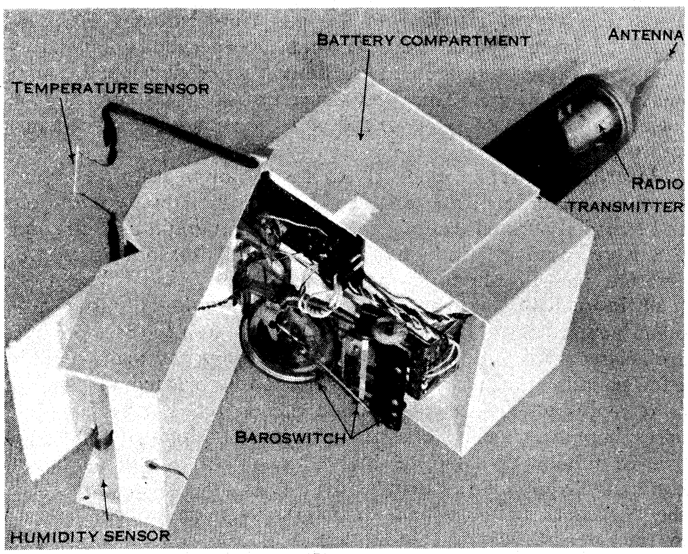
From the radio signal the ground equipment records the temperature and humidity as a function of time. Pressure is determined as indicated above. In the case of the simple radiosonde, the height of the balloon is estimated from the temperature, humidity and pressure data. The addition of direction-finding equipment at the ground station makes it possible to plot the position of the radiosonde transmitter and thus determine the direction and velocity of winds at various levels; such equipment is known as rawinsonde. Wind data in the upper atmosphere also may be gathered with standard radar sets or, visually, with the theodolite, a special telescope equipped with scales from which altitude and azimuth readings can be taken.

Constant-level balloons known as transosondes can be flown across oceans or uninhabited land areas to provide weather information otherwise unavailable. The balloon carries a radio transmitter which is tracked by radio direction-finding equipment. From the balloon trajectory. wind velocities and accelerations can be deduced and major air-mass features identified.

Rockets. — In the years following World War II the rocket was developed into an effective sounding vehicle. Hundreds of them were fired to study the properties of the atmosphere and the sun. on one occasion carrying equipment as high as 242 mi. Rocket sounding began in the United States in 1945 uith the WAC Corporal and continued with captured German y-2's. The Viking, Xerobee, Aerobee-Hi, Deacon. Cajun, Kike-Deacon, Nike-Cajun, Terrapin. ASP, WASP, Rockoon and Rockair were all developed in the United States specifically for research purposes. England developed the Skylark research vehicle. France the Veronique and Monica and Japan the Kappa and Sigma.

The basic air-borne rocket-sounding system consists of the rocket, electric power supply, measuring instruments, a radio telemeter, antennas. sometimes a radio-tracking transmitter and sometimes a parachute or other means of recovering equipment and records. On the ground are the firing range with its launching and tracking facilities and a telemetering receiving station.

Sounding rockets have been used extensively to study ultraviolet radiation and X-rays from the sun, ionospheric currents, low-energy cosmic rays. auroral particles, the chemical and ionic



BY COURTESY OF U.S. NAVY; OFFICIAL PHOTO

BALLOON-BORNE RADIOSONDE SHOWING ESSENTIAL PARTS

composition of the upper atmosphere, the earth's magnetic field at high altitude and the occurrence of micrometeorites. Other phenomena which can be measured indirectly from the earth's surface are better measured with rocket-borne instruments. These include atmospheric pressures, temperatures and densities; winds; ionospheric charge densities; airglow; and auroral light.

The WASP ("Weather-Atmospheric Sounding Projectile") was designed to be launched from a 5-in. naval gun and to deliver either a metalized parachute or "chaff" (thousands of tiny strips of aluminum foil) to a point from 100,000 to 150,000 ft. above sea level. The parachute or chaff is then tracked by radar to obtain data on upper winds.

Also developed in the U.S. was a means of obtaining information on upper winds and temperatures by ejecting grenades from a flying rocket and exploding them. The measured transit times of the sound waves from the points of explosion to an array of microphones on the ground are reduced by rather complex computations to the desired data.

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(H. E. SL.; J. E. DR.)

UPPER SIND FRONTIER, formerly the northern district of Sind, Pakistan, with administrative headquarters at Jacobabad (*q.v.*). When West Pakistan was made into one province in 1955, the district was renamed Jacobabad and became part of the Khairpur division.. Area 2.046 sq.mi.; pop. (1951) 345,080. It is watered by canals from the Indus. of which the chief are the Begari and Desert canals. Principal crops are millets, oilseeds, pulses, wheat and rice. The trade from central Asia into Sind crosses the district, bringing wool and woolen goods, fruits. carpets and horses. The district is crossed by the North-Western railway's Ruk-Jacobabad-Sibi branch (giving access northward to Quetta); and from Jacobabad a 2½-ft. gauge line runs northeast to Kashmor.

UPPER VOLTA, in French HAUTE-VOLTA, a former territory of French West Africa (*q.v.*) bounded on the west and on the north by the Sudanese Republic, on the northeast by Niger, on the southeast by Dahomey, on the south by Togo and Ghana, on the southwest by the Ivory Coast. Total area 105,839 sq.mi.; pop. (1955 est.) 3,324,969.

Volta is an immense plateau (ranging between 1,000 and 1,700 ft. above sea level) on which the Volta river (*q.v.*) has its sources. The climate and vegetation are Sudanic; there is a dry, cool season from November to February. a dry but hot season from March to May and a hot, rainy season from June to October; the vegetation consists of scrub with occasional clusters of trees.

Mossi (1,663,000) are the predominant race; they began establishing kingdoms in the area in the 14th century, the most important being that of Mogho Naba. with its centre at Ouagadougou. Other peoples, in the south and in the west. are the Bobo. the Gourounsi and the Lobi. who are far less orderly than the Mossi. There are also groups of Gourmantché, Peul, Senoufo and Marka. Overpopulation and the lack of natural resources cause a considerable number of workers to emigrate to the Ivory Coast and to Ghana. Millet is the principal food crop. peanuts and *karité* the major exports. Cattle amount to 1,300,000 head.

The Mossi country was explored by L. C. Binger in 1888; and Paul Voulet induced the kings to acknowledge a French protectorate in 1896. Cpper Volta was organized as a French colony in 1919, but dissolved in 1932. In 1947 it was reconstituted as an overseas territory of the French Union and in 1958 it became an autonomous republic within the French community. In 1960 Upper Volta became an independent republic within the French Community. The capital is Ouagadougou. (HU. DE.; X.)

UPPINGHAM, a market town and rural district in the Rutland and Stamford parliamentary division of Rutland, Eng. Pop. of civil parish (1951) 1,868. The houses, mostly of golden-brown ironstone, date from the late 16th century. The church of SS. Peter and Paul, heavily restored in 1860, contains the pulpit used by Jeremy Taylor, rector of Uppingham from 1638 to 1642. Uppingham school, founded in 1584 by Archdeacon Robert Johnson, has many houses in the town including the original school building (1584). Edward Thring (*q.v.*) in the 19th century developed the school into a public school of great educational influence.

UPPSALA or UPSALA, a city of Sweden, 41 mi. N. of Stockholm. Pop. (1960) 77,397. The name originally belonged to Old Uppsala, nearly 2 mi. N. of the present city. This Uppsala, mentioned in the 9th century, was famous for its heathen temple, which gleamed with gold. Three huge grave mounds remain there. In the same place the first cathedral of the bishops of Uppsala was erected (c. 1100). But on its destruction by fire, convenience caused removal in 1273 of the archiepiscopal see to the present city, then called Östra Aros, but later Uppsala, which became a kind of ecclesiastical capital. There the kings were crowned, after their election at the Mora Stones. 10 mi. S.E. of Uppsala.

In 1567 Eric XIV murdered in the castle five most eminent men of the kingdom, three of them belonging to the family of Sture. In 1593 was held the great synod which marks the final victory of Protestantism in Sweden; in the same year the university was restored by Charles IX. In the castle, Christina, daughter of Gustavus Adolphus, resigned her crown to Charles X in 1654. In 1702 nearly the whole city burned down.

Uppsala has water communication with Stockholm by the river Fyris and the northward arm of Lake Mälar, into which it flows. The older part of the city lies on its sloping west bank.

The university, the chief and oldest in Sweden, was founded in 1477 by Archbishop Jakob Ulfsson. The main university building, completed in 1887, lies west of the cathedral. The library building was erected in 1819–41. It is on the site of the Academia Carolina. founded by Charles IX, and is known in consequence as *Carolina Rediviva.* After 1707 the library had the right of receiving every work printed in Sweden. Among the mss. is the famous *Codex Argenteus* (6th century), a translation of the Gospels in the Gothic of Bishop Ulfilas (4th century). In the old botanic garden. Linnaeus had his residence. The new botanic garden was given by Gustavus III in 1787. The observatory was founded in 1730. The Victoria museum contains Egyptian antiquities. The Royal Society of Sciences. founded in 1710 by Archbishop Erik Benzelius, has a valuable library. Much of the revenue is drawn from the estates granted by Gustavus Adolphus in 1624. Every student must belong to a "nation" (*landskap*), of which there are 13, eaçh representing a particular part of the country and having generally its own clubhouse and fund. The students have a high reputation for singing.

The cathedral stands nobly above the town; its tall western toners with their modern copper-sheathed spires are visible for many miles. It is of simple form and mainly French in style (the first architect nas a Frenchman. Étienne de Bonneuil), modified by the use of brick as building material. Ornamentation is thus slight except at the southern portal. The church was building from 1287 to 1435. It suffered from several fires, and a thorough restoration was completed in 1893. The easternmost chapel is the fine mausoleum of Gustavus Vasa. The castle was founded in 1548 by Gustavus I. It was destroyed by fire in 1702, and only part is restored. Uppsala is a book-printing centre.

UR, a very important Sumerian site and the reputed early home of Abraham (Biblical Ur of the Chaldees). Ur lies about 140 miles south of Babylon, and about 6 miles south of the modern bed of the Euphrates, about two miles from the modern Ur junction on the Baghdad–Basra railway, in 31° N., 46° E. In ancient times the Euphrates ran west of Ur, reaching open water near Eridu. The river was diverted so that it passed by Ur in the time of Rimsin. The city also lay near the ancient junction of the Tigris with the Euphrates, when the former flowed along the Shatt al Hai. Ur lies close to the low hills which form the edge of the Arabian desert. It commanded the communications of both rivers. It was close to the sea and at the same time a convenient entrepôt for the commodities of the desert. The gradual change in the coast line and in the course of the rivers has left the ruins in the desert. Although most of the ruins of Ur as seen to-day,—and the *ziggurat* is one of the best preserved in Mesopotamia,—belong in their present form to the Neobabylonian period, recent excavations have shown that the site has been occupied from extreme antiquity. Original excavations were undertaken by Taylor in 1854. but a serious examination of the site was not made till after World War I by Hall. His work has since been ably continued by Woolley.

Amid the extensive remains of cemeteries, the most recently found graves, which lie south-east of the sacred enclosure, are the most interesting. The graves fall into three periods, and are dated provisionally by Woolley at 3500 B.C., the second series are comparable with Cemetery A at Kish, and are dated by Woolley at about three centuries later, while the third series are some centuries later, but at present are undated.

The richest graves of all belong to the earliest period. Their wealth of precious metal shows that there was a very considerable and prosperous civilization, while the settled style of the art shows that this civilization was already an old one. The graves antedate the first dynasty of Ur by 400 years, they come therefore in the period subsequent to "the flood," a period in which Sumerian historians placed two dynasties, those of Kish and Erech. For these periods and for the first dynasty of Ur they record only the names of the kings, often exaggerating the length of their reigns to an absurdly great degree. The excavations at Ur have, however, produced inscriptions of the first dynasty and these early graves show that the occupation of the lower river valley is extremely ancient, while additional confirmatory evidence of an early date has recently been found at Kish.

The great temple area at Ur is both striking and has had many archaeological results. The temenos or sacred enclosure as it exists to-day is the work of Nebuchadrezzar. The outer wall appears to have been pierced by six great gateways. On the north-east side the more northerly had a corner stone with an inscription of Bur-Sin. The southerly was restored by Cyrus, the son of Cambyses. On the south-western side the gateway opposite the ziggurat had an inscription of Nabonidus.

The ziggurat stands in the north-west corner of the sacred area. It consists of three stories. The lowest, which measures 210 × 140 × 20 ft., was built by Ur-Nammu and Shulgi and was built so well that further restoration was apparently never needed. The second stage was restored by Nabonidus. A small building crowned the third stage. This was the bedchamber of the god and goddess, not a temple as Herodotus supposed The face of the first stage was blackened, the second and third was of red stone, while the shrine on the top was encased in blue brick, the work of Nabonidus. On the north-east side there were three stairways, leading from the platform to the second stage, two ran along the face of the tower from the north and east angles respectively and met in the middle, from which point there was a third stairway, running towards the face of the tower, at right angles to the other two.

East of the ziggurat lay the great temple of E-num-mah. The ruin is of three periods, prehistoric to Neobabylonian, and of the time of Cyrus. The old Sumerian foundation wall was made of unbaked brick built on a foundation of clay which had been beaten hard. On this there were two courses of unbaked bricks of Bur-Sin. S ft 9 in thick and 8 ft. 5 in high, which had been restored at various times. On either side there is a row of rooms. The temple was laid in ruins between the time of Hammurabi and the Kassite dynasty. Nebuchadrezzar II. made a complete restoration. The old temple had no great open court, an obvious need in a great temple; for this Nebuchadrezzar made provision.

South-east of the ziggurat was a much ruined temple of Ningal. The middle cella and the side chapels lie on the north-west side of the court, and the entrance, through a great recessed doorway is on this side. On either side there were two rooms connecting with antechamber and chapels and the plan recalls the temple of Ishtar at Babylon. A roadway led from the south-east of the temple of Ningal, ending in a great double gateway which gave access to the court of a great rectangular building east of the temple. There was communication from the south corner of the temple court to this street through a pair of recessed gates. At the other end of the roadway the excavators found a recess with a door opening on to a building of the Kassite period.

Between the temple of Ningal and E-num-mah lay the shrine of

Nannar. E-dub-lal-mah. This is mentioned in an old liturgy as a temple of Ur and buildings of this name occur in other cities, such as Adab. Larsa. Lagash and Isin. The tonn itself was excavated by Woolley. It has been shon-n that the old town of Ur, as it presented itself to Abraham's view, cannot have differed much from the modern mudbrick towns of Mesopotamia.

See also Index references under "Ur" in the Index volume.

See, for earlier excavations. *Cambridge* Ancient History, vol. 1, 1923 (bibliography); H. R. Hall. *Museum Journal,* XV. Woolley's reports are appearing annually in the *Antiquaries Journal* (Vol. III. onwards). See also C. Leonard Woolley, *Ur* of the Chaldees (1930); S. Langdon, *Der alte* Orient. 26 (1928). (L. H. D. B.)

URAL-ALTAIC LANGUAGES, a language-family consisting of two groups: (1) the Uralic group (Finno-Ugric languages [*q.v.*] and Samoyedic languages). are spoken in north-eastern Europe and northwestern Siberia; and (2) called the Altaic (Tarkic [*q.v.*], Mongolian [*q.v.*] and Tungus languages) in derivation from the mountain range of that name, are spoken over an area extending from eastern Poland to the Pacific ocean. The relationship between the two groups is disputed by some authorities.

The Phonetic System.— Almost without exception the Ural-Altaic languages recognize a law of vocalic harmony. Exceptions exist but are explained consistently with the general principle: that in any single word only vowels of the same "timbre" may appear; thus. if the radical vowel of a word be o or *u,* the vowels in the other syllables must be o, *u* or a. In other words, vowels in the same word must harmonize in method of articulation. On the other hand. if the root vowel is e or *i,* the vowels of other syllables of the same word must be prepalatals or anterior vowels (*i.e.,* articulated in the forepart of the mouth like e and i).

Thus in Finnish are the words kesi "hand," *kivi* "stone." *metsä* "forest." opposed to kala "fish," *sulka* "feathers." The same applies to Hungarian, *repülni* "to fly," *lélek* "soul." segiteni "to help." presenting vocalic contrast to *három* "three," olvadni "to melt," *savanyú* "sour."

In the Altaic languages, except Tungus, vowel harmony has developed into an actual sound harmony which has led to the formation of two opposite sound groups: velar (or postpalatal) and palatal (or prepalatal); *e.g.,* Turk. *qalɣan* "remained." *kälgän* "having come," soq- "to beat." *sök-* "to scold." Siberian-Turk. *oturɣan* "sitting. living," *ölürgän* "having killed," Razan-Tatar *qył-* "to do." *kil-* "to come." etc., Mongolian (Xalxa) *odon* "star," odon "feather," *suma* "arrow," *sümä* "temple, palace," *uxa-* "to dig." *üxä-* "to die." Sound harmony. without being general. is an important factor in the phonetic structure of Ural-Altaic languages.

Consonantal Alternation.— In any given word the consonant which ends the root syllable is subject to various mutations according to the nature of the syllable following (open or closed). It is especially characteristic of certain Uralic tongues, such as Lapp, Finnish and the Samoyedic languages. In the other languages it has not developed beyond the merest trace. Thus, in Finnish! *kukka* "flower:" but kukan (gen.) "of the flower"; *kuto-* "to weave," but *kudon* "I weave"; *repo* "fox," but *revon* (gen.) "of a fox"; onki "fishhook," but *ongen* (gen.) "of a fishhook"; *lintu* "bird," but *linnun* (< *lindun*) "of the bird." In their present fortn the consonantal alternations. so numerous and so varied in Finnish and, above all, in Lapp, give no indication of what they once were. In early times, it seems probable that at the end of the root syllable. there was an alternation of degree. in correspondence with two accentuation types—a strong one and a weak one. tt. kk. *pp.* and t. k. *p.* There was also an alternation which produced a contrast between *p. t.* k. and *β. δ.* y.; *m.* n. ŋ, and *β.* 6. *γ.*, etc. This alternation extended to groups of consonants opposing a strong mt to a weak *md, mp* to mb, *ks* to *γz.*

This alternation theory (German *Stufenwechsel*) was formulated by the Finnish linguist. E. N. Setälä. who proposed to extend it to Altaic tongues. where G. J. Ramstedt had discovered it in part; since N. N. Poppe's work it also can be considered as valid in Altaic.

Vocalic *Alternation.*—There exists also an alternation of vowels by which, according to the suffixes which a word may take, the vowel of the root syllable may be modified or changed. Thus. in Finnish. *pala* "to burn" (intrans.). and *polttā* "to burn" (trans.); in Ostyak, *n'ālәm* "tongue." and *n'ilmәm* "my tongue." These instances are rare in modern Ural-Altaic speech. and the Uralic tongues have best preserved the traces, although examples are also found in Xltaic.

The rules which determine the beginning and ending of words are that no word can begin with more than one consonant. and when a foreign word so beginning is borrowed it is simplified accordingly. The Swedish word *stor* "big." becomes *suuri* in Finnish. Elsewhere a vowel is put before the double consonant to facilitate enunciation: the Slav word *stolŭ* is in Hungarian *asztal* and the English "steam" is, in Osmanli, *istim,* etc.

The accent varies in position and quality. Most Ural-Altaic languages stress regularly the first syllable. but Turkic the last. In Samoyedic and other idioms such as Ostyak it varies.

Morphology.— In the first place. no language of the group uses prefixes; all the grammatical modifications expressed in English by prepositions (viz., to, on. of, for, etc.) are effected by means of suffixes. "I enter the house." is, in Hungarian, *belépek* a *házba* (*ház* "house"—ba, suffix meaning "into"). In a tale written in Kazan Tatar is found: ber *keše urmanγa barγan dej,* "a man went into the forest'! (*urman* "forest"—ya "into"). The majority of the grammatical relations affecting words are therefore expressed by suffixes. which differ in form from language to language, but play the same role throughout. These suffixes can be strengthened by post-positions: thus (Hungarian), egy fa alatt "under a tree" (egy "one, a," *fa* "tree," al-a-tt, locative. "under").

The possessive is formed by suffixes except in Mongolian. Hungarian *szemem* "my eye" (*szem* "eye" + *m* "my." with euphonic e); *szemed* "thine eye" (-d "thy. thine"); *szeme* "his eye" (-*e* "his"); *szemünk* "our eye" (*-ünk* "our"). Osmanli Turkish also has this form, *ev-im* "my house" (ev "house." *-im* "my"): *ev-iŋ* "thy house" (*-iŋ* "thy"); ev-i "his house" (-i "his"); *evimiz* "our house" (*-imiz* "our"). This use of the possessive suffix! which does not exist in Mongolian, varies since in Hungarian as in Turkic it is added directly to the root before other suffixes, except that of the plural, while in other tongues (Finnish. Lapp. etc.) they follow all other suffixes. Compare Hungarian a *házamban* "in my house" and Turkish (Osmanli) *ev-im-de* (Osmanli) with Finnish koda-ssa-ni (-ni "my") and Tungus (Evenki) oro-r-bo-s, plural, accusative, possessive second person singular "your (thine) reindeer."

The Uralic and Altaic languages appear to have developed their morphological system well before the time when the two groups began to separate regionally. Thus, not many suffixes can be restored throughout the family so far; *e.g.* one method of forming the plural was to suffix a *-t* to substantives, as in Mongolian and Uralic, a process of which Turkic and Tungus have conserved a few traces. But there are other essential morphological features which are common to both groups, such as suffixes of locativic and lativic cases and that of the accusative. The main characteristic of the Ural-Altaic tongues is the difficulty of distinguishing between nouns and verbs by their outward forms. The conjugation of the verb essentially consists of the possessive-suffix system of the noun and many verbal suffixes are identical in form with those which are used to construct new nouns. The adjective has no proper declension, and in the majority of the languages it is not declined at all, since no grammatical agreement exists there.

The pronouns still exhibit relics of a declension of their own, but have undergone a strong influence from that of the nouns.

In none of these languages has grammatical gender developed (in contrast to Indo-European or Hamito-Semitic).

While in most oi the Uralic languages the sentence structure is rather free and resembles, especially in the west of the area, that of Indo-European, the Altaic languages, with the exception of northern Tungus, have developed a rather rigid syntactical system requiring the sequence: subject, object. predicate. Except for conditional clauses, grammatical subordination does not exist, but co-ordinate participial or gerundial clauses are used instead. In the Altaic sentence, the governing link is always preceded by its governed, a rule which is valid also throughout the Uralic group.

Numerals.—The Ural-Altaic numeral system is decimal throughout. The names of the numbers in the different languages differ widely, because the primitive Ural-Altaic speech had not developed a proper numerical system before the dispersion.

Vocabulary. — A great many words dealing with rudimentary civilization are common to all the languages, such as most of those expressing relationship (father, mother, uncle, aunt), certain elements, animals and plants, primitive occupations and simple movement and gesture words. The comparative philology of these languages demonstrates a neolithic civilization of the type of which traces have been found in different parts of northeastern Europe and the Urals. This primitive vocabulary, the common patrimony of all the tongues, is augmented by words of very diverse origin. Altaic has borrowed much from Chinese, Indo-Iranian and Arabic languages. Uralic languages have drawn largely on Indo-European stocks and in historical times particularly from Iranian. In modern days Hungarian, Vogul, Ostyak, Cheremiss and Votyak have taken many words from Turkic. Tungus has a large percentage of Mongolian words; Osmanli Turkish has adopted much from Arabic and Persian. Mongolian and Turkic have lent to, and borrowed from, each other, and Paleo-Asiatic elements have enriched and varied the vocabularies of the Ural-Altaic languages spoken in Asia In Europe, Finnish, Lapp and Estonian have borrowed much from the Germanic, Baltic and Slavonic languages, Hungarian from Ossetian, Slavonic tongues and Germanic. The vocabularies of the Finno-Ugric and Turkic languages spoken on Soviet territory are rapidly becoming Russianized.

CLASSIFICATION

Uralic Languages

I. Finno-Ugric. **A.** Finnic: 1. Baltic sea Finnic: Suomi (or Finnish proper). Karelian. Olonecian. Ingrian, Liidic, Votic, Vepsä, Estonian. Livian; 2. Lappic (southwest, south and east dialects); 3. Volga Finnic: Cheremiss (or Mari—two dialects: Hill and Meadow Cheremiss); Mordvinian (two dialects: Erźa and Moksha). 4. Permian: Votyak (Udmurt) and Zyrian (Komi). B. Ugric: Vogul (Mańśi), and Ostyak (Xanty) on the lower Ob; and Hungarian (Magyar).

II. Samoyedic. A. North Samoyedic: 1. Yurak (Ńeńeć); 2. Tavgy (Nganasan); 3. Yenisey-Samoyedic (Eńeć). B. South Samoyedic: 1. Ostyak-Samoyedic (Selqup with many dialects); 2. Sayan-Samoyedic (Kamassinic and other languages, now Turkified by south Siberian Turkic).

Altaic Languages

I. Turkic. A. Central Asiatic: 1. Orkhon and Uighur (or Old Turkic); 2. New Uighur; 3. Chaghatai; 4. City Özbek; 5. Qyrghyz. B. Southwest group: 1. Osmanli Turkish (of Turkey and the former Ottoman empire); 2. Azarbaydjanian (with Qashqa'i); 3. Tiirkmen. C. Northwest group: 1. Qomanian (Codex Cumanicus of 1303); 2. Karaïm; 3. Kazan and west Siberian Tataric; 4. Bashkiric (Bashqort); 5. Noghay; 6. Qazaq-Qaraqalpaq. D. South Siberian Turkic (three subdivisions: Oyrot, Abaqan [Xakas] and Tuva). E. Northeast Siberian or Yakut. F. Chuvash (on the central Volga) which is a link of Turkic with Mongolian.

II. Mongolian. A. Literary Mongolian and the later east Mongolian languages (*e.g.*, Xalxa, Ordos, Tsakhar, etc.). B. West Mongolian or Ralmuck (Kalmyk, Xal'maq). C. Northern Mongolian or Buryat.

III. Tungus. A. North Tungus: 1. Northwestern or Evenki (many dialects, from the estuary of the Yenisey to the island of Sakhalin); 2. Northeastern Tungus or Lamut (in northeast Siberia); B. South Tungus: 1. Džürčen (Nü-chên); 2. Manchu; 3. Goldi (Nanay), with Olcha and Orok; 4. Udehe (Udekhe) with Orochi.

The relationships of some of these tongues are, as yet, far from being elucidated.

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(A. SAU.; K. H. M.)

URAL MOUNTAINS, a mountain system which extends north to south, from the Arctic ocean to the Caspian sea and separates Europe from Asia. The Urals have been affected by a series of separate upheavals, some having a north to west strike and some a north to east. They reach their maximum altitudes along a zone stretching nearly north and south. The composite nature of the Grals is best seen at the extremities of the system, where the upheavals form a distinct chain of mountains.

The Paë-khoy or coast ridge (Samoyedic "stony ridge") is independent of the Urals proper. It has a distinct north-northwest and north-west trend, and although cut through by the Yugor strait it is continued in Vaigach island and Novaya-Zemlya. Its dome-shaped summits rise 1,000 ft.

The Obdorsk or Northern Urals begin near the head of Kara bay and extend southwest to the 64th parallel and form a distinct range, stony and craggy, sloping steeply toward the southeast and gently toward the marshes of European Russia. Its highest peaks are Khard-yues. 3,715 ft.. and Pae-yer, 4,764 ft. Sometimes the main chain has on the west two or three secondary chains, formed by sedimentary rocks, and the highest peaks of the Urals (Sablya, 5,402 ft., and Tel' pos-iz or Murai-chakhl, 5,545 ft.) occur in the south of one of these. Dense forests, chiefly fir, pine and larch, clothe the mountain slopes, but every species, except the larch, gradually disappears in the north, and the upper limit of vegetation (2,400 ft. in the south) rapidly descends to the base of the mountains near the Arctic circle, and forest vegetation disappears about 65° N. (67° in the plains).

The section between 64° and 61° N. has again a wholly distinct character. Here the main water parting is a succession of plateaus stretching in a northwesterly direction. It has broad, flat. marshy valleys, while here and there are isolated summits, mostly under 3,000 ft. (Yang-tump, 62° 43' N., 4,170 ft.). The whole region, except the mountain summits, is densely clothed with coniferous forests. This part of the range is uninhabited.

The Middle Urals, about 80 mi. broad, contain rich iron, copper and gold mines (Bogoslovsk, Goroblagodatsk and Ekaterinburg Urals). The Denezhkin Kamen in the north (4,908 ft.) and the Tara-tash in the south (2,800 ft.) mark the limits of this section. Here the orographical structure is more complicated. In the north (61st to 60th parallel) there is a succession of chains with a distinct northeastern trend. South of Kachkanar (2,890 ft.) the Urals assume the appearance of broad swellings 1,000 to 2,000 ft. in height. deeply trenched by ravines. These low plateaus have been utilized for centuries as the chief highway to Siberia. The water parting between the Russian and Siberian rivers is there not more than 1,245 ft. above sea level on the great eastward road, west of Sverdlovsk (Ekaterinburg). The valleys have a decidedly southeastern direction, as has the railway from Perm to Kurgan. The Middle Urals are densely forested. The valleys and lower slopes have a rich soil and contain large and wealthy villages. The mines also support a considerable population.

The Southern Urals (55° 30' to 51° N.) consist of three parallel chains running northeast and southwest and constitute an independent part of the Ural system. The Urals proper are a low sinuous chain hardly exceeding 2,200 to 2,800 ft. in altitude. Farther west there is a parallel chain which, although pierced by rivers, reaches 5,230 ft.; while farther west still is another series of equally high chains. The gentle slopes of the hilly tracts are dotted with woods. mostly of deciduous trees, while the hollows contain rich pasture grounds. The region is being colonized.

Farther south the main range, except when deeply trenched by the rivers, is a plateau which hardly reaches 1,500 ft. It is continued toward the Volga under the name of Obshchiy Syrt.

South of the great bend of the Ural river, quite independent ranges of hills, or flat swellings, appear (*e.g.*, Dzhaman-tau, Mugodzhar hills). A range of heights connects the Mugodzhar hills with the Ust-Urt plateau

Geology. — The Ural mountains are no more than the western edge of a broad belt of folding of which the greater part is buried beneath the Tertiary deposits of western Siberia. Throughout the greater portion of the chain a broad strip of granites. diorites, peridotites, gneisses and other crystalline rocks rises directly from the Siberian plain, and is covered toward the west by Silurian, Devonian, Carboniferous. Permian and Triassic strata, which are thronn into numerous folds parallel to the length of the chain and usually rise to much greater heights than the crystalline zone.

URALSK, a town in West Kazakh *oblast* in the Kazakh Soviet Socialist Republic. U S S R on the Ural river, where the railway crosses it. Pop. (1959) 105.000. Founded in 1775, it is a centre for grain and cattle from the Kirghiz steppe. There are flour mills and leather and gut preparing works, with iron and woolen industries: also a model farm, a museum and branches of the Russian geographical and fisheries societies. Uralsk has two cathedrals. one founded in the 18th century. the other in 1837.

URANINITE, a natural form of uranium dioxide, is an isometric mineral that occurs as crystals and granular masses or, in the pitchblende variety, as dense crusts with a botryoidal or colloform structure. It is strongly radioactive, and readily yields autoradiographs upon photographic film.

Uraninite. CO,, is a major ore of uranium. It has been obtained largely from hydrothermai vein deposits, as in the Katanga district, Republic of the Congo, at Joachimsthal and adjacent places in the Erzgebirge, Saxony. and at Great Bear lake and the Lake Athabasca district. Can The uraninite of veins usually is of the pitchblende variety. The element uranium was discovered by M. H Klaproth in 1789 in uraninite from Joachimsthal, and radium was first extracted from uraninite ore from this place by P. Curie, M. Curie and G. Bémont in 1898.

Craninite is recovered as a by-product from the conglomeratic gold ores of the Witwatersrand, U. of S Af, and it is one of the ore minerals in a rather similar deposit in the Blind river area, Ont. Important deposits of fine-grained uraninite associated with coffinite and vanadium minerals are found in sedimentary rocks, chiefly sandstones and conglomerates, as in the plateau area of Colorado, Utah, New Mexico and Arizona. The sandstone-type deposits often are extensively oxidized to carnotite, tyuyamunite and other secondary uranyl minerals, which may themselves constitute important ores.

Craninite is widespread as a well-crystallized accessory mineral in pegmatites, but such occurrences are of little or no economic interest Fine specimens are found in pegmatites at Wilberforce, Ont., the Spruce Pine district, N C.. and at Grafton Center, N.H.

.Through oxidation the composition of uraninite varies between UO_2 and about $UO_{2\ 6}$. The crystal structure of uraninite is of the calcium fluoride type, and the extra oxygen is housed interstitially. Thorium can substitute for uranium in the crystal structure and a complete solid solution series extends to thorianite, ThO_2. Some varieties contain appreciable amounts of rare-earths, particularly cerium Types with a high content of thorium and rare-earths are found principally in pegmatites. Some of them have been designated by varietal names, such as cleveite and bröggerite. Lead accumulates in uraninite as a product of the radioactive decay of the uranium and thorium present, and from a knonledge of the disintegration constants can be used to calculate the geologic age of the mineral.

Uraninite is dark gray to black in colour with a steely lustre, but becomes dark brown and dull or pitchlike accompanying chemical alteration. The hardness is $5\frac{1}{2}$ to 6. The specific gravity is 10.9 in pure UO_2, hut most natural material ranges between 6.5 and 9 0 Uraninite often alters to yellow or orange-red hydrated uranyl oxides and to greenish yellow uranyl silicates to yield pseudomorphic crystals. It is not stable under weathering conditions, and the uranium may be leached and redeposited locally as autunite, torbernite or other secondary uranyl minerals.

See Clifford Frondel, *Systematic Mineralogy of Uranium and Thorium*, U.S. Geological Survey Bulletin 1064 (1958); E. W. Heinrich, *Mineralogy and Geology of Radioactive Raw Materials* (1958).

(CL. F.)

URANIUM, a metallic element that is dense hard and nickel-white in colour. During the first 150 years uranium was known, few uses could be found for it. and it was studied chiefly because it was the heaviest element then known. Rut in 1938 Otto Hahn (*q v.*) and Fritz Strassmann discovered that the uranium nucleus undergoes fission when bombarded with neutrons, and thus offered the possibility of giving up its nuclear energy in a sustained, chain reaction One pound of uranium, it was shown later, yields as much energy as 3 000.000 lb. of coal. Economically recoverable ores usable as nuclear fuels are believed to contain many times more energy than all the known recoverable deposits of fossil fuels—coal, oil, gas. The discovery that uranium was fissionable signaled the start of one of the most intense and concentrdted studies ever made of an element.

Summaries of the findings of these studies, as well as of studies made during and prior to 1938, appear in the following sections on the history, occurrence, uses, preparation for nuclear uses and properties of uranium.

HISTORY

The element uranium was discovered in 1789 by Martin Heinrich Klaproth in the course of an examination of a pitchblende mineral originating in Saxony. To this new substance he gave the name uranium in honour of Sir William Herschel's discovery of the planet Cranus in 1781. Klaproth and tno generations of chemists nho followed him were under the impression that uranium metal itself had been prepared. In 1841, however. Eugène Melchior Péligot demonstrated that Klaproth's substance was actually the oxide UO_2; Péligot then succeeded in preparing the metal by the reduction of uranium tetrachloride with potassium. Péligot may thus be properly considered the founder of uranium chemistry.

The formulation of the periodic system by Dmitri Ivanovich Mendeléyev in 1869 directed attention to uranium as the heaviest of the elements. a position nhich was confirmed and held until the discovery of the first transuranium element in 1940. In 1896 Henri Becquerel discovered in uranium the phenomenon of radioactivity, a property that was later found in many other elements (see RADIOACTIVITY. NATURAL). This significant discovery stimulated a new and lasting interest in the previously rather obscure element. Becquerel exposed a photographic plate wrapped in black paper to the action of the beautiful fluorescent salt potassium uranyl sulfate, $K_2SO_4.UO_2SO_4.2H_2O$, and observed that a distinct impression had been produced on the plate. Further experiments indicated that metallic uranium, all uranium salts and uranium minerals (especially pitchblende) give rise to the same phenomenon. These epoch-making observations were closely followed by the discovery of radium in pitchblende (see RADIUM).

In 1934, Enrico Fermi and co-workers observed that beta activities were produced by the action of neutrons on uranium, but the full significance of this observation was not understood at the time. Then in 1938 Hahn and Strassmann showed that bombardment with neutrons caused uranium to break down into radioactive isotopes of a lighter metallic element, barium, with release of energy (*see* ATOMIC ENERGY). At a conference-in the U.S. in 1939. Fermi suggested neutrons might also be released when uranium nuclei split, and in sufficient numbers to cause the reaction to sustain itself as a chain reaction. L. Szilard and co-workers; H L. Anderson and co-workers; and F. Joliot and co-workers confirmed this possibility in 1939; later investigation showed that an average of $2\frac{1}{2}$ neutrons are released during each fission. Further study showed that the uranium fissions occurred most readily in the comparatively rare isotope U^{235}, which occurs in nature only $\frac{1}{140}$ as frequently as U^{238}. Investigators also found that neutron bombardment changes U^{238} to plutonium. nhich in turn is split by neutrons. The first self-sustaining nuclear chain reaction was conducted by Fermi at The University of Chicago on Dec 2. 1942 The chain reaction nas produced in a lattice of uranium and graphite. With the development of methods for controlling the rate of fission. the first wartime and peacetime applications of nuclear energy soon followed. The first test atomic bomb was detonated July 16, 1935, and the first bomb used in warfare was dropped Xug. 6, 1945. Atomic power for propulsion was used for the first time in a submarine (U.S.S. "Nautilus") in 1955, and one of the first full-scale nuclear power electrical generators began production at Shippingport, Pa., on Dec. 2, 1957.

OCCURRENCE

Although uranium is usually regarded as one of the rarer elements. it is actually present in the earth's crust to a considerably greater extent than such "common" elements as cadmium, bismuth, mercury, silver or iodine. The bulk of the uranium seems to be present in the upper 12–13 mi. of the lithosphere in an amount estimated to be roughly 10^{14} tons, an average content of approximately 4×10^{-6} g. per gram of rock. Concentration varies in rocks between about 0.2×10^{-6} and 25×10^{-6} g. per gram of rock. with higher values present in acid (high silica content) rocks such as granite.

Relatively minor amounts of uranium are found in the "basic" basalt rocks such as form the floors of the oceans. It is also found in very small quantities in meteorites.

Uranium is present in sea water to the extent of about $\frac{1}{2,000}$ as much as is present in an equal weight of average rock. Living matter contains uranium in amounts varying from $10^{-4}\%$ to $10^{-9}\%$ by weight, but the biological significance of the element is obscure. The fixing of uranium by algae may have played a role in the formation of certain uranium deposits. There is no simple relationship between the mean concentration of an element in the earth's crust and the probability of finding economically important deposits of that element.

In the case of uranium, numerous minerals are found in nature. It is convenient to divide uranium minerals into two broad classes, primary and secondary. Particularly important are the primary minerals uraninite (UO_2; crystalline; 45%–85% uranium), pitchblende (combined UO_2 and UO_3; amorphous, black, pitchy; variable percentage uranium), davidite (cerium. iron, titanium, vanadium, chromium, uranium oxide; black; 7%–10% uranium) and the secondary minerals carnotite, autunite and torbernite which originate from the primary minerals by weathering. Carnotite is a complex potassium uranyl vanadate ($K_2O.2U_2O_3.V_2O_5.nH_2O$; 50%–55% U_3O_8); autunite is a calcium uranyl phosphate ($CaO.2UO_3.P_2O_5.nH_2O$; 60% U_3O_8); and torbernite is a closely related copper uranyl phosphate ($CuO._2UO_3.P_2O_5\,nH_2O$; 60% U_3O_8).

Estimated reserves of U_3O_8 in the second half of the 20th century included 380.000 tons in Canada; 370.000 tons in the Union of South Africa; 225,000 tons in the U.S.; between 50.000 and 100.000 tons in France: 10.000 tons in Australia: and 7.500 tons in the Belgian Congo. Important deposits also are believed located in the Joachimsthal (Jachymov) region of Czechoslovakia and Germany and in the Freghana and other districts of the U.S.S R.

At the start of the 1960s Canada. the U.S. and the Union of South Africa lead production in that order. About 90% of Canada's reserves are located in the Blind River area of northern Ontario although most of the production has been centred in the Northwest Territories. In the U.S., reserves of uranium ores at mid-20th century were estimated by states as follows: New Mexico 55,000 000 tons: Wyoming 11,500,000 tons; Utah 5,600,000 tons; Colorado 4,400,000 tons; Arizona 1,400,000 tons. By value of ore production the top-producing states were ranked as follows: Utah, New Mexico, Colorado, Wyoming, Arizona, Washington, South Dakota, Alaska, California, Nevada and Montana. It is estimated that new deposits of uranium ore are being discovered twice as fast as the need for uranium is increasing.

The extraction of uranium from ores is complicated since most uranium ores contain a great variety of accompanying metallic elements. The ore is ground and leached with either acid or alkali; the uranium is recovered from the pregnant leach liquors by various precipitation solvent extraction or ion exchange procedures. The uranium often leaves the refinery as the oxide U_3O_8. For further purification, important in nuclear applications, the U_3O_8 may be dissolved in nitric acid to yield a solution of uranyl nitrate The uranyl nitrate can then be purified by extraction into diethyl ether.

USES

Uranium had very limited uses before its use for nuclear energy. It has been suggested for filaments of lamps. A small tube of UO_2, connected in series with the tungsten filaments of large incandescent lamps used for photography and motion pictures, tends to eliminate the sudden surge of current through the bulbs when the light is turned on, and thereby extends their life. Its compounds have been used in photography for toning and as a dye or stain in the leather and wood industries. Uranium salts are mordants for silk or wool. A little ferro-uranium has been utilized in making special steels. but its value in this connection is questionable, since such alloys may be pyrophoric if they contain 20% or more of uranium. Sodium and ammonium diuranates have been used in ceramics to produce coloured glazes. Only 0.006% is needed to give good yellow colours. By increasing the percentage, the colour may be changed to orange, brown, green or black.

Cranium carbide has been suggested as a good catalyst in making synthetic ammonia. Small quantities of uranium salts are claimed to stimulate plant growth, but large quantities are poisonous to plants.

Uranium and its chain of decay products correspond to a source of radioactive energy which has some importance and has been much studied with respect to the problem of the internal heating of the earth. Its long half life makes possible determinations of the age of the earth by measuring the amount of lead, uranium's ultimate decay product, in certain uranium-containing rocks.

By far the most important use of uranium lies in its application for nuclear (or atomic) energy. This use, in fact, so increased the value of uranium as to eliminate its use for many of the purposes mentioned above.

TABLE I.—Known Isotopes of Uranium, Natural and Artificial

Isotope	Half life	Modes of disintegration and highest energy (Mev)	Source
U^{227}	1.3 min.	α (6.8)	Th^{232} (α, 9n)
U^{228}	9.3 min.	α (∽80%) (6.67) Electron capture (∽20%)	Th^{232} (α, 8n)
U^{229}	58 min.	Electron capture (∽80%) α (20%) (6.42)	Th^{232} (α, 7n)
U^{230}	20.8 days	α (5.85)	Th^{232} (α, 6n)
U^{231}	4.2 days	Electron capture α ($5.5 \times 10^{-3}\%$) (5.45)	Th^{232} (α, 5n)
U^{232}	74 years	α (5.32)	Pa^{232} β^- decay
U^{233}	1.62×10^5 years	α (4.82)	Pa^{233} β^- decay
U^{234} (U_{II})	2.48×10^5 years	α (4.77)	Natural
U^{235} (AcU)	1.13×10^8 years	α (4.58)	Natural
U^{236}	2.39×10^7 years	α (4.50)	U^{235} (n, γ)
U^{237}	6.75 days	β^- (0.249)	U^{238} (n, 2n)
U^{238}	4.50×10^9 years	α (4.18)	Natural
U^{239} (U_1)	23.5 min.	β^- (1.21)	U^{238} (n, γ)
U^{240}	14.1 hours	β^- (0.36)	U^{239} (n, γ)

Naturally occurring uranium consists of the three isotopes of mass numbers 238, 235 and 234 with relative abundances 99.27%, 0.72% and 0.006%, respectively. The isotope U^{238} is the parent of the natural uranium ($4n + 2$) radioactive series; the isotope U^{234} is also a member of this series, and thus these two are linked by radioactive decay. The isotope U^{235} is of other origin, is the parent of the actinium ($4n + 3$) radioactive series and has a great importance because it undergoes nuclear fission with slow neutrons. It is prepared at Oak Ridge, Tenn., in nearly pure isotopic composition in substantial amounts.

The synthetic transuranium element plutonium, which is also fissile with slow neutrons, is prepared by the absorption of neutrons by the isotope U^{238}. The element with its natural isotopic composition can be used in large chain-reacting piles, where the reaction is sustained by the rare isotope U^{235}, and the synthetic element plutonium (the isotope Pu^{239}) is manufactured at the same time by transmutation of the U^{238}. The self-sustaining nuclear chain reactions may be written:

$$_{92}U^{235} + \text{neutron} \longrightarrow \text{fission products} + \text{energy} + \text{neutrons};$$

$$_{92}U^{238} + \text{neutron} \longrightarrow {}_{92}U^{239} \xrightarrow{\beta^-} {}_{93}Np^{239} \xrightarrow{\beta^-} {}_{94}Pu^{239}.$$

Smaller nuclear reactors may be built to use the pure or nearly pure isotopes U^{235} or Pu^{239} as fuels. The abundant isotope U^{238} can thus be indirectly "burned," at least in part, as nuclear fuel through the transformation to Pu^{239}, leading to a more efficient use of the uranium. A fissionable isotope such as U^{235} or Pu^{239}

gives rise to an amount of "heat energy equivalent" of about 10,000.000 kw.hr. per pound, when it completely undergoes the fission reaction.

The isotopes U^{235} and Pu^{239} can be used as the explosive ingredients for nuclear (atomic) weapons (see ATOMIC ENERGY). This possibility led in a number of countries to a certain amount of control over the mining and processing of uranium. Nuclear reactors also are used to produce highly beneficial medicines. such as the radioactive isotopes Co^{60} and I^{131}, both used in treating cancer. (G. T. SG.)

PREPARATION FOR NUCLEAR USES

The use of uranium for atomic reactor purposes involves two forms: stable UO_2 powder compacts and highly purified metal as the predominant fuel.

Oxide Treatment. — The preparation of stable UO_2 from UO_3 is customarily accomplished in a screw-type continuous reactor by contact with hydrogen at above 760° C. The powder, after cooling under a protective atmosphere, can then be stored at room temperature without reversion to U_3O_8 or UO,. Oxide components are prepared by adding an organic plasticizer. cold pressing at high pressure to pellet form and finally sintering at a very high temperature in a protective atmosphere. The final shapes are frequently ground to provide a close control of dimensions.

Metal Formation. — The preparation of uranium metal normally begins by inducing the exothermic reaction between uranium tetrafluoride and magnesium metal chips:

$$UF_4 + 2Mg \longrightarrow U + 2MgF_2 + 85 \text{ kg.cal}$$

This is carried out in a steel vessel (termed a bomb) lined with magnesium fluoride to contain the reaction and to protect the uranium from contamination. A weighed amount of uranium tetrafluoride and a measured quantity of magnesium slightly in excess of the stoichiometric requirement are thoroughly blended, then packed into the bomb which is finally topped mith a layer of magnesium fluoride and closed with a steel lid. The filled bomb is heated in an electric resistance furnace to a temperature in the range of 595° to 705° C. until the reaction occurs after an appreciable holding period. Molten uranium of high purity then separates below a layer of molten magnesium fluoride (slag) because of the large difference in their specific gravities. After cooling, the bomb is emptied of metal. slag and lining for mechanical separation.

The metallurgical efficiency of the process is influenced by three factors: the residual oxygen content of the UF_4 in the form of UO_2, UO, or UO_2F_2; the temperature at which the reaction is induced; and the quantity of magnesium metal employed. The effect of oxygen is complex since it affects both the exothermic nature of the reaction and the fluidity and melting point of the slag created. In general oxygen should be held to a minimum. Temperature has a definite bearing on economic output since low holding temperatures delay the inception of the reaction and thus prolong the process; high temperatures induce local premature reactions with insufficient heating of the charge for good liquefaction and separation of metal and slag. The optimum yield is normally achieved in the temperature range of 595° to 705° C. The best yield is also obtained when the magnesium addition is only slightly in excess of the stoichiometric amount needed; the optimum value is generally inversely related to the mass of the charge employed.

The metal and slag after discharge from the bomb are broken apart for separate processing. The slag is crushed, screened and then ground to a suitable particle size for use in new bomb liners for subsequent UF_4-Mg reactions. The metal regulus (usually called a "biscuit" in laboratory terminology and a "derby" in shop phraseology) is cleaned by pneumatic chipping and then weighed to determine the reaction yield. A proper quantity of derbies is then assembled as a charge for melting in an MgO-lined graphite crucible. Heating is carried out in *vacuo* in a high-frequency induction furnace until adequate liquefaction has been achieved. When sufficiently fluid. the metal is poured into a graphite mold coated with MgO and allowed to cool in an inert atmosphere. The ingots are then removed from the molds, ground to eliminate fins, cropped to remove impurities segregated at the top, sampled, weighed and then boxed for shipment for fabrication.

Metal Forming. — Cranium may be readily hot formed in the temperature range of 535" to 650° C. by a variety of means such as rolling. forging or extrusion. Heating to the proper temperature is usually done in molten neutral salt baths which protect the metal from oxidation. The orthorhombic structure existing in this temperature range is not particularly amenable to plastic flow, and the degree of deformation to be imposed at each step of the forming process must be held within moderate limits. After rolling or extruding to rough shape. the parts are then machined to final size with conventional machine tools. A careful use of a proper coolant is essential at this stage to avoid oxidation of the chips mith the attendant hazard of fires because of the pyrophoric characteristics of the metal.

Fuel Element Fabrication. — Atomic reactor designs for production of power have in many cases called for the use of uranium in the form of GO,. This choice of the oxide has arisen because of the advantages of three of its properties: a very high melting point, permitting pile operations at temperatures more favourable for efficient heat transfer for power generation; favourable stability of structure under irradiation. making long exposures possible; and good resistance to corrosion by uater, thereby minimizing the dangers of contaminating the cooling system with radioactive corrosion products. Fuel elements of UO_2 are usually assembled in carefully sized, close-fitting tubes of corrosion-resistant metal. The tubes are sealed and then welded in suitable clusters for reactor use.

The commonest form in which uranium metal is used in an atomic reactor is as a cylinder approximately 8 in. long and 1 in. in diameter. The cylinder is encased in an aluminum jacket to protect it from corrosion by the cooling water that flows over it in the pile to control the temperature of operation. After irradiation for a time chosen to achieve the most favourable conversion of U^{238} to Pu^{239}. the cylinder (or "slug") is discharged from the pile into a water basin where it can be handled without radiation risk to the operators. Here the slugs are assembled in suitable containers for transfer to the separations area where the plutonium is chemically extracted.

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PHYSICAL AND METALLIC PROPERTIES

Uranium has the symbol U, atomic number 92 and chemical atomic weight 238.07. It occupies a position in the periodic system of the elements as the third member of a transition series, the actinide series, which includes the heaviest known elements and in which an inner electronic shell (the 5f shell) is being filled. The electronic structure of the gaseous atom has been determined to be that of the element radon plus three 5f, one 6d and two 7s electrons.

Uranium metal melts at 1,132" C., boils at 3,818' C., and has a density, calculated from X-ray data, of 19.04 g. per cubic centimetre. The metal is ductile, malleable, capable of taking a high polish and not hard enough to scratch glass. It undergoes two transitions. at 668° C. and 774° C., respectively. The crystal lattice at room temperature is orthorhombic (unit axes of crystal all at right angles to each other and all of unequal length) and can best be interpreted as having distorted hexagonal close packing; its structure is thus quite different from that of chromium, molybdenum and tungsten metals. It has not been possible to assign an unambiguous radius to uranium in the metallic state. The abnormalities of the uranium structure are reflected in various properties such as an abnormally high electrical resistivity ($32–76 \times 10^{-6}$ ohm.-cm.) of the metal at room temperature.

Metallic uranium is a highly reactive substance. It decomposes water, and in the form of powder may spontaneously inflame in air. It combines directly with oxygen at 150° to 350° C.. with chlorine at 500° C., with bromine at 650° C. and with iodine at 350° C. The metal reacts with gaseous hydrogen at 250° C. to form a hydride of the formula UH,. It reacts nith nitrogen, carbon monoxide. carbon dioxide and many other gases, uranium can therefore be used in the laboratory for the purification of gases such as the noble gases. Metallic uranium reacts with acids nith the liberation of hydrogen and the formation of compounds of U(III) and U(IV); caustic alkalies do npt act upon it. The oxidation-reduction potential for $U \rightarrow U(III)$ appears to be about 1.80 v. (on the scale in which the potential for $\frac{1}{2}H_2 \rightarrow H^+$ is taken as zero).

CHEMICAL PROPERTIES

Oxidation States of Uranium.—Uranium has the four oxidation states +3, +4, +5 and $6 and the ions in aqueous solution are usually represented by U^{+3}, U^{+4}, UO_2^+ and UO_2^{++}. The oxidation-reduction potential of uranium ions in acid solution is indicated below:

$$U \xrightarrow{+1.80\text{ v.}} U^{+3} \xrightarrow{+0.631\text{ v.}} U^{+4} \xrightarrow{-0.58\text{ v.}} UO_2^{+} \xrightarrow{-0.063\text{ v.}} UO_2^{++}$$
$$U^{+4} \xrightarrow{-0.32\text{ v.}} UO_2^{++}$$

The UO_2^+ ion is uristable in solution and undergoes disproportionation to U^{+4} and UO_2^{++}. A few solid compounds of this oxidation state U(V) are known, as, for example, UF_5 and UCl_5.

The ion U(III) forms intense red solutions in water and is oxidized by water at an appreciable rate. The rate of oxidation appears to increase with increasing ionic strength, although strong solutions are claimed to be stabilized by strong acids such as hydrochloric. Solutions of U(IV) are green: U(VI) solutions, yellow. Considerable data on the absorption spectra of the various ionic states have been obtained, and these are useful for analytical purposes.

U(IV) and U(VI) are the important oxidation states, and therefore the important chemistry of uranium may be related to the two oxides UO, and UO_3, uranium dioxide and uranium trioxide. A series of salts such as UCl_4 and $U(SO_4)_2.9H_2O$ is obtained from UO_2. The commoner uranyl salts. $UO_2(NO_3)_2.6H_2O$, UO_2Cl_2 and $UO_2SO_4.nH_2O$, in which the UO_2^{++} (uranyl ion) acts as a radical, are derived from UO_3.

The element also exhibits a formal oxidation number of U(II) in a few solid. semimetallic compounds such as UO and US. No simple ions of oxidation state U(II) are known in solution.

Uranium Oxides.—In addition to the three oxides UO_2 (brown), U_3O_8 (greenish black) and UO_3 (yellow), which have been known for a long time, there are known to exist the monoxide UO and the oxide U_2O_5. The phase relationships in the uranium-oxygen system are very complex, so that it is possible to obtain uranium "oxides" with practically any composition intermediate between UO and GO,.

Uranium trioxide exists in a number of crystal modifications. It is usually prepared by thermal decomposition of uranyl nitrate at about 300° C. The oxide U_3O_8 is formed when any uranium oxide is ignited in air at about 700° C. Uranium dioxide is usually obtained by hydrogen reduction of UO_3 at elevated temperatures (700° C.). All these oxides dissolve readily in nitric acid to give uranyl solutions. Uranium trioxide decomposes to U_3O_8 upon ignition at 500° to 700" C.; UO_2 is refractory, melting above 2.000° C.

Closely related to the oxides are the uranates and diuranates. Sodium diuranate, $Na_2U_2O_7.6H_2O$, is the uranium yellow of commerce. The simple uranates have the typical formula Na_2UO_4; this type of compound is much more difficult to prepare than the diuranates which are obtained by addition of alkali to uranyl solution. These compounds correspond to chromates and dichromates but, of course: lack the strong oxidizing properties of the latter.

Uranium peroxide, the formula of which is usuaily given as $UO_4.2H_2O$, is formed by precipitation from solutions of uranyl nitrate by hydrogen peroxide. Alkali hydroxide. hydrogen peroxide and sodium peroxide form soluble peroxyuranates, $Na_2UO_6.4H_2O$ and $Na_4UO_8.8H_2O$, when added to solutions of uranyl salts.

Uranium Nitrides and Carbides.—Three uranium carbides are known: the monocarbide, UC; the sesquicarbide. U_2C_3; and the dicarbide, UC_2. These can be prepared by direct reaction of carbon with molten uranium or by reaction of carbon monoxide with metallic uranium at elevated temperatures. The latter reaction yields a mixture of UC and UO_2.

Uranium and nitrogen form an extensive series of compounds that can be prepared by direct action of nitrogen on the metal. Uranium mononitride. UN. is the lowest nitride of uranium. If the mononitride is treated nith more nitrogen at atmospheric pressure. U_2N_3 is formed. With nitrogen under high pressure UN_2 can be prepared. but it is difficult to obtain samples of UN_2 that are completely free of UN

The carbides and nitrides of uranium are relatively inert, semimetallic compounds Uranium mononitride is stable in the absence of air to temperatures above 2 000" C.; the monocarbide is likewise refractory Both carbides and nitrides are converted to U_3O_8 by ignition in air. They are soluble with difficulty in acids.

Uranium **Hydride.**—As mentioned above, uranium metal reacts with hydrogen at 250° to 300° C to form a well-defined hydride nhich resembles the rare-earth hydrides in many respects. The formula of this substance has been shown to be $UH_{3\,00}$. Uranium hydride exists in two crystal modifications; the α form is obtained uhen the hydride is prepared at low temperatures; the β form is obtained when the temperature of formation is greater than 250° C. β-UH_3 is ferromagnetic below the Curie temperature (173° K.). The hydride undergoes decomposition nith increasing temperature: the dissociation pressure of UH_3 is one atmosphere at 436° C.

Uranium hydride is of considerable importance in the syntheses of other uranium rompounds. Since the formation of uranium hydride from massive uranium metal is accompanied by a complete disintegration of the metal to a microcrystalline ponder. and since the hydrogen can then be driven off by heating *in vacuo* to 350° to 400° C., very finely divided reactive uranium metal can be prepared. Further, the hydride itself is very reactive and can be used conveniently to prepare halides carbides nitrides etc.. of uranium at relatively moderate temperatures with the appropriate reagent.

Uranium Halides.—The halides of uranium constitute a numerous and important set of compounds. Table II lists some of the knonn uranium halides.

TABLE II.—*Halides of Uranium**

Fluorides	Melting point, ° C.	Chlorides	Melting point, ° C.	Bromides	Melting point, ° C.	Iodides	Melting point, ° C.
UF_3	(>1,140†)	UCl_3	835	UBr_3	730	UI_3	(680)
UF_4	960	UCl_4	590	UBr_4	519	UI_4	506
U_2F_9	†	UCl_5	(327)				
U_4F_{17}	†	UCl_6	179				
UF_5	(<400†)						
UF_6	64‡						

*Parentheses indicate estimated value?. †Undergoes disproportionation. In the case of UF_3, into UF_4 and U; in the case of the remaining halides, into UF_4 and UF_6 ‡Under pressure; UF_6 sublimes below its melting point.

Uranium tetrafluoride serves as a starting material for the preparation of the other fluorides. It is best prepared by hydrofluorination of uranium dioxide:

$$UO_2 + 4HF \xrightarrow{550^\circ\text{ C.}} UF_4 + 2H_2O.$$

Cranium trifluoride can be prepared by reduction of UF, with hydrogen at 1,000" C. Uranium hexafluoride. UF_6, is best obtained by direct fluorination of UF_4, although any uranium compound will yield UF_6 by reaction nith fluorine at elevated temperatures:

$$UF_4 + F_2 \xrightarrow{350^\circ\text{ C.}} UF_6.$$

The intermediate fluorides $U_2F_9(UF_{4.5})$; U_4F_{17} $(UF_{4.25})$ and UF_5 are prepared by reaction of solid UF, and gaseous UF_6 under appropriate conditions of temperature and pressure.

Uranium hexafluorirle is probably the most interesting of the uranium fluorides. Under ordinary condition.; it is a dense, white solid with a vapour pressure of about 120 mm. at room temperature. It can readily be sublimed or distilled and is by far the most volatile uranium compound known. Despite its high molecular weight, gaseous UF_6 is almost a perfect gas, and many of the properties of the vapour can be predicted from kinetic theory. Uranium hexafluoride is a strong fluorinating agent and is therefore reactive; it is sensitive to traces of moisture and must be handled by special techniques. It is used in the large scale separation of uranium isotopes by gaseous diffusion.

Uranium tetrachloride can be prepared by direct combination of chlorine with uranium metal or hydride; it can also be obtained by chlorination of uranium oxides with carbon tetrachloride, phosgene. sulfur monochloride or other powerful chlorinating agents. The trichloride is obtained by reduction of UCl_4 with hydrogen. and the higher chlorides by reaction of UCl_4 with chlorine. Uranium pentachloride disproportionates on heating to UCl_4 and UCl_6. Uranium hexachloride is a rather volatile, somewhat unstable substance. All the uranium chlorides dissolve in or react readily with water to give solutions in which the initial oxidation state of the ion corresponds to that in the solid. All the solid chlorides are sensitive to moisture and air.

The bromides and iodides of uranium are obtained either by reaction of the elements or by treatment of UH_3 with the appropriate halogen acid. The thermal stability of the halides decreases as the atomic number of the halogen increases. The uranium bromides and iodides. UBr_3, UBr_4, UI_3 and UI,, are known. A series of oxyhalides of the type UO_2F_2, $UOCl_2$, UO_2Cl_2, UO_2Br_2, etc.. is known. They are water-soluble substances which become increasingly less stable in going from fluoride to iodide.

Aqueous Systems.—As mentioned above. aqueous solutions of U(III), U(IV) and U(VI) are readily obtained. Solutions of U(III) are blood-red in appearance; hydrogen is slowly evolved with the formation of U(IV) solutions. Solutions of U(IV) are quite stable in the absence of air. As may be judged from its potential U(IV) is a strong reducing agent and is easily oxidized to uranyl by oxygen. peroxide and numerous other oxidizing agents. Uranyl solutions in turn may be reduced to U(IV) with sodium hydrosulfite, zinc or cadmium amalgam, or by electrochemical or photochemical means.

No trivalent uranium compounds can be precipitated from U(III) solutions; rapid oxidation to U(IV) compounds occurs when such procedures are attempted. Ordinarily only chloride or perchlorate solutions of U(III) are encountered, although bromide, iodide and sulfate may be obtained.

The common water-soluble salts of U(IV) are the chloride, bromide. sulfate and perchlorate. Solutions of these salts show a slight acid reaction mhich indicates a moderate degree of hydrolysis. The main absorption bands of U(IV) solutions are at 650 $m\mu$, 550 mp, 495 $m\mu$ and 430 $m\mu$. A number of different types of experiments indicate that in one molar acid the U(IV) ion is essentially U^{+4} (in the absence of complexing agents). Chloride, sulfate and bromide ions form complex ions with U(IV). Insoluble U(IV) oxalate. phosphate, fluoride, molybdate, arsenate. ferricyanide and hydroxide can be precipitated from U(IV) solutions.

Uranyl solutions are readily obtained and are more stable than those of any of the other oxidation states. Well known and extensively studied are uranyl nitrate. chloride, perchlorate, acetate, carbonate and sulfate systems. In many respects UO_2^{++} behaves like a simple doubly charged ion. Solutions of UO_2^{++} have a characteristic yellow colour and are slightly hydrolyzed. In concentrated solutions there is some evidence for the formation of polymerized ions such as $U_2O_5^{++}$.

An interesting property of uranyl nitrate solutions known since the mid-19th century is extractability with diethyl ether; uranyl nitrate hydrates are markedly soluble in ether. The addition of hydroxide. phosphate, ferricyanide, oxalate, etc., results in the precipitation of insoluble salts. The uranyl ion has. however, a strong tendency to form soluble complex ions with an excess of carbonate or oxalate ions. In general. uranyl salts of weak acids have a marked tendency to form complex ions. Characteristic is the precipitation of double salts such as sodium uranyl acetate, $NaUO_2(C_2H_3O_2)_3$, and sodium magnesium uranyl acetate, $NaMg(UO_2)_3(C_2H_3O_2)_9.9H_2O$. The latter type has considerable analytical significance. Uranyl solutions are fluorescent and undergo a great variety of photochemical reactions in the presence of organic compounds.

See RADIOACTIVITY, ARTIFICIAL; ISOTOPE: *Separation of Isotopes;* NUCLEUS: *Description and History;* NUCLEAR ENGINEERING; *see* also references under "Uranium" in the Index volume.

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URANUS, Heaven. in Greek mythology. the husband of Ge and father of Cronus (q v) and other deities (see TITANS). As such he represents the generative power of the sky, which fructifies the earth with the warmth of the sun and the moisture of rain.

The Roman Caelus is simply a translation of the Greek *Ouranos,* not the name of a distinct national divinity. In art. Uranus is shown as an old, bearded man holding a robe stretched out over his head in the form of an arch,

URANUS, in astronomy, the seventh major planet in order of distance from the sun, and denoted by the symbol ♅. Ii was discovered by Sir William Herschel on March 13, 1781. although at the time he thought it was a comet. Thus on April 6 he remarked "the comet appeared perfectly sharp upon the edges and extremely well defined without the least appearance of any beard or tail." Continued observations of the new object, however, showed that it was not moving in an elongated type of orbit like most comets. About four months later A J. Lexell announced that the object was a new planet revolving in a nearly circular path at a distance from the sun of about 19 times the distance of the earth. Herschel exercised his right as discoverer by calling the planet Georgium Sidus in honour of King George III, his royal patron. The name of "The Georgian" was used in the *British Nautical Almanac* up to 1850. But the name mas unpopular outside of England, as was also that of Herschel, proposed by J. J. Lalande The name of Uranus was chosen by J. E. Bode.

Uranus is just visible to the naked eye under favourable conditions. It is not surprising therefore that a search of the records showed it had been observed many times before Herschel's discovery by astronomers who took it for a star. Thus during the opposition of 1768–69 P. C. Lemonnier had observed it eight times. These prediscovery observations were of great help in determining a reliable orbit for Uranus

The mean distance of Uranus from the sun is 19 18 times that of the earth or 1,783,700,000 mi. It completes a revolution around the sun in 84.013 years. The mean radius of the planet is 14 700 mi. or 3.72 times that of the earth (G. P. Kuiper and D. L Harris, 1951). The planet has an oblateness of $\frac{1}{14}$, so that its equatorial radius exceeds its polar radius by 1,100 mi. These dimensions of Uranus are necessarily uncertain because of its great distance. The mass of Uranus is accurately known from the motions of its satellites to be 14.54 times that of the earth. Its density is 0.28 times that of the earth or 1 56 times that of water. Surface gravity on Cranus is 1.05, practically the same as on the earth. Uranus has an albedo of 0.66, second only to that of Venus, indicating a cloud covered surface of high reflecting power.

The visual magnitude of Uranus at mean opposition is 5.44, according to the photoelectric measures H L Giclas made at the oppositions of 1950. 1951 and 1952. From a discussion of all published observations of Uranus from 1864 to 1932 W. Becker concluded that there was a well-defined variation in the brightness of the planet having a period of 8.4 years and a visual amplitude of 0.31 magnitudes. From visual observations made between 1936 and 1947 J. Ashbrook also found evidence for an eight-year period. Giclas, from his photoelectric measures of 1950–52, found no variations in brightness. Neither could he detect any short-period variations ascribable to the rotation of the planet.

Uranus when viewed through a large telescope shows a bluish-green disk slightly less than 4″ in diameter. A white central streak and some dusky bands have been noted, but no definite spots from which the rotation period could be determined. By recourse to the Doppler principle *(see* LIGHT) Percival Lowell and V. M.

Slipher, from spectroscopic observations in 1911–12, found a rotation period of 10 83 hours. Observations by J H. hloore and D. H. Menzel from 1927–30 gave a rotation period of 10 84 hours. Moore and Menzel regard this close agreement as probably fortuitous, remarking that in their opinion it may be in error by as much as half an hour.

The first visual observation of the dark bands in the spectrum of Uranus seems to have been made by A Secchi about 1870. In the last quarter of the 19th century the spectrum of Uranus was photographed by several pioneers in astronomical photography such as H. C. Vogel, Sir William Huggins, and others. A fine series of photographs of the spectra of the planets from the violet to the limit of the visual red was published in 1909 by Slipher. The spectrum of Uranus has since been extended to 8800A

The spectra of the giant planets show dark absorption bands which grow progressively stronger from Jupiter to Neptune. The bands are so strong in the spectra of Uranus and Neptune that they absorb most of the light in the yellow, orange, red and infrared regions, thus accounting for the bluish-green tint of these planets. Despite much speculation the substance producing this absorption remained unknown until 1932, when R. Wildt showed that the most prominent planetary markings occurred at the positions of bands of ammonia (NH_3) and methane (CH_4) observed in laboratory spectra Wildt's work was later confirmed and extended by A. Adel and Slipher at the Lowell observatory, Flagstaff, Ariz , and by W S. Adams and T. Dunham, Jr., at Mount Wilson observatory, near Pasadena, Calif. The bands of ammonia are prominent in the spectrum of Jupiter but much weaker in Saturn, doubtless because of the latter's lower temperature. On Uranus and Neptune with a surface temperature of about $-200°$ C. the ammonia is probably frozen out so that only methane remains.

From cosmological considerations it has long been believed that the giant planets must contain a great abundance of light elements, particularly hydrogen and helium. Cnfortunately there seemed no way of testing this idea from spectroscopic observations. The band systems of the hydrogen molecule (H_2) in the visible and ultraviolet regions have such highly excited electronic states for their lower states, that in general they cannot appear in absorption. If a source of energy were available at a temperature sufficiently high to excite these levels. it would also be high enough to dissociate these molecules, so that again no absorption could occur. Other possible atmospheric constituents of the giant planets such as nitrogen. helium, neon and argon also give no absorption markings in the observational region of the spectrum. so that the possibility of detecting their presence seemed remote indeed. Such was the outlook about 1936.

The first direct evidence for the presence of hydrogen and helium in a giant planet was obtained in 1952—not from spectroscopy as expected—but from photoelectric measures on the diminution in the light of a star as it was occulted by Jupiter (see JUPITER). These measures showed hydrogen and helium to be so abundant in the Jovian atmosphere that by comparison methane and ammonia are present only as minor constituents. Unfortunately, occultations of a suitable type are exceedingly rare events so that this method can seldom be applied.

In 1935 G. Herzberg pointed out a possible method of detecting molecular hydrogen in planetary spectra. A homonuclear molecule such as H_2 does not give a vibration-rotation spectrum since its dipole moment is zero. Rut he remarked that H_2 might possibly show a weak vibration-rotation spectrum because of its quadrupole moment A chance to try the idea occurred in 1949 when Kuiper discovered a diffuse band at 8270A in the spectra of Uranus and Neptune that could not be attributed to methane. Herzberg noted that this band fell near the position of the S(0) line of the pressure-induced 3–0 band of the quadrupole rotation-vibration spectrum of H_2. He felt that the line could no: be identified with the planetary marking because of its great width in the laboratory spectra. By reducing the temperature of the gas to $-195°$ C.. honever. the feature observed in Uranus and Neptune was satisfactorily reproduced in the laboratory. The laboratory experiments indicate conditions in the atmospheres of Uranus and Neptune corresponding to a ratio of helium to hydrogen of 3:1, a temperature of $-195"$ C. or lower, and a partial pressure of hydrogen at the bottom of the visible atmosphere of about 2 atm. The thickness of an equivalent atmosphere of uniform density mould be about 18 km. for Uranus.

Four broad lines in the spectra of Uranus and Neptune near 7500A were still unidentified in the mid-1950s. They could not be identified with silane (SiH_4) or methyl deuteride (CH_3D). Results obtained from investigation of the spectra of methyl deuteride indicated the upper limit of the ratio of deuterium to hydrogen in the atmospheres of Uranus and Neptune to be about 1:300.

Satellites of Uranus.—In Jan. 1787. Herschel detected two satellites of Uranus, now known as Titania and Oberon. In 1851–52 William Lassell at Malta, in conjunction with his assistant A. Marth. observed two satellites revolving closer to the planet than those discovered by Herschel. These mere named Ariel and Urnbriel. Lassell's telescopes were reflectors superior in light-gathering power to others of his time, and these inner satellites were not seen by other astronomers for more than 20 years. Indeed, doubts of their reality were not resolved until 1373, when they were observed with the Washington 26-in. telescope.

A fifth satellite of Uranus was discovered Feb. 16. 1948, by Kuiper on a photograph taken with the 82-in. reflector of the McDonald observatory, Mt. Locke. Tex. He appropriately named this new satellite Miranda. It revolves around Uranus in a roughly circular orbit in about the same plane as the other four satellites. Its period is 1.4 days corresponding to a distance of 77,000 mi.

The most remarkable feature about these satellites is the high inclination of their orbit planes. This amounts to 98° to the plane of the planet's orbit, and 97 8° to the ecliptic. so that the motion of the satellites is really retrograde. The result of the high inclination is that as Uranus revolves in its orbit. there are two opposite points at which the planes are presented edgewise to view, and the satellites appear to travel nearly north and south in the telescopic field. At intermediate points their orbits appear circular.

The Safellites of Uranus

Name	Distance from Uranus in miles	Sidereal period in days	Discovery
V (Miranda) . . .	77,000	1.41	Kuiper, 1948
I (Ariel) . .	119,000	2.52	Lassell, 1851
II (Umbriel) . . .	166,000	4.14	Lassell, 1851
III (Titania) . . .	273,000	8.71	Herschel, 1787
IV (Oberon) . . .	365,000	13.46	Herschel, 1787

For the irregularities in the motion of Uranus that led to the discovery of Neptune, see NEPTUNE. (R. S. RN.)

URARTU, the Assyrian name for the country later called Armenia (*q.v.*), and for its inhabitants. It is identical with the country of Ararat on one of whose mountains Noah's ark stopped, according to Genesis. the name survived in the Armenian province of Ararat and has been transferred to Mount Ararat south of the Araxes river (*see* ARARAT). Herodotus's Alarodoi are the Urartaeans nho after the immigration of the Armenians (after 600 B C.) retained or formed a distinct nation in the valley of the Araxes The inhabitants of Urartu, however, in their cuneiform inscriptions call themselves *Chaldini* ("plural").

The writing of the cuneiform inscriptions of the Urartaeans was taken from the Assyrians, but whereas Assyrian is a Semitic language. Urartaean is neither Semitic nor Indo-European. The Urartaeans or Chaldians must have immigrated from the nest into what was then to a greater part called Naïri. Apparently Sardur I, son of Lutipris, who built a fort to the west of the rock of Van. out of huge stones brought from afar, united the "Naïri-countries" under his rule after a long war against the Assyrians about the time of Assurnasirabal II, the father of Shalmaneser III. This kingdom of Naïri was replaced by the kingdom of Urartu-Chaldia. Aram, nho was the king of Urartu. was fought by Shalmaneser III (859–824 B C.), and so was his successor Sardur (Seduri II), father of King Ispuinis nho chose the rock of Van for his residence and as the holy seat of the god Chaldis. Ispuinis was the contemporary of Adadnirari IV of Assyria—son of Shalmaneser III and husband of Queen Shammuramat; *i.e.*, the historical Semiramis—whom he fought successfully, these successes enabling him to found a Chaldian colony at Musasir, west of the pass of Kelishina. A bilingual Chaldian and Assyrian inscription was erected by Ispuinis upon this occasion.

Menuas. his son, mas the mightiest and most successful of the Chaldian rulers. His greatest work is the aqueduct (the so-called Shamiramsu "river of Semiramis") more than 75 km. in length, irrigating the plain of Van and bringing drinkable water to the eastern borders of Lake Van (whose water is undrinkable), thus enabling him to found a "Menuas-city." Menuas was succeeded by Argistis I, a son, who left records of 14 years of his reign and his successful wars, on the outer walls of the set of chambers hewn into the solid rock of Van. His son Sardur III, contemporary of Assurnirari (755–745 B.C.) and of Tiglath-pileser III (745–727) of Assyria. was defeated by the latter, who destroyed the Menuas-city (735 B.C.).

Rusas I (714 B.C.), son of a Sardur, belonging to a side line of the dynasty, removed the capital to a hill called Toprakkalah in modern times, after digging an artificial lake, the outflow of which irrigated the side of the hill and the plain where he founded the Rusas-city. All this he recorded in a stela set up only a few years after the traditional date of the founding of Rome (754 B.C.). It was taken (1898–99) to the Berlin museum. Rusas I was a most energetic enemy of Sargon II of Assyria (722–705 B.C.) against whom he summoned a coalition of the states of western Asia, of which Mardukabaliddin of Babylonia (the Merodach-Baladan of the Bible) probably was one. In a bilingual stela erected over against the capital of Musasir, which had developed into a sort of independent buffer state, Rusas commemorated his feats against Assyria in re-establishing Chaldian sovereignty and the petty king Urzana in Musasir.

But in i14 the Cimmerians, breaking into the north of Urartu through the passes of the Caucasus, drove Rusas to suicide. Sargon had made a raid into Urartu and on his return had conquered Musasir. robbing its temple and overthrowing and mutilating Rusas I's stela. which, however. was later re-erected, evidently by Rusas II, the grandson of Rusas I who once more restored the power of Chaldia. Rusas II used Cimmerian mercenaries in his combats with Esarhaddon of Assyria (680–668 B.C.) and succeeded in getting rid of the bulk of the Cimmerians who went on to the west of Asia Minor. Rusas III, son of Erimenas, finished the temple of Chaldis on Toprakkalah. Sargon's sculpture of the temple of Musasir shows its front adorned with ornamented shields, a custom which the Chaldians had in common with the Cretans of Minoan times. Such shields, with inscriptions chiefly of Rusas III, were excavated in Toprakkalah. Their circular friezes are divided into semicircles upon which the animals are going in different directions so as to prevent any one appearing to stand on its head, a peculiarity only recurring on Cretan shields of the archaic period. The royal residence at Toprakkalah and the temple of Chaldis were evidently destroyed under Rusas III. The Medes must have overrun Urartu before they crossed arms with the Lydians on the Halys (May 28, 585 B.C.).

The pottery excavated at Toprakkalah, apart from other peculiar features, partly shows in red, and sometimes in black, a glazed surface which is practically equal to "bucchero." A gold medal showing a goddess of fertility and her female adorer in beaten work, has peculiarities which have left their mark in archaic Greek, especially Ionic art. A candelabrum and parts of a throne with a baldachin show a wreath of falling leaves the latter in exactly the shape in which it (the forerunner of the *kymation*) appears on the eldest Ionian or pre-Ionian capitals. The legs of the above-mentioned candelabrum and of another one preserved in Erlangen show the "zoomorphic juncture," one member of an animal coming forth out of the mouth of the same or another animal: this feature being entirely restricted to the art of the Chaldians and of the Etruscans. A bronze vessel from Toprakkalah with vertical rims has innumerable parallels in Etruscan tombs. The way the Chaldians built their walls and towers was illustrated by a model found at Toprakkalah. A striking likeness of the bison, one of the three chief races of big cattle living in Babylonia in the oldest times, in bronze stressing the beard as its special feature shows its existence in ancient Armenia in the 1st millennium B.C. Attaches or handle figures of big bronze vessels in the form of a female divinity in the winged disk of the sun are a Chaldian speciality, recurring in archaic Greek and in Etruscan art. A bronze snake, probably Tiamat, the animal of the Chaos, shows, as do numerous other pieces, a combination of different materials, the holes, for example, being partly filled mith coloured glass.

The Chaldians must have come from more western parts of Asia Minor where they were in touch with elements of Minoan culture; their culture is principally western with only minor traces of Assyrian influence; they influenced archaic Greek art in their turn, and had peculiar relations to the Etruscans which were probably based on a former relatively close proximity. When the Armenians invaded Urartu, the Chaldians withdrew into the mountains keeping up their warlike spirit and their metallurgic accomplishments. They were also called Chalybes, probably from the name of the steel which they were the first to produce. The region south of Trebizond was one of the last resorts of the Chaldians.

(C. F. L.-H.)

URAWA, the capital of Saitama prefecture, Japan, is also a residential suburb of Tokyo and the location of Saitama university. Between 1940 and 193'5 the area of the city increased from 12 sq.mi. to about 22 sq.mi. and its population from 59.700 to 143.044. Located about 50 minutes by electric rail from the heart of Tokyo, Urawa has become a densely crowded commuters' district. (C. A. MR.)

URBAN (URBANUS), the name of eight popes.

ST. URBAN I (d. 230). pope from 222 to 230, succeeded Calixtus I. His pontificate falls entirely within the reign of Alexander Severus, a time of peace for the church. No reliable information is available about his activities: the role attributed to him in the legend of St. Cecilia is a fiction of the 5th century. His feast is celebrated on May 25. (F. X. G.)

URBAN II (Odo of Lagery) (*c.* 1042–1099), pope from 1088 to 1099, was born in Châtillon-sur-Marne, France. A pupil of St. Bruno (founder of the Carthusians) at Reims and later archdeacon, Odo became monk (c. 1070), then prior! at Cluny. Called to Rome and created cardinal (1078), he served Gregory VII as legate to France and Germany. He succeeded Victor III on March 12, 1088. As pope, Urban adopted Gregory's aims. but showed keener political sense and moderation. Henry IV's refusal to abandon his antipope Guibert of Ravenna, who as Clement III still controlled Rome, blocked reconciliation. Thus exiled and despite hardship, Urban convoked councils in Italy and finally occupied Rome as Henry's power waned. By the enthusiasms evoked at two councils in 1095 (Piacenza and Clermont). Urban launched the crusade movement, which greatly enhanced papal prestige and influence. His efforts for reunion between Eastern Christians and Rome, especially at the Council of Bari (1098), had results only in Italy's Byzantine regions. Urban died on July 29, 1099. His cult was approved in 1881, and his feast day is July 29.

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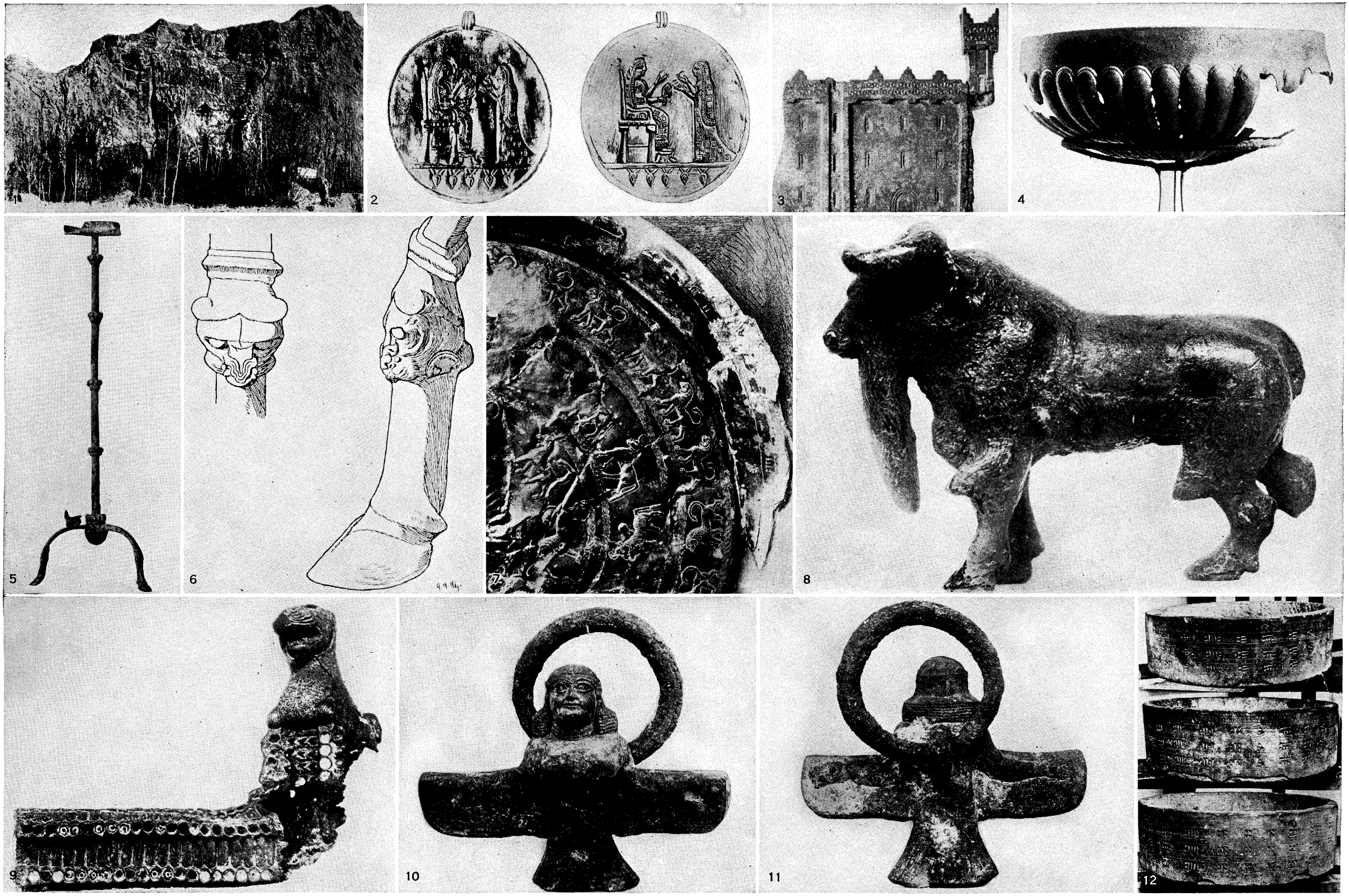
URBAN III (Uberto Crivelli) (d. 1187). pope from 1185 to 1187. was a Milanese, created cardinal and archbishop of Milan by his predecessor, Lucius III, nhom he succeeded on Nov. 25, 1185. Urban inherited the crisis nith Frederick I. soon aggravated by the marriage in Jan. 1186 of Frederick's son Henry (VI) to Constance, Norman heiress of the kingdom of Sicily. This act confronted the papacy with the ominous prospect of the union of north and south Italy under Hohenstaufen rule, long feared as a peril to its independence. Urban died before an open rupture, and the outcome passed to his successors.

See R Webster *in The Catholic Encyclopedia,* vol **xv,** *p. 211* f, *mith bibliography* (1912); *H* K *Mann, The Lives oj the Popes in the Middle Ages, 2nd ed*, vol x *(1925)*.

URBAN IV (Jacques Pantaléon) (d. 1264). pope from 1261 to 1264, was a native of Troyes, France. Professor of canon law at



REMAINS OF URARTU CIVILIZATION

1. Rock of Van Kalah showing rock chambers (to the left) and staircases, the former probably built during the fourteenth year of the reign of Argistis I. 2. Gold medal showing goddess and female worshipper; excavated at Toprak Kalah near Van in 1899. Photograph (left), and drawing (right), Berlin Museum. 3. Bronze model of wall with gate and tower. British Museum. 4. Bronze vessel inscribed with unknown signs. Berlin Museum. 5. Candelabrum excavated in 1899 at Toprak Kalah, near Van. Gewerbe Museum, Hamburg. 6. Detail of foot of candelabrum, zoomorphic juncture: bull's foot coming out of lion's mouth. 7. Sacred shield adorning wall of Temple at Toprak Kalah with inscription of Rusas III. British Museum. 8. Bronze bison; one of three chief races of big cattle living in Babylonia in the oldest times. British Museum. 9. Mythical animal Tiamat; holes partly filled with ornamental glass. British Museum. 10. Bronze vase handle in form of winged disc of the sun with goddess (front side). British Museum. 11. Reverse side of bronze vase handle in fig. 10. 12. Stone vessel of King Ispuinis, founder of the fortress on the Rock of Van. (Three views.) British Museum.

Paris, then bishop of Verdun (1253) and patriarch of Jerusalem (1255), he succeeded Alexander IV on Aug. 29, 1261. Urban IV made the fateful decision to invest Charles of Anjou. able and ambitious brother of Louis IX of France, with the Sicilian kingdom, the papal fief then ruled by the Hohenstaufen Manfred. Urban died. on Oct. 2. 1264. before Charles arrived. leaving the Angevin problem to his successors. He established the Feast of Corpus Christi (1264).

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URBAN V (Guillaume de Grimoard) (1310–1370), pope from 1362 to 1370, was born in Grisac, France. of a noble family. He became a Benedictine monk, abbot and doctor of canon law, and succeeded Innocent VI on Sept. 28, 1362. As pope at Avignon he helped restore peace in Italy. and returned to Rome in 1367. Renewed strife in Rome led him to return in 1370 to Avignon, where he died on Dec. 19, 1370. A man of austere life and a patron of learning, Urban V founded new universities at Orange. Cracow and Vienna. He was beatified in 1870, and his feast is celebrated on Dec. 19.

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URBAN VI (Bartolomeo Prignano) (1318–1389), pope from 1378 to 1389. was born at Naples. He was archbishop of Bari and one of the chief personages of the Curia when he nas elected pope (April 8, 1378) as the Roman populace, determined to end the French-dominated Avignon papacy, clamoured for an Italian pope. Once elected, the devout and competent official became a harsh. ill-tempered reformer. He so enraged the cardinals that they left Rome and, at Anagni, four months later, declared his election null and void On Sept 20 they elected the French cardinal Robert of Gene\-a, nho became the antipope Clement VII. Thus began a schism that lasted 40 years. Crban VI died on Oct. 15. 1389.

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URBAN VII (Giambattista Castagna) (1521–1590), pope in 1590. was born in Rome of a noble Genoese family on Aug. 4. 1521. Nuncio to Spain and cardinal in 1583. he was known for his charity and piety. Elected pope on Sept. 15, 1590, he died 12 days later.

URBAN VIII (Maffeo Barberini) (1568–1644), pope from 1623 to 1644. was born in Florence. where he was baptized on April 5, 1568. Nuncio to France and cardinal in 1606. he was elected pope on Aug. 6, 1623, succeeding Gregory XI7. Urban was a cultured man of authoritarian temper. Distrusting the cardinals whom he considered subservient to the Catholic governments, he was very generous to his relatives, while keeping the reins of government in his own hands. He spent much on armaments but was unsuccessful in the war with Parma. His indecisive attitude in the Thirty Years' War has been often discussed. St. Peter's basilica was finished and consecrated during his reign. He died on July 29, 1611.

See F. L. Cross (ed.), *Oxford Dictionary of the Christian Church*, pp. 1397–98, with bibliography (1957). (E. A. R.)

URBANA, a city of east central Illinois, U.S., 135 mi. S. by W. of Chicago; the seat of Champaign county and seat of the University of Illinois. Urbana adjoins the city of Champaign (*q.v.*). Surveyed in June 1833, five months after the creation of the county. it was one of the first towns to be laid out wholly on the prairie. The university is its chief source of employment; Urbana also has plants manufacturing scientific and technical instruments. radio: dairy products, paints! knock-down bleachers and athletic equipment and supplies. For comparative population figures see table in ILLINOIS: *Population*. (N. M. BE.)

URBAN SOCIOLOGY was one of the early specialized fields. first formally recognized in the United States, to develop within sociology. The term is a misnomer! used for purposes of brevity as a substitute for the more cumbersome titles "sociology of urban phenomena" or "sociology of urban communities." Rural sociology, its counterpart. had developed as a specialized field somewhat earlier.

The 1916 meetings of the American Sociological society were devoted to the central topic of rural sociology, but it was not until 1925 that the society similarly devoted its meetings to urban sociology.

Sociological interest in urban phenomena began to grow in the latter part of the 19th century nhen a number of important studies were undertaken in England and the United States. The classic English study of this period was the 17-volume work of Charles Booth *Life and Labour of the People in London* (1889), an empirical investigation of the state of the poor in that city. The most impressive U.S study of the period was Adna Weber's investigation of comparative urbanization, world-wide.

Systematic development of urban sociology first occurred in the department of sociology at The University of Chicago through the work of Robert E Park and Ernest TT. Burgess and their students, beginning in 1920 Viewing the city as a social laboratory for the investigation of human behaviour. they set a generation of students to investigate problems of human behaviour in the urban environment. The most systematic statement of this approach to investigation, referred to as the Chicago school of urhan sociology, is found in Robert Park's essay "The City as a Social Laboratory" (1915) and a later one by Louis Wirth, "Urbanism as a Way of Life" (1938). Scott E. W. Bedford's *Readings in Urban Sociology* (1927) and Nels Anderson ancl Edward C. Lindeman's text, *Urban* Sociology (1928), were the earliest attempts at textbook treatment.

Ways of *Viewing* Cities.—Cities are social facts of many dimensions. and they have been described and analyzed from many points of view other than the sociological. One way to define the sociological interest in cities is to examine some of the other views.

Men have moralized about cities throughout the history of urban settlement. The social philosopher treats cities (and city life) as objects of human preference, as moral entities. Cities are judged by men as good or bad, as parasitical or fecund entities. To the poet Shelley, "hell is a city much like London," while to the philosopher Aristotle, "the good life can only be lived in the city." The moralist's view of the city presupposes a set of values in terms of which the city is judged as to its desirability or undesirability as a place of human existence. The urban sociologist, on the other hand, seeks a factual description and analysis of cities and city life.

The political scientist views the city as a legal corporation or as a form of government. His concern is with development of urban forms of government, problems of governing the city and the reshaping or planning of the city through means available to government. The political scientist's view often is close to that of the moralist since he is concerned with matters of policy, of how government may deal with the problems of urban living.

Historians for the most part are interested in particular cities in history, usually the great cities, their desire being either to illuminate a historical period through the history of a city or to describe cities as history has made them.

The urban geographer and the human ecologist to some extent have shared a point of view in their study of urban phenomena. The urban geographer tends to treat the city as a focal point in the occupation and utilization of the earth by man. Interest in urban phenomena is dictated by an area viewpoint, by such questions as the location, distribution in physical space and changes in size, location and internal structure. The city is viewed in terms of the relationships between man and his territorial environment.

The interests of urban sociologists to some extent overlap all of those described above, but urban sociology has a distinct focus as well. The urban sociologist generally views the city as a form of human community in which there are particular ecological forces of integration. in which human beings acquire certain behaviour patterns as a result of association with one another and in which institutions and forms of social organization give to human life a characteristic aspect called urban. The urban sociologist. regards the city and its civilization as a distinctive kind of integration of human activity and as a major source for the initiation and control of social life in societies.

No single frame of reference or theory for the study of urban phenomena characterizes the discipline of urban sociology. There are, rather, three major approaches to the investigation of urban phenomena used in description and analysis. These are the ideal-type community approach, the urban trait-complex approach and the rural-urban continuum approach; they are sometimes combined.

Ideal-Type Community **Approach.**—The ideal type is a construct obtained by abstracting the characteristics of an object to their logical extreme and perfection. The ideal-type method is used in urban sociology to describe communities. Usually a number of characteristics describe the ideal type of urban community, but the more characteristics included in the type the less closely do empirical cases of communities approximate it. Some ideal-type approaches posit polar conceptions of communities. The G.S. anthropologist Robert Redfield considered folk and urban societies to represent polar types. He defined the folk society as a small, isolated, nonliterate, homogeneous society whose members have a strong sense of group solidarity. The opposite characteristics define the urban society.

The French sociologist Émile Durkheim regarded as polar the society based on mechanical solidarity and that based on organic solidarity. Members of the society based on mechanical solidarity are bound together by sharing common beliefs and sentiments, what he called a collective conscience. Members of the society based on organic solidarity, at the other pole, are bound together by a system of different, specialized and complementary functions. The English scholar Maine and the German sociologist Toennies utilized somewhat similar distinctions in their descriptions of forms of human community. The polar distinctions involved in their definitions are those between an intimate, traditional and settled form of human association in a village community as contrasted with a formal and deliberately contractual form of association in the urban community.

Common to all these ideal-type approaches to human community is use of the types to test hypotheses about human behaviour in a community or society. The ideal form of the community is seen as a source or cause of variation in human behaviour and organization. Redfield, for example, saw the decline in isolation and homogeneity of the community as factors in the secularization and individualization of behaviour of its members.

Trait-Complex Approach. — The trait-complex approach to study of urban communities is closely related to the ideal-type approach, the major difference being that the former uses empirical rather than logically pure attributes in defining a community. The empirical attributes are usually viewed as causally connected. For some sociologists a single variable is seen as the causal or generating variable in the trait complex. P. A. Sorokin and C. C. Zimmerman considered the single generating variable to be occupation: the agricultural occupation defines the rural community, while nonagricultural occupations define other forms of community. The occupational variable is seen in turn as generating other differences among communities. The most important of these usually considered by urban sociologists who use this approach are the size of community, density of settlement, homogeneity-heterogeneity of the population, social differentiation and stratification, mobility of the population and its system of social interaction. The problem of rural or urban sociology then is to see whether these differences between rural and urban worlds produce differences in social institutions and organizations, cultural and social processes, vital processes and the psychology of its resident population.

A related approach in urban sociology is that of investigating the extent to which concentration of population tends to give rise to the social phenomenon of the city as a way of life. The two features — concentration of population and the city as a way of life — are allowed to vary independently. The question then raised is, to what extent is the urban way of life limited to an urban population (one concentrated in physical space)? Investigators with this point of view do not see a one-to-one correlation between an urban population and an urban way of life. Concentration of population is seen as giving rise to certain features of social organization that are urban in character. But these features, once established: can be carried beyond the confines of the city so that it is possible to speak of rural populations as highly urbanized.

Rural-Urban Continuum Approach. — The third major approach in urban sociology posits a rural-urban community continuum in which there is a continuous gradation from rural to urban such that all human communities can be placed empirically at some point on the continuum. The definition of rural and urban polar ideal types of communities often implies such a continuum. A major difficulty in this approach is that while a given characteristic of a community may vary from rural to urban, all the characteristics of the community do not vary together with the same degree of urban or rural quality; thus it is difficult to place a given community empirically on a rural-urban continuum.

Factors Studied. — The factors investigated by urban sociologists are chosen from four major sets of community characteristics that define the community as (1) an ecological structure; (2) a unique demographic structure; (3) a characteristic form of social organization; and (4) characteristic forms of social relationships. Each of these characteristics of an urban community defines a focal concern of some urban sociologists.

Ecological.—The human ecologist studies the urban community from the perspective of community structure. The community is defined as the structure of relationships through which a localized population meets its daily requirements. The community in ecological theory is seen as the least reducible universe within which ecological relationships can be observed; it is the basic unit of ecological investigation. The urban ecologist studies the ways in which the urban community is differentiated and organized, particularly in its spatial organization. He is thus concerned with such problems as the segregation of persons and institutions in space, their concentration and redistribution, and he tries to account for the patterns formed: for example, residential patterns of ethnic groups, business establishments or occupation groups. At the same time ecologists are interested in the temporal organization of cities, the rhythm and tempo of an urban population. They therefore try to account for such things as the movement of persons between residence and workplace and the patterns of such movement. or the time relationship between communities. Finally ecologists are interested in accounting for the distribution of urban communities in space and for the movement of people and the organized relationships that are established among them. They are particularly interested in studying the functional relationships among urban communities and their hinterlands. the exchange relationships among them and their bases for functional specialization.

Demographic.—Closely related to the interest in ecological organization is the interest in community demographic structure, considered by some ecologists to be only an aspect of the ecological approach. The two most important community aspects investigated in this approach are size and density of settled area. The principal problem for demographic investigators is exploration of the aggregative aspects of the city, such as its population composition and its vital processes of population growth and mobility.

Socinl *Organization.*—The city often is viewed as a unique form of social organization or social system, the normative organization of the urbanized society and the structures developed for social interaction in cities then becoming the major objects of investigation. Some of the aspects of urban social organization most commonly studied include economic organization, system of social stratification, normative integration. kind and degree of social cohesion among the residents and nature of social control. Of particular concern in these investigations is what is uniquely urban about these institutional arrangements and their organization. Are they the peculiar products of urbanism?

Social Relationships.—Cities also are seen as generating characteristic forms of social relationships. Some sociologists see cities as particularly productive of anonymous and impersonal relationships. persons meeting one another in segmental or highly specialized social roles rather than as full personalities. Collective behaviour in the mass or crowd also is thought of as more distinctively urban. The urban sociologist therefore turns his attention to the kinds of social relationships developed in daily living, the role requirements of an urban dweller and the ways in which the human personality meets the requirements of urban living. Particular attention also is given to the way in which deviating behaviour is structured in the city, whether it is productive of mental illness, of organized delinquent gang warfare and organized crimes. of dissident social movements and so on.

Urban v. Rural. — Urban sociology is predicated upon the assumption that there are clearly distinguishable differences between urban and rural ways of life finding expression in different technologies, divisions of labour, social organizations and institutions, personalities and even social problems. Historically the country and the city are viewed as representing different stages of civilized life. Contemporaneously they reflect different modes of social existence. Some sociologists however question this assumption. maintaining that the proper study of sociology in this respect is the territorial organization of human groups into communities. Whether or not urban sociology will remain a field in a developing discipline is problematic. There are, however, certain problems dealt with in urban sociology to which the discipline of sociology will undoubtedly recur.

Process of Urbanization. — One of these is the general problem of population distribution and redistribution. An important aspect of population redistribution is the process of urbanization, a process of population concentration such that the ratio of urban people to the total population in a territory increases. Both the size of individual urban centres and the number of urban centres in a territory can increase without urbanization taking place, since only when a larger proportion of the inhabitants come to lire in cities is urbanization said to occur. There are four major factors nhich sociologists use to account for urban growth and urbanization Their effect has been intensified since the Industrial Revolution of the 19th century.

Agricultural Productivity. — First of these factors is that of greater productivity per agricultural worker, such that the agricultural system is capable of producing a surplus of food to supply urban populations and also to permit labour to be withdrawn from food production and used in the production of capital goods and services. Technological changes in agricultural production are of course the most important factor changing productivity per agricultural morker. The shift of labor from agricultural to nonagricultural occupations results from the greater income elasticity of demand for industrial as compared uith agricultural goods.

Factovy System. — The second major factor in the trend to urbanization is a direct consequence of the Industrial Revolution. giving rise as it did to the modern factory system and the industrial city. The invention of efficient techniques for converting energy in fuels and the derivative development of mass production made possible a large number of specialized cities with large populations within an area. Specialization in industrial production leads in fact to high interdependence not only between rural and urban peoples but also among cities; continued industrial production in almost any city depends upon continued production in many other cities.

Transportation and *Communication.*—The increased efficiency of the technology of transportation and communication is a third major factor in urbanization. Because of their specialization and their integration with both a rural and urban hinterland, cities become highly dependent upon trade. Increase in the efficiency of long-distance transportation therefore has a powerful effect in stimulating urban growth, since it makes possible increased trade through access to more and larger markets. Changes in local transport technology are also important in urban growth since they make possible the rapid intracity movement of persons and goods.

Population *Growth.*—The demographic transition accompanying the Industrial Revolution has been a fourth major factor in urban growth. The technology of sanitation and medicine brought with it sharp decrease in mortality, and since countries undergoing urbanization are characterized by high birth rates the result is a phenomenal population growth. The expanding population supplies the urban industrial labour force.

Rate *of Urbanization.*—The rate of urbanization has varied both historically and contemporaneously in different countries of the world. Prior to 1800 there were no highly urbanized countries since the cities required large rural populations for their support. From 1850 to 1900 rapid urbanization occurred in countries undergoing the Industrial Revolution, and by the middle of the 20th century the rate of urbanization was seen in many countries to be much faster than in the 19th, because of developing technology. Although highly urbanized areas are generally highly industrial areas. urbanization is not a simple function of industrialization.

Study of Community. — A second major problem area to which the discipline of sociology undoubtedly will recur is the relation of community to territorial location and its relations to the structure of social systems. The principal concern here lies with the study of persons in interaction in territorial locations. The subfields of rural and urban sociology have tended to subvert an interest in the study of community phenomena, so that a comparative community framework of inquiry did not emerge until the middle of the 20th century.

There are three major approaches to the study of community which overlap with the approaches to the field of urban sociology. These may gradually take the place of the earlier concerns with a rural and an urban sociology.

The first of these approaches is based on viewing the community as an ecological system. Ecologists assume that community structure manifests itself in a spatial and a temporal pattern. The ecologist's interest in community centres around generalizations about the structural features of communities and how these change in response to external conditions. The second major approach, which has characterized the work of social anthropologists in particular, views the community as a microcosm of the larger social system. Each community is describ'ed and analyzed in terms of all of the structural and functional features of the larger society since it is viewed as a territorial microcosm of the larger society. Each community thus is viewed as having a stratification system, a power structure: educational, religious. economic and political subsystems and so on. The community viewed as an aspect of structure of all social systems is a third major approach to community study. Populations are investigated in relation to their territorial location with special reference to the social relations that arise between them as a result of territorial location. Sociologists who follow this approach hold that a community system differs from other systems in that locality is a datum in the integration of the system.

When the field of urban sociology emerged within the discipline of sociology, it began as a perspective for viewing all aspects of social life. The city was not only a distinct way of life or form of community but a social laboratory within which all aspects of social life could be examined. With the view that the city was a social laboratory for the investigation of human behaviour. many investigations were carried out within the context of an urban community and the conclusions were thought of as referring to urban phenomena only because of the urban locus. As the field of urban sociology develops, this point of view gradually is being replaced by one based on a comparative sociology of the community.

As these changes occur, many of the problems that were first treated within an urban or rural sociological framework now have emerged as separate fields apart from the discipline of urban sociology. Among these are the fields of social stratification. industrial sociology and human ecology. With the continued emergence of new sociological fields, much of what was traditionally treated within the discipline of urban sociology no longer is rationally included within it.

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URBINO, a city of Marche (Urvinum Metaurense), Italy. Pop. (1951) 6.503. It is picturesquely situated on an abrupt hill 1.480 ft. above sea level: its streets are narrow and crooked, and the town has a medieval aspect. It is dominated by the ducal palace erected by Luciano da Laurana, a Dalmatian architect, in 1465–82, for Federigo da Montefeltro (well represented in a picture by Justus of Ghent in the gallery), and regarded by the contemporaries of the founder as the ideal of a princely residence. The monumental staircase. sculptured doorways, chimneys and friezes of the interior are especially fine. Some are by Domenico Rosselli of Florence. The rich intarsia work of the duke's study is by Baccio Pontelli. In the cathedral there is a Pietà in marble by Giovanni da Bologna. Opposite the palace is the church of S. Domenico. a Gothic building with a good early Renaissance portal and a relief in the lunette by Luca della Robbia (1419). S. Francesco has a fine 14th-century portico and campanile. and a handsome portal of a chapel in the interior by Constantino Trappola (15th century). S. Bernardino, outside the town. is a plain early Renaissance structure. On the walls of the chapel of San Giovanni Rattista are frescoes by Lorenzo and Giacomo Salimbeni da San Severino (1416).

The modest house where Raphael was born and spent his boyhood forms a museum of engravings and other records of Raphael's works. A monument was erected to him in the piazza in 1897. The theatre, decorated by Girolamo Genga, is one of the earliest in Italy: in it was performed the first Italian comedy, the *Calandra* of Cardinal Bibbiena, the friend of Leo X and Raphael. The magnificent library formed by the Montefeltro and Della Rovere dukes was incorporated in the Vatican library in 1657. There is a free university founded in 1506.

The ancient town of Urvinum Metaurense takes its name from the Metaurus river. The walls can be traced. It was important in the Gothic wars, and is mentioned by Procopius. About the end of the 12th century Urbino came under the rule of the family of Montefeltro, and especially of Federigo da Montefeltro, lord of Urbino from 1444 to 1482, who was an unusually enthusiastic patron of art and literature. Federigo da Montefeltro much strengthened his position by his own marriage with Battista Sforza, and by marrying his daughter to Giovanni della Rovere, the favourite nephew of Pope Sixtus IV, who conferred upon Federigo the title of duke. Federigo's only son Guidobaldo, who succeeded his father, married in 1489 the gifted Elizabeth Gonzaga of Mantua. Guidobaldo in 1508 bequeathed his coronet to Francesco Maria della Rovere, nephew of Julius II. In 1626 the last descendant of Francesco, Francesco Maria II, abdicated in favour of Pope Urban VIII. and Urbino. with its subject towns, which included Pesaro, Fano. Fossombrone. Gubbio. Castel Durante and Cagli together with outlying small villages, about 300 in number, became incorporated in the domain of the Papal states.

During the reigns of Federigo and Guidobaldo. Urbino mas one of the foremost centres of activity in art and literature in Italy. There Piero della Francesca wrote his celebrated work on the science of perspective. Francesco di Giorgio Martini his *Trattato d' architettura* and Gicvanni Santi his poetical account of the chief artists of his time.

Throughout the 16th century the state of Urbino manufactured majolica, especially at Gubbio and Castel Durante. The finest pieces were made for the dukes. Famous citizens include the Ferrarese painter and friend of Raphael, Tirnoteo della Vite. and Bramante (*q.v.*). This city was also the birthplace of Pope Clement XI, of several cardinals of the Albani family, and of Raffaelle Fabretti. and other scholars.

URDŪ. The constitution of Pakistan (article 214) designated Urdū and the Bengali language (*q.v.*) the official languages of the state. The 1951 Pakistani census reported almost 5,500.000 persons giving Urdū as their mother tongue; the Indian census (1951) recorded 13,500,000

Like Western Hindi Urdū is an Indo-Aryan dialect of the middle and upper Gangetic Doab and the country to the north and south Cultivated by Moslems. Urdū in the course of time, depended more and more on Persian as a source of new vocabulary and idiom It is, therefore an Indian language written in Persian script with a partly Persian vocabulary and (to a lesser extent) grammar As contrasted with Hindi (*q.v*) which drew its inspiration from Sanskrit and Hindu culture. Urdū looked to Persian literature for motifs and forms and to the Islamic faith for its inspiration The two dialects in their literary stages — Urdu, with its extreme Persianization and Hindi, with its Sanskritization— are almost mutually unintelligible.

Urdū prose was little cultivated before the 18th century; in poetry Amir Khusru (d 1325), who flourished in the courts of Delhi. came first. Then poetic development nas associated with the Moslem courts of Bijapur and Golconda of the Deccan, *c.* 1575–1700. and especially with the art of Wali (1668–1744) at Delhi There the language was refined by a gradual introduction of Persian figures of speech and themes and by the adoption of models based strictly on the canons of Persian poetry At the end of the 18th century, the ebbing fortunes of the Delhi kings forced the poets who were dependent on court patronage, to seek the protection of the Nanabs of Lucknow where they flourished until the middle of the 19th century.

Urdu prose was developed in the program of instruction at the College of Fort William (Calcutta) at the beginning of the 19th century Among those who contributed to it are the famed poet Ghalib (1797–1869) and the founder of Aligarh university. Ahmed Khan (1817–98). Prem Chand (1880–1936) is the only author to have gained fame for his writings both in Hindi and in Urdū

See also HINDI AND URDC LITERATURE; HINDUSTANI LANGUAGE.

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UREA (CARBAMIDE), a colourless crystalline substance, is the chief nitrogenous end product of the metabolism of proteins (*q.v.*) in all mammals and some fishes. This material occurs not only in the urine of mammals but also in their blood, bile, milk, perspiration. aqueous humor of the eye and other body fluids, Moreover, it has been recognized in many lower forms of animal life and has been identified in certain plants and in fungi and molds. Commercially, urea is of great importance as a fertilizer and as a livestock feed supplement; large quantities are used in the production of plastics and pharmaceuticals.

In 1773 H. M. Rouelle obtained, by alcoholic extraction of the solid residue from evaporated urine, an alkaline nitrogenous substance which on bacterial fermentation yielded carbonic acid and ammonia. Subsequently Antoine F. Fourcroy and Louis N. Vauquelin (1798) prepared urea nitrate from urine, and the isolation of pure urea from this same source was first accomplished by Joseph L. Proust in 1821. Friedrich Wöhler in 1828 discovered the artificial formation of urea from ammonia and cyanic acid.

Physical and Chemical Properties. — Urea crystallizes in long rhonibic needles or short prisms having a cooling, saline taste. It is readily soluble in water. methyl alcohol and ethyl alcohol but not in ether or in hydrocarbons. It melts without decomposition at 132.7" C. (270.9" F.) and sublimes in a vacuum at temperatures just below and up to its melting point. Heating to higher temperatures causes decomposition

Crea is the diamide of carbonic acid (see AMIDES), hence the alternative name "carbamide" The chemical formula $NH_2.CO.NH_2$ originally given to urea. does not explain its behaviour under all circumstances, and many others have been proposed. The view has become generally accepted that urea is a resonance hybrid. receiving contributions from the structure given above and also from the two further structures $\overset{+}{N}H_2{=}C\bar{O}{-}NH_2$ and $\overset{+}{N}H_2{-}C\bar{O}{=}NH_2$. For reasons of convenience, however. the formula is most commonly nritten in its original form, $NH_2.CO.NH_2$. and resonance with the remaining two structures is left implicit.

The above-mentioned method of Wohler for the synthesis of urea consists essentially in the isomerization of ammonium cyanate, NH_4NCO, to urea. $NH_2.CO.NH_2$. This process, however, is a reversible one and the relative amounts of cyanate and urea depend on reaction conditions.

When urea is heated above its melting point it decomposes at first to yield ammonia. ammonium cyanate and biuret and, at higher temperatures, cyanuric acid and ammelide. At elevated temperatures under pressure melamine, ammonia and carbon dioxide are produced. When aqueous solutions of urea are boiled the compound is partially converted to ammonium cyanate, which in turn is hydrolyzed to ammonia and carbon dioxide. Heating such a solution in a sealed tube at 180° C. brings about complete decomposition.

Dilute aqueous solutions of acids and alkalis have no action on urea when cold but when heated break it down to ammonia and carbon dioxide. Strong acids yield salts, such as urea nitrate.

Although urea reacts with alcohols to form urethanes (carbamic esters) with certain glycols to produce cyclic-substituted ureas, and with many aldehydes, ketones, anhydrides and other organic compounds. its most important reactions are with formaldehyde to form methylolureas and with malonic acid derivatives to form malonylurea or barbituric acid derivatives.

Urea forms crystalline addition compounds with straight-chain aliphatic hydrocarbons containing more than six carbon atoms and with their derivatives.

The enzyme urease, obtainable from the soybean and the jack bean (*Canavalia* ensiformis). brings about the rapid hydrolysis of urea. This action serves as a convenient method for the determination of urea. Other methods sometimes used are the Kjeldahl, the hypobromite and the xanthhydrol.

Commercial Manufacture of Urea.—Many ways have been found to synthesize urea in the laboratory but only: (1) the hydrolysis of cyanamide, and (2) the reaction of ammonia and carbon dioxide, have been used industrially. Method (1) was never employed extensively and since 1936 only method (2) has been in commercial use. In this method carbon dioxide and ammonia are continuously injected into a reaction vessel maintained at temperatures up to about 200° C. and pressures up to about 5,000 lb. per square inch. Solid urea is separated from the reaction vessel effluent which contains, besides urea, water and unreacted ammonia and carbon dioxide. The commercial importance of urea increased tremendously, and by mid-20th century world production exceeded 1,000,000 tons per year.

Industrial Uses of Urea.—Urea contains 46.7% of combined nitrogen in a form which is easily and rapidly converted to ammonia in the soil; therefore, it is a much more concentrated nitrogenous fertilizer than ammonium nitrate, ammonium sulfate or sodium nitrate. Moreover, modern manufacturing methods have made it possible to deliver urea to the consumer at nearly the same cost per unit of nitrogen as the other nitrogen-containing fertilizer materials. It may be used as an ingredient in the manufacture of mixed fertilizers, applied to the land alone as a nitrogenous fertilizer or applied to plants as foliage sprays for direct feeding of the leaves by absorption. (See FERTILIZERS AND MANURES.)

By the reaction of urea with formaldehyde under carefully controlled conditions. methylene-urea fertilizers can be made which release adequate nitrogen for plant growth continuously and uniformly throughout the entire growing season. With these a full year's nitrogen supply may be safely applied at one time to turf grass, ornamentals and other long-season crops.

Although the nitrogen in urea is in nonprotein form, if urea is fed to a ruminant animal along with fermentable carbohydrate material the microorganisms in the rumen build its nitrogen into proteins which can be used by the animal through action in the lower digestive tract. Experience has shown that the grain ration fed to the animal must not contain more than 3% urea. Even so, a significant part of the protein requirement can be supplied through the use of urea. During World War II, when protein feeds were scarce, this use became important and afterward increased steadily. Urea cannot be utilized by nonruminant animals such as horses, swine and poultry.

Urea is not poisonous, or, as pharmacologists prefer to say, it is practically nontoxic. However, it has little direct use in internal medicine. Formerly it was used as a diuretic and in the treatment of certain stubborn types of suppurating infections. Urea dissolves dead tissue in which bacteria thrive, and in the resulting clean wound the living cells can successfully combat bacterial invasion so that healing proceeds rapidly.

Large amounts of urea are used by the pharmaceutical industry in the production of malonylurea and barbituric acid derivatives. Over 400 of these derivatives are known and some are commonly used as soporifics and sedatives under a variety of trade names.

The most important use of urea other than as fertilizer is in the production of urea-formaldehyde resins. (See RESINS: Synthetic Resins.) The primary reaction of formaldehyde and urea is the formation of water-soluble methylolurea. Application of heat or catalyst, or both, causes further reaction of methylolurea with itself, and a hard: insoluble, infusible resin is finally obtained. Urea-formaldehyde resins are widely used as adhesives for plywood, composition board and other materials; in molded articles; as shrink- and crease-proofing agents for cotton and rayon fabrics; for imparting wet strength to paper; in lacquers and enamels; and in the impregnation of paper and fabrics laminates, etc. Urea reacts with other aldehydes, but the resinous products obtained are not so useful as those made with formaldehyde.

Some of the many other uses for urea are as a softener for glassine paper and similar products, as a solubilizing agent for starch glues and sizes, as a textile-treating agent, as an ingredient in bindery pastes and latex paints: in the seasoning and bending of wood, as a stabilizer for certain explosives and in the refining of petroleum hydrocarbons. It is also an intermediate in the preparation of chemical compounds, pigments and insecticides.

Thiourea.—The sulfur analogue of urea. $NH_2.CS.NH_2$, is manufactured on a limited scale for employment in photography, synthetic resins, insecticides, pharmaceuticals and textile-treating agents, and as a starting material for various dyestuffs. It may be prepared: (1) by heating ammonium thiocyanate at 160°–170° C.; and (2) by the reaction of hydrogen sulfide with cyanamide. Thiourea crystallizes from water in colourless, six-sided prisms or silky needles melting at 180°–182° C.

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(J. S. BY.)

UREMIA, a term coined in 1840 by Piorry and l'Heritier to designate the disease state associated with inadequate functioning of the kidneys. Etymologically, "uremia" would indicate the presence of urine in the blood, but the term is used to describe the clinical aggregate of symptoms, signs and chemical alterations associated with failure of the kidneys to perform their normal excretory function. Uremia is an imprecise term in that it does not designate any particular one of these abnormalities nor any specific combination of them. In the healthy kidney. urine is derived from blood by ultra-iiltration (removal of fat, protein and particulate elementsj followed by selective reabsorption of components of the filtrate. In addition, certain other compounds are added to the filtrate. The net result of these processes is urine, an aqueous solution of variable composition and concentration, containing organic and inorganic compounds. It is preferable not to regard urine as "waste" in the usual sense of the word, but to consider the entire complex process of urine formation as serving to regulate the composition, concentration and volume of blood and the internal aqueous environment of the body. When this function of the kidney is impaired by disease, various abnormalities in the chemical organization of body fluids result and may lead to malfunction of many organs and organ systems. The clinical manifestations of the uremic syndrome are therefore protean and variable. Practically always there is an elel-ation in the concentration of nonprotein nitrogenous constituents of blood. Other frequently occurring findings include nausea, itching, anemia, hypertension, acidosis and derangements of calcium and phosphorous metabolism.

See Stanley E. Bradley, ***The** Pathologic Physiology of Uremia in Chronic Bright's Disease (1948).* (T. N. P.)

URETHAN, the name applied to the esters of carbamic acid and more specifically to ethyl carbamate. Urethan has sedative and hypnotic properties, which were the bases for its former use in medicine. It is often used as an anesthetic in animals, acting rapidly to produce a calm sleep without depressing the physiological reflexes or the circulation. Urethan also acts on the chromosomes to produce disturbances in cell division. The principal result of this action in man and animals is a decrease in the white-cell count of the blood, which is the basis for the use of urethan in the treatment of certain forms of leukemia. It may be prepared from ethyl chlorocarbonate and ammonia, from carbamyl chloride and alcohol, by the treatment of urea with alcohol under pressure or by the action of warm alcohol on urea nitrate with the addition of sodium nitrite. It is a stable crystalline compound, readily soluble in water and melting at 49°–50° C. (V. E.)

UREY, HAROLD CLAYTON (1893–), U.S. chemist, who was awarded the 1934 Nobel prize in chemistry for his discovery of the heavy hydrogen isotope of mass two (deuterium), was born in Walkerton, Ind., April 29, 1893. After receiving his early education in rural schools, he taught in them from 1911 to 1914. He then entered Montana State university, Missoula, and received the B.S. degree in 1917, with major interests in zoology and chemistry.

After spending two years as a research chemist in industry and two years as an instructor at Montana university, he attended the University of California, Berkeley, where he was granted, the Ph.D. degree in chemistry in 1923. He was next an American-Scandinavian foundation fellow with Niels Bohr at Copenhagen, Den. (1923–24), associate in chemistry at Johns Hopkins university (1924–29), Baltimore, Md., and a member of the department of chemistry at Columbia university (1929–45). In 1945 he joined the newly formed Institute for Nuclear Studies and the department of chemistry of The University of Chicago.

After his discovery of deuterium, Urey worked out procedures for the separation of heavy isotopes of carbon, oxygen, nitrogen and sulfur. During World War II he was director of research of the Substitute Alloy Materials laboratories, Columbia university, which became a part of the Manhattan Engineers District program for the development of the atomic bomb. Urey's group provided the fundamental information for the separation of the fissionable isotope, uranium-235, from the more abundant isotope, uranium-238, by gaseous diffusion, and investigated methods for the concentration of the heavy isotope of hydrogen and for the separation of the boron isotopes. After the war he developed methods for measuring temperatures as they existed in oceans of past geological ages and also a theory for the origin of the earth, particularly its chemical aspects *(The Planets,* 1952). (W. C. J.; X.)

URFA, the chief town of a *vilayet* of the same name in southeastern Turkey, lies at the northwestern corner of the well-watered, fertile plain of Haran, controlling a historical road from Anatolia to northern Mesopotamia. Pop. (1955) 48,013. A limestone hill! on which stand the ruins of the ancient citadel, overlooks the modern town which lies spread out below. It is the centre of a rich agricultural area and a market for animal products (especially butter and wool) and wheat.

The town has a history of great antiquity, extending perhaps to the first part of the 2nd millennium B.C., and was named Edessa by the Macedonian conquerors. Through the centuries it suffered many changes of ownership, including occupation by the Crusaders in 1098, and saw many armies pass along the east-west road in victory or defeat until it was finally annexed to the Ottoman empire in 1637.

The *vilayet* of Urfa is bounded on the south by Syria, on the west by the upper reaches of the Euphrates, and is separated from Diyarbakir *vilayet* on the east by Karaca Dag (6,295 ft.). It consists mainly of a barren limestone plateau with scanty water resources. The climate is dry and the summers hot (average July temperature in the town 90° F.). Pop. (1955) 347,712; area 7,502 sq.mi. Its chief economic activity is stockraising, though agriculture is important in the irrigated Haran plain. The main exports are butter and wool. The other principal towns are Birecik, Siverek and Hilvan. (For ancient and medieval history *see* EDESSA; OSROENE.) (N. Tu.; S. Er.; E. Tu.)

URFE, HONORE D', MARQUIS DE VALBROMEY, COMTE DE CHÂTEAUNEUF (1568–1625), French novelist and miscellaneous writer, was born at Marseilles on Feb. 11, 1568, and was educated at the Collège de Tsarnon. A partisan of the league, he was taken prisoner in 1595, and, though soon set at liberty, he was again captured and imprisoned. During his imprisonment he read Ronsard, Petrarch and above all the *Diana enamorada* of George de Montemayor and Tasso's *Aminta.* Here, too, he wrote the *Epîtres morales* (1598). Honoré's brother Anne, comte d'Urfé, had married in 1571 Diane de Châteaumorand, but the marriage was annulled in 1598 by Clement VIII. Anne d'Urfé was ordained to the priesthood in 1603, and died in 1621 dean of Montbrison. Diane had a great fortune, and to avoid the alienation of the money from the D'Urfé family, Honoré married her in 1600. This marriage also proved unhappy; D'Urfé spent most of his time separated from his wife at the court of Savoy.

In Savoy he conceived the plan of his novel *Astrke,* the scene of which is laid on the banks of the Lignon in his native province of Forez. It is a leisurely romance in which the loves of Céladon and Astrée are told with digressions. Some episodes suggest the adventures of Henry IV. The two first parts of *Astrée* appeared in 1610, the third in 1619, and in 1627 the fourth part was edited and a fifth added by D'Urfé's secretary Balthazar Baro. *Astrde* set the 'fashion temporarily in the drama as in romance, and no tragedy was complete without elaborate discussions on love in the manner of Céladon and Astrée. D'Urfé also wrote two poems, *La Sireine* (1611) and *Sylvanire* (1625). He died from injuries received by a fall from his horse at Villafranca on June 1, 1625, during a campaign against the Spaniards.

URGA: *see* ULAN BATOR.

URI, one of the cantons of central Switzerland. The name is popularly derived from *urochs* or *auerochs* (wild bull), a bull's head having been borne for ages as the arms of the region.

The total area is 415 sq.mi., of which only approximately half (the lowest proportion in the confederation) is reckoned as "productive" (forests covering 48 sq.mi.), while $7\frac{1}{2}$ sq.mi. are occupied by a part of the Lake of Lucerne and more than 20% of the unproductive area is covered with glaciers. The highest summit in the Uri is the Damma Stock (11,909 ft.), north of the Furka pass. Little of the land is capable of further cultivation, for Uri is composed of the torrent section of the upper Reuss, draining, with its tributaries, steep-sided valleys. The chief railway is the main St. Gotthard line. Near Wassen are the remarkable looped and spiral tunnels. There is also an electric railway from Altdorf to its port, Flüelen. Communication is largely by the excellently planned roads which lead to the mountain passes; these give access to the cantons lying east and south; *e.g.,* Glarus (the Klausen pass, 6,391 ft.), the Grisons (Oberalp pass, 6,706 ft.), the Valais (Furka pass, 7,976 ft.).

In 1950 the aggregate population was 28,556 (69 to 1 sq.mi.). Of the 1930 population of 22,968, 22,249 were German-speaking, 594 Italian-speaking and 62 French-speaking, while 21,674 were Catholics, 1,251 Protestants and 2 were Jews. After 1814 Uri was administered by the bishop of Coire; previously all the canton except Andermatt (Urseren) was in the diocese of Constance. The capital and largest town is Altdorf (pop. 6,576 in 1950), indissolubly connected with the legend of William Tell (*q.v.*).

Uri was organized as an administrative district containing 20 communes. The legislature until 1928 was a primitive democratic assembly (*Landsgemeinde*) composed of all male citizens of 20 years of age and over. This assembly had met, uninterruptedly, since 1309, usually once annually, near Altdorf. The procedure was controlled by many antique ceremonies. After 1928 there was an elected legislature of 49 members. *(See* SWITZERLAND: *Government.)*

History.—Uri is first mentioned in 732 as the place of banishment of Eto, the abbot of Reichenau, by the duke of Alamannia. In 853 it was given by Louis the German to the nunnery (*Frauenmünster*) at Zürich which he had just founded, and of which his daughter. Hildegard, was the first abbess. As early as 1243 Uri had a common seal, and in the confirmation of its privileges (1274) granted by Rudolf of Habsburg mention is made of its "headman" (Amman) and of the "commune" (*universitas*).

It took part, with Schwyz and Unterwalden, in founding the "Everlasting league" (*q.v.*) on Aug. 1, 1291, defending its liberty in the fight of Morgarten (1315) and renewing the League of the Three at Brunnen (1315). It took part in the victory of Sempach (1386), and (1512) the conquest of Lugano. At the Reformation Uri clung to the old faith.

In 1798, on the formation of the Helvetic republic, Uri became part of the huge canton of the Waldstatten and lost all its Italian possessions. In 1803 Uri became an independent canton again, with Ursern. but without the Val Leventina. It tried hard to bring back the old state of things in 1814–15, and opposed all attempts at reform, joining the League of Sarnen in 1832 to maintain the pact of 181j. opposing the proposed revision of the pact, and being one of the members of the Sonderbund in 1845. (See SWITZERLAND: History.)

URIBURU, JOSÉ EVARISTO (1831–1914), Argentine statesman and president, was born in Salta on Nov. 19, 1831, into a family prominent in the war of independence against Spain. After taking his doctor's degree in jurisprudence in 1854, he entered public life. He served in various political positions and held important diplomatic posts in several South American countries. He became minister to Chile in 1883, and in that post he helped mediate the dispute at the end of the War of the Pacific, which Chile had waged against Bolivia and Peru. In 1892 Uriburu was elected vice-president of Argentina; he succeeded to the presidency after Luis Sáenz Peña resigned on Jan. 23. 1895. During Uriburu's term he reorganized the armed forces and made reforms in public finance so that Argentina could resume payment on the public debt. He continued peaceful relations with Chile during the serious boundary dispute with that country. He retired from the presidency in 1898. but served as interim president in 1903. He was senator in the national congress from 1901 to 1910. He died in Buenos Aires on Oct. 23, 1914. His son JosC Evaristo Uriburu (1880–19j6), historian and diplomat. served as minister (1921–27) and ambassador (1927–31) to Great Britain.

URIBURU, JOSÉ FRANCISCO (1868–1932), Argentine army officer and political leader, a nephew of Pres. JosC Evaristo Uriburu (*q.v.*), was born in Salta on July 20, 1868. He graduated from the military college of Argentina in 1888, and spent more than 40 years in army service. He served as military attaché in Madrid. London and Berlin; in 1902 he was a member of the Argentine-Chilean boundary commission. Uriburu retired from the army in 1929. In 1930 during the economic depression he led an army revolt against the Radical leader, Pres. Hipólito Irigoyen. Uriburu became provisional president on Sept. 8, 1930, and set up a government dominated by the wealthy and conservative classes. After governing by decree for a year he permitted new elections to be held on Nov. 8. 1931; he refused to seek election but he made it plain that he would never permit the Irigoyen wing of the Radical party to return to power. The successful candidate was Gen, Agustin P. Justo. who had participated in the military coup of 1930, and who had the support of the government in the election. After the inauguration of Justo on Feb. 20, 1932, Uriburu went to Paris to seek medical treatment. He died in Paris on April 29. 1932.

URIC ACID, in organic chemistry, an acid which is one of the penultimate products of the tissue-waste in the human body. (See PURINES.)

While the bulk of the nitrogen of the albuminoids is excreted by kidneys and bladder as urea (*q.v.*), a small portion of it stops at the uric acid stage. Human urine contains only a fraction of a per cent of the acid, chiefly as sodium salt; an abundance of uric acid is met with in the excrement of serpents and birds, in which it is the principal nitrogenous product of tissue waste. Pure uric acid. $C_5H_4N_4O_3$, forms a snow-white microcrystalline powder devoid of smell or taste.

URICONIUM (more correctly VIROCONIUM or VRICONIUM), chief town, as proved by an inscription, of the Cornovii, now Wroxeter on the Severn, j mi. E. of Shrewsbury. At first perhaps (47–65) it was a Roman legionary fortress, held by the 14th and 20th legions against the Welsh hill tribes. When the garrison was removed, it became a flourishing town with public baths (excavated 1859–61), town hall and market (excavated 1924–27).

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URIM AND THUMMIM (Heb. *'ūrim*, tummim), means employed by the Hebrews in divination, but their identity and use are obscure. In I Sam. xxviii. 3–6, they are listed with dreams and prophets as a means of divine communication. From I Sam. xiv, 41 (Greek text), it would appear that lots were cast by their means. Hence the common explanation of them as stones or sacred dice. Ex. xxviii, 30, and Lev. viii, 8, make it clear that they were put in the "breastplate of judgment," and were not the precious stones attached to it as some, including Josephus, have conjectured. Others, basing on the root meanings of the words, would interpret them as symbols of abstract ideas, "revelation and truth" (Greek text), "perfection and doctrine" (Latin), and similarly Philo, the Talmud, etc. Others have sought, unsuccessfully, association with Egyptian deities, Ra and Tme, or with the Babylonian god Marduk's "tablets of destiny."

It is probable, however, that the solution lies elsewhere. The initial letter of 'urim is '(aleph), the first letter of the Hebrew alphabet, and that of Tummim, the tav, the final letter. Hebrew letters were used also for numbers and " 'urim and Tummim" could have been the expression for the 22 letters, odd and even. more particularly when used as numbers. The terms have, indeed, survived in the root elements of the Greek 'arithmos, "number," derivation otherwise unknown. The letters of the alphabet were thus put into the "breastplate of judgment" and would be affected by the Shekinah (*q.v.*), which rested on the high priest. The high priest would extract letters to be treated either as numbers, odd or even. or as alphabetic letters to form words.

According to rabbinic tradition. the 'urim and Tummim were among the five things lacking in the Second Temple.

See articles in Bible dictionaries by various scholars; also articles by W. Muss-Arnolt and L. Blau in *The Jewish Encyclopedia*, 12 vol. (1901–16), and particularly that by E. Kautzsch in *The New Schaff-Herzog Encyclopedia of Religious Knowledge*, 12 vol. (1908–12).

(E. Ro.)

URINARY SYSTEM. The urinary system in adult man, as in other mammals, consists of the two kidneys, the two ureters, the urinary bladder and the urethra.

The kidneys are the organs wherein the excretory fluid, the urine, is manufactured (see EXCRETION [KIDNEY]). The production of urine is continuous, so that it is constantly flowing from each kidney into its effluent duct, the ureter. The ureters transport urine into a single commodious expansile receptacle, the urinary bladder, where the urine is stored. In the process of voiding (micturition. urination), the bladder empties itself by a series of interrelated activities largely under voluntary control, and the emptying process results in rapid transport of urine from the bladder through a passageway to the exterior of the body. This final pathway, which in the male is also intimately related to the reproductive system. is known as the urethra.

Kidneys. — The kidneys are two firm reddish-brown organs with a characteristic "kidney bean" shape. Each measures four to five inches in length, two to three inches in breadth and about one inch in thickness. The combined weight of the two kidneys in relation to body weight in humans is about 1 to 240; hence, the two weigh less than a pound. They lie on either side of the spine behind most of the other abdominal organs. The right kidney is located somewhat lower than is the left, as if to accommodate the great bulk of the liver, which monopolizes the right upper quadrant of abdominal space. Both kidneys extend upward high enough to overlap with the lowest ribs, and each is capped by another important organ, the adrenal gland. The kidney is surrounded by a considerable padding of fatty connective tissue which cushions it from the body wall behind and the intestines in front. It is indented at its medial

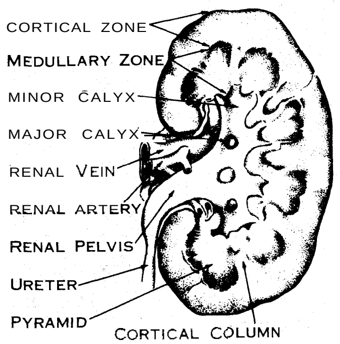

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FIG. 1.— SECTION OF KIDNEY SHOWING PARENCHYMA

margin (the hilum), which faces somewhat forward because of the sloping declivity of the posterior body wall. The organ is provided with a thin tough fibrous capsule which continues inwardly at the hilum and outlines within a potential space called the renal sinus. The fibrous capsule thereby forms a ringlike mouth at the hilum and an expanded sac inside.

Traversing the ringlike mouth and the renal sinus are the renal artery, the renal vein and the ureter. As a rule, the vein lies in front, the artery intermediate and the ureter behind and below. The ureter is expanded within the renal sinus as the renal pelvis, which in turn sprouts smaller conduits, the renal calyxes. These structures are illustrated in fig. 1, which shows how the calyxes are attached to the kidney substance. Each minor calyx fits around the apex of a pyramidal structure, the renal pyramid, which carries kidney ducts to it. Each pyramid, in turn, is the site of joining of many smaller kidney ducts which ultimately converge upon its apex (the papilla) to deliver urine into the calyxes and pelvis. The pyramids are separated from each other and from the exterior of the kidney by tissue which contains the beginning of the urinary pathway. The pathway commences at the glomerulus, which is a tuft of anastomosing arterial capillaries; each glomerulus is associated with the first part of a duct system. Although the glomeruli are located outside the pyramids (in the "cortical zone" and "cortical column" of fig. 1), their ductile continuities ultimately become incorporated into the pyramidal substance and lead successively to the calyxes, the pelvis and finally to the ureter.

Ureter, Bladder and Urethra. — The ureter or duct of the kidney begins at the hilum, descends on the back wall of the abdominal cavity, passes over the pelvic brim and opens into the urinary bladder. It is about one foot long and has a thick contractile wall. It varies considerably in calibre at different points throughout its extent. At its termination the ureter passes obliquely through the bladder wall so that, as the bladder fills, this terminal part tends to close.

The urinary bladder is a musculomembranous bag situated in the pelvic cavity. It lies in front of the rectum, from which it is separated in the female by the uterus. The bladder is capable of considerable distention, although usually it is emptied periodically when its volume reaches ten ounces or so. In distention the bladder wall may rise above the pelvic brim and become pressed against the front wall of the abdomen. In the interior of the bladder is a triangular area (the trigone) the two upper angles of which represent the openings of the ureters, while its lower mid-line angle presents the exit into the urethra. The urethral exit is kept closed by the action of a circular muscular valve except during the process of voiding. The bladder is emptied by contraction of the muscles of its wall and the relaxation of this circular valve. Physiologically the process of voiding is a somewhat complicated one involving the integration of several activities co-ordinated by the nervous system.

The urethra of the male consists of three parts, the first of which passes through the prostate gland and receives ducts from the testes (the ejaculatory ducts). This part lies above the pelvic floor (pelvic diaphragm). The second part of the urethra passes through the pelvic diaphragm and the third part traverses the length of the penis. In the male, then, the structure of the urethra is such that it serves as a final common pathway both for the urine and the reproductive secretions. The urethra in the female is much shorter than in the male. being about $1\frac{1}{2}$ in. in length and corresponding to that part of the male urethra which is above the point of entrance of the ejaculatory ducts. The female urethra also passes through the pelvic diaphragm and opens into the vestibule of the vagina, which latter receives the vaginal canal into its posterior aspect.

Embryology.—The development of the urinary system is a story of great fascination, since not one but three sets of kidneys are elaborated in each man's life history. These three sets correspond to three kidney types found at successive levels in the vertebrate hierarchy and hence are regarded as recapitulations of the evolutionary history of this organ. The first kidney to develop, the pronephros (head kidney), represents the adult kidney in primitive vertebrates such as the lamprey and hag. In bony fishes and amphibians a pronephros also develops, but it is superseded by a second organ, the mesonephros (middle kidney). Reptiles, birds and mammals have still a third kidney, the metanephros (hind kidney); but the older kidneys still spring up in the course of individual development in a remarkable series of events. which combines growth, regression and transformation, related not only to the development of the permanent kidney itself but to other parts of the body.

In man the pronephros appears very early in embryonic life and disappears quickly; its existence as a functional organ seems doubtful. It consists of a series of tubules connecting the embryonic body cavity (coelom) to a duct. Although the tubules fade away almost as soon as they are formed, the duct is more sturdy and extends downward to receive the tubules of the second kidney and, indeed, to become the mesonephric duct proper.

The mesonephros or middle kidney becomes a well-defined structure in the prenatal human and is related importantly both to the final kidney and to the reproductive system, particularly in the male. The mesonephric duct empties into the cloaca, the common lower terminus of the urogenital and digestive systems, which in turn is split into a front part, the urogenital sinus, and a back part which forms the lower digestive tract. In the partitioning of the cloaca, the mesonephric ducts retain their connections with the front part, and thus remain in contact with the lower part of the urogenital system, rather than with the digestive system.

The metanephros begins as an outgrowth from the lower part of the mesonephric duct. This diverticulum grows and divides to become the ureter, pelvis, calyxes and collecting ducts of the kidney. The rest of the kidney (intrinsic blood vessels including the glomeruli, the upper tubules) develops from a mass of embryonal connective tissue which concentrates about the end of the outgrowing ureter and its sprouts. The tubules which differentiate from this connective-tissue mass during development form the upper part or beginning of the urinary pathway. In fig. 2 these are labeled "proximal convoluted tubule." "Henle's loop" and "distal convoluted tubule." In order for the urine, which is largely formed in this upper part of the urinary system, to flow into the lower part, it is necessary for the upper tubules to make connection with the outgrowing sprouts from the ureter. This union takes place in the upper part of the pyramids or in the extensions of the pyramids toward the kidney surface, so that millions of tiny canals are developed, each leading from a single glomerulus to larger and lower parts. Once the collecting ducts are reached, the system begins to converge until the ureter finally emerges as the single common duct for each kidney.

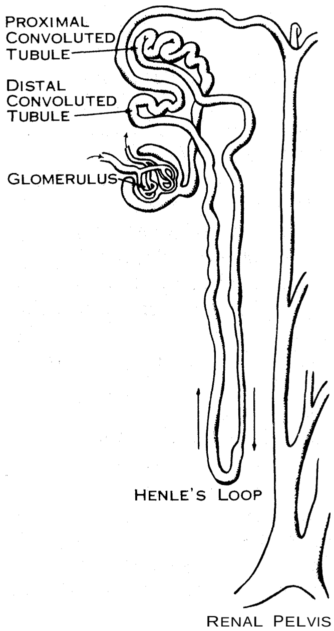

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FIG. 2.— DIAGRAM OF A NEPHRON

As the human kidney develops, it is distinctly lobulated, each lobe representing tissue related by drainage into a single pyramid. Certain mammalian kidneys have only a single pyramid, and hence are not lobulated.

In other mammals such as the

cattle, the bears, the seals and the whale, the fetal lobulation persists throughout life.

In man fetal lobulation is largely effaced in the process of growth and maturation, and it is usually not recognizable or becomes very indistinct in the adult.

For a while in mammalian development the ureter empties into the mesonephric duct from which it arises, and this arrangement persists in reptiles. Later on the ureters and mesonephric ducts become separated, as is the case in birds. Finally, mammals take an extra step, in that the upper part of the urogenital sinus develops into the bladder and the lower part into the urethra. In this process of differentiation the ureters establish their final continuity with the hladdcr and the mesonephric ducts become associated with the urethra.

The fate of the mesonephric ducts differs in the two sexes. In the male each duct becomes associated in its upper part with the testis. Below, the ducts retain their connection with the urethra. In consequence, the male urethra is capable of transporting urine from the bladder and sexual secretions from the testes, a dual function which is explained by its embryological history. By contrast with the sequence of events in the male subject is the behaviour of the mesonephric duct in females. Here the mesonephric duct is not appropriated by the reproductive system, but regresses almost completely, being represented in the adult only as a series of vestigial structures. The female generative tract owes much of its final form to another pair of ducts, the paramesonephric ducts. These tubes are present in both sexes in early embryonic life. They fail to develop in males, but continue to flourish in females to become the uterine tubes, the uterus and part of the vaginal canal. Like the mesonephric ducts, the paramesonephric ducts contact the urogenital sinus. Above their point of entry, the sinus differentiates into bladder and urethra; below, it becomes the vestibule of the vagina. Again, the adult relationships (urethra and vaginal canal communicating with a common lower vestibule) are explained by the developmental history of the organism. For the functions of the urinary system, and its diseases, see BLADDER AND PROSTATE, DISEASES OF; EXCRETION (KIDNEY); KIDNEY, DISEASES OF; UROLOGY.

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URINE, the fluid excreted by the kidneys, containing waste products of bodily metabolism and foreign substances absorbed from the gastrointestinal tract. *See* EXCRETION (KIDNEY); URINARY SYSTEM.

URMIA (URUMIA), renamed Rizaiyeh, a city in the province of W. Azerbaijan in Iran, on a plain at an elevation of 4,400 ft., in 37° 34′ N., and 45° 4′ E., 1jj mi. around the lake by road via Marand and Khoi from Tabriz. The population in 1956 was 67,580, being mainly Turkish, with Armenian and Assyrian (Nestorian) minorities. The plain of Urmia is fertile. By means of irrigation cultivation, especially of fruits and tobacco, reached a high standard.

In World War I there was a wholesale exodus of Christians —said to have reached 59,000—in July 1918, during the Turkish advance after the Russian debacle; and, in the same year, there were massacres by the Turks and Kurds of two-thirds of those who remained. In 1919, the remnant of 600 Christians was transferred to Tabriz, but some survivors were repatriated by the Iranian government.

URMIA (URUMIA), **LAKE OF,** in northwestern Iran, between 37° 10′ and 38° 20′ N. and between 45° 10′ and 46° E., which takes its name (Pers. *Deryacheh i* Urmia, Turk. *Urmi göl*) from the town of Urmia, situated near its western shore, but is also known as the Deryache-yi Shahi and Shahi göl.

The limits of the lake vary much, the length (north to south) from 80 to 90 mi., the width (east to west) from 23 to 31 being greater in the season of high water in spring when the snows melt.

The mean depth of the lake is 16 ft., and its greatest depth probably does not exceed 49 feet. The lake has exhibited extraordinary changes of level, either due to a movement of the earth's crust or merely to an increase of rainfall as compared with evaporation. De Morgan gave an area of 4,000 and 6,000 sq.km. (1,544 and 2,31; sq.mi.) for low and high water respectively.

In the south is a cluster of about 50 rocky islands, the largest of which, Koyun daghi, *i.e.*, "Sheep-mountain," is 3 to 4 mi. long and has a spring of sweet water near which a few people graze their goats and sheep.

All the other islands are uninhabited. The lake is about three-fifths as salt as the Dead sea—far too salt to permit of any life, except of lower organisms.

By the U.S.S.R. treaty with Iran, of 1921, the railway from Tabriz to Julfa and branch line from Sofian to Lake Urmia and all the properties pertaining to navigation on the lake—formerly a Russian concession—were gratuitously transferred to Iran. From the port of Sharaf-Khaneh on the eastern shore of the lake a fleet of motor boats of 20–160 h.p. is operated in conjunction with the railway. The service is weekly. The lake is also navigated by clumsy craft with round bows and flat sterns carrying enormous sails. *(See* URMIA.)

URMSTON, an urban district in the Stretford parliamentary division of Lancashire, Eng., 6 mi. S.W. of Manchester. Area 7.5 sq.mi. Pop. (1951) 39,237. The district, largely residential, comprises the three townships of Urmston, the administrative, shopping and transport centre, Flixton, and Davyhulme, in the northern part of which is the Trafford Park industrial estate. Flixton house, dating from the 17th century, is used as an assembly hall and communal centre, and at Urmston a covered swimming pool was built in 1932 and a large civic hall in 1947. The district is bounded by the river Mersey on the south and the Manchester Ship canal on the west and north. Its industries, nearly all in Trafford Park, include the production of commercial and household goods, asbestos roofing sheets, pipes, railway wheels and axles and soap. There, too, large imports of heavy oil are dealt with.

URODELE, a term used for tail-bearing amphibians, salamanders and allies, belonging to the order Urodela. Some authorities prefer the later terms caudate and order Caudata. *See* CAUDATA; AMPHIBIA.

UROLOGY. Urology is the branch of medicine, chiefly surgical, that deals with diseases of two systems, the urinary tract of both sexes and the male genital tract. These genitourinary organs are the pair of adrenal glands, kidneys, ureters, bladder, urethra, penis, prostate, seminal vesicles, testes, *vas deferens* and other scrotal contents.

The specialty of urology has passed through a remarkable period characterized by invention of diagnostic and therapeutic instruments and standardization of surgical technique. For example, a cystoscope which uses a right-angle optical system can be inserted in the urethra and the inside of the hladder visualized without performing surgery. The foroblique lens system of the panrndoscope is employed to observe the entire lining of the urethra. Transurethral use of the foroblique telescope in a resectoscope permits excision of certain hladder tumours or benign enlargement of the prostate. Many bladder stones are crushed into small pieces by the transurethral use of a lithotrite and then washed out of the bladder. Instruments are available for transurethral extraction of small stones in the lower ureter. All these instruments obviate the need for major lower abdominal surgerj-. While cystoscopy is being performed, fine hollow tubes (catheters) can be inserted up the ureters to the kidneys and urine collected for study of individual renal function. As these catheters are radiopaque, an X-ray film will demonstrate not only the renal outlines but also the catheters in the ureters. If a solution containing an iodized organic compound is instilled into each kidney and an X-ray taken, the entire lining of the kidneys can be visualized (retrograde pyelography). If X-rays are taken at specific time intervals following intravenous injection of a similar compound, renal form and function can be determined without cystoscopy. X-ray films taken after presacral air insufflation can often demonstrate adrenal tumours. Through the scientific precision of these and other instruments and methods, urologic diagnosis has achieved a high degree of accuracy.

Urologic investigation necessary to determine diagnosis and plan of treatment often consists of the following: history and physical examination, urinalysis, cystoscopy and retrograde pyelograms or intravenous pyelograms and tests of renal function. Infection can be determined by microscopic examination of the urinary sediment (urinalysis) for an increase in the normal number of white blood cells; by demonstration of glitter cells or double refractile fat bodies in the urinary sediment; by Gram stain of the sediment for demonstration of nonspecific bacteria, or by Ziehl-Neelsen stain, culture or guinea pig inoculation to reveal tuberculosis bacilli. Various types of urine culture enable identification of particular organisms. A specialized staining technique (Papanicolaou) can sometimes detect malignancy of the kidney. bladder or prostate by staining exfoliated cancer cells in the urine. Detection of urinary sugar can lead to the diagnosis of diabetes mellitus. Albumin indicates renal disease but may be associated with infection of kidney, bladder or prostate, with genitourinary tumours or with functional conditions. Waxy, granular or hyaline casts in the urinary sediment may be the only sign of serious renal disease. An increase in the normal number of red blood cells may have the same significance or may stimulate an investigation for tuberculosis or tumour. Certain other studies of the urine and blood afford remarkably accurate methods for determination of kidney damage or failure.

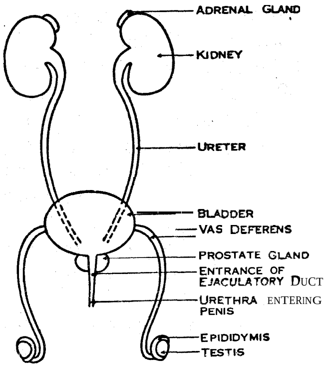

FIG. 1.— MALE GENITOURINARY SYSTEM, ANTERIOR VIEW

The functions of the kidney are (1) to filter the plasma through the glomeruli; (2) to maintain normal acid-base balance of body fluids by conserving base in the tubules; and (3) to regulate body fluids by reabsorption of water and other compounds. The kidney filters or excretes 40 to 50 g. of solids, such as urea, ammonia, uric acid: creatinine, chloride, sodium, phosphorus, potassium and calcium, per litre of urine. The filtrate formed by the glomeruli amounts to 150 to zoo 1. (about 180 qt.) per 24 hours. All this fluid volume would be urinated each day were it not for the fact that the renal tubules reabsorb about 99% of it. Urochrome is the normal urinary pigment. Function tests of glomeruli or tubules are often of great value in diagnosing urologic disease, assessing degree of renal damage and determining whether or not surgical intervention is possible or would be of help to the patient. Methods to determine renal insufficiency are based on retention of nonprotein nitrogenous waste products in the blood, evaluation of rate of excretion of these products and measurement of failure of the renal tubule to dilute or concentrate or reabsorb water.

When kidney disease becomes overwhelming, death ensues from uraemia. Uraemia is characterized most often by an increase in serum concentration of nonprotein nitrogenous waste products (urea, uric acid, creatinine); increased concentration of serum potassium: which can produce fatal cardiac disease; an increased serum phosphorus and a decreased calcium, which can produce tetany; an increase in serum chloride; acidosis; anaemia; normal, decreased (oliguric) or absent (anuric) urinary output, depending on the type of renal disease producing the uraemia.

UROLOGIC DISEASES

Congenital and Other Anomalies. — Most urologic anomalies consist in absence, underdevelopment, incomplete or complete duplication or abnormalities of position. The majority of anomalies produce no signs or symptoms and require no treatment. If symptoms are caused by urologic anomalies, it is usually because of obstruction to the conduction of urine. This in turn may produce infection and possibly stone formation proximal to the obstruction, and often requires surgical correction. A few of these abnormalities such as absence of both kidneys (but not one), are incompatible with life. In other conditions the obstruction may cause such severe destruction to the kidneys that death from uraemia ensues. Still other conditions, such as polycystic kidneys or bilateral renal hypoplasia, may be fatal to the patient by their very nature or natural course.

Kidney. — A hypoplastic or infantile kidney may be associated with hypertension (high blood pressure). Horseshoe kidneys are the commonest form of fused kidneys and consist in union of the lower pole of the kidney with its opposite mate. Surgical separation of the kidneys or partial or complete unilateral nephrectomy may be necessary. An ectopic or misplaced kidney may be found anywhere from below the location of the normal kidney to within the pelvis resting just behind the bladder. Nephroptosis is abnormal mobility of the kidney; it seldom requires treatment. Polycystic renal disease is bilateral and fatal, as the enlarging cysts destroy renal tissue and the patient dies from uraemia. It may produce hypertension.

Ureter.—Congenital ureteral obstruction can occur at the ureteropelvic junction and if untreated may destroy the kidney. Treatment consists of surgical removal of the obstruction and plastic ureteral procedures. If severe hydronephrosis exists, nephrectomy may be indicated. Ureterocele is caused by a defective union of ureter to bladder. If not treated it may produce renal damage. Treatment consists of fulguration of the ureterocele.

Bladder. — Exstrophy consists of failure of union of the anterior wall of the bladder and abdominal wall over it, with exposure and extroversion of the posterior wall of the bladder and ureter. If untreated, about 70% of those suffering from it die from renal disease before reaching 20 years of age. Treatment should be early and consists of excision of the bladder and anastomosis of ureters to the large bowel. Patent urachus represents the remains of the embryonic allantois at the dome of the bladder. It may become infected, abscessed, develop a calculus, tumour, perforation or urinary fistula and is cured hy surgical excision.

Urethra and Penis. — Phimosis exists when the opening in the redundant foreskin is too small to permit the prepuce to be drawn back over the glans. When the phimotic prepuce has been retracted in back of the glans penis and cannot be replaced, it is termed paraphimosis. Immediate reduction of paraphimosis is necessary. Treatment for both conditions is circumcision. Failure to have circumcision performed during infancy is considered an important factor in development of penile cancer. Congenital urethra1 valves can cause obstruction, abnormalities in urination, residual urine and even death from uraemia. Surgical excision of the valves should be performed. Hypospadias is caused by failure of the distal portion of the male urethra to close. As a consequcnce, voiding occurs through an opening which can be at any point throughout the length of the urethra. Surgical treatment consists of correction of chordee (angulation of the penis) and construction of a urethra from the meatus to the tip of the penis.

Hermaphroditism is another anomaly; true forms of this condition are rare, as a person of one sex usually has some features of the other sex. Treatment, if any. is directed at determination of the predominant sex. and surgical creation of structures most like that gender with excision of organs and structures of the opposite sex.

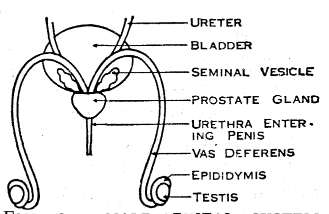

FIG 2.— MALE GENITAL SYSTEM, POSTERIOR VIEW

Testis.—Cryptorchism consists of a failure of descent of one or both testes from the retroperitoneal or inguinal areas into the scrotum. Administration of gonadotrophic hormone or, if this is unsuccessful, surgical relocation of the testes should be employed before age six, for at this time injury to the seminiferous tubules by temperature variant begins which may produce sterility. The condition rarely causes impotency. Congenital hydrocele is an accumulation of fluid around the testis usually associated with a hernia. Excision of the hydrocele sac is carried out at the time of herniorraphy.

Injuries. — Serious traumatic injuries to the genitourinary system are not common. A highly protected anatomical position (kidney, ureter, bladder, prostate) or extreme mobility (penis, scrotal contents) acts to lessen any trauma. Penetrating wounds, crush injuries or blows account lor most cases. The two most important complications are bleeding and extravasation or leakage of urine from its normal channel into the surrounding tissues. Bright red blood in the urine (haematuria) after an injury to the flank or back indicates renal injury. While surgery is seldom necessary, in rare instances excision of the kidney (nephrectomy) may be a lifesaving procedure.

Injury to the lower abdomen or perineum may cause rupture of the bladder or urethra with extravasation of urine. If extravasation caused by rupture of the bladder is not diagnosed and urinary drainage of the tissues is delayed for 48 hours, the condition is often fatal. Rupture of the bladder is usually characterized by inability to urinate. Passage of a urethral catheter to the bladder reveals no urine or a small amount of bloody urine. After injection into the bladder of a sterile radiopaque solution, anterior and oblique X-ray exposures will reveal the solution outside the bladder. Surgical exploration of the bladder and peritoneal cavity with insertion of drains is a mandatory immediate procedure.

Urethral ruptures require the insertion of a catheter into the urethra and bladder. where it is left indwelling by means of a small inflatable bag on its tip (Foley catheter). If there is oedema or swelling, indicative of a haematoma or collection of blood in the tissues of the perineum, scrotum or penis. and it is impossible to insert a catheter into the urethra to the bladder. open surgery should be performed immediately.

Urinary Tract Obstruction.—Obstruction to the outflow of urine may he present anywhere from the kidney to the tip of the urethra. Narrowing of a renal infundibulum may produce dilatation of its calyx; ureteropelvic obstruction can lead to hydronephrosis; ureteral stricture or ureterocele can produce ureteral dilatation and hydronephrosis; bladder neck obstruction of any type can cause bilateral hydronephrosis and, if severe, death from uraemia; the same may be said of urethral stricture or even of a narrow urethral meatus. If the obstruction is diagnosed in time and relieved by urinary tract drainage. much of the renal insufficiency may be reversible. The effects of obstruction may be infection, stone formation and renal damage.

The commonest obstructions are median bar or benign prostatic hypertrophy and urethral stricture. Approximately 60% of men over 50 years of age have benign enlargement of the prostate gland in the form of an encapsulated adenoma, but only about 35% of these men require surgery. The prostate surrounds the urethra at the outlet of the bladder. With enlargement, this benign tumour compresses the urethra and can produce alteration in voiding characteristics. urinary retention or renal damage. Rectal examination reveals the enlarged prostate gland. Excision of the prostatic adenoma is performed by one of four methods of "prostatectomy": suprapubic, retropubic or perineal for large adenomas, and transurethral resection for small, hypertrophied glands. The operative mortality is between 1% and 2%. Ligation of the vas *deferens* is performed. which greatly reduces the incidence of acute infection of the epididymis. Postoperatively these patients have complete urinary control and potency.

Crethral stricture may occur occasionally after prostatectomy or after severe chronic urethral infection or trauma. Gentle insertion of curved metal instruments (sounds) in the urethra establishes diagnosis and dilates the stricture.

Turnours.—Kidney.—Renal cancer of children is named Wilms's tumour, embryonal carcinosarcoma or embryoma. There is seldom haematuria or pain, but the tumour attains large size. Best results are obtained by nephrectomy and postoperative irradiation therapy. Cure rate ranges from 14% to 58%. Renal cancers of adult life may be divided into tumours of the parenchyma or renal tissue itself and tumours of the pelvis and calyces. Parenchymal tumours (hypernephroma, clear cell or Grawitz' tumour and medullary carcinoma) comprise about 90% of adult renal tumours. Haematuria is the most constant sign, but this often occurs after the development of distant metastases or spread. If no distant metastases are present, treatment consists of excision of the kidney with its surrounding fatty covering. Neoplasms of the renal pelvis or calyces comprise about 10% of adult kidney cancers. They are usually either papillary or squamous cell neoplasms. Papillary lesions tend to involve or reappear in the ureter; therefore, the ureter and cuff of the bladder as well as the kidney are excised. Cure rate is in the range of 15% to 20%.

Bladder.—Bladder tumours produce haematuria and symptoms of bladder irritation. They may be classified in three groups: Papillary tumours are benign lesions, but they eventually become malignant and are therefore resected by high-frequency electrodesiccation. Papillary carcinoma and sessile tumours are true cancers, which must be treated by (1) transurethral resection with a resectoscope and fulguration of the base; (2) implantation of radon seeds; (3) excision by open operation of the segment of the bladder containing the lesion; or (4) removal of the entire bladder (cystectomy) and anastomosis of the ureters to the large bowel or skin. Far-advanced bladder cancers can produce death from uraemia or haematuria.

Prostate Gland.—Adenocarcinoma of the prostate arises in the posterior lobe in more than 90% of cases. Early prostatic cancer presents no signs or symptoms and is detected only by the presence of a prostatic nodule on rectal examination. Treatment consists of excision of the entire prostate and seminal vesicles. Postoperatively about 5% of patients have some loss of urinary control, and nearly all are impotent. The operation offers a 38%–50% cure rate.

If the patient presents X-ray evidence of spread, or metastases, or an increase in either serum acid or alkaline phosphatase, radical surgery does not cure him; palliative endocrine therapy often lessens pain and prolongs life. Growth of the prostate is dependent on androgen, or male hormone, produced by the testes. The antiandrogenic control of prostatic cancer consists of removal of the testes (orchiectomy) and administration of female hormone (estrogen). Activity of advanced prostatic cancer may be determined by the concentrations of serum acid and alkaline phosphatase.

Testis.—The common testis cancers are teratoma, seminoma, embryonal carcinoma, chorioepithelioma and terato carcinoma. Testis cancer usually becomes apparent as a painless mass during the period of greatest endocrine activity (ages 15–35 years). Chorioepithelioma may produce gonadotrophic hormone that may be measured in the urine, and patients may have gynaecomastia. In addition to orchiectomy, lymphadenectomy should probably be used for all but chorioepithelioma and seminoma. The cure rate for chorioepithelioma is practically zero, and seminoma is sensitive to irradiation therapy and offers an excellent prognosis.

Infection.—Infection of the urinary tract is a common condition most often caused by obstruction, atony or a focus of infection from a distant organ, This infection may spread to other organs of the urinary tract; for example, a renal infection (pyelonephritis) may produce a secondary bladder infection (cystitis). Successful treatment of any urinary tract infection depends on search for and removal of the cause and on prolonged administration of the specific drug in doses sufficient to produce a high tissue level concentration.

Urine culture and sensitivity studies will determine not only the organism but also the specific drug necessary for treatment. Eighty per cent of these infections are due to Gram-negative bacteria and are treated successfully with one of the sulfonamide drugs such as gantrisin, elkosin or thiosulfil. Resistant organisms may require use of other compounds: Aerobacter *aerogenes* is frequently sensitive to achromycin (tetracycline). *Pseudomonas* aeruginosa (pyocyaneus) is often cured with terramycin (oxytetracycline). *Proteus vulgaris* responds well to furadantin. *Escher*ichia coli is best treated with either oxytetracycline or tetracycline. Sensitivity studies may indicate use of chloramphenicol (chloromycetin), streptomycin or erythromycin or methenamine (mandelamine) niandelate. Gram-positive organisms are ireated with either penicillin or sulfonamides. Mixed infections may be treated by a combination of antibiotic or chemotherapeutic drugs.

Pyelonephritis can be of an acute or chronic type. The acute type is often associated with high fever, chills, nausea and vomiting and back pain. Treatment with antibiotic drugs routinely effects a dramatic cure. Chronic pyelonephritis produces a much milder degree of the above signs and symptoms and is most difficult to cure as the aetiology is often obscure. If inadequately treated, some patients with chronic pyelonephritis develop fatal hypertension.

Renal tuberculosis is frequently characterized by gross or microscopic haematuria or symptoms of a secondary cystitis. This is a disease caused by tuberculosis infection elsewhere in the body, although the focus can be identified clinically in only 25% of patients. It is treated by nephrectomy. In cases of small unilateral lesions or bilateral involvement, treatment consists of streptomycin, isonicotinic acid hydrazide and para-aminosalicylic acid.

Cystitis is a bladder infection, usually of women or children, producing symptoms of vesical irritation. It can be caused by pyelonephritis, obstruction at the bladder neck, bladder calculus, cystocele, vaginal discharge, infected Fallopian tube, teeth, appendix or tonsils or other focus of infection.

Epididymitis is usually secondary to an infection originating in the prostate gland. It is usually nonspecific and characterized by fever, pain, swelling and tenderness of the epididymis. Administration of antibiotic drugs, elevation of the scrotum and bed rest are used as standard treatment. Tuberculosis of the epididymis can originate from renal tuberculosis or prostatitis. While surgical excision is commonly practised, use of streptomycin, isonicotinic acid hydrazide and para-aminosalicylic acid have been recommended.

Calculus Disease.—Normally, urinary colloids tend to hold urinary crystalloids in solution and prevent stone formation. A stone is formed by a nucleus composed of a mass of epithelial cells, pus cells, protein aggregate, bacteria, etc., and surrounded by many layers of organic and inorganic material. Stones are sometimes composed of a pure compound such as uric acid or cystine; others have a mixed composition such as calcium phosphate, calcium urate or calcium oxalate.

The cause of urolithiasis in humans is not well understood. Calculi can form as a result of the following conditions: urinary tract obstruction, increased activity of the parathyroid glands (hyperparathyroidism), gout, certain types of urea-splitting infections of the kidneys, prolonged immobilization as in paraplegia, defective cystine metabolism and hypercalcaemia. It is not possible to demonstrate these "known" causes of stone formation in more than 15% of patients with calculus disease. About 50% of patients with urolithiasis have infection of the urine. Fortunately, more than 90% of stones can be visualized by X-ray films.

Stones may form in the renal parenchyma (nephrocalcinosis) or renal calyx or pelvis. If a stone develops in either of the latter locations it can enter the ureter or can remain in the kidney. If it remains intrarenal it may increase in size to a remarkable degree and completely destroy the kidney without producing any marked symptomatology, or it may remain the same size. Most stones in the ureter pass into the bladder without operative intervention. Passage of a ureteral calculus may become arrested at the ureteropelvic junction, in the lower third of the ureter or at the ureterovesical junction. Because of this obstruction it may produce severe renal colic. renal damage or marked pyelonephritis. Any or all of these findings can indicate the need for surgical removal of the stone. Calculi in the lower third of the ureter can be removed frequently by plastic, nylon or metal snarelike instruments manipulated transurethrally through a cystoscope.

About 8% of patients with stones develop recurrences. In order to decrease the recurrence rate of calculi, the cause (if determined) should be removed, infection controlled and fluid intake increased. Patients with cystine or uric acid stones should be given alkalinizing agents. The use of acid or alkaline or other special diets to prevent the recurrence of calculi has proved unsatisfactory.

Most bladder calculi originate from the kidney. When a calculus passes down the ureter (4 mm. in diameter) to the bladder, it usually is expelled through the urethra (9 mm. in diameter) at once. If it remains in the bladder it can increase greatly in size over a short period of time. Small bladder calculi may be crushed transurethrally with a lithotrite and then washed out of the bladder. Large bladder calculi are usually removed by open surgery. I'atients with prostatic calculi always have infection of the prostate. It is not known whether this infection is primary or secondary to the calculi.

Infertility and Impotency.—In most cases of sterility both male and female partners should be studied. Sterility in the male may be due to loss of erections (impotency); inability to direct the ejaculate to the proper location, as in some patients with hypospadias or after bladder neck surgery; obstructive lesions preventing exit of the spermatozoa from the ejaculatory ducts into the urethra. as in chronic prostatitis or bilateral epididymitis; and qualitative or quantitative deficiencies of the spermatozoa.

The cause of impotency in more than 95% of patients is psychoneurosis. Neurogenic causes, such as disease or injury of the central nervous system or local peripheral nerves, injury to the body of the penis or absence of the testes may produce this condition. A few men with fatigue or debility can fail to have erections.

The most frequent cause of sterility is a decrease in the quality or quantity of the spermatozoa. A total of about 60,000,000–80,000,000 spermatozoa is considered at the very lower limit of normal consistent with ability to procreate, provided all other characteristics are normal. Minor (10%) abnormalities of morphology or form of the spermatozoa are not considered of as serious importance as decreased motility. Any or all of these abnormalities may be caused by seminiferous tubular immaturity, mumps, trauma or thermal injury (cryptorchism). Frequently such damage is of unexplained aetiology.

See M. Campbell (ed.), Urology, 3 vol. (1954); F. H. Colby, Essential Urology, 2nd ed. (1953). (RR. B.)

URQUHART, SIR THOMAS (1611–1660?), Scottish author. translator and polymath whose works are marked by originality of both language and method. was born in 1611, the eldest son of Sir Thomas Urquhart of Cromarty. After studying at King's college, Aberdeen, he traveled in France, Italy and Spain. He was back in Scotland in time to fight against the Covenanters at Turriff (1639), and was knighted by Charles I in 1641. His strong royalist convictions led him to join the army of Charles II in 1651, and he was taken prisoner at the battle of Worcester and incarcerated in the Tower of London and at Windsor. His imprisonment mas fairly nominal: Cromwell allowed his release on parole and after 1653 he appears to have been at liberty. At any rate he died abroad, traditionally "in a fit of excessive laughter, on being informed by his servant that the King was restored" in 1660.

Urquhart's earliest production. *Epigrams: Divine and Moral* (1641). was an undistinguished collection of verses, which gave no hint of what was to come. In 1645 he published *The Trissotetras*, an almost impenetrably obscure treatise on trigonometry, paying tribute to the recently invented logarithms of his fellow countryman John Napier, but couched in a fantastic verbal symbolism whose would-be mnemonic value is far less assimilable than the normal mathematical terms. This was followed in 1652 by "ΠΑΝΤΟΧΡΟΝΟΧΑΝΟΝ," a highly imaginative demonstration of the pedigree of the Urquharts of Cromarty, traced back to Adam "surnamed the Protoplast." Also in 1652 appeared a more important work, "ΕΚΣΚΥΒΑΛΑΥΡΟΝ," an unclassifiable compound of personal, historical and patriotic reminiscence and exhortation; containing his deservedly famous account of the life of James ("the Admirable") Crichton (1560–85?). *Logopandecteision* (1653) was subtitled "An Introduction to the Universal Language," but the ostensible subject is overlaid by a series of autobiographical and apologetic digressions of great interest and some historical value. These are, as Urquhart says. "bookes, on subjects never hitherto thought upon by any," and the style he develops is equally idiosyncratic: rich, full, inventive; polysyllabic but vigorous; pedantic and eccentric yet capable of presenting sharp description and sharper comment.

Urquhart found the perfect medium for his "literate and compleat elucubrations" in translating the *Works of Mr. Francis Rabelais* (books i–ii, 1653: book iii, 1693). Though he is not always accurate. and though he frequently amplifies the original, Urquhart produced in this work a classic of translation and one of the most vivid examples of 17th-century English prose. (Although Urquhart was Scottish. he used very few Scottish words.) His linguistic exuberance and his sympathy with the free spirit of Rabelais combined to make this the established version in English.

Urquhart's *Works,* excluding the translation of Rabelais, were edited by G. Maitland for the Maitland club (1834); *Selections* were edited by J. Purves for the Saltire society (1942); Urquhart's Rabelais was edited with an introduction by C. Whibley (1900).

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URQUIZA, JUSTO JOSÉ DE (1800–1870), Argentine rancher and provincial *caudillo,* or military-political leader, who conquered the powerful dictator Juan Manuel de Rosas (*q.v.*) and laid the constitutional foundations of modern Argentina, was born in the province of Entre Rios on March 19, 1800. Urquiza became its governor in 1842, as an ally of the Buenos Aires dictator Rosas. In 1851 he turned against Rosas, mainly for economic reasons, raised the latter's siege of Montevideo and defeated him in the battle of Caseros (Feb. 1852). Urquiza called a convention which wrote the enduring constitution of 1853 and was elected president for the term 1854–60. Buenos Aires, determined to lead the nation. seceded from the new confederation and under Gov. Bartolomé Mitre defeated Urquiza and the confederation forces at Pavón (1861). Urquiza then retired to his lands. He was assassinated on April 11, 1870, by the agents of López Jordán, an ambitious local *caudillo.* (T. F. McG.)

URSA MAJOR (THE GREAT BEAR), in astronomy, a constellation of the northern hemisphere, supposed to be referred to in the Old Testament (Job ix, 9; xxxviii, 22), and mentioned by Homer, Ἄρκτος θ', ἣν καὶ ἅμαξαν ἐπίκλησιν καλέουσι (*Il.*, 18, 487). The Greeks identified this constellation with the nymph Callisto (*q.v.*), placed in the heavens by Zeus in the form of a bear together with her son Arcas as "bear warder," or Arcturus (*q.v.*); they named it Arctos, the she-bear, Helice, from its turning round the polestar. The Romans knew the constellation as Arctos or Ursa; the Arabs termed the quadrilateral formed by the four stars α, β, γ, δ, Na'sh, a bier, whence it is sometimes known as Feretrum Majus. The Arabic name should probably be identified with the Hebrew name 'Ash and 'Ayish in the book of Job (*see* G. Schiaparelli, *Astronomy* in *the Old Testament,* 1905). Ptolemy catalogues eight stars. Of these, the seven brightest (six stars: α, β, γ, ϵ, ζ and η, are of the second magnitude and δ is of the third magnitude) constitute one of the most characteristic figures in the northern sky; they have received various names—Septentriones, the Wagon, Plow, Dipper and Charles's Wain (a corruption of "churl's wain," or peasant's cart). With the Hindus these seven stars represented the seven Rishis. The stars α and β are called the pointers, since they point to the polestar. Five stars of the Plow form an associated group with common proper motion; but α (the upper pointer) and η (the last star of the tail) have no connection with the others. Stars in other parts of the sky have been found to belong to the same cluster; in particular Sirius is a stray member of it.

URSA MINOR (THE LITTLE BEAR), in astronomy, a constellation of the northern hemisphere, mentioned by Thales (7th century B.C.). By the Greeks it was sometimes named Cynosura (Gr. κυνός, dog's; οὐρά, tail)! alleging this to be one of the dogs of Callisto, who became Ursa Major. The Phoenicians named it Phoenice. or the Phoenician constellation, possibly in allusion to the fact that the brightest star; Polaris, being situated very close to the north pole. is of incalculable service to navigators. Polaris, a second magnitude star, was in 1937 distant $1°\ 2'$ from the celestial pole. It is a Cepheid variable with very small light range.

URSINS, MARIE ANNE DE LA TRÉMOILLE, PRINCESSE DES (1642–1722), lady of the Spanish court, daughter of the duke of Noirmontier and Renée Julie Aubri. After the death of her second husband, Flavio Orsini, duke of Bracciano. she assumed the title of Princess des Ursins, a corruption of Orsini, and for her unofficial services in securing Neapolitans and Spaniards of rank at Rome as French partisans in view of the approaching death of Charles II of Spain, she was rewarded in 1699 by a pension. When Philip. duke of Anjou. grandson of the French king. was declared heir by the will of Charles II, the princess took an active part in arranging his marriage with a daughter of the duke of Savoy. Appointed *camarera mayor* by quiet diplomacy and the help of Madame de Maintenon. she accompanied the young queen to Spain in 1701. Till 1714 she was the most powerful person in the country. She was expected to look after French interests in the palace and to manage the Spanish nobles. But she wisely held that the young king should rely on his Spanish subjects and was in frequent conflict with the French ambassadors. Recalled in 1704, she still had the support of Madame de Maintenon, and her own tact placated Louis XIV. In 1705 she returned to Spain with practically the power to name her own ministry. During the War of the Spanish Succession she was the real head of the Bourbon party. She was so far from offending the nation that when Louis XIV threatened in 1709 to desert his grandson she dismissed all Frenchmen from the court. On the death of the queen, acting by advice of Alberoni, she arranged a marriage for the king with Elizabeth Farnese of Parma. She was rudely disillusioned in her hopes of governing the new queen as she had done the old. Driven from Elizabeth's presence with insult, at Quadraque. whither she had gone to meet her, she was sent out of Spain without being allowed to change her court dress. After a short stay in France, Madame des Ursins went to Rome. where she died on Dec. 5, 1722.

See F. Combes, *La Princesse des Ursins . . .* (1858); *Lettres inédites de Mme. de Maintenon et de . . . la Princesse des Ursins* (1826; Eng. trans., 1827): *Lettres inédites de la princesse des Ursins* (1859); C. Hill, *Story of the Princess des Ursins in Spain* (1905).

URSULA, SAINT, legendary leader of 11,000 virgin martyrs believed to have suffered at Cologne. The story rests on a 4th- or 5th-century inscription stating that an ancient basilica had been restored on the site where some holy virgins had been martyred. These are mentioned again in an 8th- or 9th-century sermon, their number now having increased to several thousand who are reported to have suffered under the emperor Maximian. A later form of the legend names Ursula, a British princess, as their leader, who was said to have gone to Rome accompanied by 11.000 virgins and to have been killed together with them by the Huns on her return from the pilgrimage. The discovery in 1106 of an ancient Roman burial ground at Cologne believed to contain the remains of the martyrs was the occasion of additional legends, which were further embellished by revelations of the visionary Elizabeth of Schonau.

Ursula is remembered especially as the patron of the Ursuline nuns. Her feast day is Oct. 21.

See M. Tout. "The Legend of St. Ursula and the Eleven Thousand Virgins," in *Historical Essays by Members of the Owens College Manchester,* pp. 17–56 (1902). (H. C. G.)

URSULINES, a religious order founded at Brescia by Angela Merici (1470–1540) in November 1535, primarily for the education of girls and the care of the sick and needy. It was approved in 1544 by Paul III, and in 1572 Gregory XIII declared it a religious order under the rule of St. hugustine. In the following century it was encouraged by St. Francis of Sales and the Ursulines in Canada did valuable work among the French and Indian:.

URTICACEAE (nettle family), a family of flowering plants belonging to the order Urticales. There are 41 genera, with about 480 species, mainly tropical, though several species such as the common stinging nettle (*Urtica dioica*) are widely distributed and occur in large numbers in temperate climates. Six genera, *Urtica, Parietaria, Boehmeria, Hesperocnide, Laportea* and *Pilea,* are represented in North America, with about 15 native species. *Urtica* and *Parietaria* are also found in the British Isles.

The plants are generally herbs or somewhat shrubby, rarely, as in some tropical genera, forming a bush or tree. The simple, often serrated leaves have sometimes an alternate sometimes an opposite arrangement and usually, with the exception of *Parietaria,* bear stipules. Stinging hairs often occur on the stem and leaves. The bast fibres of the stem are generally long and firmly attached end to end, and hence of great value for textile use. Thus in ramie (*q.v.*) (*Boehmeria nivea*) a single fibre may reach nearly nine inches in length, and in stinging nettle as much as three inches. *Maoutia* and *Urtica* have also been used as sources of fibre.

The small inconspicuous regular flowers are arranged in definite (cymose) inflorescences often crowded into headlike clusters.

They are unisexual and monoecious or dioecious. The four or five green perianth leaves (or sepals) are free or more or less united; the male flowers contain as many stamens, opposite the sepals. The flowers are adapted for wind pollination. The female flower contains one carpel bearing one style with a brushlike stigma and containing a single erect ovule. The fruit is dry and one-seeded; it is often enclosed within the persistent perianth.

The family is divided, according to Engler, into two main classes: (1) the Urereae with stinging hairs, including the genera *Urtica*, *Urera*, *Laportea:* (2) others, without stinging hairs. *See* also NETTLE; PELLITORY.

COMMON NETTLE (URTICA DIOICA)

URTICARIA: *see* HIVES.

URUAPÁN (URUAPÁN DEL PROGRESO), a town of Mexico in the state of Michoacán, about 270 mi. W. of the federal capital. Pop. (1950) 31,409. Uruapán, Tarascan for "where the flowers abound," was founded in 1533. It is famous for its colourful lacquer ware and handicrafts produced by the Tarascan Indians. Tourists have been attracted there by its healthful climate and the many picturesque sights in Uruapán and the surrounding countryside, including the volcano Paricutin, which appeared in 1943. (R. B. McCK.)

URUBAMBA, a river in southern Peru, rises in the Nudo de Vilcanota on the border between Cuzco and Puno departments, and flows for about 450 mi. to its junction with the Apurimac (*q.v.*) to form the Ucayali. Its upper part: where it passes Sicuani, Urcos and Urubamba, is densely settled by Indian farmers. Below Urubamba, in the Gorge of Torontoy, the river plunges from 11,000 ft. to 8,000 ft. in 20 mi. The Inca ruins of Machu Picchu overlook the lower Urubamba. The deeply cut valley bottom around Quillabamba is sparsely populated. (P. E. J.)

URUGUAIANA, a river port on the left bank of the Uruguay river in the state of Rio Grande do Sul, Brazil, is located opposite the Argentine town of Paso de los Libres. The two towns are connected by a bridge which was completed in 1945. Uruguaiana is about 350 mi. W. of Pôrto Alegre, with which it is connected by rail. The Gruguay river is 2 mi. wide and 154 ft. above sea level at this point. It is navigable for shallow-draft river boats only for short distances between the numerous rapids that interrupt its course. Uruguaiana is a livestock centre and has meat-processing plants. Its factories produce candles, soap, tanned leather goods, perfumes and tobacco products. The former spelling was Uruguayana. Pop. (1950) 32,639. (P E. J.)

URUGUAY (officially the Rephblica Oriental del Uruguay, and still locally called the Banda Oriental, the "eastern shore" of the Uruguay river), the smallest (area 72,152 sq.mi.) independent state in South America. It lies between Brazil on the north and the estuary of the Rio de la Plata on the south, extending from the Uruguay river to the Atlantic coast. It has a seaboard of about 120 mi., a shore line on the Plata of 235 mi. and one of 270 mi. along the Uruguay.

This article is divided into the following sections:

There are also short articles on the departments and more important cities.

I. PHYSICAL GEOGRAPHY

Geology. — The eastern and southern half of Uruguay is a low hilly land, with a subsoil of weathered ancient schist and granite, through which protude low ridges of less weathered rocks. In central and north-central Uruguay a basement of ancient schist is overlain by nearly horizontal Permian beds. which form a low plateau. The northwestern portion is occupied by a southward extension of the Paraná plateau of southern Brazil. This plateau is formed of horizontal beds of Triassic red sandstone of continental origin, in places faulted and capped by sheets of Triassic basalt. The plains of Uruguay are covered with Pleistocene deposits of sand and clay like those found on the pampas of Argentina and with alluvial beds.

Physiography. — The southeastern part of the country consists of low rolling hills, a southward extension of the Brazilian highlands. The coast line is fringed with tidal lakes and sand dunes: the banks of the two rivers are low, unbroken stretches of level land. The northwestern section of the republic presents greater variety of relief, with occasional ridges and low plateaus, alternating with broad valleys. a southward extension of southern Brazil. None of the hills and plateaus of Uruguay exceeds 2,000 ft. in elevation.

There are no large rivers entirely within Uruguayan territory. The Negro, the largest stream; is navigable only in its lower part. No other streams are navigable except for vessels of light draught. The Santa Lucía, Queguay and Cebollati are the other principal watercourses. The Uruguay river, along the border, is navigable for steamers of 14-ft. draught from its mouth to Paysandú, and above that point for smaller vessels to the falls at Salto, 200 mi. in all. *(See* also PLATA, RÍO DE LA.)

Climate. — Uruguay has a truly temperate climate. The average temperature for the summer months of January and February being about 71° F. and that of the coldest month, July, being 50°. Frost is almost unknown. The weather of both summer and winter is marked by great variability from day to day, a result of the passing of cyclonic storm centres. Brusque wind shifts are common, the hot northerly wind sometimes being followed immediately by the chill pampero from the southwest and bringing a sudden drop in temperature. These changes give a middle latitude character to the climate of Uruguay.

There are no decided rainy and dry seasons. A rainfall maximum is reached in the autumn (April and May), not in the winter months as is often supposed. Winter rains are most frequent but autumn rains are heaviest. The mean annual precipitation is about 35 in., decreasing with distance from the sea, but everywhere well distributed throughout the year. In summer there are frequent thunderstorms. Fogs are common from May to Oct., but seldom last all day on land.

Vegetation. — Uruguay is mostly covered with tall rich prairie grass. There are more trees, however, both native and introduced, than on the pampas, but these are found chiefly in narrow ribbons along the bottom lands of the watercourses. The principal species are the ombú, alder. aloe, poplar, acacia, willow and eucalyptus. The *montes,* by which are understood plantations as well as native thickets, produce, among other useful wood, the algarrobo, the guayabo, the quebracho and the urunday. Indigenous palms grow in the valleys of the Sierra de San José Ignacio, as also to some extent in the departments of Lavalleja, Maldonado and Paysandh. The myrtle, rosemary, mimosa and the scarlet-flowered ceibo are common.

The valleys within the hills are fragrant with verbena and aromatic shrubs. The prairies are gay with the scarlet and white verbenas and other brilliant wild flowers.

Animal Life. — As in most of the inhabited parts of the world, the wild animals have largely disappeared. Even the rhea (the American ostrich) is now seldom seen, except in a semidomesticated state. Pumas and jaguars are found on the wooded islets and banks of the larger rivers and along the northern frontier. The fox, deer, wildcat, the carpincho. or water hog. and a few small rodents nearly complete the list of native quadrupeds. A little armadillo. the mulita, is the living representative of the extinct giants, *mylodon* and megatherium. whose fossils are found over the pampa. There are a few specimens of the vulture, a native crow (lean, tall and ruffed) and many partridges and quails. Parakeets are plentiful in the *montes* and the lagoons swarm with waterfowl. The most esteemed is the *pato real,* a large duck A characteristic sight on the prairies is that of the tiny burrowing owl, sitting on top of every little eminence. Large flocks of the lapwing, terutero, are common, with their habit of warnıng other game of the approach of danger. Of birds of bright plumage, the humming bird and cardinal — the scarlet, the yellow and the white—are the most attractive, while white herons are frequently seen in swampy lands. The scorpion is rare. but large and venomous spiders are common.

The principal reptiles are a lizard, a tortoise, the *vibora de la cruz* (a dangerous viper, so called from marks like a cross on its head) and the rattlesnake in Maldonado and the stony lands of Minas. Along the upper waters of the Uruguay river the cayman (alligator) is not uncommon. Seals are found on small islands oil the southeast coast, particularly Lobos Island, which so gets its name.

II. GEOGRAPHICAL REGIONS

Uruguay is the most coherent of all the states of Latin America. Not only is the whole of the national territory effectively occupied, but also there is little contrast between the different parts of the country. When Uruguay became independent in 1828 its national territory was so uniformly occupied that only very minor geographical regions could have been distinguished. The "no-man's land" along the eastern shore of the Uruguay river was neither wholly Spanish nor wholly Portuguese. The land was then used almost exclusively for the grazing of herds of scrubby cattle on the unfenced range, and there were few permanent settlements outside of Montevideo and Colonia, and the villages along the Uruguay.

After independence, Uruguay received a small influx of immigrants, chiefly from Italy and Spain. This was a time when Argentina nas torn by civil strife, and settlement on the Pampas was not yet attractive. The newcomers entered Uruguay through Montevideo and settled in a zone along the Plata and Uruguay rivers. After 1852, the European immigrants to the Plata region preferred to go to Argentina. As a result the agricultural zone in southern Uruguay remained static, because, unlike in Argentina, livestock grazing, and the cultivation of crops remained in separate geographic areas. Southward toward Montevideo, there was in the early 1940s a notably sharp boundary between the pastoral region to the north and the agricultural region to the south at the town of Florida, only 50 mi. N. of the capital. However, since the mid-1940s there has been a great increase in the area devoted to agriculture. The sharp boundary between the two regions disappeared. Crops are more important than pasture as far north as Durazno, more than 100 mi. N. of Montevideo: and the crop zone has also extended northward along the Uruguay river as far as Salto.

The grazing of animals in the pastoral region is no longer on the unfenced range. Barbed wire, first introduced to Uruguay during the 1870s, is used throughout the interior to separate one pasture from another, and to border the highways and animal driveways. Planted pasture grasses have replaced the native grasses, and the carrying capacity is very high — about one animal unit per acre. There are many large ranches or *estancias,* some more than 25,000 ac., in the pastoral region. Sheep are more significant than cattle in the northwest, especially on the relatively dry low plateaus on diabase and red sandstone. Cattle are of major importance south of the Negro river.

The agricultural zone, on the other hand, has little land devoted to pasture. The chief crop is wheat, but there are important areas also of flax (for linseed), oats, barley and grapes. In the 1940s the government began to support agricultural prices and encourage agricultural expansion. The acreage in wheat more than doubled between 1950 and 1955, but the acreage of flax (an export crop) declined. Other crops that have increased in acreage include rice. maize, fruit orchards and vineyards. There are large acreages of sunflowers, the cheapest source of cooking oil, in the northeast of Uruguay, as well as in the southern part of the country.

Montevideo is the largest urban centre, in which there is the chief concentration of manufacturing. Industries were also established at Fray Bentos, Salto (*qq.v.*) and Paysandú along the Uruguay. A hydroelectric station on the Negro river provides power. (P. E. J.)

III. HISTORY

The area was explored by Juan Díaz de Solís (*q.v.*), who sailed into the Rio de la Plata in 1516; other early explorers were Ferdinand Magellan and Sebastian Cabot. Little was done with it since there was no mineral wealth and the local Charrúa Indians were fierce nomads. The latter were eventually pacified by Jesuit and Franciscan missionaries. The Banda Oriental del Uruguay (the east bank of the Uruguay river), as it was called, became a tremendous unfenced pasture where wild cattle practically roamed at will and where bands of cattle skinners made periodic forays. In 1680, the Portuguese moved down from Brazil and established Novo Colonia do Sacramento on the Río de la Plata opposite Buenos Aires. To counteract Portuguese influence, the Spanish set up San Felipe de Montevideo in 1726 as a garrison town, and drove the Portuguese back (*see* MONTEVIDEO). This exemplified the colonial period, which was marked by a prolonged struggle between the Spaniards of Argentina and the Portuguese of Brazil.

Independence. — Uruguay, one of the last areas colonized in South America, was swept into the general Latin American fight for independence. The brief British occupation (Feb. 3–Sept. 9, 1807) of Montevideo under Sir Home Papham during the Napoleonic mars (since Spain was an ally of France) brought new ideas. The city's first newspaper, La *Estrella del Sur,* was published by the invaders. Buenos Aires' declaration of independence in 1810 spurred José Gervasio Artigas, leader of the gauchos (*q.v.*), the cowboys of the Uruguayan interior, to besiege the Spanish garrison in Montevideo in 1811. Artigas became caught up in the struggle between Buenos Aires and the interior for leadership in emergent Argentina. After nine years of heroic effort, during which an Uruguayan national conciousness developed, Artigas, considered Uruguay's national hero, was forced into exile in Paraguay.

The Banda Oriental was in turn occupied by Portuguese, Brazilian and Argentine troops. Its separate existence is due in part to Uruguayan resistance, reactivated in 1825 by Juan Antonio Lavalleja and his *Treinta* y *Tres* .(band of 33) who organized an army with Argentinian-help and defeated the Brazilians at Ituzaingó, Feb. 20, 1827, in larger part. to the inability of either Argentina or Brazil to annex the area and, lastly, to British mediation which suggested the establishment of Uruguay as an independent buffer state. Uruguayan independence was proclaimed by a treaty between Brazil and Argentina signed at Rio de Janeiro Aug. 27, 1828.

On July 18, 1830, Uruguayan leaders duly promulgated a unitarian (centralist) constitution and almost immediately chaos developed The names of Fructuoso Rivera and Manuel Oribe crystallized the history of the era which was wretchedly confused by civil strife. Both were lieutenants of Artigas, both had gaucho armies! both were presidents of Uruguay, Rivera the first, Oribe the second. They soon broke with each other and their gaucho followers wore the ribbons that were to mean so much for so long, the *Colorado* (red) of Rivera: the *Blanco* (white) of Oribe. It was impossible to contain the fight within Gruguay, since both Argentina and Brazil still had designs on the area or, at least, wanted friendly governments in Montevideo. By 1843 Oribe, supported by Juan Manuel de Rosas, dictator of Argentina was besieging Rivera in iliontevideo. France and England, anxious to break Rosas, supported the defenders of Montevideo. This mas the Great War, the siege of Montevideo. the New Troy as Alexander Dumas called it. Giuseppe Garibaldi, the Italian patriot and his legion of red shirts were among the defenders of the city. It lasted nine years, with relatively little fighting, but it dug deep into Uruguayan consciousness, and party affiliation, Colorado or the Blanco, became a family, even a religious matter.

The siege was lifted in 1851, the first event of a chain which led to Rosas' fall in Argentina, and new hope filled Uruguay. The educated classes, the so-called *doctores,* hoped to do away with *caudillos* (personalist leaders) and the two traditional parties—they failed. The period from 1852 to 1872 was, if anything. more disastrous than the earlier one. Argentina was settling by force the long standing struggle for internal supremacy between Buenos Aires and the interior. Uruguay, as an area of intrigue and a theatre of war, could not escape. Brazil made countermoves; alternative presidents of Uruguay, both Colorado and Blanco, sought support from their more powerful neighbours. Venancio Flores, Rivera's successor as Colorado *caudillo,* was able to get both Brazilian and Argentine support in 1865 and firmly established the Colorados in control. Uruguayan participation in the victorious Brazil-Argentine war against Paraguay 1865–70 was the price exacted. The end of the Paraguayan war coincided with the settlement of Argentina's internal problems. Thereafter, Uruguay was increasingly able to avoid intervention by its neighbours in its affairs.

The 40-year period following independence had taken a terrible toll in livestock consumed by revolutionary armies, in ranches destroyed, in government projects which had to be abandoned. A huge public debt further complicated political life. Once more the new *doctores,* now doctrinaire liberals with degrees from the University of Montevideo, tried to end the traditional parties. And they failed. as had their predecessors. Their failure produced the advent of militarism: government by professional army officers. First Col. Lorenzo Latorre in 1875. then Gen Máximo Santos, next Gen. Máximo Tajes who served from 1886 to 1890. Latorre used assassination, coercion and exile as weapons. His iron rule broke the power of the interior *caudillos* and secured the power of central government.

The military peace encouraged ranchers to import blooded breeding stock and to fence their *estancias,* this marked the beginning of modern ranching in Uruguay. Railroads, financed mostly by British capital under profit guarantee by the Uruguayan government, started communications between Montevideo and the interior. Modern public utilities, again financed from abroad, began transforming Montevideo. A system of free public education was established. Trickles of immigrants began entering the country. The gaucho. however, suffered privations as he was not needed on fenced ranches.

Military government became increasingly corrupt and unpopular. Both political parties, Colorado and Blanco, were maturing, developing permanent organizations and programs. The country was changing, prosperity and optimism were in the air. General Tajes recognized this and supported a civilian, Julio Herrera y Obes, as his successor. Herrera y Obes the shrewdest of the new liberals proceeded to break the power of the military. He disappointed the Blancos, or Nationalists as they were now called, by governing as a Colorado partisan and alienated one Colorado wing by his fraudulent manipulation of elections. He had to face the economic crash of 1890, brought on by a speculative building boom, but he did re-establish civilian government in Uruguay.

Jose Batlle y Ordóñez.—Civilian government was not enough: nationalists wanted to participate in government, dissident Colorado wanted free elections. The successor to Herrera y Obes was confronted with Natidnalist revolution and Colorado indifference. His assassination in 1897 brought a rapid political realignment. The Nationalists, in exchange for control of six of Uruguay's 19 departments, supported the new government as did the once dissident Colorado wing, one of whom, José Batlle y Ordóñez (*q.v.*), managed to get himself elected president for the period 1903–1907 by the narrowest of margins.

Batlle's first difficulty was with the Nationalists who felt defrauded at his election and who revolted in 1904. The revolt was suppressed, after eight bloody months and Batlle became a Colorado hero, for having defeated the greatest threat to that party's domination since Flores had elevated it to power in 1865. He proposed to use his authority to transform armed politics to electoral-politics. The 1904 civil war was the last serious armed uprising in Uruguayan history.

The ensuing peace enabled ranchers and businessmen, cautious since the 1890 crash, to invest in livestock and new enterprises. Refrigerated packing plants went into operation. Trade was increased and tax receipts rose providing the government with regular budget surpluses, and making large-scale public works possible. Batlle initiated a reform program. Innovations included government ownership of banks, businesses and utilities, which would provide cheap services and replace foreign corporations; introduction of labour legislation, the eight-hour day and old-age pensions, to benefit the previously neglected working classes; educational expansion; divorce and paternity legislation to raise moral standards and weaken Catholic influence. Batlle envisaged a progressive land tax which ultimately would end the unearned increment and put land to use.

Despite his political acuteness—he was the only Uruguayan president elected to a second term, 1911–15—Batlle faced increasing difficulty in carrying out his program. Even his closest supporters balked at his favourite political solution, which he advanced to end presidential omnipotence, namely the substitution of a plural executive (collegiate government) for the presidency of the republic. His second term was hectic, his party split. In 1916 his plan for a nine man executive was put to a vote. For the first time the secret ballot was used and the total Nationalist-dissident Colorado vote exceeded the pro-government vote. A compromise constitutional solution was worked out. The 1917 constitution established a nine man council of administration composed of six members of the majority party and three of the minority. The president of the republic controlled the ministries of war, police and foreign affairs.

1916 to Date.—From 1916. Uruguay has had recurrent political problems. Splits within both traditional parties, furthered by proportional representation, made it difficult to secure legislative majorities for the enactment of advanced progressive legislation. Elections became increasingly important, but government jobs were baits used to attract voters. The result was to expand the bureaucracy excessively by increasing the number of workers in government-run enterprises, which no longer ran at a profit. Urbanization, Montevideo especially, grew, for ranches could not use many hands.

Livestock production did not keep pace with the rising urban consumption, less meat was exported, and the state of the Uruguayan economy increasingly depended on the rise and fall of world wool prices.

In the 1920s the political and economic problems were apparent. Batlle formed the Batllista party within the Colorado party and remained Uruguay's dominant political figure until his death in 1929. The delicate political situation, made worse by Batlle's death and complicated by the economic depression of the 1930s, caused Pres. Gabriel Terra (*q.v.*) to overthrow the 1917 constitution and govern as dictator in 1933. This bloodless revolution from the top shamed Uruguayans who considered it an affront to their hard won electoral democracy. Even Terra's successor and close relative Gen. Alfredo Baldomir shared this view and overthrew, in turn, Terra's 1934 constitution. From 1946 to 1958 the Batllista party won every election. In 1951 it was successful in reforming the constitution and establishing a plural executive. A nine man council of administration, six from the majority party, three from the minority, governs Uruguay.

On Nov. 30, 1958, after 93 years of Colorado government, the Nationalists were elected by an overwhelming majority. They won in Montevideo and 17 other departments, only the border department of Artigas remained Colorado. Various causes explain this reversal. Internal Colorado Batllista splits weakened the governing party. The public lost patience with notoriously bloated and inefficient government operations. Export volume and wool prices fell. The Colorado government's attempts to control inflation and restore prosperity failed. Voters turned to the Nationalists who proposed to accomplish these ends through a program of modified austerity.

On March 1, 1959, without turmoil, the historic rotation of parties took place. Shortly thereafter on April 8, 1959, Luis Alberto de Herrera, principal Nationalist *caudillo* since the 1920s, died. The already difficult economic situation was dealt a further blow by one of the worst flood disasters in Uruguayan history. Yet, the sometimes criticized plural executive was an excellent cushion for political transition, especially because it provided for three Colorado minority members. This ability peacefully to rotate parties after almost a century of one party rule, in the midst of flood, death, political complications and economic adversity is striking proof of the maturity of Uruguayan democracy.

Uruguay. a small country with democratic leanings and powerful neighbours, has traditionally stood for collective security at peace conferences. the League of Nations, the United Nations and in the Pan-American movement. It declared war on Germany and Japan on Feb. 15. 1945. The election of José A. Mora, an Uruguayan, as secretary-general of the Organization of American States indicated the respect accorded Uruguay as Latin America's voice of conscience. Democratic sympathies and a desire for a counterweight to her big neighbours have also made Uruguay a traditional friend of the United States. In the mid-1950s this friendship was dampened by Uruguayan displeasure at U.S. economic policy which Uruguay considered extremely damaging to its exports. Changes in U.S. policy following the visits of Vice-Pres. Richard Nixon (April 1958) and President Eisenhower (March 1960), and U.S. assistance during the April 1959 Uruguayan floods helped strengthen friendly relations. (M. I V.)

IV. POPULATION

Number and Distribution. — The last official population census in Gruguay was taken in 1908. Therefore any current estimates of the number of inhabitants. the growth of population or the manner in which the population is distributed among the departments may be subject to a large margin of error. It also means that Uruguay is not included in the countries for which the United Nations supplies comprehensive information on the composition or characteristics of the population Under these circumstances it is inevitable that the figures secured from different sources will vary greatly. Estimates of the total number of inhabitants in Uruguay given in the *Demographic Yearbook* of the United Nations place the population at 1,479.000 in 1920, 2.155,000 in 1940. 2,407,000 in 1950, 2 615,000 in 1955 and 2 679,000 in 1958. Other sources indicate that the nation's population was about 1.870.000, 2,050,000, and 2,175,000 in 1940, 1950. and 1955, respectively. If one accepts the estimates presented by the United Nations there was a density of about 36 persons per square mile; the annual population increase after 1955 averaged about 30 000, the rate of growth was 1 7%, the birth rate 18 per 1 000 population and the death rate 7. The lower estimates, on the other hand, would mean a population density in 1955 of 30 per square mile, an annual increment since then of about 25,000, a rate of growth of 1.2% per annum. a birth rate of 21 per 1,000 population, and a death rate of about 9.

Uruguay's population is highly concentrated in its capital, Montevideo (*q.v.*), which by 1958 probably had approximately 1.000.000 inhabitants. Almost one-half of the nation's people live either in this city or in Montevideo department. The remaining inhabitants are distributed among the 18 departments into which the country is divided, of which Canelones and Salto are the most populous. Other leading cities, with populations between 35,000 and 50,000, are Mercedes, Salto, Paysandú, Minas, Melo, Florida and Rocha.

Area and Population

	Area* (in sq.mi)	
TOTAL	68,369	2,800,921
DEPARTMENTS		
Artigas	4,682	70,426
Canelones	1,735	224,446
Cerro Largo	5,317	118,947
Colonia	2,378	149,386
Durazno	4,710	110,729
Flores	1,982	41,081
Florida	3,985	117,387
Lavalleja	3,936	128,918
Maldonado	1,824	76,480
Montevideo	208	853,649
Paysandú	5,474	101,012
Río Negro	3,655	57,403
Rivera	3,511	100,863
Rocha	4,252	96,070
Salto	5,546	123,003
San José	1,912	106,789
Soriano	3,414	110,939
Tacuarembó	6,105	132,473
Treinta y Tres	3,743	80,923

*Adjusted subsequent to 1950: 72,152 sq.mi.; no subdivision data available.

Composition. — The population of Uruguay is predominantly of the white race most of its people being the descendants of immigrants from Spain, Italy and other European countries who arrived during the 19th and 20th centuries. The native American Indian population of the republic is now extinct. and less than 5% of the present inhabitants exhibit Indian physical features to any noticeable extent. The yellow races of Asia are practically unrepresented There are a few Negroes and mulattoes in the population. but probably not more than 10,000 of the former and 50.000 of the latter.

Due to the lack of any modern population census. the age distribution of Uruguay's people is not known nith any degree of certainty. The best estimates indicate 'that persons less than 15 years of age make up no more than 30% of the total, the lowest figures for any of the Latin American countries. Persons aged 15 to 64, inclusive, probably constitute about 65% and those of 65 and over at least 5% of the population. The figure for the aged is the highest in Latin America; and this proportion seems likely to increase, due to the low death rate, the comparatively low birth rate, and the fact that the immigrants who come in such large numbers during the first quarter of the 20th century are now in or approaching the retirement ages.

Comprehensive and recent statistical data on the religious affiliations of Uruguay's people are lacking, but general observation is sufficient to indicate that the majority profess the Roman Catholic faith. State and church are separated and there is complete freedom of worship.

Spanish is the official language and also that spoken in the home by the overwhelming majority of the nation's families. In the villages and towns along the Brazilian border, however, in common usage many Portuguese words and phrases are mixed with the Spanish.

Growth of Population.— —The two early censuses of Uruguay's population that were made indicated a population of 915.647 in 1900 and 1,042,686 in 1908. Hence. for this period the rate of population increase was about 1.5% per annum. with irnmigation contributing significantly to the annual growth. For later decades, however, it is difficult to determine the extent to which immigration has contributed to the population increase since the data are very involved. Uruguay was the first South American country to legalize divorce and by mid-20th century Montevideo and its satellites became temporary places of residence for thousands of divorce seekers from across the Rio Plata in Argentina, and from other parts of the continent. Such short-term immigation beclouds statistics. Nevertheless, almost all the growth of population during the 1940s and 1950s was probably due to the excess of births over deaths.

If the birth rate is actually about 18 per 1,000 population and the death rate 7, as estimated by the statisticians of the United Nations. then the annual rate of increase should be about 1 5%; or if the birth rate is 21 and the death rate 9. as estimated elsewhere the increase is only 1.2% annually. In either case, in comparison with rates of population growth in other Latin American countries. that in Uruguay is relatively low. (T. L. SH.)

V. ADMINISTRATION AND SOCIAL CONDITIONS

Government. — From March 1952, when the offices of president and vice-president were abolished, Uruguay was governed by a nine-man national council elected for a four-year term, six members of which belong to the majority party and three to the leading minority party All nine were given equal power. The presidency of the council, responsible for domestic and foreign policy, rotates annually among the four highest majority-party members on the ballot, and for protocol purposes the president of the council serves as president of the republic. The legislative branch consists of a senate of 30 members and a chamber of deputies of 93, elected for four years, the political parties having proportional representation. This general assembly was given power to override the council by a two-thirds vote. It also elects a supreme court of five judges for a ten-year term. The death penalty was abolished in 190i and replaced by long term penal servitude.

Living and Working Conditions.—With 1953 figured as 100, the cost of living had risen to 314 by 1960. The gross national product was computed at U.S. $382 per person. Approximately 875,300 Uruguayans were gainfully employed. The strength of the labour movement is reflected by the number of workers (approximately, 200,000) who were members of internationally affiliated trade unions in the late 1950s.

Welfare Services.—Since the first administration of Pres. José Batlle y Ordóñez (1903–1907) Uruguay—often called the "Switzerland of South America"—has played a leading role in the development of social security. Uruguay's comprehensive program includes extensive provisions for unemployment insurance, compensation for injuries to workmen, family allowances, and aid to the aged and indigent. With respect to problems of health and sanitation, Uruguay is among the most fortunately situated of the Latin-American countries. In 1959 the infant mortality rate was 87.1 per 1,000 births; there were 860 people per physician and 2,156 people per dentist in the country; 5.9 hospital beds existed for every 1,000 Uruguayans; and the daily per capita calorie consumption stood at 2,810. Long a South American pioneer in international co-operation, Uruguay participates in the technical assistance programs of the United States, the Organization of American States, and the United Nations.

Education.—Uruguay made marked progress in education after the reforms of 1877 instigated by José Pedro Varela, who urged that education be free, compulsory, co-educational and under secular control. This progress was reflected in the high literacy rate (about 80%). From 1934 there was a compulsory attendance law, though it was not rigidly enforced. In the late 1950s there were approximately 1,800 primary schools with 250,000 pupils and 7,000 teachers, and 200 secondary schools with 50,000 pupils and 4,500 teachers.

The University of Montevideo (founded 1849) has an enrollment of more than 10,000. It has ten faculties, including a distinguished medical school which draws students from many South American countries. There is also a privately supported Institute of Higher Studies devoted to scientific research. Vocational training is given by the Technical university which organizes and controls a number of industrial and night schools.

Defense.—The army, composed of volunteers enlisting for 1 year or 2 years, comprised (1955) 9 regiments of cavalry, 6 of engineers, 5 each of infantry and artillery and a tank regiment. There is a small navy and an air force of about 200 planes. With a reserve trained every year under the compulsory military training law, it was estimated in the 1950s that about 120,000 troops could be mobilized in case of war. (G. I. B.)

VI. THE ECONOMY

The foundation of Uruguay's economy was said to have been laid in 1603 when a farseeing governor of Paraguay, Hernando Arias de Saavedra. having observed the fertility of the empty southern pastures, shipped about 100 head of cattle and 100 horses and mares downstream from Asunción. These animals were landed on the Uruguayan river bank, where they were left to run wild and multiply. Later in the century the herds were so abundant that they attracted gauchos from Buenos Aires, who crossed the Rio de la Plata and began a trade in hides. The gauchos were nomads, with no desire to settle, but gradually merchants from Buenos Aires established themselves on the Uruguayan side of the estuary. As more and more cattlemen arrived boundaries had to be fixed, and thus there came into existence the great estancias that are still characteristic of the country.

The relatively high standard of living enjoyed in and around Montevideo is closely related to the earnings from pastoral and agricultural exports; prosperity is somewhat precarious because these primary products are subject to sudden fluctuations in world demand and prices. To reduce the nation's dependence on external trade, successive governments have encouraged the development of domestic industry by means of protective tariffs, import controls, exemption of machinery from import duties and preferential exchange rates. But as there are no local sources of petroleum, coal or iron, and no heavy industries, Uruguay is obliged to import most of its fuel and industrial raw materials and all of its vehicles and industrial machinery. These essential supplies have to be paid for with the produce of the ranches and farms and the income derived from foreign tourists.

Nevertheless, the economic crisis which afflicted the republic in the late 1950s was not entirely the result of the deterioration in world prices for primary products. The financing of the "welfare state" imposed heavy burdens on the producers; and the government's agrarian and exchange policies were often designed to gratify the consumer, *i.e.,* the majority of voters, rather than to remove, by necessarily unpopular measures, the causes of inflation and of the decline in the value of the national currency.

Livestock and Agriculture.—The whole of the available land in Uruguay is in use for grazing or agriculture and production can therefore be increased only by technical improvements in breeding and cultivation. In general, such improvement has been slow.

High wool prices during and after World War II encouraged sheep breeding, and the Korean war further stimulated this activity. In the late 1950s there were about 23,000.000 sheep on the pastures. and even when prices dropped wool continued to be the greatest source of foreign exchange; the number of beef cattle dropped to about 7,000,000 head. Domestic consumption of meat increased with the growth in the population, but cattle breeders were discouraged by government price restrictions; moreover, the official policy of subsidizing the production of nheat caused much good grazing land to be transferred to agriculture. It became more profitable to dispose of cattle on the black market, or to smuggle them over the frontier into Brazil, than to sell them to the meat-packing plants. The latter therefore received insufficient supplies and the meat export trade suffered accordingly. The original object of the government's policy of subsidizing wheat production was to ensure that the nation should become self-sufficient in that grain. In practice, however, the inducement proved to be so attractive that too much wheat was planted. The cost of the subsidy. moreover, was a serious burden on the national budget, especially as the Uruguayans continued to resist the introduction of income tax. Other crops include flax, maize, oats and barley. Fruits grown are oranges, lemons, peaches, grapes (sufficient for the local wine industry), pears and apples.

Power and Industry.—The state operates a large number of public corporations. It controls electricity and the refining of imported petroleum; it manufactures alcohol and cement; it directs a meat-packing plant and the processing of fish; and it controls the railways (purchased from their British o ners at the end of World War 11), the principal banking institutions and insurance.

As the low, rolling countryside of Uruguay is not generally suited to hydroelectric development, most of the electric installations were formerly dependent on imported coal or oil; but two hydroelectric plants were built on the Negro river.

The processing of food and other products of the land is the basic form of industry. The subsidized wool-combing industry has added to the country's exports. Consumer goods manufactured locally (mainly in the neighbourhood of Montevideo) include textiles, tires and other rubber goods, shoes and many household appliances.

Foreign Trade.—In the late 1950s wool exports amounted to at least 50% of the national total, while meat and by-products varied from 10% to 20%. Hides, skins and wheat were the other principal items. The chief markets were the Netherlands, the United Kingdom, the United States. western Germany and Brazil. During the same period the principal imports were raw materials for industry, vehicles, machinery and fuels. The chief suppliers were the United States, Brazil, the United Kingdom, German Federal Republic and Belgium-Luxembourg. In spite of strict import controls the balance of payments during the 1950s was usually unfavourable.

Transportation.—Uruguay has more than 3.000 mi. of paved highways (including the Pan-American highway), among the best in South America, which radiate from Montevideo This city is also the rail hub of the country, and the main airport at Carrasco, 13 mi. outside. is served by local and international airlines.

See also Index references under "Uruguay" in the Index volume.

(GE. P.)

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URUGUAYANA: *see* URUGUAIANA.

URUGUAY RIVER, forms with its tributaries the second major river system of the Rio de la Plata estuary. It rises on the coastal range of south Brazil and flows west and southwest for 1.000 mi. along the Brazil-Argentina and Uruguay-Argentina borders to join the Paraná river.' *See* PLATA. RÍO DE LA.

URUMCHI (TI-HUA, WU-LU-MU-CH'I), capital and Chinese garrison centre for. Sinkiang, (*q.v.*), commanding strategic routes through the Tien Shan as well as the highway and rail routes along the north flank of this range leading from China to Soviet central Asia. Its 1953 population was about 140,700, predominantly Chinese, but also including considerable Uighur, Khazak, Tungkan, and Manchu minorities. It shares the steppe climate of the Dzungarian basin but depends upon impounded irrigation water from the Crumchi river for its oasis farmlands. The town is a trading centre for the steppe nomads and also has numerous small industries based on nearby coal, iron and copper ore deposits. A thermal and a small hydroelectric plant supply power for industries making cotton textiles. electric light bulbs, cement. chemicals. flour and for motor vehicle repair. A small iron and steel plant was enlarged in the late 1950s. It is the seat of Sinkiang Medical college and has institutes of Russian languages, minorities and agriculture. (H. J. Ws.)

USBEGS. The Usbegs form the ruling clan in Bokhara, Khiva and Kokand, occupying there a very similar position to that of the Osmanli in Turkey. They are also found in Samarkand and in some parts of Syr Daria and Ferghana, in nhich latter place the Kipchak also live. and should probably be classified as Sarts. They are a mixed people. closely allied to the Mongols, and are in a transition from a nomad to a sedentary life.

USHAK or USAK, a town of Turkey, in the Kutaiah (Kütahya) vilayet, connected nith Smyrna and Konia by rail. Pop. (1955) 23 366. It is noted for its heavy pile carpets, *khali*, known as "Turkey carpets." There the Turkish army captured the Greek commander in chief, Gen. Trikoupis. Sept. 2. 1922

USHANT (Fr. *Ouessant*), a rocky, reef-fringed island lying $11\frac{1}{2}$ mi, offthe mainland of northnestern France (Brittany). Pop. (1954) 2.071. Cshant, has a maximum east-west length of 5 mi. and a north-south width of 2 mi. Maximum elevation. 1jo ft. Most of the coast is cliffed or high; only on the southeast at Lampoul, the major village, is access easy. The population is dominantly engaged in fishing. Garden crops are cultivated and sheep are pastured.

USHAS, in Vedic Hindu mythology goddess of the dawn (from the same root as Lat. *Aurora* and Gr. 'H ώς). Celebrated in some 20 hymns of the *Rig-Veda*, Ushas is its most graceful creation. Borne on a car drawn by ruddy kine, the sun is her lover. She rises resplendent . . . showing her charms—ever shortening the lives of men she reveals their paths and bestows new life . . . she opens the doors of darkness as the cows their stalls.

USHER or USSHER, **JAMES** (1581–1656), Irish divine and archbishop, was born in the parish of St. Nicholas, Dublin, on Jan. 4. 1581. He was sent to a school in Dublin opened by two political agents of James VI of Scotland. nho sought to secure a party for James in Ireland in the event of the queen's death.

In 1594 Usher matriculated at the newly founded university of Dublin. whose charter had just been obtained by his uncle, Henry Usher, archbishop of Xrmagh. He graduated M.A. in 1600, became a fellow of Trinity college, and was ordained in 1601. In 1607 he became regius professor of divinity and also chancellor of St. Patrick's cathedral. Dublin. In 1613 he published his first printed work, though not his first literary composition—*Gravissimae Quaestionis de Christianarum Ecclesiarum, . . . Historic Explicatio*, wherein he took up the history of the Western Church from the point where John Jewel had left off in his *Apology for the Church of England*, and carried it on from the 6th till past the middle of the 13th century.

James nominated him archbishop of Armagh in 1625. As archbishop he discountenanced (1629) Bishop William Bedell's proposal to revive the Irish language in the service; he shared in drafting (1634) the code of canons of the Irish Church, and defeated the attempt to make the Irish Church conform exactly to the doctrinal standards of the English. In 1640 he paid another visit to England on one of his usual scholarly errands, meaning to return when it was accomplished. But the Great Rebellion of 1641 prevented his return. Usher pleaded in vain with Charles I not to abandon Strafford. By way of compensation for the loss of his Irish property he received the temporalities of the vacant see of Carlisle. In 1643 he declined a seat in the Assembly of Divines at Westminster. He quitted Oxford in 1645 and went into Wales, where he remained till 1646, when he returned to London, and was in 1647 elected preacher to the Society of Lincoln's Inn, an office which he continued to hold until near his death.

In 1648 Usher conferred with Charles I in the Isle of Wight, on the abortive negotiations with parliament on the question of episcopacy. In 1650–54 he published the work which was long accounted his most important production, the *Annales Veteris et Novi Testantenti*, in which he propounded a now disproved scheme of biblical chronology, whose dates were inserted by some unknown authority in the margin of reference editions of the Authorized Version. In 1655 Usher published his last work, *De Graeca LXX Interpretum Versione Syntagma*. He died on March 20, 1656, in Lady Peterborough's house at Reigate, and was buried in Westminster abbey.

Usher's works are very numerous, and were first collected by C. R. Elrington and J. H. Todd (Dublin, 1847–64) in 17 vol. See *Life* by Carr (1895); W. B. Wright, *The Ussher Memoirs* (1889).

USK, THOMAS (d. 1388), the author of *The Testament of Love*, a prose work formerly attributed to Geoffrey Chaucer, was born in London, Eng. In 1897 Henry Bradley interpreted the acrostic comprised of the initial letters of its chapters—"Margarete of virtw, have merci on thin Usk"—as a statement of authorship. Thomas Usk was clerk of the closet to John of Northampton when he was mayor of London, 1381–83. In 1384 Usk was put in prison, but he was released on promising to bring charges against Northampton, who had been arrested for treason. Usk freely produced evidence which sent Northampton to prison. Usk fell aith the king in the successful rebellion led by the duke of Gloucester, the king's uncle, in 1387.

Tried for treason in 1388. Usk was condemned to death. At his execution, March 4. 1388, he was first hanged and then beheaded by 30 blows with a sword.

The *Testament of Love*, which includes passages similar to the translations of Boethius by Chaucer, is a work of almost 60.000 words. It portrays the author in prison as he has interviews with an apparition in the form of a beautiful lady called Love. Excessively tedious, its obscurity and dullness was demonstrated by the fact that successive editors did not discover that the leaves of the original manuscript had been shuffled and the body of the treatise misarranged. No manuscript of the work was preserved; it was first printed by William Thynne in his edition of *Chaucer* (1532). In 189; Walter William Skeat, with cancelled sheets to cover the unlucky mistake referred to above. issued a revised and annotated text in his *Chaucerian and other Pieces*.

USK, a small market town and urban district in the Monmouth parliamentary division of Monmouthshire, Eng., on the river Usk, 11 mi. S.N.E. of Newport by road. Pop. (1951) 1.609. Area 1 sq.mi. It xas a Roman fort, *Burrium*, and there are ruins of a castle built by the Clares in defense of the Welsh marches. The castle was taken by Simon de Montfort in 126j and suffered under Owen Glendower. The church of St. Mary perpetuates a Benedictine nunnery founded by Richard de Clare in 1236.

USK, a river of Wales and England, 70 mi. long, flowing to the Bristol channel. The source is on the north flank of Carmarthen Van, a summit of the Brecon beacons; the course passes Brecon, Crickhowell, Abergavenny, Usk and Caerleon. The river is noted for its salmon and trout fishing. Newport (*q.v.*), Monmouthshire, lies on its estuary.

USTI NAD LABEM (AUSSIG A. D. ELBE), a town in a region of the same name, Czechoslovakia, in a highland district at the confluence of the Bela and the Elbe, is an important Elbe port. Pop. (1950) 56,920. The town was ceded to Germany in 1938 by the pact of Munich, and reverted to Czechoslovakia after World War II.

USURY, the charging of interest in excess of that allowed by law for a loan of money or for the extension of the maturity of a debt. In early English law, usury meant compensation for the use of money regardless of amount.

The laws against usury are of ancient origin. Early lams of China and India prohibited usury. The Mosaic law limited the exaction of interest; the Roman law proscribed or regulated such charges. In England during the middle ages the practice of charging interest was maligned by the church and outlawed by the state. But the credit requirements of modern commerce caused removal of these restrictions in England and elsewhere. While the exaction of oppressive interest is not illegal under the common law of England or the Gnited States, a public policy which protects debtors from overreaching lenders has been implemented by the statute lam of both countries. In England the Moneylenders acts of 1900 and 1927 constituted a code providing for registration of moneylenders, governing the form of their contracts, limiting rates of interest and providing for the reopening by the court of moneylending transactions.

The state usury statutes in the U.S. impose a wide variety of limitations. Typically, they establish a maximum rate of interest which may be charged on loans. Some provide that contracts which require payment in excess of the lawful rate are void. These laws permit the borrower to avoid payment of principal as well as interest. Other statutes affect only the lender's right to recover interest in excess of the legal rate. Some usury laws protect natural persons but not corporations; others permit certain lenders to charge higher rates because they assume greater risks. In general, these statutes reflect a policy to protect borrowers without crippling the lenders and lending institutions.

See also MONEY-LENDING. (R. M. A.)

UTAH, which took its name from the Ute Indians, is a mountain-desert state in the western part of the United States. It is bordered on the north by Idaho and Wyoming, on the east by Colorado, on the south by Arizona and on the west by Nevada. The 45th state admitted to the union (in 1896), it is the 11th largest, about 345 mi. long and 269 mi. wide, with an area of 84,916 sq.mi., of which 2.577 sq mi. is water surface. Its people call themselves Utahns (not Utahans). Commemorative of incidents in pioneer history, the state flower is the sego lily and the state bird the sea gull; the state tree is the blue spruce. The capital is Salt Lake City.

PHYSICAL GEOGRAPHY

Physical Features. — Utah (situated between approximately latitude 37° and 42° N. and longitude 109° 3' and 114° 3' W.) is divided into three major physiographic areas, the Colorado plateau province, embracing most of the eastern half of the state and including the drainage basins of the Green, Colorado, San Judn and Virgin rivers with their tributaries; the Basin and Range province, better known as the Great basin, of which the western third of the state forms a part; and the northern Rocky mountains province, the northeastern sixth of the state, primarily consisting of the Wasatch and Uinta mountains (see also COLORADO RIVER; GREAT BASIN, THE).

More generally, Utah is divided into two Iargely arid regions by the rain-catching high mountains and plateaus which comprise the eastern rim of the Great basin. East of that divide lies the brilliantly coloured, fantastically eroded country which makes Utah a geological and scenic marvel, with deeply incised canyons, natural bridges and arches, and towers and turrets of every description. West of the divide lies the long chain of valleys collectively known as the Wasatch oasis, once covered by the 19,000 sq mi. Pleistocene Lake Bonneville, of which Ctah lake is a freshwater remnant and Great Salt lake, Sevier lake and Little Salt lake are saline remnants. Deposits laid down in the prehistoric lake created fan-shaped deltas at canyon mouths where all the principal Utah cities have been built and where most of the irrigable land is found. In the southwest, the warm valley of the Virgin gives Utah a subtropical region locally called Dixie.

Altitudes range from the 13,498 ft. of Kings peak, in the Uintas, to an approximate 2,100 ft. in the southwest corner, where Beaverdam wash flows into Arizona. The average elevation is 6,100 ft., but about 90% of the population is estimated to live at altitudes between 4,250 and 4,650 ft.

Climate. — Precipitation varies from less than 5 in. annually west of Great Salt lake to more than 40 in. in the Wasatch mountains. In general the climate is temperate, variations occurring, of course, relative to latitude and altitude. Seasons are well marked; low relative humidity minimizes the range in temperature, which may vary from 100' F. in summer to zero or below in winter. The highest recorded temperature is 116°, the lowest −50°. As a rule, the weather is sunny and pleasant.

Soils. — The aridity that has limited Utah's agricultural development has at the same time conserved the minerals in the soil. Some soils are 60% limestone and may never require additional lime. Elsewhere, the weathering of mountains that contain extensive phosphate deposits has produced soils with half again the amount of phosphorus found generally in the earth's crust. Excessive irrigation has damaged some soils by flushing out the plant foods or by bringing alkali salts to the surface; and precipitation of minerals by saline lakes has poisoned surrounding soils. Most farming is done on the sloping surface of lacustrine soils laid down in old Lake Bonneville, which are fertile, well-drained and advantageously situated for irrigation.

Vegetation. — Over 4,000 species of plants are found in Utah, reflecting six climatic plant zones, from the Lower Sonoran in the Virgin valley to the Arctic above the timber line on the higher peaks. Plants that grow in the warm southwestern deserts include creosote bush, screwpod mesquite, cactus and sword plant, and the Joshua tree. Juniper and sagebrush grow in all parts of the state, the latter denoting fertile, nonalkaline soils. Shad scale, saltbush and greasewood thrive in the alkaline desert areas. In the mountains grow many species of spruce, fir and pine. along with nurturing aspens. Cottonwoods characteristically mark out the courses of creeks; other common native trees are the big-tooth maple, red birch, mountain alder, box elder and such shrubs as scrub oak, dwarf maple, chokecherry, serviceberry, hawthorn and willow. Numerous beautiful wild flowers vary from prickly pear to columbine, sego lily to Indian paintbrush. Less agreeable are poison ivy, poison oak and stinging nettle. Native grasses, extending up into alpine meadows, are the basis of the state's grazing industry.

Animal Life. — Mule deer, brown bear, pronghorn antelope and cougar are the sole large animals that have maintained themselves in Utah. Bison, elk. grizzly bears and timber wolves became extinct, but the first two have been reintroduced. Infrequently, a moose nanders down from the north. Coyotes, bobcats and lynxes, like cougars, are hunted as predators. Fur-bearing animals include the weasel muskrat. beaver. badger, skunk, marten, fox and ringtailed cat. Among the rodents are jack rabbits, cottontails, snowshoes, pygmy and rock rabbits, prairie dogs, tree and ground squirrels, marmots, rats and field mice, and porcupines. Migratory waterfowl include many species of ducks and geese. Principal upland game birds are sage hens, pine hens, ruffed grouse and quail, and the introduced hybrid ring-necked pheasants. The golden eagle is the largest predatory bird; hawks and owls are numerous, as are magpies, and crows and vultures occasionally are seen. Songbirds include larks, blackbirds. finches, water ouzels and commoner birds. On bird refuges in Great Salt lake live great blue herons, white pelicans and sea gulls. To native trout, whitefish, suckers. chubs, minnows and other common fish have been added other species of trout, carp, catfish, bass, yellow perch and grayling. Reptiles and amphibians include rattlesnakes. gopher snakes! water racers. garter snakes, toads. frogs. salamanders, desert tortoises and lizards (among which the poisonous Gila monster is rare). A brine shrimp is one of the few life forms that can survive in Great Salt lake.

Parks, Monuments and Recreation. — Utah at mid-20th century had two national parks. Bryce Canyon and Zion; eight national monuments, Arches. Capitol Reef, Cedar Breaks. Dinosaur. Hovenweep. Natural Bridges. Rainbow Bridge and Timpanogos Cave: and the Golden Spike National Historic site. An expanding state park system initially included Camp Floyd near Fairfield. Dixie State park near St. George. the Old State house at Fillmore and the Pioneer monument at Salt Lake City. The High Uintas Wilderness area, like Utah's nine national forests. provide:, fishing. hunting. hiking. riding and packing and skiing. The Wasatch mountains adjacent to Salt Lake City and Ogden offer winter sports facilities.

River-running down the Green. Colorado and San Juan attracted enthusiasts prior to World War II. and the building of new multipurpose dams on those rivers at mid-century further stimulated boating in regions once inaccessible.

HISTORY

The Indians who occupied Utah when white chroniclers entered the region were principally of Shoshonean stock—Utes occupying the mountainous eastern half of the state, southern Paiutes living in the arid valleys of southwestern Utah and western Shoshone dwelling in the yet more arid reaches of northwestern Utah. Northern Shoshone and Bannocks occasionally ranged into northern Utah from present Idaho and Wyoming; and in the basin of the San Juan river lived the Navahos. an Athapascan people. All these Indians had a hunting and gathering culture, but some Pahvant Utes, Paiutes and Navahos practised simple agriculture. raising corn and pumpkins by rude irrigation. (See also NAVAHO; PAIUTE; SHOSHONE: UTE.)

Exploration. — The chasms and naked aridity of the Colorado plateau region rebuffed the earliest venturers to approach the Utah country, and not until 1776 was the first Spanish penetration made. Two Franciscan friars. Silvestre Vélez de Escalante and Francisco Xtanasio Dominguez, seeking a route from Santa Fe to missions newly established on the California coast. explored up through Colorado. then proceeded west across Green river above present Jensen and on through the Cinta basin to Utah valley. Impressed by its natural advantages. the priests recommended colonization of the valley. They turned south to the Sevier and Virgin rivers. and, finally. having abandoned the effort to reach Monterey, journeyed back to Santa Fe.

Spain (and after 1821. Mexico) never found the resources to establish a new colonial frontier. and only obscure Indian traders entered Utah from New Mexico for nearly half a century. The advance of the fur frontier into the interior nest. however, brought British trapper.; under Michael Bourdon into northern Utah in 1819, and between 1824 and 1527 the Utah country was fully explored by trapping parties—Americans coming northwest from Taos and southwest from South pass. while British trappers came south from western Montana. Great Salt lake was discovered and named at this time, and in 1826–27 Jedediah Smith, while making the pioneer overland journey from the Missouri river to California. became the first man to traverse Utah from north to south and from west to east. Of 16 annual rendezvous of the fur trade, the hrst four were held in Utah. 1825–28.

Tiear-round settlement by white men began in 1837–38. when Xntoine Robidoux established a trading post in the Uinta basin. originally near the mouth of White river but soon moved to present Whiterocks. His "Ft. Uintah" was abandoned in 1845, the year before Miles Goodyear established "Ft. Buenaventura" on the site of Ogden. the initial white settlement in the valley of the Great Salt lake. Goodyear sold out to the Mormons in 1847.

Meanwhile, between 1829 and 1831, a cars\-an route known as the Spanish trail was worked out between Santa Fe and Los Angeles; traversing southern and central Utah, it was used till 1849. In 1841 the Bartleson party, called the first overland emigrants to California, took wagons through northern Utah en route to their destination. John Charles Frémont, with a government exploring expedition, reconnoitered northern Utah in 1843, also visiting Frémont Island in Great Salt lake. Returning from California in 1844, he rode up through Utah as far as Utah valley before turning east. Frémont came back with another exploring expedition in 1845, pioneering south of Great Salt lake and across the Salt desert a new route made notorious as the Hastings Cutoff by California emigrants who used it in 1846. En route to the scene of their frightful starvation in the Sierra Nevada. the Donner-Reed party, among these 1846 emigrants, cut through the Wasatch mountains a route made a permanent road by the hlormon pioneers in 1847.

Settlement and Territorial Period. — The vanguard of the westward-moving Mormons reached the site of Salt Lake City between July 21 and 24. 1847, and under Brigham Young began establishing a commonwealth. Utah was then Mexican territory, but by the treaty of Guadalupe Hidalgo it came under U.S. sovereignty in 1848. From their ecclesiastical government the Mormons evolved a provisional state of Deseret (a Book of Mormon word, meaning "honeybee" and signifying industry) and in 1849 sought admission to the union. Deseret would have extended from the Rocky mountains to the Sierra Nevada, including a portion of the southern California seacoast, thus embracing not only present Utah and Nevada but also large parts of California, Oregon, Idaho, Wyoming, Colorado, New Mexico and Arizona. By the compromise act oi Sept. 9, 1850. however, congress created Utah territory, n-hich within Utah's present north and south boundaries extended from the Rockies to the eastern line of California. These initial boundaries were reduced by the creation of Colorado, Nevada and Wyoming between 1861 and 1868.

As soon as the Mormons were firmly established in Utah. Brigham \-oung began colonizing all the fertile valleys north and south of Salt Lake City. wherever streams permitted irrigation. This was a planned economy of a type and on a scale no other state had seen. and it gave Utah a culture differing from that of all other western states, a mixture of New England and the west. Salt Lake City from the time of its founding has been the Mormon world capital and. except for a brief period during the 1850s, the political capital of Utah. Other principal cities which developed early were Ogden, Provo and Logan (*qq.v.*).

Utah had a turbulent territorial history. Almost constant friction between U.S. officials and Mormon authorities led to the "Utah war" of 1857–58, when federal troops were sent to put down "rebellion." Although they were withdrawn on the outbreak of the American Civil War, California-Nevada volunteers under Col. Patrick Edward Connor took their place in 1862, garrisoning Ft. Douglas above Salt Lake City. These soldiers prospected widely, and their placer gold strike in Bingham canyon opened up Utah's mining economy. until then deliberately neglected by the Mormon leaders, who feared its possibly destructive impact on Mormon society. Meanwhile, comniunications were improved with mail service to California and the east. dramatized by the pony express (*q.v.*). Completion of the Pacific railroad at Promontory in 1869 induced the Mormons to build a connecting line from Ogden to Salt Lake City. followed by other roads north and south. which gave further impetus to the mining industry. These Mormon-built railroads. for the most part, were taken over later by the Denver and Rio Grande Western, which entered Utah from Colorado in 1882, or by the railroad completed to Los Angeles in 1905, now incorporated into the Union Pacific system.

Brigham Young's view that it was cheaper to feed the Indians than to fight them militated against widespread Indian wars, though there were periods of Ute hostility, the Walker War of 1853–54 and the Black Hawk War of 1865–68. The Utes were eventually placed on a reservation in the Uinta basin, Paiutes and Shoshone on smaller reservations; much later. lands south of the San Juan river were incorporated into the Navaho reservation.

After 1870 internal strains developed in the Mormon church between liberal and conservative elements, in part because of the evolution away from a basically agricultural economy, Simultaneously an influx of gentile (non-Mormon) elements brought political strife between Liberal and People's parties, continuing until the early 1890s. Both were factors in Utah's complex political relations with the federal government, which from 1862 began to search for ways and means to break down the tightly knit Mormon hegemony, viewed as incompatible with the American political system.

Statehood. — Five vain efforts to achieve statehood were made after 1849. Constitutional conventions of 1856, 1862, 1872, 1882 and 1887 accomplished nothing in the face of the determination of the federal government to force abolition of polygamy, which became the symbol of the supremacy of U.S. law over the Mormon way of life. The road to statehood opened only after the Mormons lost conclusive battles in the U.S. supreme court over damaging antipolygamy laws of 1882 and 1887. The church publicly surrendered in 1890 when the president, Wilford Woodruff, issued a manifesto declaring his intention to submit to the law and to use his influence to cause other church members to do likewise. In 1895 a new constitution was drafted, and on Jan. 4, 1896, the proclamation of statehood was signed by Pres. Grover Cleveland.

With the coming of statehood, the old social hostilities in Utah began to die out concurrent with the integration of the Mormons into U.S. society. Sharing in three wars, a far-reaching depression and a markedly expanding economy made Utah a part of the nation as it had not been before, bur the state's culture continued to be distinctive, of as much interest to modern visitors as the scenic splendors of its former badlands. Politically Utah became a two-party state when Mormon and anti-Mormon parties disbanded in anticipation of statehood. Until the era of the New Deal, representation in congress was usually mixed, and the state had governors from both parties. From 1932 to 1950 the Democrats were the dominant power, but the Republicans by the latter date had made such gains as to restore the state to its original balanced political complexion.

World War II brought important economic gains, including a vastly expanded steel industry, followed by major oil developments and a perceptible industrialization. This was reflected in renewed population gains and increased effortto develop the state's agricultural potential. Federal reclamation in Utah, supplementing the irrigation works of pioneer times, effectively began with the Strawberry reservoir project of 1912–16, which pioneered in diverting irrigation waters from one Utah watershed to another. Vastly greater projects were authorized during the 1950s, including the Weber basin and Central Utah projects, and the spectacular multipurpose dams at Flaming gorge and in Glen canyon, to conserve the waters of the upper Colorado river basin. From these extraordinary developments Utah could anticipate more water, more usable land, more power, more trade and varied new recreational facilities.

See also, for history, LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF.

GOVERNMENT

The Utah constitution was formed by a convention at Salt Lake City, March 4–8, 1895, was ratified on Nov. 5 and came into effect when Utah was admitted to the union. One provision, irrevocable without the consent of the U.S. government, guarantees religious freedom, forbids sectarian control of public schools, prohibits polygamy and defines the relation of the state to the public lands. The constitution grants equal civil, political and religious rights to males and females alike, prohibits any law restricting freedom of the press or the establishment of religious sects, and forbids imprisonment for debt unless the debtor absconds. The right of suffrage is conferred on all U.S. citizens who have lived in Utah a year, in the county four months and in the precinct 60 days, but only those who have paid a property tax the year before may vote in elections levying special taxes creating indebtedness or increasing the state rate of taxation.

Executive. — The principal executive officials are the governor, secretary of state, state auditor, treasurer, attornt v general and superintendent of public instruction. The governor has the right of veto, but may be overruled through repassage of a bill by a two-thirds majority in both houses of the legislature. The board of pardons is made up of the governor, justices of the supreme court and attorney general. The board of examiners consists of the governor, secretary of state and attorney general.

Legislative.-- he legislative power is vested in a senate and a house of representatives, and in the legal voters, who have the power of initiating legislation and of referendum on all laws not passed by a two-thirds vote of both houses. A legislator must be a citizen of the United States, at least 25 years old, a qualified voter in the district from which he comes and a resident of Utah for three years and of his district for one year. Regular sessions of the legislature are held in odd-numbered years. Representatives are elected for two years, senators for four. The number of senators must not exceed 30, and there must be at least twice as many representatives as senators.

Judiciary. — The judicial power is vested in the senate sitting as a court of impeachment, and in a state supreme court, district courts, city courts, justices of the peace and other courts inferior to the supreme court, as established by law.

Local Government. — The basic local government is that of the county, functioning by statutory delegation of power from the legislature. The legislative and governing authority is an administrative tribunal, the board of county commissioners. Elected officers include (in addition to the three commissioners) a treasurer, sheriff, clerk, auditor, recorder, attorney, surveyor and assessor, who carry out administrative, recording, judicial, law enforcement, financial, election, educational, welfare, health, roads and agricultural functions. Cities and towns may be organized from parts of counties by municipal incorporation. According to population, Utah municipalities are divided into three classes. Cities of the first class, with population exceeding 90,000, are governed by a mayor and four commissioners. Cities of the second class, with population between 15,000 and 90,000, elect a mayor and two commissioners. Smaller cities elect a mayor and five councilmen; and towns are governed by a board of trustees consisting of a president and four trustees. The office of city auditor is elective for the first two classes, city treasurer for the third. State lam also permits the city council and board of trustees of any city or town to appoint a qualified person as city manager. Within a more restricted sphere, the powers and duties of municipal governments parallel those of county governments.

Finance. — Gross state revenue of the late 1950s was about double what it had been a decade earlier, reflecting both the expanding economy and the development of new sources of revenue. The sales tax, instituted in 1935, contributed almost one-third of all tax revenue. Other sources were income and mine occupation levies and proceeds from corporation, franchise, motor fuel, cigarette, beer and similar taxes. Licences and fees came chiefly from educational sources, reflecting the growth of the institutions of higher learning. Liquor income originated in the state monopoly of liquor sales. Federal grants-in-aid encompassed roads, public health and welfare and education, also including sizable miscellaneous grants.

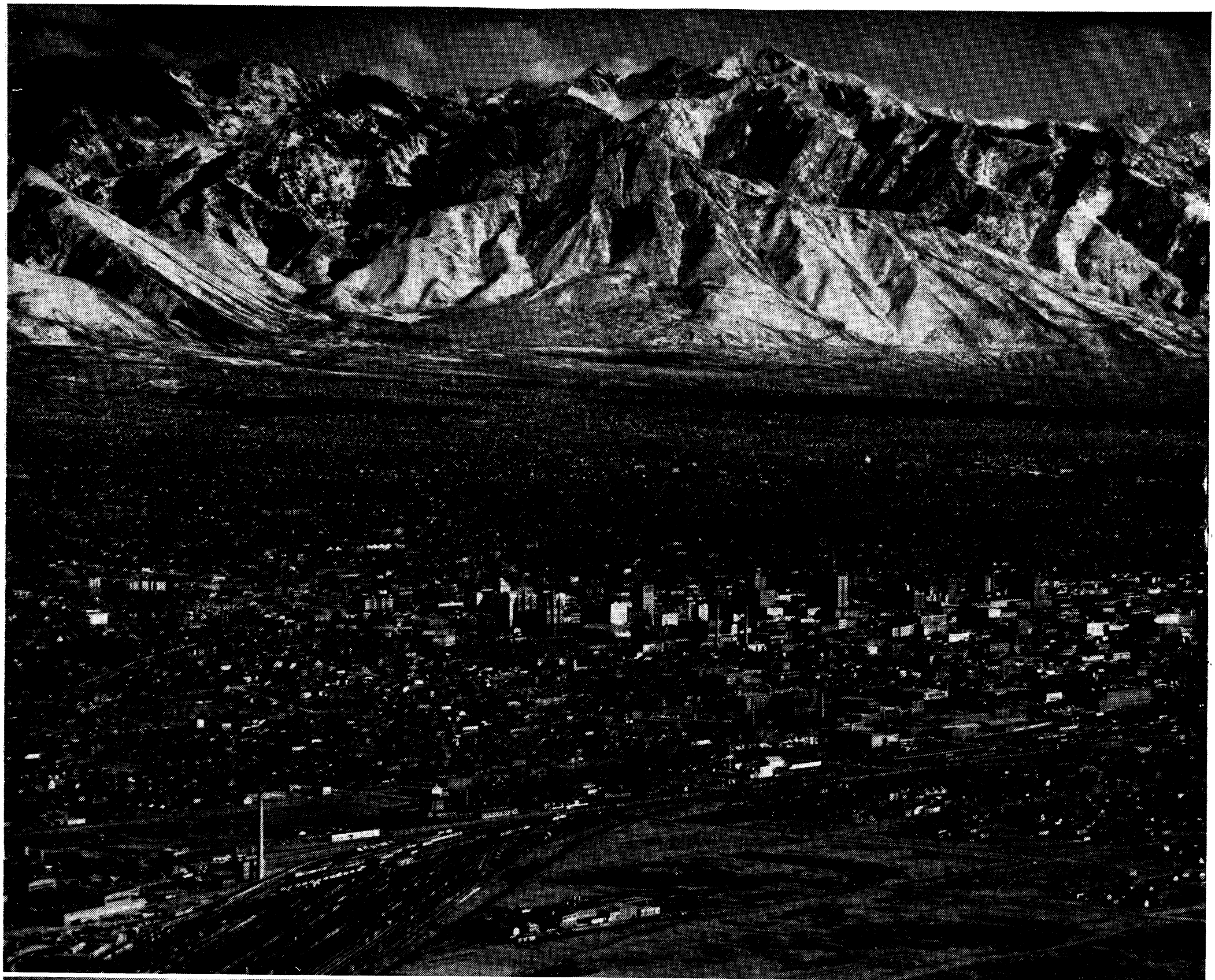
Educational disbursements, amounting to almost one-third of total expenditures, were allotted to local school districts for equalization of educational opportunity, to universities and to junior colleges.

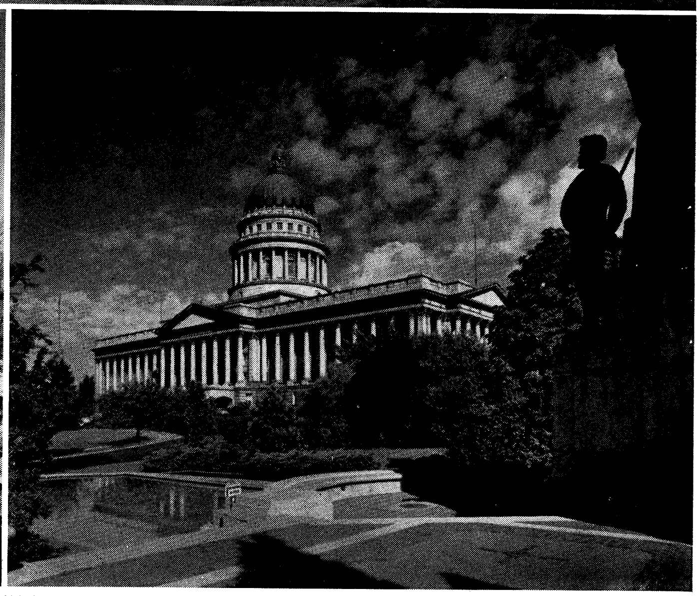
Expenditures and revenue had increased together, but between 1939 and 1955 the state retired its bonded indebtedness and became free of debt.

POPULATION

The population of Utah in 1850 was 11,380; in 1880, 143,963; in 1910, 373,351; in 1940, 550,310; in 1950, 688,862; and in 1960, 890,627. The population per square mile in 1960 was 10.5, as compared with 8.1 in 1950 and 6.7 in 1940 and with 49.6 in the U.S. in 1960. Such figures, however, do not take into account the concentration of most of Utah's population in a small area; close to three-fourths of the total population lives in the valleys extending 50 mi. north and south of Salt Lake City, one-fourth in Salt Lake City alone.

The 1960 census found that 561,546 or 63.1% of the population





BY COURTESY OF (BOTTOM LEFT) UTAH DEPARTMENT OF PUBLICITY AND INDUSTRIAL DEVELOPMENT. (BOTTOM RIGHT) UTAH TOURIST AND PUBLICITY COUNCIL; PHOTOGRAPH (TOP) HAL RUMEL

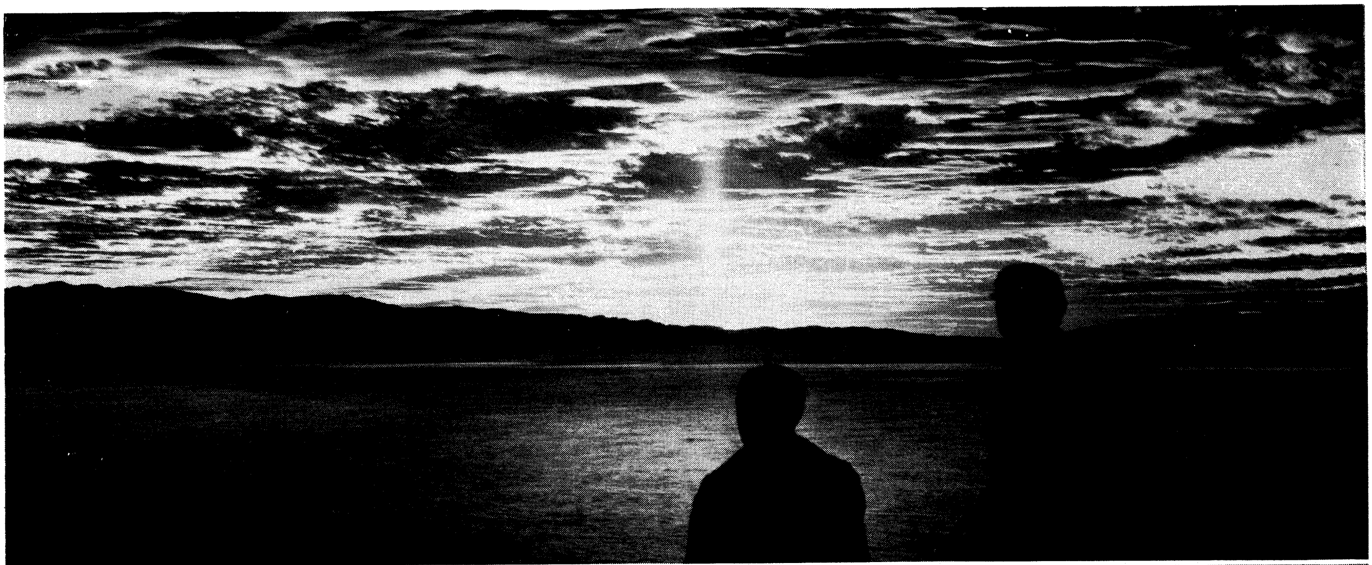
SALT LAKE CITY

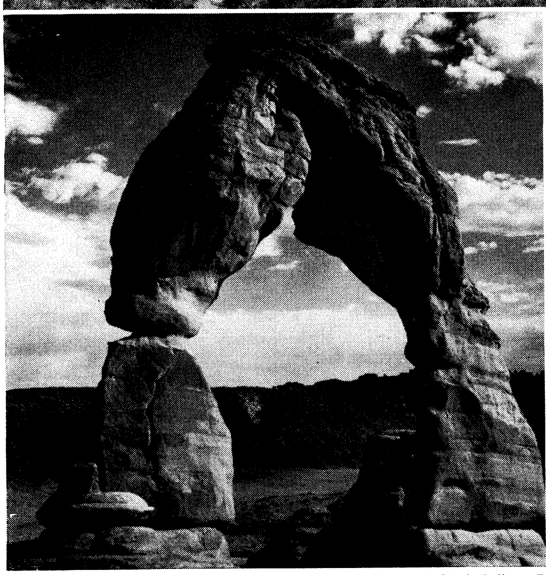
Top: Salt Lake City from the air, with the Wasatch mountains in the background

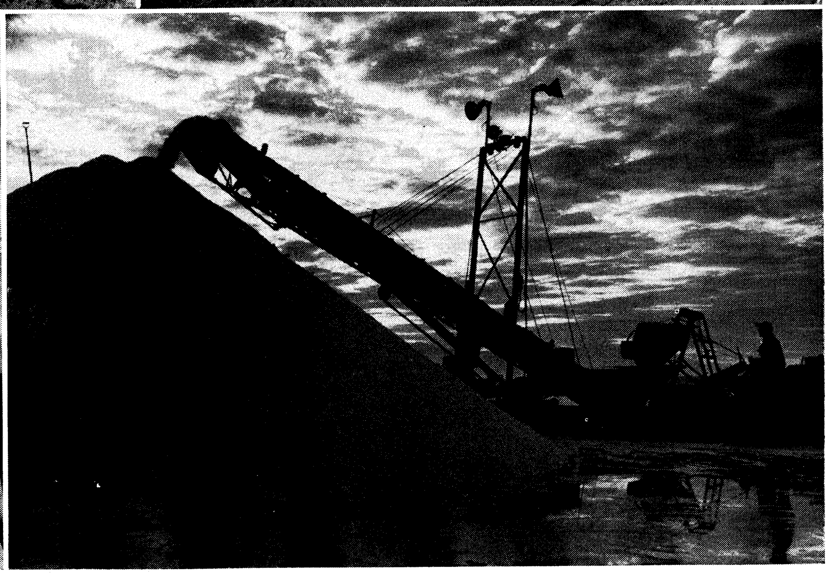
Bottom left: The great Mormon temple, built of gray granite (1853–93) with walls six feet thick. The temple has six spires on the highest of which (220 ft.) stands a gold-leaf covered copper statue of the angel Moroni

Bottom right: The state capitol of Utah stands on an eminence dominating the entire valley. The finely colonnaded building of marble and Utah granite was completed in 1915

UTAH







BY COURTESY OF (BOTTOM RIGHT) MORTON SALT CO.; PHOTOGRAPHS, (TOP, CENTRE LEFT AND CENTRE RIGHT) JOSEF MUENCH, (BOTTOM LEFT) AL MORTON

SCENES AND INDUSTRY IN UTAH

Top: Great Salt Lake at sunset. The lake, a shrunken remnant of an inland sea, contains an average salt density from 14% to 23%

Centre left: "This is the Place" monument near Salt Lake City, marks the spot where Brigham Young decided to settle the Mormons in 1847

Centre right: Open-pit copper mine at Bingham, the largest of its kind in the world

Bottom left: "Delicate Arch," near Moab, in the Arches National Monument, a region of desert sandstone and deep, winding canyons with fantastic examples of erosion

Bottom right: A salt harvester at work. In the spring, water from Salt lake is pumped into ponds. During the summer solar evaporation prepares the salt for harvesting in the fall lived in incorporated places of 2,500 or more, as compared with 59.9% in 1950 and 55.5% in 1940. These findings are conditioned somewhat by the fact that the historic pattern of Mormon life has

*Utah: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	890,627	688,862	550,310	449,396	276,749
American Fork	6,373	5,126	3,333	2,763	2,732
Bountiful	17,039	6,004	3,357	2,063	1,442
Brigham City	11,728	6,790	5,641	5,282	2,859
Cedar City	7,543	6,106	4,695	2,462	1,425
Clearfield	8,833	4,723	1,053	—	—
Kearns	17,172	—	—	—	—
Layton	9,027	3,456	646	—	—
Logan	18,731	16,832	11,868	9,439	5,451
Magna	6,442	3,502	—	—	—
Midvale	5,802	3,996	2,875	2,209	—
Murray	16,806	9,006	5,740	4,584	—
Ogden	70,197	57,112	43,688	32,804	16,313
Orem	18,394	8,351	2,914	—	—
Price	6,802	6,010	5,214	2,364	539
Provo	36,047	28,937	18,071	10,303	6,185
Roy	9,239	3,723	998	—	—
St. George	5,130	4,562	3,591	2,215	1,600
Salt Lake City	189,454	182,121	149,934	118,110	53,531
South Ogden	7,405	3,763	1,407	—	—
South Salt Lake	9,520	7,704	5,701	—	—
Spanish Fork City	6,472	5,230	4,167	4,036	2,735
Springville	7,913	6,475	4,796	3,010	3,422
Tooele	9,133	7,269	5,001	3,602	1,200
Washington Terrace	6,441	5,841	—	—	—

*Populations are reported as constituted at date of each census.
Note: Dash indicates place did not exist during reported census, or data not available.

been for the people to live in compact towns and farm outlying areas. The state has three standard metropolitan statistical areas, which are Ogden, Provo-Orem and Salt Lake City. These areas had a total population of 600,770 or 67.5% of the total population of the state in 1960.

More than 70% of the state population belongs to the Church of Jesus Christ of Latter-day Saints.

EDUCATION

Public Schools. — Thirty weeks' annual school attendance is compulsory for Utah children aged from 6 to 18 years, though' local school boards may make exceptions after the age of 16. The state's 40 public school districts must make a stated financial effort in support of their schools, after which equalization aid is provided. As shown by the 1960 census, a larger proportion of children go to school in Utah than in most states. They also rank higher in level of grades completed; in the late 1950s it was found that 58% of the population over age 25 had completed high school, as compared with 20% nationally. The state has made a consistently superior effort in support of its schools, one-third of the state revenue being expended for this purpose and an estimated 7% of personal income.

Higher Education. — The University of Utah at Salt Lake City, chartered in 1850 as the University of Deseret, underwent a great expansion, particularly of its graduate schools, after World War II. and by the late 1950s it had about 10,500 regularly registered students annually. Governed by a 15-member state board of regents, the university comprises schools and colleges of letters and science, social work (graduate), business, education, engineering, law, medicine, mine and mineral industries, nursing and pharmacy.

Utah State university at Logan, chartered in 1888 as Utah Agricultural college, has 4,600 students. and includes colleges of engineering and forestry. Branches are the College of Southern Utah (1897) at Cedar City and Snou (1888) at Ephraim. Weber college at Ogden. founded in 1889, enrolls 3,150. Smaller state colleges are Carbon (1938) at Price and Dixie (1911) at St. George.

Brigham Young university at Provo, maintained by the Mormon church, matched the gronth of the University of Utah with an enrollment in the late 1950s of 10,400. The Mormon church also operates religious institutes near the state colleges. Westminster college (1875), operated by three Protestant denominations but nonsectarian, is in Salt Lake City. Smaller colleges are maintained by the Roman Catholic Church in Salt Lake City, Ogden and Price.

HEALTH, WELFARE AND CORRECTIONS

Public health and welfare are supervised by the state board of health. Unemployment insurance, old-age assistance and other social legislation conform to the federal Social Security act of 1935, but industrial accident insurance was provided for by law in 1917, and legislation governing hazardous occupations and hours for women and children is as old as statehood. Penal and charitable institutions operated by the state include a prison in Salt Lake county; an industrial school for delinquent boys and girls at Ogden; a school for the deaf and blind at Ogden; a training school for mentally incapacitated children at American Fork; a hospital for the insane at Provo; and a tuberculosis sanatorium at Ogden. Many private hospitals are operated by religious denominations.

THE ECONOMY

Three basic industries, manufacturing, mining and agriculture, backed up a fourth equivalent "industry," national defense, and by supporting industries — in which tourist trade and the exploitation of Utah's recreational potential bulk increasingly large — by the late 1950s had emerged as the foundations of the state's economy. Other major elements of the economy are wholesale and retail trade; government exclysive of defense; service and miscellaneous; transportation, communications and utilities; construction; and finance, insurance and real estate. Government — federal, state and local — is the largest employer; the seven large installations operated by the U.S. department of defense alone (chiefly in the Salt Lake City periphery) pay annual wages of about $100,000,000.

Agriculture. — Topography, climate, type of soil and, above all, lack of water have limited Utah's agricultural development. Although nearly 90% of the land, including the high mountains with their multiple-use national forests, is put to use, 87% must be utilized for grazing. Only 4% is used for crop production. and only two-thirds of that for irrigation farming, which explains Utah's low rank among the agricultural states (41st in the late 1950s) and the keen interest taken in reclamation projects under development in the Colorado river basin Income from farm marketing throughout the 1950s was stable, at about $150,000,000 annually. Almost 75% of farm income comes from livestock and livestock products (dairying, poultry. beef and lamb's wool), the rest from field crops (wheat, barley and other grains, dry beans, hay, alfalfa, potatoes and sugar beets), fruit (cherries, apples, peaches, apricots, berries and melons) and canning crops (tomatoes, peas and corn).

Mining. — Thanks in large part to the great opencut Utah Copper mine at Bingham, Utah continued as an important mining state after most of its early mines were exhausted, and through the 1950s, among the western states, ranked first or second in production of uranium, second in copper, gold and silver, third in lead and sixth in zinc. Almost 70% of mineral production is in the form of metallic minerals, 40% from copper alone, but iron mines in southwestern Utah after the 1940s gave the state fourth rank in iron, and, together nith coal from the extensive beds in Emery and Carbon counties, provided the base for a vigorous new steel industry. Petroleum recovery on a large scale began in eastern Utah in 1948; ten years later, with more than 35 oil pools discovered estimates of proved reserves ran from 2,000,000,000 to 3,000 000.000 bbl. Four counties, Duchesne, Grand. San Juan and Uintah produce all of Utah's oil. Utah's known reserves of uranium ore (estimated at 5 700,000 tons in the late 1950s) place the state third among the states in reserves of this mineral and first in richness of ore. Many other metallic and nonmetallic minerals give weight to the mining economy.

Manufacturing. — Manufacturing assumed its dominance in the Utah economy during and after World War II, rising in value from $87,000,000in 1939 to $450,000,000 in 1957, with over 1,000 manufacturing firms. About 40% of total employment is associated with the smelting, refining, processing and fabricating of metals and minerals, while another 25% is connected with food processing. Printing and publishing, stone, clay and glass products, petroleum and coal products, chemicals, lumber and wood products and apparel are also important. Yew manufactures associated with defense include microwave and electronic transmitting tubes, ram-jet engines and solid-propellant rocket engines. A minor but interesting development was increased use of Utah's magnificent scenery by motion-picture makers.

Transportation and Communications.—On May 10, 1869, the transcontinental railway was completed when the Union Pacific and Central Pacific were united by the golden spike at Promontory. The Union Pacific has remained the dominant Utah railroad, having taken over many locally built roads as well as the Los Angeles & Salt Lake, and being connected with the Southern Pacific at Ogden. The Denver and Rio Grande Western at Salt Lake City has a similar California outlet in the Western Pacific. Federal. state and local governments by the early 1960s had constructed nearly 32,000 mi. of streets and roads in Utah, including six major U.S. highways, which served about 400,000 vehicles licensed in the state. More than 60 airports scattered over the state mainly served private aircraft, but major facilities were the expanding commercial airport at Salt Lake City and the Hill air force base near Ogden.

Five daily newspapers were published in Utah in the late 1950s, and about 55 weeklies or biweeklies. The Church of Jesus Christ of Latter-day Saints, which operates its own publishing plant, issues several monthly publications. Five television stations were operating, and numerous radio stations.

See also Index references under "Utah" in the Index volume.

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Current statistics on production, employment, industry, etc., may be obtained from the pertinent state departments; the principal figures, together with the current history, are summarized annually in the *Britannica Book of the Year*, American edition. (D. L. M.)

UTAMARO KITAGAWA (1754–1806), Japanese painter and print designer, one of the best known of the designers of colour prints. was born at Kawayoye in 1754. His landscape paintings and drawings of insects are highly regarded by Japanese critics, but his fame among Europeans will always rest on his designs for colour prints, the subjects of which are almost entirely women—professional beauties and the like. Utamaro's colour prints are distinguished by an extreme grace of line and colour, and his composition is superb.

Even in his lifetime Utamaro achieved enormous popularity. His work had a considerable reputation with the Dutch who visited Nagasaki, and it was imported into Europe before the end of the 18th century. (E. F. S.; X.)

UTE, a Shoshonean-speaking group of Indians of western Colorado and eastern Utah, whose name was given to the latter state. When Father Silvestre Vélez de Escalante traversed their territory in 1776, the Ute had no horses and lived in small family clusters subsisting by food collecting. At that time. there was no clear distinction between the Ute and the southern Paiute, both of whom speak the Ute-Chemehuevi branch of Shoshonean. After acquiring horses in the early 19th century, however, the Ute of western Colorado and later of northern Utah, became organized in loose bands of hunters. As the area became settled by Europeans, these bands became predators on livestock. In the southern regions of Utah, Nevada and California, however, the Ute-Chemehuevi remained afoot and became known as southern Paiute.

After the Indian wars, most of the Colorado Ute were settled on a reservation in southwestern Colorado, while those of Utah were placed on the Uintah reservation. where most of them remain today. They numbered about 1,000 in Colorado and 2,660 in Utah in the second half of the 20th century.

See also SHOSHONE. (J. H. SD.)

UTICA, a city of ancient Africa, 15½ mi. N.W. of Carthage. Agathocles easily captured it in 310. After the destruction of Carthage it received, the rank of a *civitas libera* with an accession territory. After the battle of Thapsus in 46 Cato shut himself up in Utica for the final struggle against Caesar. and there committed suicide. Utica was captured by Gaiseric and the Vandals in 439, reconquered by the Byzantines in 534 and finally! in 698, it fell into the hands of the Arabs and was depopulated.

UTICA, a city of central New York, C.S.. the seat of Oneida county and a central city of the Utica-Rome standard metropolitan statistical area (Herkimer and Oneida counties). Situated on the Mohawk river in the upper Mohawk valley, 90 mi. N.W. of Albany, Utica is on the main line of the New York Central railroad, the State Barge canal and the New York thruway. Its county airport is the home port of Mohawk Airlines.

Rich in early American history, the area was the country of the Iroquois federation. specifically the tribes of the Mohawks and Oneidas. French Jesuit missionaries were the first white men to enter the valley after Champlain and Hudson sailed to its edge. They were followed by Protestant missionaries, the most distinguished of whom was perhaps Samuel Kirkland, who in 1793 founded Hamilton Oneida academy, for Indians, in the territory later named after him as the Town of Kirkland. (Hamilton college. for men, developed from this academy.) The first settlers were Dutch and Palatinate Germans. followed by New Englanders. Among the many pioneers the most distinguished was Peter Smith (1768–1837), later a partner of John Jacob Astor. and father of Gerrit Smith (*q.v.*), born there in 1797. The area was the scene of many battles between Indians. French. Dutch and English interests; the most famous action was the battle of Oriskany (9 mi. W. of Utica), during the American Revolution, in which Gen. Nicholas Herkimer's continental troops stopped the advance of the British through the valley. A monument marks the spot.

Utica was incorporated as a village in 1798 (its name was drawn from a hat) and as a city in 1832. It stands at the centre of an east-west chain of the communities of Little Falls. Herkimer, Ilion. Mohawk. Frankfort, Rome and Sherrill (the last founded by the Oneida Community, a Utopian society which became known for its manufacture of silverware). The population of Utica was 100,410 in 1960. a loss of 1.1% since 1950; that of the standard metropolitan statistical area was 330,771, an increase of 16.4%. There are in the population Welsh. German. Irish, Italian and Polish elements. the descendants of immigrants who followed the original settlers.

Utica has always been an important transportation and textile centre. It became more diversified in the second part of the 20th century with the replacement of textiles by metals and machinery manufacture, and important government facilities.

Two new coeducational institutions were founded in 1946 in Utica. The Mohawk Valley Technical institute is a county-state junior college. Utica college of Syracuse university is a four-year college of arts and sciences. In addition to Hamilton college, mentioned above. there is also an art gallery and school of painting, the Munson-Williams-Proctor institute. The state Masonic home is located there.

Utica has a planning board to guide its physical development and its satellite villages are following this lead. The city has an excellent system of large parks supplemented by other recreational facilities. Its location in the heart of many fine state parks, including the immense Adirondack park, makes it a favoured spot for every kind of outdoor sport. (V. C. C.)

UTILITARIANISM, the ethical theory that holds that an action is right if it achieves the greatest good of the greatest number of people.

The "greatest good" or, more precisely, the "greatest happiness" first appears as a formula for a moral standard in Richard Cumberland's De *Legibus naturae* (1672) where its authority is derived from God, Whose basic law it is. This theological version was further developed by John Gay, Abraham Tucker and William Paley.

It was with Jeremy Bentham, however, that the term "utilitarian" originated and the theory became well known and influential. Bentham first took it up as a criterion for distinguishing good from bad laws, and his use of it was throughout practical and political rather than theoretical. He defended utilitarianism as a moral theory in *Principles of Morals and Legislation* (1789) and in *Deontology* (published posthumously. 1834). He held that the only object a man ever pursues as an end is happiness. that is, pleasure and the absence of pain (hence his theory is sometimes called hedonistic or eudaemonistic utilitarianism). To explain how an individual, whose sole pursuit is his own pleasure, can have a duty to pursue the general happiness, he invoked certain "sanctions": if I do not take account of the pleasures and pains of others, I shall be arrested (the political sanction) or ostracized (the moral or social sanction) or punished hereafter (the theological sanction). To call a motive good merely means that it usually brings good consequences and is therefore approved merely as a means. *(See* BENTHAM, JEREMY.)

J. S. Mill in *Utilitarianism* (1863) provided the theory with its classic expression but at the same time imported into it elements inconsistent with its hedonistic (or pleasure) basis: for example, the assertions that some pleasures are higher or nobler than others and that ends other than pleasure, such as virtue or knowledge, can be desired for their own sake. The last important "happiness-utilitarian" was Henry Sidgwick. In his *Methods of Ethics* (1874) he explicitly rejected the psychological hedonism on which Bentham and Mill had based their arguments and presented a very full defense of the "greatest happiness principle" as the only fundamental principle of morals. *(See* MILL, JOHN STUART.)

G. E. Moore in *Principia Ethica* (1903) rejected the view that happiness is the only thing good as an end. Knowledge, aesthetic enjoyment and personal affection all contribute elements of intrinsic value to the *summum bonum.* But, in *Ethics* (1912), he defended the principle that an act is right if it achieves the greatest good of the greatest number. His version of the theory is therefore sometimes called agathistic or ideal utilitarianism to distinguish it from the hedonistic or eudaemonistic utilitarianism of his predecessors. Moore also recognizes that. besides judging actions as right or wrong (on the utilitarian criterion), we also judge them by reference to their motives and intentions as praiseworthy or blameworthy; he treats this as an independent type of judgment and does not attempt to treat motives merely as means to an end, as the earlier utilitarians did.

Moore is clear that it is the rightness of a particular act which is determined by the utilitarian criterion. Mill and Sidgwick sometimes show traces of an alternative view. On this view. it might sometimes be right to do an act which did not produce the best possible consequences. because this act was required by a rule (of justice, or of gratitude. or of truthfulness). These rules mould then be justified by their general utilitarian value. But this more plausible view is neither fully worked out by them nor is it distinguished from the simpler view characteristic of Moore.

Utilitarianism owes its permanent attractiveness to its apparent ability to combine two incompatible positions. If my only possible aim is my own happiness. then benefits to others are relevant only so far as it pays me to achieve them. If I can aim at the good of mankind as an ultimate end, then it is false that my only aim is my own happiness. *See* ETHICS; ETHICS; HISTORY OF; *see* also Index references under "Utilitarianism" in vol. 24.

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UTILITY. In economics the utility of a good is not conceived to be its usefulness, as judged by any objective standard. but its importance to a consumer. Capacity to excite desire rather than to yield benefits or bestow happiness is the measure of a good's utility, in this technical sense, and only as the conduct of life is completely rational and guided by adequate foresight are the two capacities the same.

The law or principle of diminishing utility, which serves in economics as a logical foundation for the laws of demand, is merely a general statement respecting an obvious aspect of the way in which men apportion their time and their means. Summarized, it is that progressively diminishing importance is attached by a consumer to successive additional increments of a good. Diminishing utility has two aspects: absolute and relative. One suit of clothes is more important than a second, and a second is more important than a third. It is more important that in a cold climate one should have enough coal to keep one room warm during the winter than that a second, a third or a fourth room should be heated. It cannot be said, however, that all luxuries, and particularly such as minister to the "desire for distinction," have different uses which can be ranked in an order of diminishing importance.

Marginal utility is the utility of the last increment (not necessarily last in point of time) which the consumer thinks worth acquiring. *See* also ECONOMICS and VALUE. (A. Yo.)

UTMAN KHEL, a Pathan tribe who occupy the hills to the north of Peshawar in West Pakistan. They claim to be descendants of Baba Utman, who accompanied Mahmud of Ghazni in his expedition into India in 997. The Utman Khel are a tall, stout and fair people, but in dress and general customs follow the neighbouring peoples of Bajour.

UTO-AZTECAN FAMILY, perhaps the most numerous and important stock of North American Indians. named after a representative northern and southern tribe, extended in a long irregular tract, broken only in 'Arizona. from ldaho to Tabasco. Mex., and beyond as far as Panama in scattered populational islets. The bond of union was linguistic and geographic rather than racial or cultural.

In customs there was little common to the lowly northern tribes and the more advanced ones of southern Mexico.

See INDIAN, NORTH AMERICAN. (A. L. K.; X.)

UTOPIA, an ideal commonwealth whose inhabitants exist under perfect conditions. Hence "utopian" is used to denote a visionary reform, which fails to recognize defects in human nature. The word first occurs in Sir Thomas More's *Utopia,* published in Latin as *De optimo reipublicae statu, deque nova insula Utopia* (Louvain, 1516). It was compounded by More (*q.v.*) from the Greek *οὐ,* not! and *τόπος*, a place, nowhere.

The idea of a utopia is, even in literature, far older than More's romance; it appears in the *Timaeus* of Plato and is fully developed in his *Republic.* The idealized description of Sparta in Plutarch's life of Lycurgus belongs to the same class of literary utopias. A similar idea occurs in the Greek. and the mediaeval Norse, Celtic and Arab legends which describe an earthly paradise in the western or Atlantic ocean *(see* ATLANTIS). Few of these survived after the explorations of Columbus, Vasco da Gama and others in the 15th century; but in literature More's *Utopia* set a new fashion: the imaginary voyager arrives at the ideal state.

In the writings of Thomas Hobbes. Sir Robert Filmer and Jean Jacques Rousseau an ideal state of society is described. In Francis Bacon's *New Atlantis* (1624–29) science is the key to universal happiness; Tommaso Campanella's *Civitas Solis* (1623), which portrays a communistic society, was largely inspired by Plato's *Republic;* James Harrington's *Oceana* (1656), which had a profound influence upon political thought in America, is a treatise rather than a romance and is founded on the ideas that property, especially in land, is the basis of political power, and that the executive should only be controlled for a short period by the same man or men. With these may be compared the Christian utopias, J. V. Andreae's *Christianopolis* and S. Golt's *Nova Solyma* (1648). Bernard de Mandeville's *Fable of the Bees* is unique in that it describes the downfall of an ideal commonwealth.

Other utopias are the "Voyage en Salente" in Fénelon's *Tilemaque* (1699), Vairasse's *Histoire des Sevarambes* (1716); Mercier's *L'An 2440* (1742); James Burgh's *Account of the Cessares* (1764); J. B. Say's *Olbie* (1800); Étienne Cabet's *Voyage en Icarie* (1848); Bulwer Lytton's The *Coming Race* (1871); Samuel Butler's *Erewhon* (1872) and *Erewhon Revisited* (1901); Edward Bellamy's *Looking Backward* (1888); William Morris' *News from Nowhere* (1890); H. G. Wells's *Anticipations* (1901), *A Modern*

Utopia (1905) and *New Worlds for Old* (1908). Many utopias, like the *Fable of the Bees* and *Erewhon,* are satires. Others were based on socialistic ideals; among these may be mentioned *Freiland, ein soziales Zukunftsbild* (1890) and *Reise nach Freiland* (1893), by the Austrian Theodor Hertzka (b. Budapest, 1845), portraying a commune in central Africa.

UTRECHT, the smallest Netherlands province, has the Zuider Zee washing its very short northern frontier. Its area is 511 sq.mi., and with a population of 650.304 (1957 est.) it ranks third in the list of most densely populated provinces. This is also the position which it occupied at the beginning of the 20th century, but between 1900 and 1930 its average density increased from 470 per square mile to 773 per square mile. Utrecht city (*q.v.*) had (1957 est.) 249,324 (mun.) inhabitants (fourth in the country) and Amersfoort 66.403 (mun.). The other settlements are relatively small. The province falls entirely within the Rhine delta. The southern limit of the Scandinavian ice passed diagonally through the province from northwest to southeast in the vicinity of Ctrecht city, and the western part of the province consists of clay lands and, in the northwest, of low fen.

The sand and gravel eastern region is covered with bare heaths and patches of woods, and the occupations of the scanty population are chiefly those of buckwheat cultivation and peat digging. Amersfoort is the only large town there, but along the western edge of this tract there is a row of thriving villages. such as Amerongen, Driebergen. Doorn and Zeist.

The southern area is picturesque with more extensive woodlands and has long been popular for country seats: Zeist provided a hunting box for William III, and Doorn a retreat for former Kaiser Wilhelm II. Veenendaal, on the southeastern border. became a market for the local beekeeping industry, and Amersfoort, one of the chief seats of the Old Catholics, a thriving garrison town with a variety of crops, including tobacco, growing on the sandy hills in its neighbourhood. It retained the Koppelpoort gateway spanning the Eem, probably the finest and least altered medieval entry to any town in the Netherlands. Within the town the old ramparts were laid out as leafy promenades. Baarn, farther downstream, is a popular summer resort for Amsterdam citizens, and on the east side of the Eem are the typical peaceful fishing villages of Bunschoten and Spakenburg.

At Maarsen, near Utrecht, was built Zuylen castle. Rhenen was once the seat of an independent lordship, though afterward joined to the bishopric of Utrecht. The ancient church was provided with a fine tower (1492–1531). Wijk-by-Duurstede, originally a Roman settlement, was of considerable commercial importance as early as the time of Charlemagne but decayed as a result of Norman raids in the 10th century. The tower of the ruined castle of the bishops of Utrecht still stood in modern times.

Ecclesiastical History.—The province represents the bulk of the ancient see, founded in 722 by St. Willibrord. The bishopric was weak compared with Holland, Gelderland and Brabant, and the middle ages saw local wars. Holland's growth in the 14th century forced Gelderland and Brabant to relinquish their claims over the see. Later, in the 15th century, its supremacy passed to the dukes of Burgundy and, still later, to the emperor Charles V. Notwithstanding the elevation of Utrecht to an archbishopric (1559), it was one of the seven provinces on the Protestant side which signed the union of Utrecht (1579) against Spain. The chapter of the see was secularized and the power of the members of the five ecclesiastic colleges was severely curtailed.

Under the vicariate of De la Torre (1651), trouble began with Rome, which claimed the right of appointing successors. In 1702 Codde, the nominee of the Dutch secular clergy, was accused by the Jesuits of Jansenism (*q.v.*). Although innocent, he was deposed, and his chief opponent, De Kock, was appointed in his stead. De Kock was expelled from the country by the states-general and the Church of Utrecht was without a head.

In 1713 the French government enforced the bull *Unigenitus,* and many refugee priests entered Holland, including Dominique Varlet who settled in Amsterdam in 1720. Steenoven, in 1723, was elected archbishop by the chapter of Utrecht and his subsequent consecration by Varlet led to a general excommunication by the pope. The Jansenist Church of Holland was continued as an independent body accepting the general councils, but rejecting *inter alia* the Vatican council and the infallibility of the pope. Two suffragan sees were created: Haarlem (1742), Deventer (1757); and though, in the next century, the church lost membership, yet it later attracted numbers of the less rigid Roman Catholics. At first the Jansenist church of Utrecht established close relations with the Old Catholic movement in Germany, but it subsequently strongly disapproved the departures of the German members from Catholic tradition. The Jansenists refused to recognize the validity of Anglican orders, and in 1908 a singular offshoot of the Church of Utrecht was established in England when Gerard Gul (Jansenist archbishop of Utrecht) consecrated Arnold Harris Mathew bishop of the Old Catholics in England. Meanwhile, in 1851, in Holland itself the Roman Catholic hierarchy had been restored, with Utrecht as the archiepiscopal see.

For general statistics see HOLLAND.

UTRECHT, the capital of the province of the same name, lies in the centre of the Netherlands, on the Kromme Rijn (winding Rhine), the Leyden Rhine. the Vecht and the Amsterdam-Rhine canal, 19 mi. S.S.E. of Amsterdam. Area 19.8 sq.mi. Pop. (1957 est.) 249,324.

Utrecht is well known for its university, the Industries fair and as a junction of railways, waterways and highways. It is a picturesque old town, especially in the centre. Unique in the whole of western Europe are the Oude Gracht and the Nieuwe Gracht (sunken canals) with their wharves and deep cellars, formerly used by merchants for storage. The Dom tower, in Gothic style. is about 360 ft. high and has two chapels and a fine chime of bells. Formerly this tower was connected with the Dom church opposite, but the nave of the church (1254–1517) collapsed during a hurricane in 1674 and was never rebuilt. The transept, the choir and two chapels remained and are still in good condition. The chapter room (1409), connected to the church by a beautiful Gothic cloister, is now used by the State university as its main hall. Other churches are Janskerk (1040), Pieterskerk (1048) with a beautiful Romanesque crypt, Nicolaikerk (1131), Jacobikerk (1173), Buurkerk (10th-century), Geertekerk (1260) and St. Catharijnekerk (1468) which is now owned by the Roman Catholic archbishopric. Paushuize (Pope's house) was built for the only pope of Dutch blood, Adrian VI, about 1520; it is now the residence of the queen's governor for the province of Utrecht. In the 19th century and later, modern residential districts have arisen, with fine parks, as well as the Town hall (1830), office buildings and the Municipal theatre (1941). The Maliebaan (1636) is the loveliest promenade in the Netherlands. The old ramparts along the moats were replaced by parks and pleasure grounds in the 19th century.

The Utrecht State university (1636) is the largest of the Dutch state universities. The university library, partly housed in the palace built for King Louis Napoleon, contains about 300,000 vol. Utrecht has a great many special schools for architecture, mechanical technology and electrical engineering, typography, engineering, horticulture, textiles, etc. There are a municipal symphony orchestra, a modern theatre and a number of museums including the Central museum (pictures, sculpture, historical costumes, period style rooms, archaeological finds); the Archiepiscopal museum (medieval art); the Dutch Railway museum; the Netherlands Gold, Silver and Clock museum; the Museum of New Religious Art; the Old Catholic museum; the State Forestry museum; and the Acoustical museum.

Communications and Industry.—Utrecht is connected with other towns in the Netherlands and abroad by means of railways, highways and water. The Amsterdam-Rhine canal, running beside the town, is one of the busiest west European waterways.

Utrecht has a great many industries, such as the construction of bridges and wagons, iron and steel foundries, aluminum, clothing, furniture, foodstuffs, typographical and chemical industries, etc. Many of the products are exported. There are big vegetable and fruit markets and the cattle market is one of the largest in the country. The state mint is in the city as well as banking, credit and insurance businesses.

Industries Fair.—The Royal Dutch Industries fair, founded in 1916. is an important international commercial event. General international fairs are held in spring and in autumn. The so-called professional fairs are held in the Industries fair buildings, situated in Vredenburg (1921–38), Bernhard hall (1953), Margriet hall (1954). Juliana hall (1956) and Merwede hall (1958).

History.—Utrecht is a city of great antiquity. It was first mentioned by Roman writers as Trajectum. Its present name derives from "Uut" (downstream) and "Trecht" (ford). In 48 B.C. the Romans built a fortress called Albiobola. which was part of a belt of fortifications along the northern frontier of the Roman empire. Around this fortress arose a settlement from which Utrecht originated. Albiobola existed up to the 3rd century A.D. Later the Franks built, on the site of the fortifications, a church dedicated to St. Martin, which was probably the first Christian church in the northern Netherlands. Early efforts made to propagate Christianity from this church were in vain. but after A.D. 690 the Frankish king Pepin (Pippin), who had just defeated the Frisians. allowed the Anglo-Saxon Bishop Willibrord to establish his see there. Willibrord became the archbishop of the Frisians and, starting from Utrecht, converted to Christianity most of the northern Netherlands. Under the bishop of Utrecht the city became an important temporal as well as ecclesiastical power and a centre of trade and industry. Its greatest prosperity was in the 11th.and 12th centuries. Toward the end of the 13th century trade declined, partly because of political disturbance and partly because of the rise of other towns, such as Amsterdam and Dordrecht; but industry, mainly cloth weaving, held its ground and for centuries provided a living for many of Utrecht's citizens.

In the middle ages Utrecht remained the most powerful and important town in the northern Netherlands. The citizens opposed the temporal power of the bishops and it mas the guilds particularly that led the way in this struggle. As early as 1304 an urban council was created. In 1528 the bishop of Utrecht, Henry of Bavaria, renounced his temporal rights in favour of Charles V of Spain. Spanish domination prevailed up to 1577, when the women of Utrecht, led by Katrijn van Leemput, an ensign's wife, scaled the fortress of Vredenburg. built by Charles V. and started to pull it down. After that time Utrecht supported the cause of the prince of Orange. Partly as a reaction to Spanish occupation Utrecht became a firm stronghold of Calvinism and remained so for many centuries. A treaty to drive out the Spanish soldiers was concluded in 1579 and signed by seven provinces. This treaty, known as the union of Utrecht (although Utrecht had hardly any say in the matter), exercised great influence on the history of the Netherlands and may be regarded as the foundation of the later kingdom of the Netherlands.

In 1713 Utrecht witnessed the conclusion of the treaty of Utrecht, which ended the War of the Spanish Succession. In 1807 Napoleon's brother Louis Napoleon. king of Holland (1806–10), made up his mind to make it his residence, but the course of history decided differently. Utrecht gradually became an ordinary provincial town. Thanks to its central position in the Netherlands and to the numerous big institution. and enterprises settled there. Utrecht developed and flourished in the 20th century. It is the seat of the provincial government, of a Roman Catholic archbishopric, of the Old Catholics, of the county court and is a centre for congresses and meetings. (J. C. J.)

UTRECHT, TREATY OF, the general name given to the important series of treaties which in 1713 and 1714 concluded the War of the Spanish Succession (*q.v.*).

The congress opened on Jan. 29. 1712. But it was not until July 10, 1712, that Ring Philip of Spain signed a renunciation of his rights to the succession of the crown of France. Then, England and France having concluded a truce, the pace was quickened and the main treaties were signed on April 11, 1713.

By the treaty between England and France. Louis XIV recognized the Protestant succession in England and undertook to give no further aid to the Stuarts. France ceded to England, Newfoundland. Nova Scotia or Acadia. the island of St. Kitts or St. Christopher. and the Hudson's bay territory. and promised to demolish the fortifications of Dunkirk.

The treaty between France and the United Provinces was mainly concerned uith securing the barrier of fortresses. These arrangements were somewhat complicated and to a large extent provisional, as Austria and Bavaria, two countries deeply interested in the fate of the Netherlands, had not yet assented to the terms of peace. By a commercial treaty concluded on the same day, France gave the Dutch privileges similar to those enjoyed by England. Other treaties concluded at the same time were between France and Savoy, France and Prussia, and France and Portugal. By the first the duke of Savoy regained Savoy and Nice, and France undertook to obtain for him the island of Sicily and the title of king. By the second Prussia secured some small additions of territory, including part of Gelderland and Neuchâtel; in return France definitely and finally obtained the principality of Orange. The treaty between France and Portugal mainly concerned the Portuguese settlements in Brazil, her claim to these being recognized by France.

Other treaties were signed at Utrecht between Spain and the allies, Philip now concluding these as the recognized king of Spain. On July 13, 1713, a treaty was signed between England and Spain, which embodied certain commercial arrangements previously made between the two countries. Spain ceded to England Gibraltar and Minorca, and promised to give up Sicily to Savoy. She gave also to England the monopoly for 30 years of the lucrative slave trade uith Spanish America, hitherto enjoyed by France: this was the famous Asiento treaty. The peace between Spain and the United Provinces was signed on June 26, 1714, but the conclusion of that between Spain and Portugal was delayed until the following February. The former was concerned mainly with commercial matters, Spain giving the United Provinces most-favoured-nation treatment.

The treaty of Ctrecht also provided compensation for the Emperor Charles VI as soon as he surrendered his claim to Spain. He was to receive Naples and Milan, and also the Spanish Netherlands, henceforward known as the Austrian Netherlands.

But the general pacification was still incomplete, as France and the empire continued at war. It was not long, however, before Charles VI realized that without allies he was no match for France.

Accordingly, his representative, Prince Eugène, met the French marshal Villars at Rastatt in Nov. 1713, and here peace was made on March 7, 1714, Charles VI concluding the treaty without waiting for the assent of the states of the empire. This consent, however, was necessary, and a little later the representatives of some of the princes of the empire met those of France at Baden, where, on Sept. 7, 1714, the treaty of Baden, the last of the treaties included in the general peace of Utrecht, was signed. This dealt entirely with the question of the frontier between France and the empire, which was restored as it was before the war except that France gained Landau.

One other important matter was dealt with at Utrecht. A second barrier treaty between England and the United Provinces was signed on Jan. 30, 1713, and a third treaty signed at Antwerp on Nov. 1;, 1715 clinched the matter. Seven fortresses were to be garrisoned by a total of 35,000 men, three-fifths of the cost being borne by the imperial government and the remainder by the United Provinces.

The treaties were bitterly assailed by the Whigs, and after the accession of George I four of its Tory authors, Bolingbroke, Oxford, Ormonde and Strafford, were impeached for concluding it, the charges brought against them being that they had corresponded with the queen's enemies and had betrayed the honour and interests of their own country.

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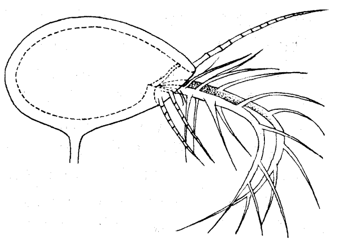
UTRICULARIA, a genus of the bladderwort family (Lentibulariaceae) containing about 250 species of carnivorous fresh-water and land plants. Closely related are the genera *Biovularia* (two species) and *Polypompholix* (probably four species). They are commonly called bladderworts because of their numerous small hollow traps, first regarded as bladders and thought. erroneously, to serve for floating the plant. Since land forms also have "bladders." this view was obviously open to question, and was shown to be false. *Utricularia* species live in various environments; some are aquatic, some are terrestrial and some are intermediate. growing either in water or on wet soil. The aquatic plants live either submersed in or floating upon usually still, fresh waters, though two species are known which live attached to stones or other firm surfaces in rapidly running streams. In the latter the traps are, literally, streamlined, and are thus adapted to moving water. The land forms grow recumbent upon wet soils, usually of quartz, sand, mud or moss. In jungles, a few species grow upon moist foliage; one or two species grow in the water held by the leaf rosettes of certain epiphytic bromeliads (related to the pineapple) in South America.



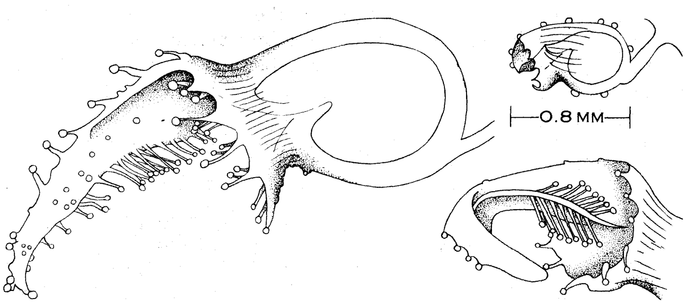
FROM LLOYD, "THE CARNIVOROUS PLANTS" (CHRONICA BOTANICA CO.)

FIG. 1.—UTRICULARIA GIBBA SHOWING SIDE VIEW OF A TRAP

These plants are of world-wide distribution, ranging longitudinally from Greenland to south Africa, North America has about a dozen species including a number of land forms (*e.g., U. subulata*). Europe has about four species, all of which are submersed or partly submersed forms. The largest. common to both hemispheres in the temperate regions, is U. *vulgaris.* Floating in quiet waters, this attains a length of three feet or more, with several branches and with finely dissected leaves bearing numerous traps, two to three millimetres long, which serve to catch minute animals, such as water fleas (Crustacea), larvae of flies, including mosquitoes, small spiderlike creatures, etc. The prey serves as a source for nitrogenous food. and probably for salts of various kinds. Minute algae (*e.g., Euglena)* often are found living apparently happily within the traps, subsisting on the readily available food source.

A few land forms are of considerable stature, as U. *globulariaefolia* of Trinidad and *U. renifolia,* with large showy flowers, of the Organ mountains of Brazil. The latter is showy enough to be grown in greenhouses, where it is usually segregated with the orchids, less for its superficial resemblance than for its similar requirements of high humidity and temperature. But the vast majority of land forms are small and inconspicuous save for their flowers, which, though often small, are quite readily seen. The larger, though having small vegetative parts, have tall inflorescences, the flower stalks in U. *cornuta* being a foot high. The smaller, except for their showy, small flowers, are inconspicuous among the mosses: etc., in which they grow. Still others are almost microscopic in size.

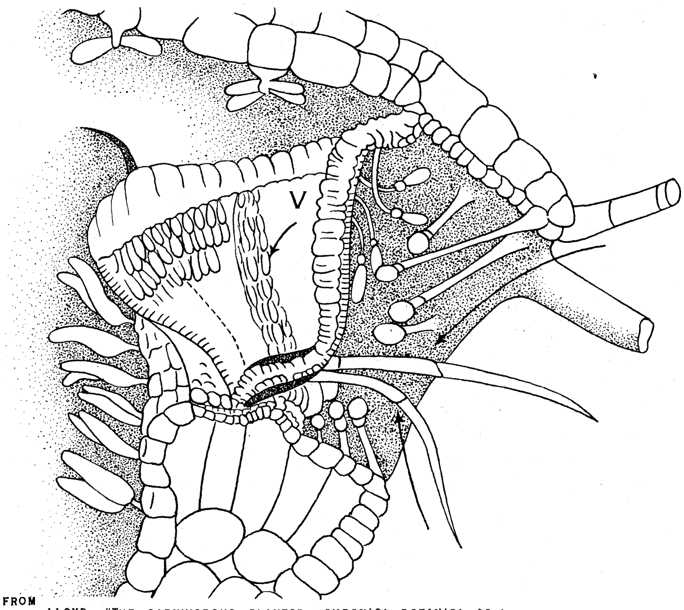
Plant Structure.— The plant body consists of a more or less horizontal stem (a stolon) bearing simple or divided leaves placed in a variety of relations, not following any obvious rule. A peculiar and significant feature, noted by Karl Goebel. is that the leaves face away from the apex of the stolon which bears them, the reverse of the usual condition. Correlated with this is the occurrence of the axial bud in a correspondingly reversed position.



FROM LLOYD, "THE CARNIVOROUS PLANTS" (CHRONICA BOTANICA CO)

FIG. 2.—UTRICULARIA ROSEA WITH A FUNNEL-SHAPED ENTRANCE AND KNIFELIKE ROSTRUM

In *Utricularia* the calyx has two members, a dorsal and a ventral one. In *Polypompholix* there are two additional. in lateral positions. The corolla is entire and of the personate type, two lipped, with the mouth closed by a palate and provided with a spur from the lower portion. The spur is very large in *U. menziesii* and vestigial in *U. minor,* and is represented by a wide, cuplike expansion in U. *cymbantha.* The spur is a nectary, but nectar glands occur also in the bowl-shaped condition. The colour of the corolla may be white, very often yellow, pale blue to purple, and in one species brilliant crimson, variously marked on the palate with other colours. Reproduction is by means of seeds, by winter or resting buds and by adventitious growth from various parts, as from leaf buds. The inflorescence is a raceme, and in some floating kinds is held up in position by means of a whorl of floats, which are leaves in which the midrib is much inflated, as in the American *U. stellata.* Expansions of the stolons lead to the formation of tubers. which, containing sap and starch, can serve to resist drying during adverse periods and act as reproductive structures.



FROM LLOYD, "THE CARNIVOROUS PLANTS" (CHRONICA BOTANICA CO.)

FIG. 3.—UTRICULARIA GIBBA

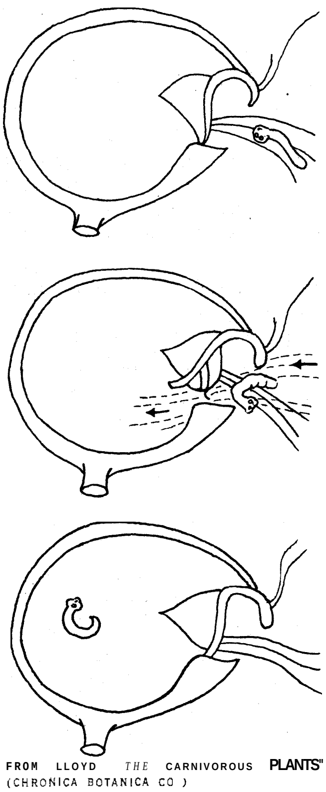
Diagram of the entrance in longitudinal section. The outer surface of the door and the sides of the entrance bear mucilage glands. The arrows point at the tripping bristles and indicate the direction of the prey's approach. V indicates velum

Mechanism of Capture.—The most noteworthy feature of the three genera considered here is the occurrence of traps, usually, but incorrectly, called bladders. From the time of Darwin and Ferdinand Cohn (1875) until that of Frank Brocher (1911), these structures were thought to be passive traps, consisting of a hollow, bladderlike sac guarded by a curved, flexible door or valve. This, it was interpreted, would be pushed in by an intrusive animal of a suitable size, and permit easy entrance; but since the valve is a check valve, permitting movement in only one direction, the animal remained captive, balked of escape by a now resisting wall. This account was shown to be quite inadequate by Brocher, a Swiss entomologist, who during a study of mosquitoes and *Utricularia* in relation to each other. discovered that, when a larva is caught, the sides of the trap, normally impressed and concave, were then definitely expanded. This could be explained only as being the result of an inflow of water, and that the prey was washed into the trap thereby. This indicated that the valve or door was fixed in a position of unstable equilibrium which was upset by impact of the prey on certain bristles, four in number, projecting from the door surface. This was later confirmed (by E. M. Merl and T. Czaja), and it was shown also that the action could be repeated, 14 repetitions of the action having been counted. This could be explained only when it was discovered that the wall of the trap constantly excretes water from the inside of the trap to the outside and that the door is so postured that it can resist the relatively increased water pressure on the outside.

Later it was found that the door posture of itself is insufficient to render it watertight, which it must be to allow the maintenance of reduced water pressure on the inside. It was then found that, in addition to the door, there is a second valve, the "velum." which consists of a membrane attached to the valve seat on which the door edge rests, applied against the lower zone of the door in such manner as to prevent the inleakage of water under it. as can readily occur at the side reaches of the door edge (F. E. Lloyd). The valve seat, called by Darwin the "collsr," is a stout, curved weal of tissue, lined with a soft cellular lining, the cells of which'supply the velum by exfoliation of their cuticles, which remain attached to each other and to the front edge of the collar. After action, the valve or door reseats itself on the upper surface of the collar, and the velum folds upward over the door edge. The trap is then sealed, and, after sufficient excretion of the inner water, mill again react.

In order to set the trap into action, the door is provided with a trigger mechanism In *U. vulgaris* and the like, this consists of four to six stout, curved bristles which, when disturbed by the impact of prey, bend, and, in doing so, twist slightly the edge of the door, releasing it from its delicate equilibrium and allowing the external water pressure to push it in, carrying the prey uith it. The inward swing of the door is followed, as the pressure of the insurging water decreases, by a return to approximately the original posture. the whole occupying about $\frac{1}{35}$ second The walls of the trap are now more or less bulging, due to the greater contained volume of water. The trap is now in the relaxed state. The set state is reached in 15 to 30 minutes *(U vulgaris),* during which time the door changes its posture somewhat, because of the now increased uater pressure, and is again ready for repetition. As the result of somewhat different mechanical conditions in the traps of many species, the change in posture of the door from the relaxed to the set state is very marked and readily observed (U. *capensis; Polypompholix)*

The expulsion of water from the inside to the outside of the trap through the walls demands a mechanism, and this is found in two sets of trichomes. one on each surface. uhose capital cells are bare of cuticle. These are. on the inside. the quadrifid and bifid hairs, as Charles Darwin called them, and on the outside hairs with rounded or elongated capitals. Since the rest of the wall surfaces are covered with cuticle, this seems to be the only reasonable conclusion. The quadrifid hairs are numerous in *U vulgaris,* and few, but relatively much larger, in small traps such as those of *U. subulata*

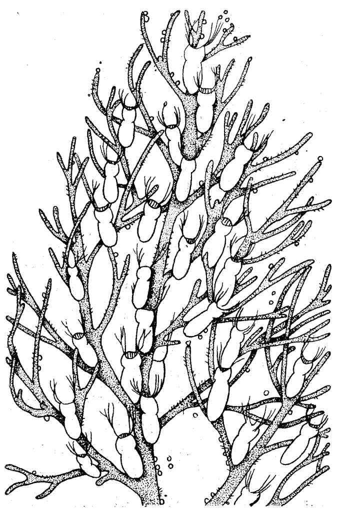


FROM LLOYD *THE* CARNIVOROUS PLANTS" (CHRONICA BOTANICA CO)

FIG 4 —UTRICULARIA GIBBA SHOWING THREE STAGES IN CAPTURE OF PREY

Door being sprung by larva (top); door opening (centre); larva caught and door again closed (bottom)

The trigger mechanism is widely different in various species. but is always composed of trichomes of various shapes and dispositions. Aside from these, the remaining appendages of the trap consist of variously shaped and disposed emergencies, ranging from branching arms to extensive wings. In *U. vulgaris* there are two curved arms extending from the upper corners of the entrance. Between them on the edge of the entrance stand several delicate, long bristles, with similar ones, about four. in an oblique row extending along the "cheek" of the mouth. These form a sort of guiding funnel leading to the mouth, and hence to encounter with the trigger bristles. In various species the upper edge of the entrance may be strongly developed into a single, or a bifurcate rostrum, armed with large glandular trichomes. The single rostrum may be broad and rounded, or may have the shape of a knife blade. Again, a rostrum may arise from the lower edge of the entrance and extend far forward and upward, as in the American *U. purpurea.* In Australian species the rostrum may be much branched and in such case the trap bears two ventral wings extending obliquely toward the entrance and acting as guides thereto. Again, the whole margin of the entrance map be draun out to form a deep funnel lined with radiating rows of glandular hairs. which it has been suspected secrete. beside mucilage, some substance or substances attractive to prey. thus acting as a lure. Convincing evidence is, however, lacking.



FROM LLOYD THE CARNIVOROUS PLANTS (CHRONIC4 BOTANICA CO)

FIG 5 —UTRICULARIA VULGARIS LEAF SEEN FROM BELOW

The genus *Polypompholix* has traps which have thick and massive walls, three in number, so that the trap is triangular in section. The entrance is blocked in front by a swelling of the stalk, so that approach to it must be made from the sides. Wings and rows of bristling hairs serve to guide the prey appropriately These plants are all found in central south and southwestern Australia.

Biovularia has two species, one in Cuba and one in South America. They are characterized by the possession of only two ovules, in contrast to the 100 or more of *Utricularia.* Certain species of Africa, because of the fact that only three ovules occur, have been regarded as belonging in *Biovularia,* but the traps are like those of *Utricularia.* Those of *Biovularia* have six tripping bristles set at about the middle point of the door instead of near the lower edge, as in *Utricularia.*

It is not satisfactorily determined whether the dissolution of captured organisms in the traps is the result purely of secreted enzymes, of bacterial action, or both. Much of the difficulty of deciding the question arises from the small size of the traps.

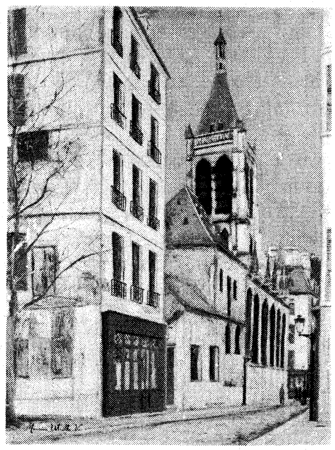
See also CARNIVOROUS PLANTS.

See F E Lloyd. *The Carnzvorous Plants* (1942) (F. E. L)

UTRILLO, MAURICE (1883–1955), French painter, noted for his scenes of Montmartre, was born in Paris on Dec 2j, 1883, the natural son of the model and artist, Suzanne Valadon (1865–1938). His father was not known, and he uas given a name by the Spanish art critic. Miguel Utrillo. Utrillo had no instruction as an artist apart from that given by his mother, who herself was untutored. When, as an adolescent, Maurice became an alcoholic, his mother encouraged him to take up painting as therapy. Despite frequent relapses into alcoholism, painting became Utrillo's obsession. and he produced thousands of oils, as well as a few drawings and lithographs. In 1924, to keep her son permanently away from the bars of Montmartre. Suzanne Valadon moved with him to a château near Lyons. In 193j the artist married a widow. Lucie Pauwels (Lucie Valore), herself a Sunday painter, and settled in Le Vésinet. a fashionable suburb of Paris

Though Utrillo was initially attracted by the Impressionist paintings of Camille Pissarro and Alfred Sisley, he had neither aesthetic concepts nor artistic preferences, nishing only to reproduce what he saw, as faithfully as possible. Shy and withdrawn, he painted very few portraits: except for a number of flower pieces, the bulk of his compositions are devoted to the old. deteriorating houses and streets of Montmartre. its windmills (no longer existing ı. and its cafés and amusement places. Trips to Brittany and Corsica also yielded a few paintings.

His best work is that of his "white period" (*c.* 1908–14), so called from the lavish use of zinc white. In heavy. rich pigment he built up aging. cracked walls. often covered with large inscriptions. These freshly conceived and freely brushed oils brought him fame and a great fortune. In 1929, he was made a chevalier of the Legion of Honour. In his later years, his painting. largely based upon picture postcards. declined sharply in originality and vigour. He died at Le Vésinet on Sov. 5, 1955.



BY COURTESY OF NATIONAL GALLERY OF ART, CHESTER DALE COLLECTION (LOAN) WASHINGTON 3 C

"THE CHURCH OF SAINT-SÉVRIN" BY MAURICE UTRILLO. NATIONAL GALLERY OF ART. WASHINGTON. D.C.

First-rate Utrillos are few. but critics have linked him. as a landscapist. with such masters as Guardi. Hubert Robert and Corot. Unfortunately. countless crude forgeries have done much harm to his reputation. In Paris. a room in the Musée National d'Art Moderne is devoted to his work and that of his mother Suzanne Valadon and his step-father André Ctter.

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UTTAR PRADESH, a state in the republic of India. Area 113.423 sq.mi. Pop. (1951) 63.215.742. During the period of British rule the state was known as the North-Western Provinces until 1902: as the United Provinces of Xgra and Oudh from 1502 to 1937. and thereafter as the United Provinces. The title Uttar Pradesh was introduced at the time oi the declaration of the republic of India in 1950.

The state includes the former states of Rampur, Tehri-Garhwal and Benares. It is bounded on the north and northeast by Tibet and Nepal and comprises the whole of the upper part of the Gangetic basin, from the Himalaya and the Punjab border to the T'indhyan plateau and the ricelands of Bihar, an area roughly corresponding to the Hindustan of the old Moslem chroniclers. To this it adds the great semicircular tract. watered by the Gogra and the Gumti, which was formerly the kingdom of Oudh. The capital is Lucknow (pop. [1951] 444,711).

The population is larger than that of any other state of the republic. In the census of 1941, 83.3% of the population were Hindus and 15.3% Moslems. In 1951, 85% were Hindus and 14.3% Moslems. which shows that the movement of population caused by partition did not greatly affect the general distribution by religion in this state. The number of displaced persons in Uttar Pradesh was 475,822 in 1951. Hindustani or Urdu and Hindi (eastern and western) are the chief languages.

Physical Aspects.—At one end the state rises into the Himalaya and includes. at one extreme, some of the grandest of the peaks which look out upon upper Asia. At the other extreme. where it borders on central India, it has a fringe of rough, broken and picturesque country. Apart from these, however. it is a level and somewhat monotonous expanse, well-drained. closely cultivated and studded with villages. the number of which (nearly 105,000) far exceeds that in any other state. Many of them. standing high on the dehris of older sites. have the air of fortified places; and the fine mango groves which often adjoin them redeem the bareness of the surrounding plain.

The flora of the forests is rich and varied. The sal tree yields the most important timber. 'The hard wood of the *shisham* is also valuable. and several other timber trees afford materials for furniture or roofing shingle. Among the scattered jungles in various parts of the state. the mahua tree is prized alike for its edible flowers. its fruits and its timber. The fauna comprises most of the animals and birds common to the Gangetic plain; but the wild elephant is now practically unknown. except when a stray specimen loses its way at the foot of the hills. Tigers are found in any numbers only in the *tarai* (swampy lowland belt near the Himalaya). Leopards haunt the canebrakes and thickets along the banks of the rivers; and nilgai and antelopes abound. Game birds consist of teal and wild duck, snipe. jungle fowl and peacock.

The Ganges and its great affluents. the Jumna, the Ramganga and the Gogra. rise in the Himalaya and meet n·ithin the state. In addition there are the secondary streams: the Kalinadi and the Hindan flow through the Doab; the Chambal intersects the trans-Jumna tract. In Bundelkhand the principal streams are the Betwa and the Ken. The Ramganga, rising in Garhwal. pursues a tortuous course through Rohilkhand: the Gumti flows past Lucknow and Jaunpur to join the Ganges and the trans-Gogra region is divided into two nearly equal parts by the Rapti. These rivers are constantly modifying the adjacent lands.

Climate.—The climate as a whole is hot and dry. The Himalayan districts of course are cool and have a much greater rainfall than the plains. They are succeeded by a broad submontane belt. the *tarai*, which bears the reputation of being the rnost unhealthy in all India: in many parts only the acclimatized aborigines can withstand its deadly malaria. The plain country is generally warm and dry. the heat becoming more oppressive as the general level of the country sinks ton·ard Allahabad and Benares (Banaras). or among the hills of Bundelkhand. The rainfall varies from 30 to 44 in. in the plains. increasing gradually toward the Himalaya. The temperature in the hot season ranges from 86° to 115° F. and even higher in the shade.

Minerals and Agriculture.—Because of the loamy nature of the soil. few minerals of any kind are found; and the chief underground product is the abundant nodular limestone (*kankar*) which is used ior road making. Iron and coal exist in the southern hills but not in paying quantities. and there are traces of old iron-workings in the lower Himalaya. The course of tillage comprises two principal harvests: the *kharif*, or autumn crops. sown in July and reaped in October or November: and the *rabi*, or spring crops. sown in October or November and reaped in March or April. The great agricultural staple is wheat, but millets, rice, barley and pulses are also largely cultivated. Speaking broadly. rice and oilseeds predominate in the eastern and sub-Himalayan districts, millets and cotton in Bundelkhand and n·heat in the greater part of the Gangetic plain. Sugar cane, condiments and tobacco are locally important; and a little tea is grown in the submontane districts of Almora Garhwal and Dehra Dun.

Irrigation.—The Doab is intersected by canals drawn from the great rivers. The major productive works are the Upper and Lower Ganges, the Eastern Jumna and the Xgra canals. The greatest work in the state and one of the greatest irrigation works in the world, is the Upper Ganges canal, which is taken from the river where it leaves the hills. some 2 mi. above Hardwar. In the first 20 mi. of its course this gigantic canal crosses four great torrents. which bring down immense volumes of water in the rainy season. The total length of the main canal is 213 mi., navigable throughout and designed to irrigate 1,500,000 ac. The Lower Ganges canal is taken from the river at Narora. 149 mi. below Hardwar. After crossing four great drainage lines. it cuts into the Cawnpore and 7 mi. lower down into the Etawah branches of the Upper Ganges canal. These branches are below the point of intersection. part of the Lower Ganges canal system. The irrigating capacity of this canal is 1,250,000 ac. The Sarda canal, opened in 1928 to carry the waters of the Sarda into Oudh. was extended in 1941, making the total length of its main canals and branches 7,236 mi.. one of the longest systems of its kind in the world, the area irrigated being more than 1,200,000 ac. (including 200.000 ac. of sugar cane).

Land Tenure.—Under British rule the system of land tenure was not uniform. In the Benares division. the land revenue was permanently fixed in 1795, on the principles that had been previously adopted in Bengali and there a special class of tenants, as well as the landlords, enjoyed a privileged status. Throughout the rest of the province of Agra temporary settlements were in force, usually for a term of 30 years, the revenue being assessed at one-half the "assets" or estimated rental value. The settlement was made with the landholders or zamindars, who were frequently a group of persons holding distinct shares in the land and might be themselves petty cultivators. The privileged tenants were those possessing "occupancy" rights, defined by statute. All other tenants were merely tenants-at-will. In Oudh. after the convulsion of the Indian mutiny, all rights in land were confiscated at a stroke; and the new system adopted was in the nature of grants to the talukdars, or great landlords, who were declared to possess permanent, heritable and transferable rights. with the special privilege of alienation, either in lifetime or by will, notwithstanding the limits imposed by Hindu or Mohammedan law.

On July 1. 1952. an act of 1951 abolishing zamindari took effect. Compensation (eight times the annual income) went to 2,000,000 zamindars at a cost of £112.500,000, the 12,000,000 tenants holding their 60,200,000 ac. (83.3% of the total agricultural land) directly from the state.

Manufactures and Trade. — The principal manufactures are those of sugar. metal and coarse cotton cloth. Ornamental metalwork is made at Benares. Among the factories are the Elgin and Muir cotton mills at Cawnpore, the Cawnpore wool mill, tanneries and leather factories: the Shahjahanpur rum distillery and the breweries at Mussoorie and Xaini Tal. There are also iron and brass foundries. lac factories and oil mills. Agra is a shoemaking centre, and glass bangles are made in large quantities at Firozabad and exported to all parts of India.

The export trade is chiefly confined to agricultural produce. The principal staples include wheat, oilseeds, raw cotton, sugar, molasses, timber and forest produce, dry stuffs, ghee and tobacco. The imports consist mainly of English piece goods, metalwork, manufactured wares, salt and European goods. The chief centres of trade are Cawnpore, Allahabad, Agra, Mirzapur, Benares, Meerut and Moradabad.

Railways. — The state is well supplied with railways. The main lines of the Northern and North-Eastern traverse it from end to end connecting with \Vest Bengal on the one side and the Punjab on the other and linking up with the Central railway line at Allahabad. Agra and Cawnpore.

Besides this broad-gauge system, there is also a metre-gauge connection which serves the whole of the submontane tract and projects into \Vest Bengal. while it also joins with the Western railway at Rluttra. The trade of the state thus has access to the sea at Bombay and Calcutta.

Administration. — Under British rule the United Provinces were under the direction of a governor with an executive council and ministers. The legislature had 118 members, to whom the ministers were responsible. After the transfer of power the legislature remained until 1952, when elections were held under the new Indian constitution. The assembly then had 430 members with a legislative council of 72 members. The first governor after the transfer of power was the poetess politician, hlrs. Sarojini Naidu, who died during her term of office on March 2, 1949.

The state has 51 districts; each under a collector and magistrate (called also deputy commissioner in Oudh and Kumaon). The supreme judicial tribunals are the high courts at Xllahabad, with jurisdiction over the part of the state that was formerly Agra, and the chief court at Lucknow with jurisdiction over Oudh.

(E. HD.; S. GL.; X.)

UXBRIDGE, a market town and municipal (19jj) and parliamentary borough of Middlesex, Eng., 1j mi. W. of London by road and linked with London by the Metropolitan and underground railways. Pop. (1951) oi old urban district, 55,960. Area 16 sq.mi. Uxbridge does not appear in Domesday Book, but as early as 1139 it is mentioned in a deed of that time as Oxbridge. It was the scene of negotiations between commissioners of Charles I and parliament for peace terms in 1645. Part of the Treaty house in which they took place still remains. The Grand Junction canal forms the western boundary of the borough and on its banks are sawmills and wharves. In Uxbridge are engineering works (making cash collection and control machines, transport ticket machines, centrifugal pumps, generators, instruments. tools. etc.), brickworks, a brewery, horticultural nurseries! etc. Uxbridge is well known for the R.A.F. depot, from the control room of which the battle of Britain was directed.

UXMAL, the ruins of an 'ancient Mayan capital city of the New empire about 50 mi. S. of Merida, in Yucatan, Mex.: in 89° 42' W. and 20° 18' N. It was one of those frontier Mayan cities that did not rise to prominence until shortly before A.D. 1000 when the League of Mayapan was formed with three cities, Mayapan, Chichen-Itza and Uxmal, dominant in "the New empire" of the Mayas. With the earlier fall of the Old empire in Guatemala and southern Mexico the Itza established themselves at Chichen ("The Mouths of the Wells"), the Cocom made hlayapan their capital, and the Tutul Xiu. a kindred tribe. settled at Uxmal. The period subsequent to the formation of the League of Mayapan constitutes the golden age of the New empire of the Mayas, when peace and plenty provided favourable opportunity for the development of tradq and religion and science and art, particularly architecture.

Great stone temples and colonnades elaborately carved and ornamented rose in every city; religion flourished; the sciences. especially astronomy and mathematics, mere fostered; and a renaissance of culture held sway for over two centuries. The buildings of this period at Uxmal surpassed those of the other cities in their grandeur and elegance. When the New empire crumbled under internal dissension and the conquest of the Aztec-Toltec imperialists from central Mexico, about the middle of the 1jth century, Uxmal succumbed with the rest, and it is reasonably certain that only vagrant tribes lingered about the old ruins at the time of the Spanish conquest.

The region of the Uxmal ruins, like most of Yucatan, is a dry grass savanna, in places rather heavily wooded as about Uxmal. The relief is negligible. the terrain for the most part being as level as a floor, though a range of low hills lies between Uxmal and Ticul, the railway station about 20 mi. eastward. The water supply of the city was furnished by "cenotes," or wells, within the city, or by pools some distance to the west, now partly filled up and vanished, but in the rainy season so marshy as to be the breeding places of myriad mosquitoes that spread malaria. fever and disease. It may have been some of the mosquito-borne pestilences that destroyed the Mayan civilization.

The main ruins occupy an area not much over 160 ac., but outlying remnants indicate a residential district much larger, for which the central group, massive and extremely impressive, merely constituted the religious and civic nucleus. The stone used in the structures is the pale, yellowish and reddish-gray limestone, obscurely marbled, which was probably obtained not far from the city, though the quarry has not yet been definitely located. The body of the walls and the framework of the temples is generally of fragmental stone set in a whitish mortar of excellent composition made of lime burned in the neighbourhood. The facings and ornaments are all cut exquisitely yet daringly, and in view of the fact that the Mayan artisans laboured without metal tools. the excellence of their work is amazing. The faces and edges are graved and hewn with perfect precision and the joints are in many cases so perfect as to conceal the mortar. Much plastering was done, and nearly all surfaces, and apparently even the intricate details of moldings and sculptures, were smoothed painstakingly by white plaster and finished in many colours.

The walls are massive. averaging 3 ft. in thickness, but in some ruins 9 ft., approximately vertical on the exterior to the full height, and to the spring of the arch inside. Few recesses or projections disturb the smoothness of the exterior walls, but elaborate ornamentation relieves the monotony. Rigid moldings divide the walls into upper and lower zones. the latter faced with smooth stone except for a narrow band of design near the base, and the former, a development of the entablature, compositely graven and bordered by a heavy band of moldings at the top. The shoe-shaped coping stones held the level cement roof. The corners of the buildings were square or rounded. No windows or other openings admitted air or light (or mosquitoes). The doorways, confined to the lower panel of the wall, were simply constructed and of medium to large size. The jambs mere faced with cut stone and the longer lintels were of sapote wood dressed squares.

The buildings were generally long and rectangular with one, or more usually two, ranges of rooms; and as a rule these buildings were arranged in groups of four forming a quadrangle. None of the buildings was over one story in height, and nearly all were built on terraces or pyramids of varied ground plan and profile The rooms were high and spacious. with vaulted ceilings formed of the usual wedge-shaped arch built from horizontally laid stones corbeled and beveled with the slope. Stairways nere numerous. wide, steep and well built of cut stone.

Five principal buildings or groups of structures were the pyramid temple of the magician crowning a majestic pyramid 80 ft. high and 240 by 180 ft. at the base; the Nunnery quadrangle composed of four large rectangular buildings enclosing a court. all on a terrace 300 ft. square and 1j ft. above the level of the plain, and all divided into numerous small rooms probably occupied by the priesthood; the governor's palace, an imposing structure set upon a triple terrace, and said to be the most important single unit of' its kind in America: the House of the Turtles. a smaller structure distinguished by a frieze of sculptured turtles on the molding, and the House of the Pigeons, a quadrsngle like the Nunnery quadrangle, of which one building carries a peculiar roof-comb of colossal size perforated by hundreds of openings which make it appear like a great dovecot, and nhich may have been occupied by statues like the roof-combs of Palenque. Besides these a number of smaller or less important ruins or groups of ruins dot the locality and help to create a scene of ancient power, prosperity and culture, probably unsurpassed in Yucatán and certainly rivaled only by Mayapan and Chichen-Itza

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(W E E.)

UZ, a land, the scene of the story of the book of Job. Its precise location is uncertain, but the name in the Old Testament appears to be associated nith three districts.

1. Northern Mesopotamia, a district to which Uz, son of Aram, is commonly referred (Gen x, 23).

2 Damascus and the country lying to the south of it. Josephus (*Antiq.,* i, 6. 4), commenting on Gen. x, 23, remarks that Uz founded Trachonitis and Damascus.

3. Edom. In Gen. xxxvi, 28, Uz appears in the genealogy of Seir in the land of Edom, and in Lam. iv, 21, Uz stands as a parallel to Edom.

The suggestion has been made that if the name is so widespread. the explanation may be that it is tribal rather than territorial. The transcription of the name in the Greek version suggests the Arabic Audh, a well-known deity, and might well be a tribal designation. Lam. iv, 21, appears to be the sole passage, which gives a clear indication of locality, and it is emphatic for Edom. (E. Ro.)

UZBEKISTAN. A soviet socialist republic of west central Asia, which in 1924 was carved out of the former Turkestan Autonomous Soviet Socialist Republic. It is bounded on the northwest and the north by Kazakhstan; its share of the Fergana (Ferghana; *q.v.*) valley is surrounded on the north. east and south by Kirghizia; its southeastern neighbour is Tajikistan, and on the south it is bounded by Afghanistan and Turkmenistan.

Physical Geography. — Uzbekistan extends from the westerly spurs of the Tien-shan, which enclose the Fergana valley, and from the Afghan frontier along the Amu Darya (Oxus), northwestward across the Kyzyl Kum ("Red Sands") to include the Kara-Kalpak autonomous republic around the lower Amu Darya and the southern and western shores of the Aral sea. Much of the area is thus desert. The Ust Urt plateau, a tableland rising 600–900 ft. above sea level, approaches the Aral sea (about 170 ft.) on the west in an abrupt slope. The Aral sea, rarely more than 60 ft. deep, is rich in sulfates.

For about 300 mi. between the Xral and the mountain foothills stretches the Kyzyl Kum, an area of sands stabilized by vegetation, providing sparse grazing, and with few patches of true dune sand. It lies generally below 600 ft.. but in places hills of Palaeozoic rocks stand above it. The only permanent river in the Uzbek portion of the Kyzyl Kum is the lower Amu Darya. Its former tributary the Zeravshan no longer manages to join it. The Amu spreads much debris in a wide flood plain over which it flows in constantly changing braided channels. Drawing its main supplies of water from melting snows, the river shows a marked contrast in volume between summer and winter. Its true delta begins at Nukus, but some water is diverted along the old Kunya Darya channel (*see* TURKMENISTAN) to maintain the Khiva oasis.

Southward rises a belt of dry loess plains which, with a number of alluvial fans. fringes the foothills. The remainder of the republic is a close association of mountain spur and valley. In the north the Chatkal range, southeast of Tashkent, feeds the Chirchik and Angren rivers which water the oasis round that city before joining the Syr Darya. Southward the range drops to the tectonic trough of the Fergana valley, which measures about zoo mi. by 70 mi. Loess-covered alluvial gravel cones descend from the surrounding slopes, while the floor is occupied by loess, sands and the Syr Darya flood plain, at an altitude of up to 1,500 ft. Many of the streams upon which life in the basin depends descend from the Alai and its westerly continuation, the Turkestan ranges, to the south, but. south of these again, their drainage and that of the Zeravshan and Hissar ranges is toward the Amu Darya.

The mineral wealth of Uzbekistan lies almost entirely in the mountainous south. Petroleum is found in the Fergana valley and near Termez on the Afghan frontier, zinc, coal and copper in the Angren valley, salt and sulfur in Fergana. antimony at Kassansai north of Fergana, and tungsten and molybdenum at Lyangar in the Nura-Tau, a continuation of the Zeravshan range.

In a country of such varied relief it is not easy to generalize about the climate, beyond saying that it is everywhere continental. Winters are cold. the January mean in the lowlands being about 28° F., while the summers are very hot (July mean often above 80°). Mountain basins suffering intense cold on their floors in winter, because of temperature inversion: in summer become ovenlike. Rainfall is slight in the lowlands, three to four inches falling mainly in spring in the Amu Darya delta. In the mountains the total may reach 24 in., coming chiefly in summer. Local winds are of significance. Thus the valleys and foothills may be warmed in winter by foehn winds descending from the Tien-shan. In the south. Termez receives a cold dusty wind, the *afganets,* on as many as 70 days in the year, blowing out from the central Asiatic high pressure area in winter and spring.

In the Ust Urt and Kyzyl Kum the vegetation varies from sparse semidesert to true desert. An ephemeral cover of grasses and sedges flourishes with the coming of the spring rains, but soon withers in the scorching summer sun. The *juzgun* shrub (*Calligonum*) and the ahite *saxaul* characterize sandy areas, and in saline clayey areas black *saxaul, boyalych* shrub (*Salsola arbuscula*), *biyurgun* (*Anabasis salsa*) and *Artemesza* can tolerate the conditions. The steppe and the loessic piedmont plains bear an ephemeral cover of blue grasses and sedges. Along the banks of the rivers there develops the *tugay* belt of saline meadows and forest in which poplars (*P. diversifolia* and *P. pruinosa*) are the main trees. with tamarisk, small willows and Russian olive. With increasing altitude the grasses improve until at about 4,000 ft. there are permanent meadows and tree junipers. succeeded by deciduous forest of walnut, maple, apricot, etc., above which alpine meadows and, in places, conifers occur.

Of the extensive fauna, lizards, jerboas, *sulsiks* and other sand-adapted types live in the desert, as also hyena. jackal and more rarely mild ass and antelope. The Turkestan tiger is found in the *tugny* forests of the Amu delta. In the mountains, wild goat, mountain sheep, leopard and cheetah are noteworthy.

(B. L. C. J.)

HISTORY

Uzbekistan's history must be considered with that of the whole of Turkestan or Turkistan; *i.e.,* a country inhabited by the Turkic peoples (*q.v.*) and stretching from the Caspian sea on the west to the Tien-shan on the east and from a line embracing the Aral sea and Lake Balkash in the north to Kapet Dagh and the Hindu Kush chains in the south. The history of this area, sometimes described as the Turanian basin. is essentially the history of human settlements in the valleys of the two great rivers, Syr Darya (Jaxartes, Saihun) and Amu Darya (Oxus, Jaihun), of nomadic invasions and also of changes in the courses of the main rivers.

Crossroads of Dead Empires. — The original population of Turkestan was probably Iranian, and the southern part, the satrapies of Sogdiana and Bactria, belonged to the Persian empire. These two provinces were also part of the empire of Alexander of Macedon. Soon after his death they became a Bactrian kingdom which in the 2nd century B.C. suffered an invasion from the east of a people described by Chinese sources as Yue-chi and Hiung-nu.

At the end of the 7th century and the beginning of the 8th century an Arab army under Emir Kotaiba ibn Muslim conquered Khorezm (Khiva; *q.v.*) and Sogdiana (Bukhara; *q.v.*). Under the Abbasid caliphs of Baghdad the Persian influence became dominant in the oasis cities of Transoxiana. About 874 the country was conquered by the Persian Samanid dynasty from Balkh. In 999 a Turkic Karakhanid dynasty, the first to embrace Islam, supplanted the Samanids in Samarkand and Bukhara. The new rulers even pushed south of the Amu Darya, but they were stopped by Mahmud of Ghazni and thenceforward that river became the dividing line between Iran and Turan. At the beginning of the 11th century the Seljuk Turks passed through Transoxiana and appointed a hereditary governor at Khorezm, while leaving the Karakhanids at Samarkand. In 1141 yet another dynasty appeared in Transoxiana. the Kara Kitai from north China, who were not converted to Islam, although later some of them became Christian (Nestorian). Under the Seljuk shahs Khorezm remained a Moslem outpost.

The Mongol invasion of Jenghiz Khan in 1219–20 brought destruction and great ethnic changes among the population. After Jenghiz' death in 1227 most of Turkestan was ruled by his son Chagatai (or Jagatai). Yet the conquerors became assimilated and adopted the Turkic language, also known as Chagatai. Timur or Tamerlane. who seized power in Transoxiana about 1370 and created another short-lived empire, with Samarkand as capital, was a Turkicized Mongol.

At the beginning of the 16th century Turkestan was conquered by another wave of Turkic nomads, the Uzbeks (Usbegs), whose name derived from Uzbek Khan, a chief of the Golden Horde, who died in 1340. The term Uzbek was used in the 15th century to indicate Moslem as opposed to shamanistic Turkic *ulus* or tribes. The Uzbek leader Mohammed esh-Shaibani forced Baber, the Timurid ruler, to abandon the Fergana valley and enter India.

The Shaibanid dynasty ruled from Bukhara for a century. Abdullah Khan, its last representative (d. 1597), united Khorezm with Bukhara. After his death another branch of the Shaibanids assumed power and ruled from Gurganj (later renamed Urghench). but, because of the change in the course of the Amu Darya (*c.* 1573). their capital had to be moved to Khiva. Bukhara recovered its independence in 1599 first under the Ashtarkhanids and from 1753 under the Manghyts, both Gzbek houses. In the 18th century Kokand (*q.v.*) made itself independent from the emirate of Bukhara. but was soon subject to China, which had conquered eastern Turkestan, called Sinkiang ("New Dominion"). The khanate of Khiva became in 1688 a vassal of Persia. but recovered its independence in 1747. While the Uzbek emirs and khans ruled central Turkestan, the wide steppes in the north were the homeland of the Kazakhs. In the west. between the Caspian and Aral seas, north of Kapet Dagh, lived the nomadic Turkmens. In the east, in the valleys of the Tien-shan, dwelled the Kirghiz, and in the southeast, in the highlands north of the Hindu Kush, was the homeland of the Persian-speaking Tajiks.

Russian Conquest. — Eighteenth-century Turkestan presented a picture of economic decay and political anarchy. Khiva and Bukhara were protected by desert from the growing Russian empire. In 1714–17 Peter the Great sent a military expedition against Khiva. This was a disaster, but, as a result, three small fortresses, including Krasnovodsk, were built on the eastern Caspian coast. In the mid-18th century the Russians established a chain of fortresses along the Cral (Yaik) river, Orenburg (later Chkalov) being the most important. In western Siberia a military frontier stretched to Omsk on the Irtysh and up that river to Semipalatinsk.

In 1853 Xk-Mechet ("White Mosque," renamed Perovsk, later Kzyl Orda), on the Syr Darya, was conquered by the Russians, and the following year the fortress of Vernoye (later Alma-Ata) was established. On June 29, 1865, Tashkent, then a city of about 200,000 inhabitants, was taken by Gen. M. G. Chernyayev. Alim Kul. the khan of Kokand, was wounded in the battle and died soon afterward. On July 29. 1867, Gen. C. P. Kaufmann, a German Balt, was appointed governor general of Turkestan with headquarters in Tashkent. On May 14, 1868. he captured Samarkand. On July 5 Mozaffar ed-Din, emir of Bukhara, signed a treaty making his country a Russian vassal state uith much-reduced territory. Khiva mas conquered by Gen. N. N. Golovachev, and on Aug. 24, 1873, Khan Mohammed Rakhim Kuli had to become a vassal of Russia. Furthermore. all his possessions east of the Amu Darya were annexed to the Turkestan governor-generalship. The khanate of Kokand was suppressed and on March 3, 1876, became the Fergana province.

On the eve of World War I Khiva and Bukhara were enclaves within a Russian Turkestan divided into five provinces or *oblasti*. Together with the four steppe provinces in the north (latter-day Kazakhstan). Russian central Asia, according to the 1897 census, had a total population of 9,922,000. In 1914 this population was estimated at 13,579,000. According to the 1939 census the total population in an almost identical area was 16,356,177. The tsarist government did not attempt to Russify the indigenous Turkic or Tajik populations, preferring to keep them backward and illiterate. Military conscription was not applied to them, and rioting broke out when, on Aug. 7, 1916, their conscription was ordered.

Turkestan Divided Into Soviet Republics. — The revolution of March 1917 created a confused situation in the area. In Tashkent there was a Turkestan committee of the provisional government; a Communist-controlled council of workers', soldiers' and peasants' deputies; also a Moslem Turkic movement, Shuro-i-Islamiya, and a Young-Turkestan or Jaddidi (Renovation) party. The last-named party claimed full political autonomy for Turkestan and the abolition of the emirate of Bukhara and the khanate of Khiva. After the Communist *coup* d'dtat in Petrograd, the council of people's commissars on Nov. 24 (Dec. 7), 1917, published an appeal to "all toiling Moslems in Russia and in the east" proclaiming their right to build their national life "freely and unhindered." In response, the Moslem and Jaddidi organizations in Dec. 1917 convoked a national congress in Kokand which appointed a provisional government headed by Mustafa Chokayev (or Chokaioglu; 1890–1941) and resolved to elect a constituent assembly to decide whether Turkestan should remain within a Russian federal state or proclaim its independence. The Tashkent Communists in Feb. 1918 sent a force against the Kokand government, which collapsed.

At that time Turkestan was cut off from Russia because Adm. A. V. Kolchak's army was in possession of Orenburg. In the spring of 1919 a Red army group defeated Kolchak and in September its commander, M. V. Frunze. arrived in Tashkent with V. V. Kuibyshev as political commissar. The Communists were still much too weak in Turkestan to proclaim the country part of Soviet Russia. Faizullah Khojayev organized a Young Bukhara movement, which on Sept. 14, 1920, proclaimed the dethronement of Emir Mir Alim, who fled to Afghanistan. Bukhara was made a soviet people's republic. In Khiva Khan Asfendiar Bahadur was assassinated in 1917 and was succeeded by his son, while a Turkmen revolutionary leader. Junaid Khan, assumed power. In 1920 the Tashkent Communist government declared war on Junaid. who took to flight, and Khiva became another soviet people's republic. In Oct. 1921 Enver Pasha, the former leader of the Young Turks, appeared in Bukhara and assumed command of the Basmachi movement. (*Basmach* means "bandit" in Turkic. but for anti-Soviet nationalists it had become identical with "patriot.") In Aug. 1922 he was forced to retreat into Tajikistan and died on

Aug. 4, in a battle near Baljuvan. According to the official Soviet sources the Basmachi rebellion had ended in 1924, hut its chief, Ibrahim Beg Lakai. mas not captured and shot until 1931. Munavar Kary, the Jaddidi leader was executed in the same year.

Birth of Uzbekistan.— Khiva concluded a treaty of alliance with the Russian S.F.S.R. in Sept. 1920 and Bukhara followed suit in March 1921. Theoretically, a Turkestan Autonomous Soviet Socialist Republic had existed since May 1, 1918; in 1920 this "Turkrepublic." as it was called. was proclaimed part of the R.S.F.S.R. In 1923, however, J. V. Stalin stated that as Turkestan was "the most important Soviet republic from the point of view of revolutionizing the east," the time had come to transform it accordingly. On Sept. 18, 1924, the Uzbek and Turkmen peoples were authorized to form soviet socialist republics of their own, and the Kazakhs, Kirghiz and Tajiks to form autonomous soviet socialist republics. On Oct. 27, 1924, the Uzbek and Turkmen S.S.R. were officially constituted and the former was formally accepted on Jan. 1j. 192j. as a member of the U.S.S.R. Tajikistan was an autonomous soviet republic within Uzbekistan until Dec. 5, 1929, when it became a soviet socialist republic. On Dec. j. 1936, Uzbekistan was territorially increased by incorporating into it the Kara-Kalpak A.S.S.R. (*q.v.*), which had belonged to Kazakhstan until 1930 and afterward had come under direct control of the R.S.F.S.R. In Oct. 1952 the Uzbek Communist party had 142,355 members, including 25.416 candidates. Khojayev. who in 1924 became the first chairman of the council of ministers, and Akmal Ikramov. the first secretary-general of the Uzbek Communist party. were shot on March 13, 1938, for pan-Turkic tendencies.

Population.— The republic's area is 157.876 sq.mi. Its total population (within the 1936 boundaries) was 6,282,450 in 1939. and 8,105,572 in 1959. The area of the Kara-Kalpak A.S.S.R. is 63,938 sq.mi. and its population was estimated in 1959 to be 510,101. The total number of Uzbeks in the U.S.S.R. was 3,954,701 in 1926 (3,012,900 or 66% in their own republic) and 4,844,021 in 1939. No percentages of the national composition of the population in 1939 were given, but the Uzbek supreme soviet of 400 members. elected on Feb. 16, 1947, included 249 Uzbeks (62%).

The first capital of Uzbekistan was Samarkand, but the atmosphere there was considered too nationally Uzbek, and the capital was moved to the more cosmopolitan city of Tashkent. This city's population grew from 323,613 in 1926 to 911,930 in 1959, the increase being mainly to the advantage of the Russians; the town council elected in 1950 included 51% Uzbeks and 37% Russians. The population of other cities was as follows (1939; 1959 in parentheses): Samarkand 134.346 (195,000); Kokand 81.665 (105,000); Andizhan 83.691 (129,000); Namangan 77.351 (122,000); Bukhara 50,382 169,000). The Uzbeks are Sunni Moslems.

Education.— Before 1914 about 97% of the Uzbek population was illiterate. but by 1939 the proportion was only 32.2%. In 1951 there mere approximately 5,000 schools in the republic with 1,300,000 pupils; there were 36 institutions of higher education, including the Tashkent (Russian) and Samarkand (Uzbek) universities, with a total of 32,000 students. An Uzbek Academy of Sciences was founded in 1943.

Economy.— Uzbekistan is important as a cotton-growing country. While in 1913 its production amounted to 516,000 metric tons, in 1939 it was 1,600,000 tons. 60% of the total Soviet production. This policy made Uzbekistan depend on Russia for food supply. Before 1914 the country had no textile mills; one cotton mill was inaugurated at Fergana in 1930 and another at Tashkent in 193j; a silk mill operated at Marghelan. In 1950 there were more than 150 large and small textile enterprises. In 1944 an iron and steel plant was inaugurated at Begovat, receiving coking coal from Angren; opened in 1940, the Angren coal mine produced 100,000 tons in 1945. At Chirchik and Farkhad big hydroelectric power stations mere established; while in 1913 the country's electricity capacity amounted to 3,000 kw., in 1945 it was 180,000 kw. Chirchik. a new town, had also a large nitrogen plant. 4 superphosphate plant was inaugurated in 1946 at Kokand. The Great Fergana canal. built in 1939–40, is 205 mi. long, 27–33 yd. wide and 4.4 yd. deep; it irrigates an area of 1,675,000 ac.

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UZÈS, a town of southern France standing on a height above the Alzon. Pop. (1954) 4,136. Uzès, the seat of an episcopal see from the 5th century to 1790, has a cathedral flanked by a 12th-century round tower of five stories. The Duché preserves a 12th-century donjon; the main building, flanked by a Gothic chapel, is Renaissance in style.

UZICE (now Titovo Uzice), the capital of the Uzice district. Yugos, Pop. (1961) 20.069. Uzice (meaning "the narrow places") is built in a narrow, lonely glen, 1,385 ft. above sea level, on a stream spanned by two mediaeval stone bridges. Though poor. it has a well-built school, in the entrance to which is a Roman altar stone. and also a girls' school where weaving is taught. The surrounding heights produce excellent tobacco, and there are linen and cotton mills. Commerce is retarded by the bad roads.

In the 13th century Uzice was the seat of St. Sava, the first archbishop and patron saint of Serbia.

UZZIAH, more correctly called Azariah. was seated on the throne of Judah in succession to his father Amaziah by popular choice at the age of 16 (II Kings xiv. 21 et *seq.*; xv. 1–7). The records assign to him a reign of 52 years, covering roughly the first part of the 8th century B.C., but during part of this time his son Jotham, who succeeded him c. 740 B.C., acted as regent, because Uzziah had become a leper. He was for several years contemporary with Jeroboam II of Israel; and both kingdoms flourished. Uzziah repaired the walls of Jerusalem and recovered and rebuilt the port of Elath on the Gulf of Aqaba. The account of his military reorganization and successful campaigns in II Chronicles xxvi is probably not without historic basis. The chronicler explains his leprosy as a punishment for infringing priestly prerogatives. A certain Azriau of Yaudi appears in the inscriptions as leading a combination against Tiglath Pileser III *c.* 739. It has been contended that the reference is to Xzariah of Judah. Despite the striking coincidence of names, it seems probable that the leader was king of Y'di, a small independent kingdom mentioned in the Aramaic inscriptions found at Zenjirli. (W. L. W.)

V THE history of this letter is identical with that of *U,* from which it was not differentiated till the 15th to 17th century. The letter passed out of Latin having a majuscule pointed form V and a minuscule rounded form u and doing duty for two sounds. the high rounded voael (English *oo*) and the voiced labial spirant (English *v*). The consonantal sound was that most usually occurring when the letter was initial, in which position the majuscule form V would most generally be used. Thus the pointed form V became identified with the consonant, the rounded form with the vowel. A minuscule v and a majuscule *U* were then adapted as required. (B.F.C.A.; J.W.P.)

VAAL, a river of South Africa, chief affluent of the Orange (*q.v.*). It rises at an elevation of over 5,000 ft. above the sea in the Drakenberg mountains, of the Transvaal, about 170 mi. in a direct line west of Delagoa bay. It flows in a general S.W. direction, with a markedly winding course, across the plateau of inner South Africa, joining the Orange in 29" 3' S., 23° 36' E. The river valley is 500 mi. long, the length of the river being 750 mi.

The first considerable tributary is the Klip (80 mi. long), which rises in the Drakenberg and flows N.W., its junction with the Vaal being in 27° S., 29" 6' E., 12 mi. S.W. of Standerton. From this point to the eastern frontier of the Cape, the Vaal forms the boundary between the Orange Free State and the Transvaal. The river is usually shallow and is fordable at many places, known as *drifts.* But after the heavy summer rains the stream attains a depth of 30 or more feet. At such times the banks, which are lined with willows and in places very steep, are inundated. As a rule little water is added to the Vaal by its tributaries. On the north the basin of the Vaal is contracted by the Witwatersrand and the Magaliesberg ranges, and its tributaries are few.

The Mooi rises in the Witwatersrand west of the Klip and, after running almost due S. 7j mi., unites with the main stream about go mi. below Vereeniging. In its course through Griqualand West, the Vaal flows in a wide rocky channel, with banks 30 ft. high, through an alluvial plain rendered famous in 1867–70 by the discovery of diamonds in the bed of the river and along its banks. The diamonds are washed out by the water and found amid debris of all kinds, frequently embedded in immense boulders. The last affluent of the Vaal, the Riet river, rises in the Beyers Bergen S.E. of Reddersburg and flows N.W. 200 mi. through Orange Free State, being joined, a mile or two within the Cape frontier, by the Modder river (190 mi.), which rises in the same district as the Riet but takes a more northerly course. The united Riet-Modder joins the Vaal 18 mi. above the Orange confluence.

The name Vaal is a partial translation by the Dutch settlers of the Hottentot name of the river—Kai Gariep, properly Garib (yellow water) which refers to the clayey colour of the stream. The Transvaal is so named because the first white immigrants reached the country from the south by crossing the Vaal.

VAALPENS (dusty-bellies), a little-known nomadic people of South Africa, who lived in small groups in the Zoutpansberg and Waterberg districts of the Transvaal, especially along the Magalakwane river. The Vaalpens were so called by the Boers from the dusty look of their bodies, due, it is said, to their habit of crawling along the ground when stalking game. But their true colour was black. In height the men averaged about 4 ft., *i.e.,* somewhat less than the shortest Bushmen. The Vaalpens lived entirely by hunting and trapping game. and dwelt in holes, caves or rock shelters. They wore capes of skins, and procured the few implements they needed in exchange for skins, ivory or ostrich feathers. Their speech was full of clicks.

VACARESCU, the name, according to tradition, of one of the oldest noble families in Walachia. The first member of historical importance was IANACHE (b. 1654), the grand treasurer of Walachia, who was killed with his master, Prince Brancovan in Constantinople, 1714. His grandson through his son Stephan, also called IANACHE (or "Enakitza the Ban," 1720–1796?), started a line of Rumanian scholars and poets; he was the author of the first known Rumanian grammar in the vernacular, printed in 1787. While in exile in Nicopolis he wrote the contemporary history of the Turkish empire in two volumes (1740–99). He was also the first to attempt Rumanian versification. Greater as a poet was his son ALECU (Alexander), who died as a prisoner in Constantinople in 1798. In 1796 a collection of his poems appeared in Rumania. His brother Nikolaes (d. 1830) also wrote some poems, but they remained in ms. until 1860, when they were published.

By far the greatest member of the Vacarescu family in the male line was IANCU (1786–1863), the son of Alexander. An ardent patriot, he sided with the national movement in 1821, and assisted in establishing the Rumanian theatre, translating many books and plays from German and French into Rumanian, notably the *Britannicus* of Corneille, a literary event of no small importance at the time. He inaugurated modern Rumanian poetry. In 1830 appeared his first volume of verse. He died in 1863. A niece of Alexander was the gifted writer ELENA VACARESCU (Hélène Vacaresco) (1866–1947), maid-of-honour to the queen of Rumania, and Rumanian delegate to the League of Nations, who inherited the talent of her family and enriched Rumanian literature with her *Bard of the Dimbovitza,* and other poems and novels in Rumanian and in French, including *Chants d'Aurore,* which was crowned by the French academy; *L'Âme Sereine,* and *Rumanian Ballads,* which obtained the Prix Jules Favre at the French academy. (M. G.)

VACARIUS (1120–1200?), Italian scholar of civil and canon law, the first known teacher of Roman law in England, was of the school of Bologna, though of a later generation than the hearers of Irnerius. He was taken to Canterbury, possibly by Thomas Becket, together with a supply of books upon the civil law, to act as counsel (*causidicus*) to Archbishop Theobald in his struggle, which ended successfully in 1146, to obtain the transfer of the legateship from the bishop of Winchester to himself. Vacarius is next heard of as lecturing somewhere in England in 1149, to "crowds of rich and poor," and as preparing, for the use of the latter, a compendium in nine books of the *Digest* and *Codex* of Justinian, "sufficient," it was said, "if thoroughly mastered, to solve all legal questions commonly debated in the schools." It became a leading textbook in the nascent university of Oxford, where, perhaps by' 1149, perhaps not until 1169, Vacarius mas teaching; and its popular description as the *Liber pauperum* gave rise to the nickname *pauperistae* applied to Oxford students of law. Nearly complete manuscripts of this work remained in existence, notably in the cathedral libraries at Worcester and Prague and in the town library at Bruges. Fragments of it were also preserved in the Bodleian library and in several college libraries at Oxford. Another manuscript was found in the British museum, London, in 1959.

The new learning mas not destined to make its way without opposition. King Stephen silenced Vacarius and ordered the destruction of the books of civil and canon law that had been imported by Theobald. The edict to this effect, however, seems not to have been in force after the death of its royal author in 1154, since John of Salisbury wrote, *eo magis virtus legis invaluit quo eam amplius nitebatur impietas infirmare* ("the value of the law was strengthened in proportion as wickedness tried to weaken it"). In any case. Vacarius was soon called to practical work, as legal adviser and ecclesiastical judge in the northern province, by his old friend and colleague at Canterbury, Roger de Pont l'Évêque, after the promotion of the latter to the archbishopric of York in 1154. Thenceforth the name of "magister Vacarius" is of frequent occurrence in papal letters and the chronicles of the period, as acting in these capacities. He was rewarded with a prebend in the collegiate church of secular canons at Southwell, half of which he was allowed in 1191 to cede to his "nephew" Reginald. He is last heard of in 1198, as commissioned. together with the prior of Thurgarton, by Pope Innocent III to carry into execution in the north of England a letter with reference to the crusade. Of two works attributed to the second half of Vacarius' life, the *Summa de assumpto homine,* on Christ's humanity, is of a theological character and the *Summa de matrimonio* is a legal argument to the effect that the essential fact in marriage is neither, as Gratian maintained, the *copula* ("consummation") nor, as Peter Lombard, consent by *verba* de *praesenti* ("pledge from the present party"), but mutual *traditio* ("surrender").

BIBLIOGRAPHY.—*The Liber Pauperum of Vacarius, ed.* by F. de Zulueta (1927), contains a life and a bibliography. *See* also Ilarino da Milano, *L'eresia* di *Ugo Speroni nella confutazione del maestra Vacario* (1945). (J. F. LR.)

VACCINATION, strictly speaking, is the implanting of the living virus of cowpox in a person to protect him against smallpox. The procedure was introduced to supersede "inoculation," the artificial implanting of smallpox virus, in order to protect against smallpox acquired in the natural way. The inoculated smallpox commonly gave only a sparse general eruption of pocks, with a fatality rate much lower than that of the natural smallpox, which otherwise was a hazard to be expected by everyone in the 18th century.

Edward Jenner (*q.v.*) in his original publications of 1798–1800 did not use the term "vaccination" but spoke of "inoculation for the cow-pox." In devising a Latin term for this disease, previously without medical description, he called it *Variolae* (plural noun meaning "smallpocks" j *vaccinae* (adjective meaning "of the cow," from Lat. *vacca*, "a cow"). From this Latin of Jenner's the French in 1800 coined the term "vaccination," half in derision, for the implantation of cowpox. To the French and to those versed in Latin. "vaccination" would mean "en-cowing." "Vaccine." an adjective meaning "of the cow," then "of the cowpox," later became a noun meaning the material used for vaccination.

Jennerian vaccination against smallpox was the first and for nearly a century the only successful immunizing procedure against any disease, other than by inoculation with, or exposure to, the real disease itself.

In 1881 Louis Pasteur demonstrated immunization against anthrax by the injection of a comparatively harmless attenuated culture of the bacillus causing that disease. He then used the terms "vaccine" and "vaccination" for prophylactic inoculation in general as homage, he said, "to the merit and to the immense services rendered by one of the greatest of Englishmen, Jenner." Four years later Pasteur developed rabies vaccine. His work led to wide extension of immunizing methods against many diseases with correspondingly widened meanings of the terms "vaccination" and "vaccine," applying them to the use not only of living but also of dead material.

The present article deals with vaccination in its original and stricter sense; that is, vaccination against smallpox. This is still approximately the most perfect method of immunization against any disease, judged by the security and duration of protection in proportion to its inconvenience.

Jenner, trusting too much to the stories of the country people in his neighbourhood, believed that the cowpox, and perhaps the smallpox, originated in an infection of the heels of horses. The evidence accumulated, however, that the natural occurrences of cowpox started from the hands of milkers afflicted with smallpcx when the latter disease was widely prevalent. The infection was disseminated through dairy herds by other milkers on whose hands it took the changed form of cowpox. Strains of good cowpox virus were artificially started, chiefly in Germany, by transfer of smallpox virus to the cow, more readily through other animals, such as the monkey or the rabbit, first. Such strains propagated from smallpox virus were called variola vaccine.

Smallpox virus is not so easily transmitted to lower animals as is vaccine (cowpox) virus. The different establishments preparing vaccine virus have had the habit, when their particular strain showed signs of weakening, of reinforcing it with strains of virus from other establishments. Thus the strains can hardly be traced back to any one particular source. Jenner himself lost strain after strain, using new ones from time to time derived from natural cowpox found in dairy herds or their milkers. The remarkable fact is that his descriptions and pictures of the day-to-day appearance of the vaccinated arm, and the descriptions and pictures of the most careful observers since his publication, have coincided exactly with the appearance of arms vaccinated with good strains of modern vaccine virus, particularly the rapid spread of the area of redness surrounding the vesicle after the seventh day in a previously unimmunized person. This is different from the appearance after any other sort of inoculation, and such an inoculation has always given protection against smallpox anywhere in the world. Even the obsolete inoculation with smallpox virus itself produced a different course of events as to the inoculated arm, besides later giving rise to an eruption of pustules over the other areas of the body.

Originally the virus was carried from arm to arm, the vaccinated persons being told to return on the seventh day so that the contents of the clear vesicles at that time could be transferred to the arms of the next set to be vaccinated. Crusts of the dried vesicles, or vesicle contents dried on quills or threads or ivory points, were also used. Later, strains of vaccine virus were carried back to the cow for one or more passages in an attempt to make them stronger. This was called "retrovaccination." By the early years of the 20th century nearly all vaccine virus was propagated on calves (carabao in the far east), suspended in glycerine solution and distributed in hermetically sealed capillary tubes. Occasional passage through other species, such as the rabbit, appears to aid in maintaining the purity and the potency of the virus. In Spain rabbit-brain virus was used instead of calf virus, and many essays have been made to substitute growth in the chick embryo (fertilized egg) for growth on the bovine skin. A theoretical objection to such procedures—not without some confirmation in experience—is that the virus should not be adapted to deep proliferation in the layers of body tissue; human vaccination is safest from disagreeable results when it is as superficial as possible. Dried virus has also been used, and, though inconvenient and expensive to dilute unless many are to be vaccinated at one time. it has served a useful purpose where prolonged transportation to warm climates is necessary. The greatest advance in the prevention of smallpox in the 20th century was the cold storage of the vaccine virus (below freezing) up to the time of use.

Need.—Increased global travel, the presence of virulent strains of the disease in various parts of the world (*see* also SMALLPOX OR VARIOLA), its great contagiousness and the fact that no population is sufficiently vaccinated to be proof against a smallpox epidemic are sufficient reasons for keeping up vaccination in spite of the remarkable decline in smallpox cases. Vaccinations regularly carried out are preferable to emergency vaccination of a population at risk. All foreign travelers in both directions need the successful application of fully potent vaccine before undertaking the journey

Efficacy and Time of **Vaccination.**—Jenner was misled into thinking that one successful vaccination gave lifelong protection. It is possible that the continual exposure to smallpox to which people were subject in his day tended to keep up the immunity initiated by cowpox. Vaccination every five years is a safe general rule, but for nurses physicians and hospital attendants constantly in danger of exposure, and for foreign travelers in similar danger, once a year is safer. There is always the danger that the tube of vaccine used may not have been constantly refrigerated; this explains accounts of smallpox after recent vaccination **A** case of smallpox within two years after a successful vaccination is extremely rare even though exposure is ample, and such a case of the disease is mild. There are great differences between individuals in the firmness of holding onto immunity toward smallpox. just as there are toward other infections. **A** not inconsiderable proportion of a population might be protected against smallpox for life by one vaccination, though they would lose their immunity to vaccinia (cowpox) more readily. Long after complete protection subsides, a former vaccination modifies the severity of an attack of smallpox.

There are great advantages in having the first vaccination performed during the early months of life. Infantile vaccination, if properly performed and cared for, is milder than a later first vaccination, usually giving rise to no inconvenience whatever; it makes the subsequent vaccinations, if decades are not allowed to pass without revaccination, much milder affairs. Protection is gained not only against smallpox but also against accidental vaccination from the arm of a playmate or associate; and the scar of such an early vaccination becomes much less noticeable than if the first vaccination is performed later. The first spring of a child's life is probably the most favourable time for vaccination.

Disadvantages — The former and cruder methods of preparing the vaccine and performing the inoculations, together with the stern measures with which compulsory vaccination was enforced, naturally aroused opposition. One cannot expect something for nothing, and the remarkable protection which vaccination bestows is bound to entail a slight risk, at least of inconvenience. With proper vaccine, procedure and care, the risk is negligible compared to the advantage to the community and the individual. Clean technique, with a small adequate inoculation in only the most superficial layers of the skin, on an arm which is kept dry and cool, covered by no dressing except the loose clean sleeve of the child's garment, ensures for the great majority of vaccinations a perfectly satisfactory course. No practical cleansing can remove all the bacteria from the skin, however, and occasionally, especially in leg vaccinations, the vesicle may become purulent on this account and the drying process be delayed or even require attention. Eruptions soon after the maximum reaction are seen at times but disappear rapidly without treatment. Tetanus following vaccination formerly occurred once in a while, but later was entirely prevented by proper technique and particularly by allowing the vesicle of vaccination to dry naturally without dressing, shield or bandage. Authentic cases of demyelination encephalomyelitis have been reported after vaccinations as after other inoculations or infectiocs, but never where the above precautions were followed and the first vaccination was performed in early infancy.

Course. — In a first vaccination on a ch ld with good vaccine and good technique, nothing is usually seen until the third day, when a papule (pimple) appears at the site. The central part of this papule soon develops into a vesicle (that is, contains fluid) and is surrounded by a narrow red zone. It is the behaviour of this red zone which constitutes the characteristic and important detail in the course of the reaction. While the vesicle is enlarging at the rate of about a millimetre a day in diameter, the red zone remains of moderate size until about the 7th day, when it rapidly begins to enlarge, reaching its greatest diameter between the 8th and the 14th day after vaccination, then disappears as rapidly. The vesicle meanwhile continues to enlarge slowly, but before the height of the reaction is reached starts drying from the centre, forming a dark crust (scab) which drops off about three weeks after vaccination, leaving a clean pink scar which becomes white in about a year. A day or two of fever is often observed without particular relation to the course of the reaction. Care should be taken (as in bathing) to keep moisture away from the vesicle and crust until the latter comes off. The reaction above described is called primary vaccinia.

In more than half the revaccinations performed with fully potent vaccine on a group of people who had their previous vaccinations 10 to 40 years before, the appearance of the arm on successive days will be somewhat similar to that described in the preceding paragraph except that the course will be accelerated to give the greatest diameter of the red zone between 72 hours and seven days after vaccination: usually the spread and subsidence of the redness is more gradual than in vaccinia. Such a reaction is called vaccinoid and indicates partial protection against smallpox.

In what may be called the early reaction of vaccination the broadest redness occurs within 72 hours after vaccination and there may or may not be a visicle. One is not justified in saying that this indicates previous complete immunity against smallpox unless full potency of the vaccine can be assured; the history of the cold storage and the results with that batch of vaccine are seldom sufficiently known. Practically an exact counterpart of the early reaction or even one simulating the vaccinoid reaction may be given on a person with little or no immunity when vaccine of less than full potency is used.

If observation is thorough, every adequately performed vaccination with potent vaccine will be found to give a reaction which can be classified in one of the above categories: vaccinia, vaccinoid or early reaction.

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VACCINE THERAPY. Vaccine therapy results in the induction of a state of active immunity in an individual, either for the purpose of preventing the development of a specific infectious disease, or in some cases as a means of treatment of an already established infection. The actively immune state is induced in the person or animal being immunized by the introduction into the body of a vaccine cornposed of suspensions of living or dead microorganisms of a specific kind, or of some of their metabolic products.

These substances in the vaccine stimulate the body cells to modify normal globulin molecules so that they acquire a very high degree of specificity against the disease-producing microorganisms or their products from which the vaccine was originally prepared.

The altered globulin molecules or antibodies, as they are called, are the immune substances in the blood, and distributed throughout the body. which combat the subsequent invasion of the microorganisms. or help control the multiplication and spread of infectious agents already established in the body.

The principle of using a less virulent, or attenuated, microorganism to induce active immunity for protection against a particular disease originated in the orient. In ancient times the crusts from lesions of very mild cases of smallpox, containing the weaker virus, were applied in one of several ways to the skin or nasal mucous membranes of persons who wished protection against a severe case of smallpox. The Turks accomplished the same purpose by scratching the crusts from lesions of mild smallpox into the arm of the person to be immunized. This procedure, known as variolation, was introduced into England by Lady Mary Wortley Montagu (1689–1762). The practice was not free from risk, and some persons developed a virulent generalized case of smallpox and died.

To Edward Jenner, a British country physician, goes the credit for his discovery, reported in 1798, that infectious material (vaccinia virus) from lesions of cowpox (vaccinia) could be inoculated artificially into the skin of man, and thus induce immunity against smallpox. Hence the terms vaccination and vaccine were originally used only in relation to immunization against smallpox with vaccinia virus. Louis Pasteur and others later applied the same principles to the prophylaxis of other virus, bacterial and rickettsial infections. Consequently, the term vaccine Lame to be used in a broader sense, including suspensions of living attenuated or dead infectious agents, emulsions of their cellular constituents and solutions of their altered metabolic products (toxoids). Sir Aimroth Wright extended the principles of active immunization to include not only the prevention but also the treatment of infectious diseases. Regardless of whether the desired result of active immunization is the prophylaxis or therapy of a particular infectious disease, the procedures of vaccine preparation and immunization are essentially the same. The person to be immunized is usually inoculated with the vaccine by intradermal, subcutaneous or intramuscular injections at regular, specified intervals. The degree of immunity resulting from the administration of a vaccine is quite variable; it depends on several factors including the antigenic potency of the preparation, the dosages given, the time interval between injections and the degree of ability of the person to produce antibodies when properly stimulated.

Early successes in the development and use of vaccines in the prevention of smallpox, anthrax and rabies encouraged attempts to develop actively immunizing agents for many other diseases. Effective vaccines were also developed for active immunization against typhoid and paratyphoid fevers, cholera, plague, tuberculosis, undulant fever, whooping cough, tularaemia, chronic staphylococcal and streptococcal infections, diphtheria, tetanus, influenza, yellow fever, Japanese B encephalitis. Russian tick-borne encephalitis. St. Louis encephalitis, equine encephalomyelitis, Rocky mountain spotted fever, typhus and against several important diseases of animals.

A true evaluation of the efficacy of vaccine prophylaxis is exceedingly difficult to obtain for many diseases. It may be readily understood that it is often impossible to arrange experiments involving sufficient numbers of individuals in the inoculated and uninoculated or "control" groups to assure statistically significant analyses of the results. This is particularly difficult in diseases which have relatively brief incubation periods, or in which exposure to the disease is irregular and unpredictable, such as those diseases which do not ordinarily occur in epidemic form in the population. At mid-20th century, adequate statistical data concerning the effectiveness in humans of some of the virus vaccines was still lacking, although protection tests in experimentally infected animals indicated their probable value. The difficulty in correctly evaluating the effectiveness of vaccines is even greater when they are employed in the treatment of individuals already suffering from an established infection. Such cases must be judged separately; other therapeutic measures and the possibility of coincidence must be seriously considered when attempting to form a correct estimate of the value of vaccine therapy. In many diseases, such as typhoid and paratyphoid fevers, there is overwhelming evidence for the high degree of protection established by vaccination; in other diseases there is evidence of definite value from vaccination, even though it may not always be protective, as in whooping cough; in still others, the results of vaccination are equivocal. However, there is no question concerning the importance of specific active immunization.

Types of Vaccines. — There are two main types of vaccines — stock or heterogenous, and autogenous. Stock vaccines are prepared from microorganisms previously isolated irom persons having a particular infectious disease. After identification of the causative agents, they are cultivated or stored in the laboratory. Since bacteria of the same species may exhibit biological variations and minor differences in antigenic structure, stock vaccines may be composed of several different strains of the same species, thereby rendering the vaccine polyvalent. Treatment with such polyvalent stock vaccines is of distinct value particularly in certain chronic infections. Stock vaccines must of necessity be used only in an attempt to immunize the normal individual prior to exposure to infection by the corresponding infectious agent.

Autogenous vaccines are prepared irom the actual microorganism isolated from the particular patient being treated. Such preparations are definitely superior to even polyvalent stock vaccines in the treatment of chronic infections, such as sinusitis or pyoderma, since the resulting antibodies developed are entirely specific for the particular agent causing the disease. For the prevention of tetanus and diphtheria, diseases in which the chief symptoms and pathology result primarily from effects of the bacterial toxins in the body, the modified toxins, or toxoids as they are called, comprise the vaccine, and stimulate the production of immunity which is antitoxic rather than antibacterial.

Preparation of Vaccines. — Bacterial vaccines, whether stock or autogenous, are prepared in a manner somewhat as follows: the selected microorganism is grown, usually on a solid culture medium under conditions which are optimum for maximum growth. The resulting bacteria are suspended in a sterile physiological solution of sodium chloride, washed by centrifugation and resuspended in more of the sterile saline solution. If the vaccine is to be composed of intact bacterial cells, the microorganisms are usually killed, either by heating in a water bath at 60° C. for one hour or by the addition of some chemical. The number of bacteria per unit volume of suspension is determined by any of several ways: by density determinations, by chemical analyses or by direct or proportional microscopic counts. The bacterial suspension is then adjusted to the desired standard by either dilution or concentration, as the need may be, and cultured to ensure its sterility. The standardized sterile vaccine is stored in sterile glass vials or ampuls and is ready for use. If the vaccine is to be composed of fragments of bacterial protoplasm, rather than of the intact bacteria themselves, the bacteria are killed by disrupting the cells, after their concentration is standardized, either by repeated rapid freezing and thawing of the suspension, by grinding in a ball mill, by ultra-violet irradiation or by ultrasonic vibrations. The resultant mixture of bacterial antigens is tested for sterility to ensure its noninfectivity, and a preservative, such as phenol, is added in proper concentration.

Virus and rickettsial vaccines are prepared in a manner somewhat similar to the above, except that these microorganisms must be cultivated in the presence of living animal cells. Ernest Goodpasture's development in 1931 of the embryonated hen's egg as a culture medium for many viruses and rickettsiae provided the opportunity for producing vaccines of many of these infectious agents.

Salk Poliomyelitis Vaccine. — Later developments in the field of tissue and cell cultivation *in vitro* made possible the demonstration in 1949 by John F. Enders, Frederick Robbins and Thomas H. Weller that all three types of viruses which cause poliomyelitis (infantile paralysis) could be grown in test-tube cultures of a variety of living human and monkey cells of non-neural origin. This contribution, which won for its developers the Nobel prize for medicine and physiology in 1954, coupled with the discovery in 1952 that poliomyelitis viruses circulate in the blood during the preparalytic phase of the infection, suggested the feasibility of a vaccine to stimulate active immunity to poliomyelitis.

Jonas E. Salk and his associates prepared a poliomyelitis vaccine by growing all three types of virus in cultures of living cells from the kidneys of rhesus monkeys imported from Pakistan and India. The viruses were separated irom kidney tissue, killed by formalin, and standardized for both potency and safety. In 1954 a large scale field test of effectiveness of the Salk poliomyelitis vaccine was conducted in nearly 2,000,000 children in epidemic areas of the United States. This evaluation of the vaccine revealed in 1955 that: (1) its greatest effect was in the prevention of the most fatal form (bulbospinal) of the disease; (2) it was from 60% to 70% effective against disease caused by type I viruses; and (3) it was 90% or more effective against the disease caused by viruses of types II and III. Developments in production and administration of Salk vaccine indicated even greater future effectiveness. The vaccine is given intramuscularly in a series of tao injections separated by an interval of two to four weeks, followed by a third injection seven months later.

The successful adaptation by the pharmaceutical industry of tissue culture methods to the enormous scale required for virus vaccine production made likely future developments of vaccines against the infectious diseases still to be brought under control.

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VACCINIUM, a genus of shrubs of the heath family (Ericaceae, *q.v.*), comprising about 130 species found widely throughout the northern hemisphere and extending to Madagascar and the Andes. They are erect or creeping shrubs, with deciduous or evergreen leaves. The small flowers bear much resemblance to those of the true heaths *(Erica),* from which they ditier in having the ovary inferior. The fleshy, often delicious, berries are usually edible.

In North America about 40 species occur, more abundant in the northern and mountainous parts of the continent. In the eastern states and adjacent Canada several species, commonly known as blueberry (*q.v.*), are prized for their fruits. In northern Canada the red whortleberry, commonly called mountain cranberry, is gathered for cooking purposes. V. *macrocarpon,* the American cranberry, is extensively cultivated. Several species occur in the Rocky mountain region and about ten are found in the Pacific states, the latter including V. *occidentale,* the western blueberry; V. *parvifolium,* the red bilberry; and V. *ovatum,* the California blueberry.

Four species occur in Great Britain: V. *myrtillus,* the bilberry, blaeberry or whortleberry; V. *uliginosum,* the bog bilberry; V. *vitis-idaea,* the red whortleberry or cowberry; and V. *oxycoccos,* the cranberry (*q.v.*), all of which are found widely distributed throughout large areas in Europe. Asia and North America, being especially abundant in cool northern and mountainous regions.

VACUUM, empty space; specifically, an enclosed space devoid of matter. Physically, the condition of complete absence of matter is never realized; even the most nearly perfect vacuum contains gas or vapour in a state of great rarefaction — how great may be realized by considering that the lowest practicably attainable pressure in a tight vessel is of the order of 10^{-7} mm. of mercury, whereas atmospheric pressure is about 0.75×10^3 mm.—the height of the mercury column in a barometer. The ratio of these pressures is about 1.3×10^{-10}; in round numbers, therefore the pressure in the vessel, as well as the number of molecules of gas in it, has been reduced by a factor of 10,000,000,000. In each cubic centimetre of gas at normal atmospheric pressure there are 2.7×10^{19} molecules. Reducing the pressure to the practicable limit therefore reduces the number of molecules by a factor of, say, 10^{10}, leaving behind 2.7×10^9 molecules, or roughly 3,000,000,000, in each cubic centimetre of space within the vessel. Whereas at atmospheric pressure the mean free path (average distance covered between collisions) of a molecule in air is about 9.5×10^{-6} cm., this becomes 14 m. at the low pressure mentioned.

During the years between the World Wars I and II, and particularly during the prodigious scientific and technological efforts in the United States and Great Britain brought forth by the exigencies of World War II, great strides were made in the application of high-vacuum technology to many problems and situations, both in the laboratory and the factory, in fields of great diversity in pure and applied science.

It is general knowledge that Thomas A. Edison's incandescent electric lamp required that its glass envelope or bulb be "pumped out" to prevent its carbon filament from uniting with the oxygen of the air and chemically burning out. The commercial needs of rapidly exhausting the air from light bulbs resulted in improvements in methods of pumping. The "Edison effect"—forerunner of the Fleming valve, the Deforest audion, and the multitude of modern electronic tubes—was discovered because it had become possible by 1883 to pump the air out of a lamp bulb to the point where a current through the residual gas could be detected. The rapid growth of the radio industry, accompanying the development of broadcasting methods and of means for broadcast reception, which occurred in the decade beginning about 1920, could not have occurred without the concomitant development of techniques for exhausting the radio valves, or vacuum tubes, to the requisite high vacuum by methods that were technically and economically feasible.

Metallurgical processes by which such rare metals as tantalum and tungsten are produced in pure state from their ores depend for their success on high-vacuum furnaces in which the vacuum can be rapidly produced and readily maintained while the metallic bars, at white heat, are giving off great quantities of gas. Practically all optical instruments used in World War II were greatly improved in their ability to transmit light by having the optical surfaces of their lenses and prisms coated or "bloomed" with a hard, transparent mineral layer a few molecules thick, to reduce the reflection and therefore loss of light at these surfaces. The coating process is carried on in a high vacuum: and its development to commercial practicability comprises many highly ingenious procedures. In the optical field also, the best first-surface mirrors are produced by a vacuum distillation process, in which the metal is vaporized by electric heat and caused to condense on the glass surface from which light is to be reflected. The mirrors of practically all astronomical reflecting telescopes are now prepared by evaporation and condensation of metal—usually aluminum—in a high vacuum.

The production of vitamin A from fish-liver oil, by fractional distillation in a high-vacuum still, is now a highly successful commercial process; but this is only a single example of a well-developed technology in the fields of nutrition and pharmacology yielding useful and valuable and sometimes unexpected returns. High-vacuum technology plays an essential role in the production, in commercial quantities, of penicillin, and in the rapid dehydration of blood plasma and serums.

In the basic science laboratories, particularly those of physicists, the availability of apparatus for the rapid production of high vacuum has profoundly influenced the success of many researches, It has, in fact, been the *sine qua non* of soine of the most fundamental experiments in electronics, nuclear physics and X-rays. Without high vacuum there would be neither radio broadcasting nor radio reception; and without it, television could not have been developed. For it is only in high vacuum that the electrons may be given off and controlled to make tubes and circuits possible in which a weak signal may be amplified ten-millionfold and more; and it is in high vacuum that light may cause useful emission of electrons from a photosensitive surface which constitutes the heart of the television transmitter. The cathode-ray oscillograph, one form of which is essential to the production of a visible image in a television receiver, likewise depends on high vacuum. The cathode-ray oscillograph may be said to have saved England, for it is one of the essential components of radar. The cyclotron, the betatron, the electron microscope, the mass spectrograph—all are useful, practicable instruments because of high vacuum. The separation of U-235, the fissionable atom of uranium, from its isotopes of atomic weights 234 and 238, was accomplished in high vacuum, in a magnetic field, by applying the principle of the mass spectrograph.

These examples from industry and the research laboratory have been cited to show the importance of vacuum, and particularly of modern high-vacuum technology. The requirements of the innumerable situations in which high vacuum is an essential factor have given rise to a modern technology that may be designated "high-vacuum engineering." This comprises a knowledge of the means for producing high vacuum, namely, the several kinds of vacuum pumps, formerly called air pumps; the means for measuring vacuum—the several kinds of manoineters or vacuum gauges; and the unusual methods and artifices that must be employed in order that a vacuum system—consisting of the pump or pumps, the vessels or containers being exhausted, the measuring and controlling devices and the tube-lines connecting all together properly—may function most effectively. These several aspects of production and measurememt of high vacuum and the management and control of vacuum systems will be discussed in this article.

Rotary Oil-Sealed Pumps.—About 1920 the reciprocating-piston vacuum pump was displaced by the rotary mechanical types. Some ten years earlier the Gaede *Kapselpumpe* had appeared. It was characterized by a cylindrical rotating member, or rotor, eccentrically mounted within a cylindrical housing, or stator, of somewhat larger diameter (fig. 1). The rotor A contained tno diametrically opposite slides, S and S', bearing against the inner surface of the stator B under spring pressure and centrifugal action. Air in the space V_d ahead of the slide S′ is swept out through an exhaust port, as the volume of the space decreases; whereas, behind the slide S the volume increases, causing air to enter through an intake port from the vessel being exhausted. Air in the space V betueen the two slides. at the pressure of that in the vessel being exhausted, is compressed. as soon as slide S′ has passed the exhaust port and V has become V_d, to atmospheric pressure. and is expelled through the valve E to atmosphere. Small clearance and an oil film at C keep the compressed gas in V_d from entering V_i. Many rotary pumps of various specific designs but employing the same principle have appeared and are in common use in shops and laboratories. The Gaede rotary *Kapselpumpe* was designed to serve as a primary or forepump (Ger.: *Vorpumpe)* in series with the Gaede rotary mercury pump with which high vacuum could be slowly produced. More recent designs of rotary pumps have been used in large numbers as torepumps with the mercury vapour diffusion or condensation pumps, and with the oil-vapour pumps of this type.

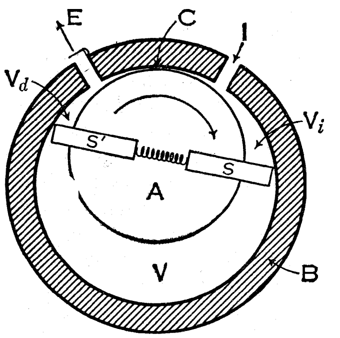


FIG. I.—SECTION OF THE GAEDE "KAPSELPUMPE"
I, intake of pump from vessel to be evacuated; E, exhaust; A, rotor; S′, S, slides; B, stator; V_d, volume of exhaust air; V_i, volume of intake air; V, volume of air at pressure of that in vessel being exhausted; C, seal between stator and rotor

The type of rotary pump, which was responsible for displacing the reciprocating air pump from laboratories generally, is a series known as "Hyvac"—with displacements ranging from about 170 cc. to 17,000 cc. per second. These represent the first rotary, oil-sealed pumps capable of producing a vacuum — with exclusion of vapour from the system — of better than 0.001 mm. of mercury. In principle this type differs from the pump of fig. 2 in having its rotor eccentrically mounted on a shaft, and in having a single vane in the stator to separate the high-pressure from the low-pressure side.

In fig. 2 Rotor **A** is eccentrically mounted on a shaft concentric with the cylindrical cavity of stator B. At C the surface of the rotor is ground, for a short distance, on a radius almost equal to that of the stator cavity, to provide sealing contact over a finite area rather than along a cylindrical element, or line. The slide S is maintained in contact with the rotor by spring pressure. The intake is at D, the exhaust port at E; the latter is provided with a ball valve. With rotation as indicated, the space V_i increases and V_d decreases at each cycle from the instant of passage of the sealing area C beyond the slide S. In its practical embodiment, this pump may consist of two pumping units in series. They are arranged side by side, separated by a common wall, ground plane-parallel, through which a hole is drilled that constitutes both the exhaust port of the high-vacuum unit and the intake port of the forepump unit. While the space V_d in the former is decreasing, it is expelling the air into the space V_i of the latter. Thus the air in the space V_d of the high-vacuum unit is not compressed appreciably. As a result, leakage into the high-vacuum side is minimized. In illustration of the effectiveness of such an arrangement, a single-stage pump of this type produces a vacuum of about 0.05 mm., whereas the two-stage pump produces about 0 0005 mm., two orders of magnitude better.

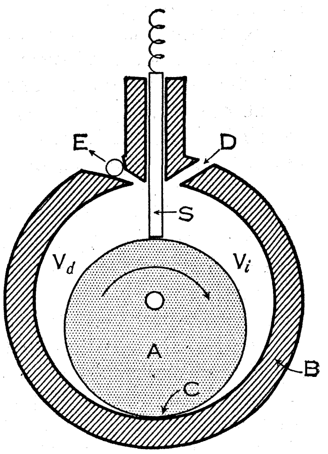


FIG. 2.—CENCO-HYVAC ROTARY VACUUM PUMP
D, Intake of pump from vessel to be evacuated; E, exhaust; A, rotor; B, stator; C, sealing area between rotor and stator; S, slide; V_i, intake volume; V_d, exhaust volume

Pumps Utilizing Liquid Mercury. — In the second half of the 19th century various types of mercury pump were introduced, which were used in all the early experiments on the discharge of electricity through gases at low pressure. The principle of all these pumps is to connect the receiver with a Torricellian vacuum created by the pump; the equalization of pressure will then bring part of the air in the receiver into the Torricellian space. The receiver which is being exhausted is then cut off from the vacuous space, and the vacuum re-created. This process can be carried out in various nays. The simplest and earliest form of apparatus is that described by Heinrich Geissler in 1862. This consists simply of a vessel connected by a flexible tube to an open reservoir of mercury; the vessel can by means of a two-way stopcock be connected either with the outside air or with the space to be exhausted. The stopcock being turned so as to give passage to the air, the reservoir is raised until the vessel is full of mercury; the stopcock is then turned so that the vessel is cut off from the air and connected to the space to be exhausted, and the reservoir is lowered. This tends to create a Torricellian vacuum in the vessel, into which the air from the space being exhausted rushes. The cycle can be repeated as often as desired, the fraction of air removed each time depending upon the relative volumes of space to be exhausted and the vessel.

A type of pump possessing many advantages over the Geissler pump was devised by August Töpler; it avoids all stopcocks, the connections and disconnections being made by the mercury itself. An improved form of Topler pump is shown in fig. 3, from which the working of the pump can easily be understood. V is a cylindrical vessel connected by the tube S to the space to be exhausted. M is a mercury reservoir which must be of somewhat greater capacity than V. When the mercury levels are as in fig. 3, V contains gas at the same pressure as S. The reservoir M is then raised; the mercury rises in the tube Z, cutting off V from S, and fills the vessel V, driving the gas from it down the tube T. The gas being thus expelled, M is lowered again, and the vacuous space V is once more in connection with S. The process is repeated as often as may be required. A valve at C, consisting of a glass float, the top of which is ground to fit on a seating at O, serves to prevent the mercury ever passing over into the vessel S, while the inclined position of the cylindrical vessel V has, among other advantages, that of lessening the shock of the rising mercury against the top of the vessel. Pumps of the Topler type were widely used for producing a vacuum in the researches of the first ten years or so of the 20th century, but were then gradually superseded by rotary and other types. Pumping uith them was a tedious business. By mid-20th century they were used only when it was desired to collect the gases which were being pumped out, a purpose for which they are excellently adapted.

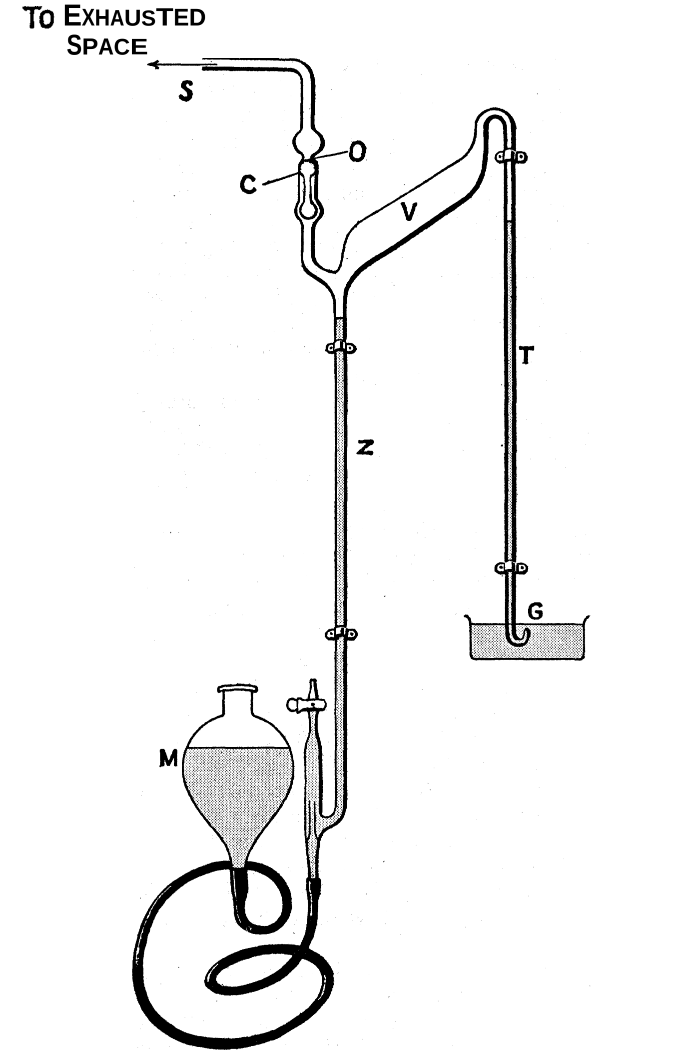
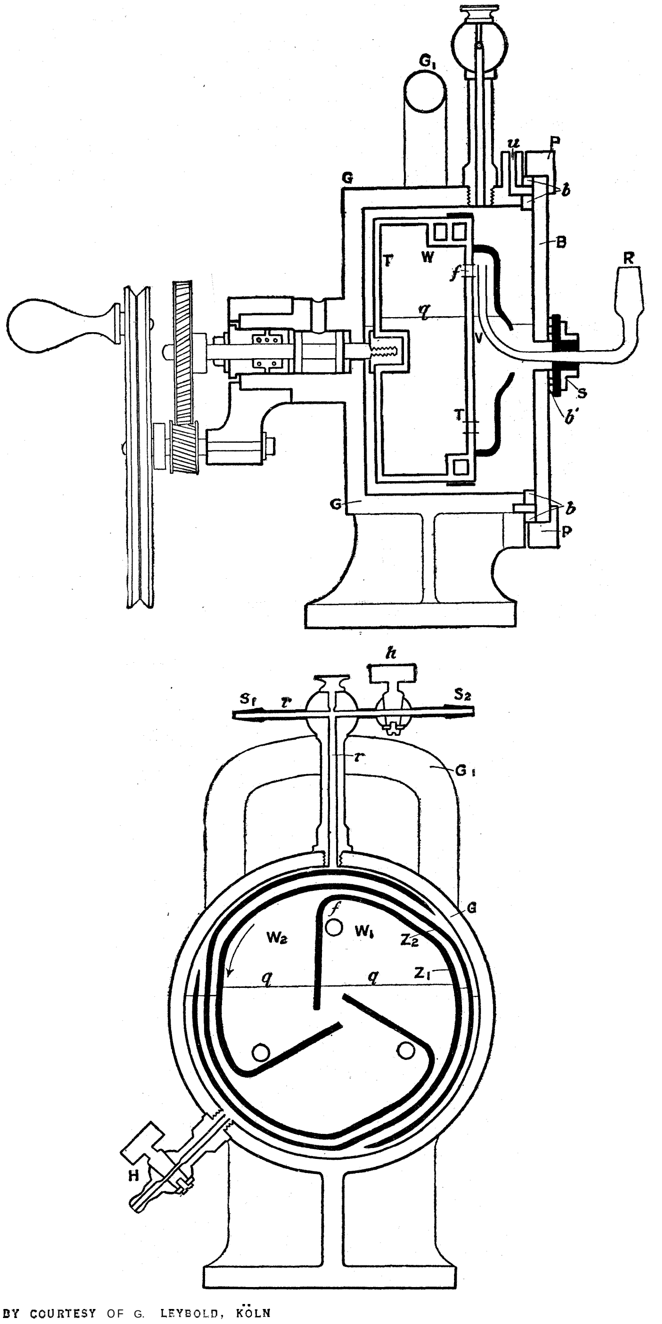


FIG. 3.— THE TÖPLER MERCURY PUMP
When the reservoir M is lifted the mercury rises into the vessel V, and expels the gas down tube T. C is a float valve, seating at O, which cuts off the exhausted space

To avoid the tedious raising and lowering of the reservoir, a process which may have to be carried out for an hour or two to obtain the desired vacuum, automatic mercury pumps were devised. The earliest was that of Herman Sprengel, which consists essentially of a narrow tube down which mercury flows in a succession of drops, filling the bore of the tube, from a reservoir; the top of the tube is connected to the space S to be exhausted. If the tube is of barometric height the pressure at the top will be zero, air will pass into it from S, and will be carried down as bubbles by the mercury and discharged into a collecting vessel or into the air, as desired. This type of pump was much improved by Gimingham in 1877, and in this form used by Sir William Crookes in his extensive investigations on electrical discharges in vacuum tubes. These pumps were not strictly automatic, in that the reservoir gradually emptied and had to be refilled by hand. Devices were introduced by which the reservoir could be kept automatically refilled; a typical pump of this kind was that of G. W. A. Kahlbaum (1894), in which the flow of mercury was maintained by the help of a water-operated filter pump of ordinary type. The Sprengel type of pump, which came to be extensively used, like the widely known Topler type, was the subject of many modifications.

A revolution in high-vacuum technique was brought about in 1905 when Gaede introduced his rotary mercury pump. In principle the pump, which is illustrated in fig. 4, is something like a gas meter run in reverse. It consists of a porcelain drum W, rotating on an axis A, mounted in an iron vessel GG, the front of which is closed by a glass plate B, as shown in the upper figure. The drum is divided into two parts by a vertical wall T, the portion on the right of this wall enclosing a space V which communicates through the tube R with the vessel to be evacuated. The portion to the left of the wall is divided into three compartments by walls of the shape shown in the lower figure. The pump is filled with mercury up to the level qq. When the drum rotates in the direction of the arrow the compartment W_1, which communicates with V by the hole f, is filled with gas from the receiver, while the gas in the compartment W_2, drawn from the receiver just before, is displaced by the mercury and ultimately passes into the space between the revolving drum and the casing. The action is continuous. It is, however, clearly necessary that the pressure prevailing in the space between drum and casing shall not exceed a few millimetres or so of mercury; the pump must therefore be run in connection with a suitable forepump, which first reduces the pressure to a value at which the rotary mercury pump can be put in operation, and subsequently removes, as long as necessary, the gases displaced by the mercury pump. The forepump is connected to the tube S_2, the other branch S_1 being connected to a rough mercury gauge.



BY COURTESY OF G. LEYBOLD, KÖLN

FIG. 4.—GAEDE'S ROTARY MERCURY PUMP

As the drum W rotates, the air is displaced from the chamber W_2 into the space between drums and casing G, and is drawn frcm the receiver into the chamber W, through opening f. The chamber W, moves into the position of chamber W_2, and the process is repeated

With mercury pumps of this type a pressure as low as 10^{-5} mm., as measured with the McLeod gauge, can be attained. There is, however, always the pressure of the mercury vapour itself, amounting to about 0.001 mm. at ordinary room temperature, unless special precautions are taken to trap the vapour between pump and receiver. Moreover, the pump cannot deal with condensable vapours, such as water vapour, for the decrease of volume of the chamber during the expulsion of the gas leads to condensation of the saturated vapour in the drum. The pump requires about 40 lb. of mercury. It has, however, the advantage that it can be stopped without detriment to the vacuum already attained, nhich cannot be done with other types of pump to be described. The speed is about 100 cc. per second over a wide range, an exceedingly slow rate as compared with modern pumps.

Aspirators **and Ejectors.**—When water flows through a pipe with a constricted section, the pressure in the region of higher velocity, at the narrow section. is lower than it is in the larger sections of the pipe. Because of the reduced pressure, air or other gas may be drawn into the stream through an opening in the pipe at the reduced section. This simple application of Bernoulli's principle is the basis for the water aspirator. a form of air pump usually attached to a water tap, and operated by opening the cock. A side arm, with the opening into the section at reduced pressure, provides means for connection of the receiver to be exhausted. A well-designed aspirator is rapid and produces a pressure of between 1 j mm. and 25 mm., depending on the temperature of the water, the attainable limit being the vapour pressure of the water. This simplest of air pumps is useful for many operations in the laboratory that do not demand high vacuum, but it is not adapted to serving as a forepump for condensation and diffusion pumps (see PUMP).

In principle the steam ejector resembles the water aspirator, except that the operating fluid is steam. The gas being pumped is drawn into the high-speed jet of steam. Such an ejector, operating into atmospheric pressure, may produce a pressure of the order of 50 mm. to 100 mm. To produce lower pressure by the same means, two ejectors may be used in series, with a resultant pressure of about a j mm. to 50 mm. Still lower pressure is thus attainable by adding another ejector to the series, usually with a condenser interposed between the second and third ejector. This condenses the working steam from the ejectors operating at loner pressures. With three ejectors, a pressure of 0.1 mm. has been achieved; with five in series, a pressure of 0.03 mm. has been reached. This is sufficiently low for many industrial uses.

If the steam ejector worked on exactly the same principle as the water pump, the lowest pressure obtainable would be that in equilibrium with steam at room temperature. or 1; mm. to 20 mm. Hg. That much loner pressures are obtainable is evidence that all the molecules of steam in the high-vacuum jet have been given a velocity so far in excess of their normal thermal velocity that few can return into the evacuated space.

Ejectors employing steam or oil vapour are employed as forepumps and booster pumps in modern vacuum systems.

Mercury Diffusion and Condensation Pumps.--In 1915

Gaede once again appeared with an idea for making the processes developed on the basis of the kinetic theory of gases work toward the production of a high vacuum. The scheme of operation of his diffusion pump may be understood by reference to fig. 5. A stream of mercury vapour passes upward in a tube which has a side branch closed with a porous plug or narrow slit through which gases may diffuse. The branch connects a vessel containing air at reduced pressure. The pressure of the mercury vapour may be of the order of 1 mm., corresponding to the temperature at which evaporation occurs. Some of the vapour diffuses through the barrier into the space containing air and this, in greater part, condenses; at the same time, air diffuses in the opposite direction, where the molecules are entrained in the blast of vapour. The rates of diffusion in opposite directions depend on the respective molecular weights, the mean size of the capillary passages in the diffusion barrier, and the partial pressures on opposite sides of the barrier of the two gaseous mediums. Thus the diffusion of the air into the vapour stream will continue so long as there is air in the vessel connected to the side arm, and theoretically approaches a perfect vacuum. Although the mercury continues to diffuse in the opposite direction, its vapour pressure on the right of the barrier remains low, corresponding to the low temperature of its surroundings, namely that of the cooling jacket surrounding the exhaust tube.

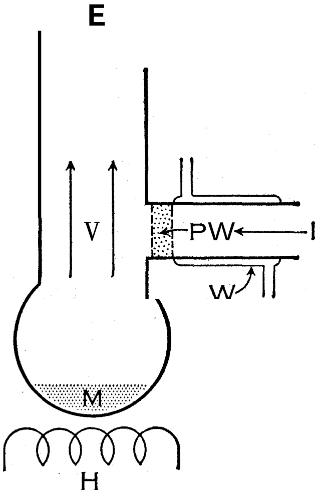


FIG. 5.—GAEDE DIFFUSION PUMP
I, intake; E, exhaust; P, diffusion barrier: W, water cooling jacket; V, mercury-vapour stream; M, mercury; H, heater

Because of the manner in which diffusion takes place in a gas, the porous plug or Gaede's equivalent of it, a narrow slit, is not necessary. In Gaede's original pump, the blast of mercury vapour was made to pass a narrow slit through which the air diffused into the stream of vapour. According to his reasoning. the greatest speed of pumping was attained when the width of the slit was of the same order as the mean free path of the air molecules. The mercury vapour diffusing through the slit was immediately condensed on a cooled surface opposite the slit. Although the pump produced a vacuum higher than had theretofore been attained, its speed was slower than that of the Gaede rotary mercury pump.

By eliminating the slit and arranging for cooling of inner wall surfaces in such a manner that the mercury vapour could not diffuse back into the vessel being exhausted, or prevent the air from diffusing rapidly into the stream of vapour, Irving Langmuir greatly increased the speed of exhaust and rendered the pump less subject to variations in performance with changes in temperature of the boiler. Langmuir reasoned that the mercury molecules could readily be prevented from diffusing in the direction opposite that of the air molecules by cooling the walls of the tube at a point just beyond the tube through which the: air is diffusing into the vapour stream. Thus. the air molecules are rapidly carried away from their outlet, the vapour is rapidly condensed, and the temperature in the vicinity of the outlet is maintained so low that practically no mercury is re-evaporated in this region. Because of the dependence upon condensation of the mercury vapour for proper functioning, Langmuir designated this type as a condensation pump, as distinguished from Gaede's diffusion pump. However, both types depend upon both diffusion and condensation for operation. Gaede's has a restricted area through which diffusion takes place, uhereas Langmuir's has a large area. Modern refinements in condensation pumps have given them extremely high pumping speeds, speeds limited only by the physical dimensions that are practicable in specific cases.

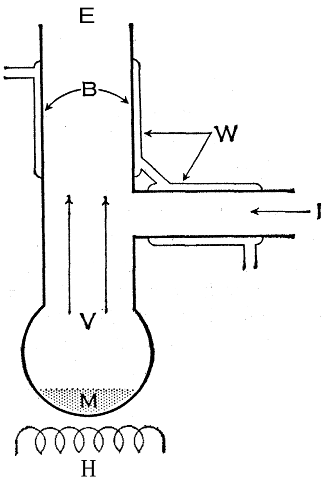
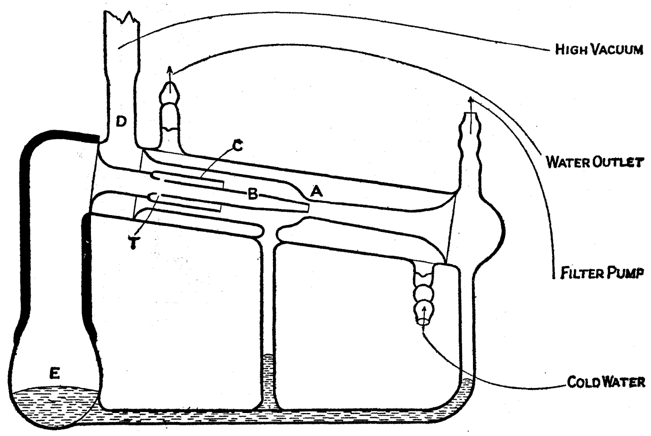


FIG. 6 —LANGMUIR CONDENSATION PUMP
I, intake; E, exhaust; W, water cooling jackets; V, mercury vapour stream; M, mercury; H, heater; B, condensation surfaces tor mercury vapour

Mercury Vapour Pumps.—Two- and three-stage mercury vapour pumps, in which the stages are arranged in series, so that the high pressure side of one is the low pressure side of another, are made for rapid work. Since at very low pressure the mercury vapour stream loses its jet form, the stream in a diffusion pump exerts no action such as the steam jet does in an ordinary injector. However, at higher pressures the Bernoulli effect comes into operation, and is utilized in the preliminary stage or stages of a multiple stage pump, where, because of the higher pressure, the diffusion principle is less effective. One of the early two-stage mercury vapour pumps as designed and built by Dunoyer mhich will work against a forepressure of 25 mm. or 30 mm. is illustrated in fig. 7. The first mercury jet A acts like the steam injector, and is forced into a conical diffuser which is connected to the forepump. This first jet lowers the pressure in B, into which an annular stream of vapour is sent from the sleeve C. This jet still further diminishes the pressure in D, which is joined to the system requiring evacuation. The annular jet is formed by vapour which gets into C by the small holes T, the remainder of the vapour going on to form the jet at A. The high vacuum in D is created by diffusion and condensation in the same way as in the Langmuir pump.



FROM DUNOYER, "VACUUM PRACTICE" (BELL)
FIG. 7.— A TWO-STAGE MERCURY VAPOUR PUMP. DESIGNED BY DUNOYER

Oil Vapour Pumps.—For many years mercury was the only pumping fluid used in diffusion and condensation pumps. Beginning about 1929 C. R. Burch in England and K. C. D. Hickman in the United States prepared some organic oils uhich proved to be useful as pumping fluids. Some of these have extremely low vapour pressures, a property which was exploited to obtain lower pressures. The principles underlying mercury vapour pumps are also basic to oil vapour pumps. Recognizing that oils contain components which, because of their different vapour pressures, boil at slightly different temperatures, Hickman developed the fractionating pump. Two of the first practicable fractionating pumps are shown in Pl. I, figs. 2 and 4. The two-stage fractionating pump seen in Pl. I, fig. 4 is made of glass and is capable of producing a vacuum of the order of 10^{-7} mm. in a closed system. This is made possible by a design which by application of known principles of distillation and condensation controls the passage of oil and oil vapour through multiple boilers. After the unit has run for a short time, the extreme volatiles have been distilled into the alembics of the vertical tube. The condensed oil from the jets returns to the first boiler (boiler under the vertical tube) where the highest relative temperature is maintained. The more volatile constituents in the oil are vaporized and stream from the jet. The material of lower vapour pressure passes through the connecting tube to the second boiler. The second stage produces better vacuum at high speeds because the oil which reaches it has been rectified in the first stage; *i.e.,* fractions of higher vapour pressure have been eliminated. The small boiler at the end of the pump serves as a still in which the dark-coloured nonvolatile residue collects while the more active components are distilled and returned to the other two boilers by the overhead glass tubes leading to these boilers. The addition of another boiler and jet as seen in Pl. I, fig. 2 broadens further the use of the principle of fractionation and realizes the ultimate possibilities of oils as pumping fluids.

A metal fractionating oil pump is illustrated in Pl. I. fig. 3, and in fig. 8. This pump is not so efficient in fractionating the oil as is the horizontal glass pump described above but it does afford considerable self-conditioning of the pumping medium, is robust, compact and capable of reaching pressures of 10^{-6} mm. and lower. This design of pump may be built in different sizes resulting in a series of pumps with a wide range of pumping speeds.

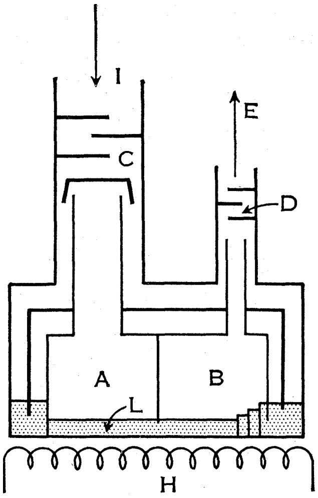


FIG. 8.—SECTION OF AN ALL METAL, TWO-STAGE, FRACTIONATING PUMP

I, intake; E, exhaust; C, high vacuum section; D, forevacuum section; A, high vacuum boiler; B, forevacuum boiler; L, pumping fluid; H, heater

The boiler of this pump is divided into two sections, A and B in fig. 8. The high vacuum section C has an umbrella jet and the forepressure section D has an upright jet. There are baffles in each section above these jets to provide cool areas for oil vapours to condense on and be returned to the boilers. The two stacks of this pump may be either air-cooled or water-cooled. The stacks in Pl. I, fig. 3 are air-cooled; external fins enlarge the cooling surface. In the forepressure boiler B there are small dams making the oil pass over a longer path enabling the more volatile constituents to evaporate in this boiler and allowing the less volatile constituents to get over to the high-vacuum boiler which serves the high-vacuum jet.

Similar to the multijet mercury diffusion pumps, oil diffusion pumps may be made as nonfractionating one-, two- or three-jet types. However, most oil pumps are designed to produce some partial fractionation of the oil, since the employment of this principle always results in a more efficient pump. In a three-stage oil diffusion pump, as shown in Pl. II. fig. 3, the condensed vapour enters the circular boiler from the outside edge. The chimney is common to the three jets. supplying the jets with vapour in a manner similar to the mercury vapour condensation pump previously described. There is built into the forepressure arm a series of alembics for collecting the highest volatile substances and preventing their return to the pumping fluid. In another type of upright, three-jet oil diffusion pump, there are three separate concentric chimneys for the three jets. The outside chimney feeds the lowest vacuum jet and the inside, the highest. The condensed vapour enters from the outside edge into the boiler and on its passage to the centre chimney the higher volatiles are boiled off into the higher vacuum jets. This results in a semifractionation of the oil.

The pumping speeds of mercury vapour and oil vapour pumps range from 1 l. per second up to many thousands of litres per second at 10^{-4} mm. and under proper conditions will attain an ultimate pressure of 10^{-7} mm.

Booster Pumps.—With the development of the oil diffusion pump, certain limitations in its use were soon discovered. Although higher speeds at lower pressures mere obtainable because of improved pump construction and lower vapour pressure of the oils, it was noted that the pressures into which the oil diffusion pump would satisfactorily discharge the gases were comparatively lower. Another may of stating the same thing is that the forepressure breakdown, or pressure into which or against which the oil diffusion pump would operate, was low. This resulted in low speeds in the regions of pressure between the optimum working pressure for the mechanical pump and the optimum forepressure for the high speed diffusion pump. To overcome this difficulty it was necessary to develop another type of pump which would discharge into a region of comparatively high forepressure. These pumps are known as "booster pumps" (Pl. II, figs. 1, 2 and 4). They operate on the diffusion-condensation and jet ejector principles and will maintain a low pressure into which a high-speed diffusion pump may exhaust.

Measurement of Low Pressures.—Vacuum Gauges.—Pressures down to a few millimetres of mercury can be measured by an ordinary mercury manometer, consisting of a U-tube having one side closed at its upper end and filled with mercury. When the other branch is connected to the vessel in which the pressure is to be measured the difference of level in the two branches, which may be read with vernier attachments or with a cathetometer, indicates the excess pressure in the vessel above the Torricellian vacuum in the closed branch. Such manometers are commonly used for rough readings, since, in the vacuum range of 1 mm. and less, this small difference in levels cannot be measured with great accuracy. A more sensitive mercury manometer is one in which the two mercury surfaces are kept precisely in contact with fine vertical pointers. The difference of pressure is measured by the angle through which it is necessary to tilt the manometer in order to restore the level when it is disturbed by the presence of gas on one side. This gauge has been used to measure pressures from 1.5 mm. to 0.001 mm. Another way of measuring very small displacements of the mercury surface in a U-tube manometer is by means of a little float on the surface supporting one end of a lever carrying a small mirror; the tilt of the mirror is measured by a lamp and scale.

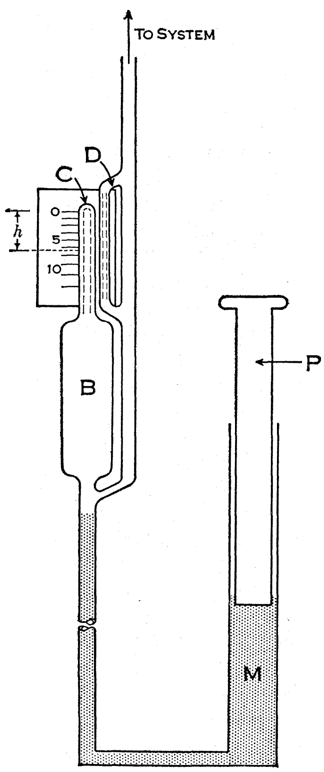


FIG. 9.— MCLEOD GAUGE

B, bulb; C, D, capillary; P, plunger; M, mercury

The first successful special device for measuring pressure too low to be accurately measured by the ordinary U-tube manometer was the gauge invented by McLeod in 1874, and known by his name. It consists in principle of a bulb B, some 250 cc. in capacity, provided with a fine calibrated vertical capillary C, fig. 9. The mercury surface can be adjusted to any desired height by the device of a mercury reservoir with displacement plunger P connected to the apparatus. The bulb B is connected to the space in which the pressure is to be measured. The mercury surface is raised, cutting off a known volume of gas, at very low pressure, in B, and then forcing it into the capillary C. The pressure which the amount of gas present exerts in this confined space is then observed. To avoid error due to capillarity in measuring the pressure a side-tube D is provided of exactly the same bore as C, and the difference of levels h in C and D measured. The level in D is opposite the top of the capillary C. Assuming Boyle's law, and knowing the volume of the bulb B and of the graduated tube C, the original pressure in B, which is the pressure required, may be calculated from $p=ah^2/V$, where p is the pressure of the gas in mm., a is the cross section of the capillary C, h is the head of mercury which is compressing the gas (difference of level in C and D) and V is the combined volume of the bulb B and the capillary C.

The McLeod gauge was by mid-20th century the standard instrument for the accurate measurement of pressures down to 10^{-6} mm. with certain gases and proper precautions. Many other types of gauges are calibrated using this gauge as the standard of reference. The accuracy of the gauge depends upon the closeness with which the gas in question obeys Boyle's law, perfect compliance with which is assumed in the deduction of the equation for the pressure. The gauge cannot be used with condensable vapours, such as those of water or ammonia, which tend to liquefy on the walls; even with carbon dioxide the readings are not reliable. With such gases as hydrogen and nitrogen, on the other hand, the gauge works down to its limit of pressure measurement.

Since McLeod gauges cannot be used with such gases as chlorine, which are chemically very active and attack mercury, various types of membrane manometer have had to be devised. Very thin spiral glass tubes, working on the principle of the Bourdon gauge used for steam pressures, have been used for such gases, the displacement of the end of the spiral being measured with mirror and scale. Such gauges are not sensitive to pressures less than about 0.1 mm. The mechanical deformation of a very thin metal or glass membrane has been used to measure small pressures. One side of the membrane is exposed to the gas or vapour, while on the other side the vessel is evacuated by a high-vacuum pump. The very small movements produced are measured by an interference method, and results have been obtained down to 0.001 mm., but the instrument is difficult to manipulate.

The exceedingly low pressures produced by modern techniques have led to the construction of a whole class of new manometers, depending for their operation on the behaviour of gases at low pressures; *i.e.*, the behaviour of gases when the mean free path of the molecule is comparable with the linear dimension of the vessel. The thermal conductivity and the viscosity are properties which are independent of the pressure so long as the mean free path is small, but change rapidly with the pressure when the pressure is very low, becoming proportional to the pressure below a certain value of pressure, depending upon the nature of the gas and the dimensions of the vessel. Again, at low pressures, the radiometer effect manifests itself; that is, there is a mechanical repulsion between a warm surface and an opposing colder surface when gases at low pressure lie between them. Further. with simple forms of triode vacuum tubes, as long as (1) the pressure is low enough for the electrons to have a free path greater than the distance between the hot wire and the surrounding grid and (2) the potential fall accelerating the electrons which is well above the ionization potential of the gas, the ionization produced between the grid and the surrounding cylinder is proportional to the pressure. All these effects have been utilized in the construction of special low-pressure gauges.

Two types of viscosity gauges may be mentioned. In one, devised by Langmuir and Dushman, a very light horizontal disk of mica hangs suspended by a quartz fibre directly above a second horizontal disk. This second disk is carried on a vertical shaft which can be set in rapid rotation by a rotating magnetic field outside the glass vessel. The drag of the rotating disk on the suspended disk, which is proportional to the speed of rotation and to the pressure of the gas between the disks, is measured with the aid of a mirror attached to the suspended disk. The effective viscosity depends not only upon the pressure but also upon the nature of the gas, so that the gauge requires special calibration. Because of secondary effects this gauge is not reliable at extremely low pressures, and on account of the lack of proportionality between drag and pressure it cannot be used at pressures above 0.02 mm. Hg. The gauge has not found wide use.

A much simpler form of viscosity gauge, developed by Langrnuir, consists merely of a vertical quartz fibre, rigidly fastened at the upper end to the top of the vessel. When the vessel is tapped, the fibre is set in vibration, the amplitude of which decreases at a rate determined by the pressure of the residual gas in the vessel. The gauge can be used down to pressures of 10^{-4} mm. Hg.

The Pirani gauge is based on the physical principle that the thermal conductivity of a gas is related to its pressure by the approximate relation, $K = C \times p$, for pressure below values where the thickness of the gas layer is of the order of the mean free path. K is the thermal conductivity of the gas, p its pressure and C is a constant. The thermal conductivity is indirectly measured by ascertaining the change with pressure in the resistance of a hot filament in the vacuum chamber. As the pressure about the filament alters, so the speed at which heat is conducted away from the filament changes. The heat is conducted away from the filament by molecules of gas colliding with the filament and, in turn, colliding with cooler surrounding surfaces. The more of these collisions (higher pressures) the greater the cooling effect on the filament and hence the lower resulting temperature of the filament. The change in temperature effects a change in the resistance. These resistance changes are measured by a Wheatstone bridge arrangement, fig. 10. The filament used should be of a metal with as high a variation in resistance with temperature as possible; tungsten and platinum wire and a "thermistor" unit are satisfactory in this respect.

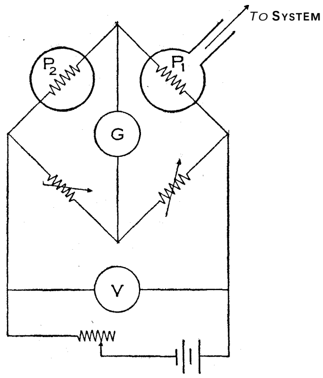


FIG. 10 —PIRANI GAUGE

In fig. 10, P_1 is the gauge filament which is enclosed by a housing attached to the vacuum System, P_2 is an identical filament whose housing has been evacuated to an extremely low pressure. The instrument has to be calibrated against a McLeod gauge.

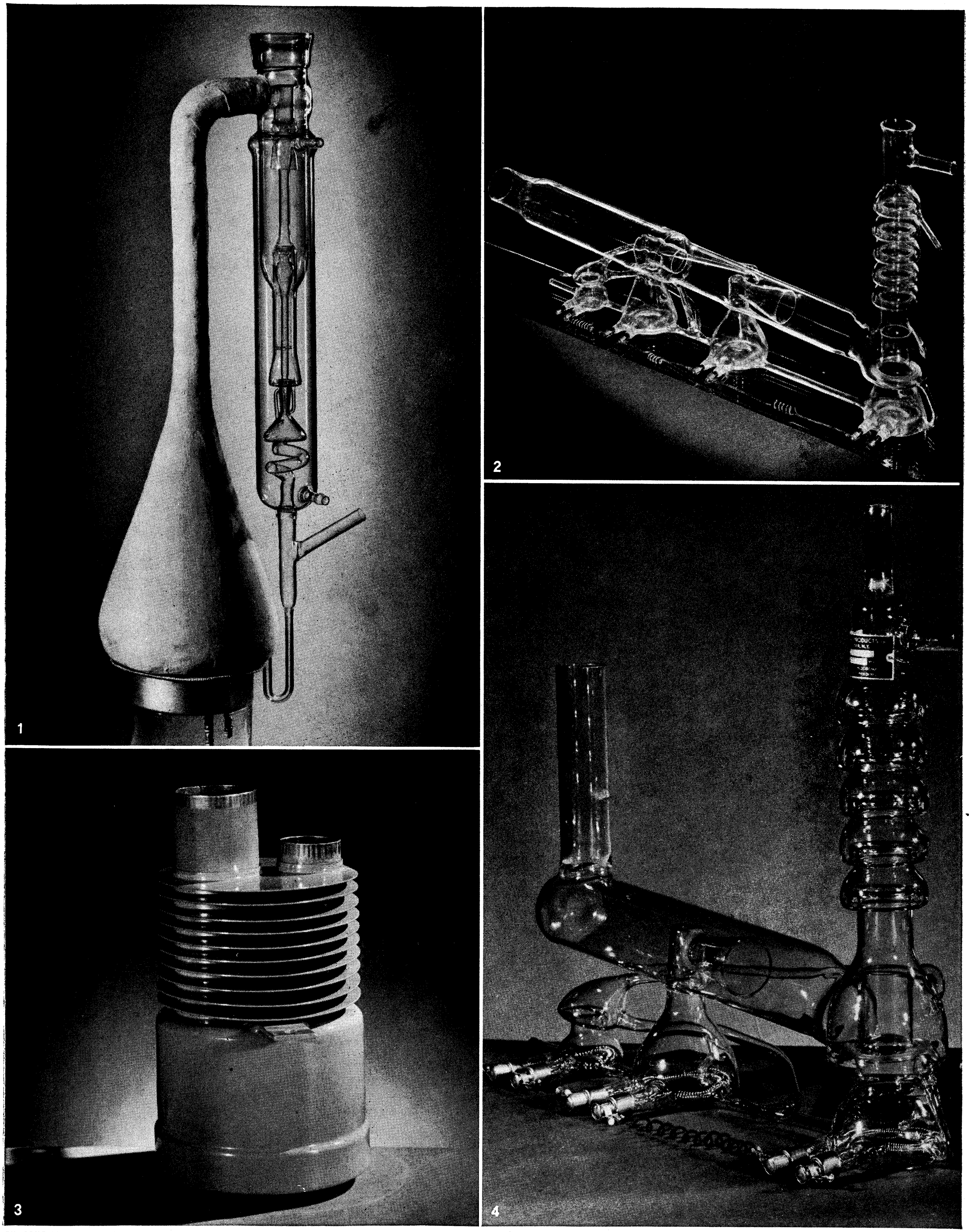
The total pressure is indicated by the gauge; *i.e.*, it shows the pressures of condensable gases and vapours, for example, water vapour. Unfortunately the heat loss of the filament is determined by the nature of the gas molecule and so the gauge can be accurately calibrated for only one particular gas. It is very important, therefore, to avoid the introduction of water or other vapour when measuring air pressures. However, despite this fault it has the virtue that it will indicate the presence of unsuspected vapours which the McLeod gauge would completely fail to reveal. The other advantage is the ability to indicate the pressure instantaneously and continuously.

The useful range of the Pirani gauge is from 10^{-1} mm. to 10^{-4} mm. This gauge is widely used.

Another conductivity gauge is the thermocouple gauge, which, in operation, closely resembles the Pirani gauge, and is subject to the same operating conditions. It differs from the Pirani gauge in its utilization of thermoelectromotive force in place of change of electrical resistance as the actuating means. A thermoelectric junction of small dissimilar wires, fig. 11, is supported inside a glass bulb. A small heating element, spot-welded to the junction, is also supported inside this same glass bulb. The bulb is joined to the system in which the pressure is to be measured. A current of the order of 0–100 milliamperes is passed through the heating element. The thermoelectric current developed is measured by a sensitive meter. Since the temperature attained by the junction depends on the conductivity, and hence on the pressure, the surrounding gas pressure is indicated in terms of meter deflection, and the scale of the meter may be calibrated in pressure units if desired. The useful range of the gauge is between 10^{-1} mm. and 10^{-4} mm.

The ionization gauge, fig. 12, in its usual form is similar to a three-element vacuum tube. The electrons from a heated filament are accelerated toward a collecting electrode which may be either the grid or the plate of the tube. The positive ions formed through bombardment of gas molecules by this electron stream are collected on the third electrode; *i.e.*, on the plate if the electron current is collected on the grid. The positive ion current varies with the pressure in the region of the grid and plate.

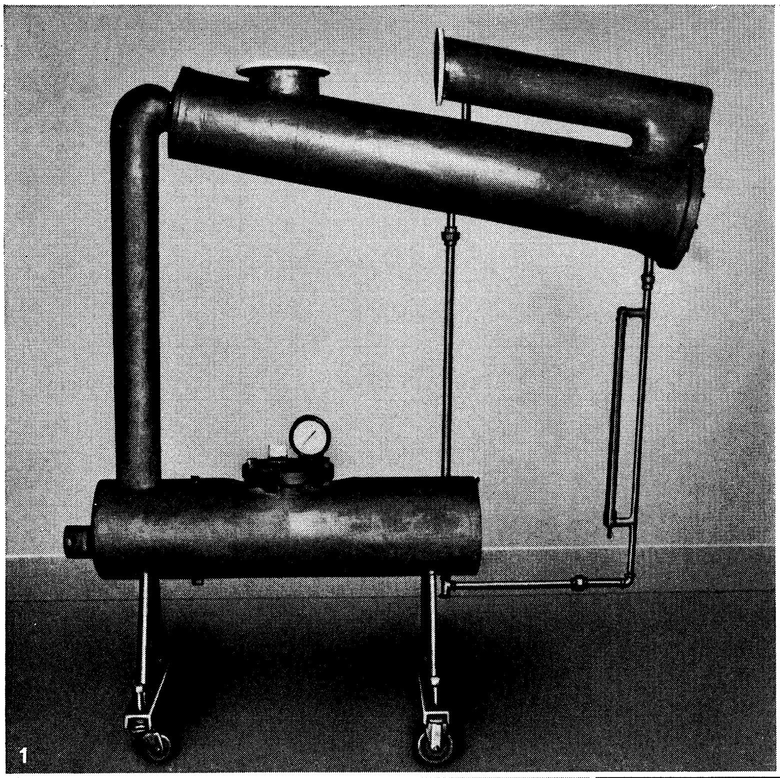
In fig. 12 the grid is the electrode which collects the electron current. The grid is positive with respect to the filament and nega-



BY COURTESY OF DISTILLATION PRODUCTS, INC.

1. DPI three-jet mercury vapour pump
2. DPI three-stage fractionating oil diffusion pump (Hickman)
3. DPI-VMF series, all metal, two-stage fractionating oil pump
4. DPI two-stage fractionating oil diffusion pump (Hickman)

VACUUM



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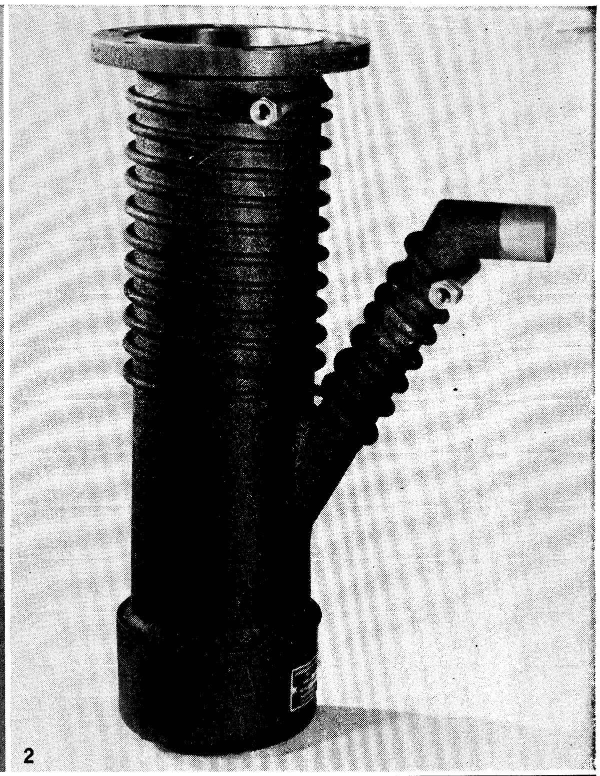

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3

4

BY COURTESY OF DISTILLATION PRODUCTS, INC.

1. DPI metal booster pump (KB 300)
2. DPI metal booster pump (MB 100)
3. DPI glass-metal, three-jet, oil diffusion pump
4. DPI glass, two-jet, booster pump

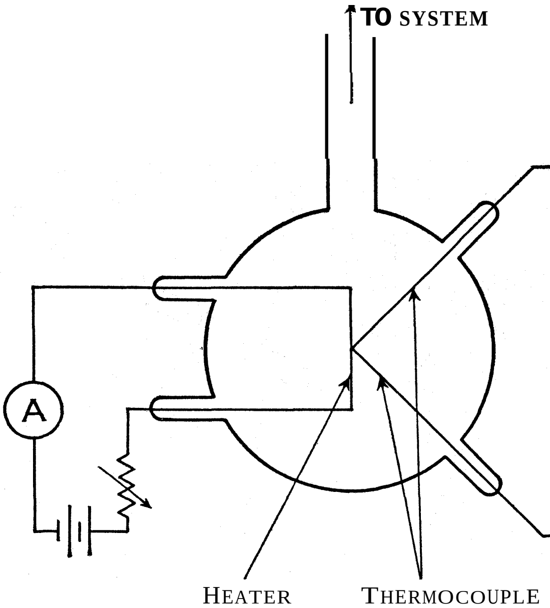

FIG. 11.— THERMOCOUPLE GAUGE

tive with respect to the plate. Some of the electrons after receiving energy caused by the voltage drop between the filament and the grid pass through the grid openings into the region between the grid and the plate. In this region the electrons bombard gas molecules and produce positive ions which migrate to the plate. The equivalent current is read on the microammeter.

In a second arrangement the plate is positive with respect to the filament and the grid is negative. The negative plate arrangement is the more sensitive method but the procedure when using the negative grid is the easier.

The electron or filament emission current is about 10 milliamperes whereas the ionization current is about 50 microamperes. Below 10^{-4} mm. the pressure is directly proportional to ionization current. With the emission of 10 milliamperes the plate voltage needs to be about -20 v. and the grid voltage of the order of

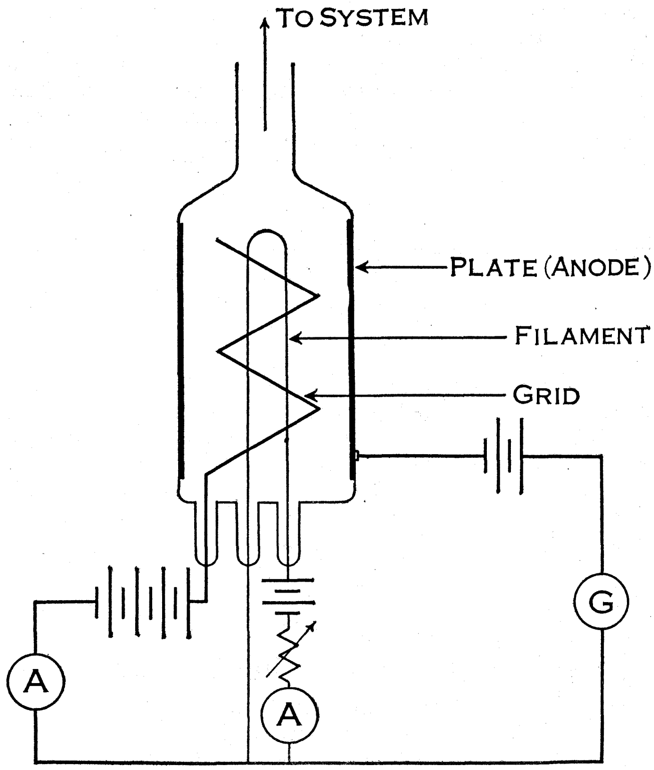

FIG. 12.— IONIZATION GAUGE

200 v. For given pressure, anode voltage and anode current, the ionization current is proportional to the number of free electrons in the gas. Thus the gauge is selective and needs to be calibrated for each gas used. The lowest pressures attained, of the order of 10^{-8} mm., have been measured with an ionization gauge. The extremely low limit of pressure capable of being measured with it is the great advantage of the gauge. The two principal disadvantages of the gauge are its low maximum pressure reading, and the fact that it needs calibration for each gas used. By the same token, for accuracy of reading, vapours must be excluded. Because of possible oxidation of the hot tungsten filament the gauge should not be operated above 10^{-3} mm.

Calibration is done by means of the McLeod gauge. Great care needs to be taken to ensure purity of gas and equality of pressure throughout the system during this calibration.

The cold-cathode ionization gauge, fig. 13, uses a cathode glow-

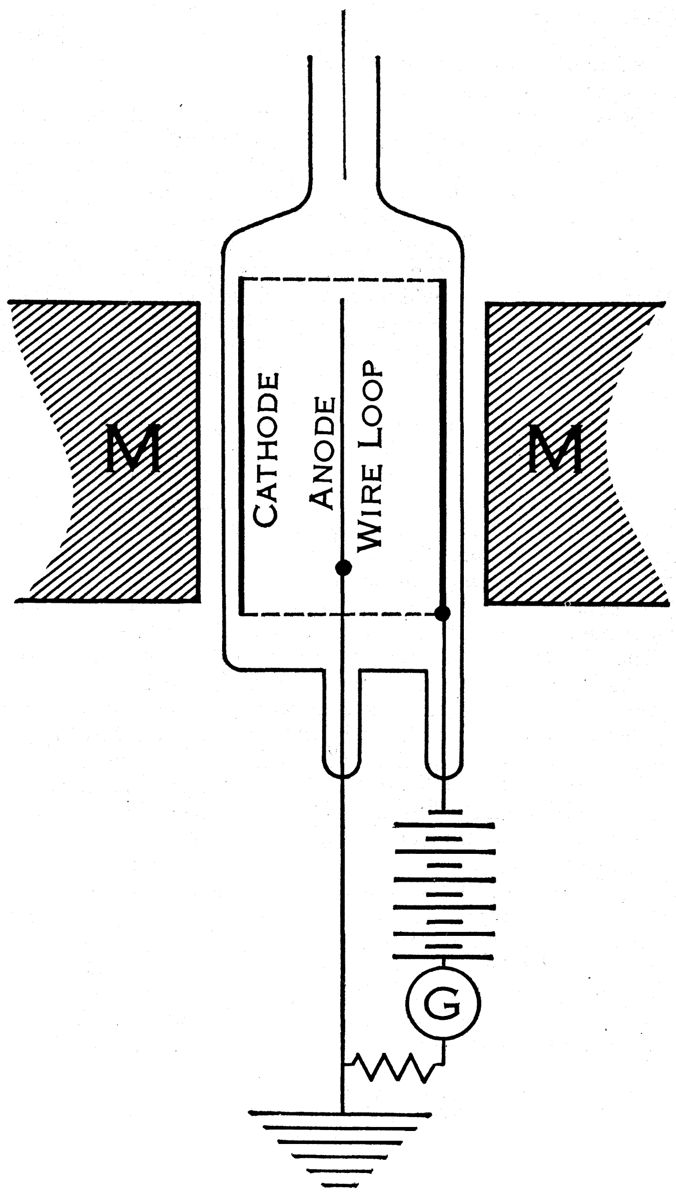

FIG. 13.— DISCHARGE IONIZATION GAUGE

discharge as the means for ionizing the gases in the envelope of the gauge tube. A permanent magnet is used in some designs of cold-cathode gauges to increase the length of the electron-molecule collision path. The electrons ejected from the surface of the cathode by the high potential gradient at the cathode ionize the gas in the gauge envelope. The electrons resulting from this ionization are either collected by the anode and the resulting cathode-anode current measured by a sensitive meter or the electrons produce further ionization which results in more electrons. The additional electrons are collected by the anode and the total electron current measured. There is a proportionality between number of gas molecules and electron current produced by ionization.

In some designs of the cold-cathode gauge the electron paths from cathode to anode are made several hundred times longer than the direct path by applying a magnetic field across the tube causing the electrons to move in a spiralling or sinuous path. Increasing the travel of the electron will, in proportion, increase the probability of an electron ionizing the molecules of the residual gas, and so an ionization current is obtained several times greater than would prevail if the electrons travelled in straight lines from cathode to anode impelled by the electric field only. Since the cold-cathode gauge does not depend upon a hot tungsten filament for its operation it may be used at higher pressures than the hot-filament ionization gauge. Also, it cannot measure extremely low pressures. The range of the cold-cathode ionization gauge is from 0.0001 mm. to 0.03 mm. Opening the gauge to atmospheric pressure does not harm it.

Fig. 13 shows the electrode and circuit arrangement for the cold-cathode ionization gauge with magnetic field. The anode and cathode are shown in their relative positions. Magnet M maintains a strong magnetic field. The voltage across the tube is of the order of 2,000 v. D.C. and the magnetizing field around 400 oersteds. The cathode is made of zirconium, thorium or other material giving a copious supply of electrons under the "cold" discharge. The gauge should be calibrated against a McLeod gauge for each gas used. This gauge coupled with the Pirani or thermocouple gauge makes a very useful combination because the two cover the range from a few millimetres to approximately 10^{-4} mm. pressure.

A third type of ionization gauge, in many ways like the cold-cathode gauge, is the alpha-ion gauge. Ionization of the gas molecules in the gauge is accomplished by the alpha particles which are discharged at constant rate by a radium source. The radium is sealed into the gauge housing. The range of this gauge is from 0.001 mm. to 10 mm. It extends to higher pressure ranges than the cold-cathode gauge and also is not damaged by opening to atmospheric pressure. Calibration of the cold-cathode and alpha-ion gauge is made using a McLeod gauge as the reference.

The Knudsen gauge provides continuous readings from 10^{-3} mm. to 10^{-7} mm. It is an absolute gauge and needs no calibration against a McLeod. The gauge consists of an aluminum vane suspended from a fine tungsten wire within a metal casing, fig. 14. The deflection of the vane is measured by an optical system in which a beam of light is reflected onto a translucent scale from a small mirror attached to the vane. Two electric heaters are located parallel with the vane on opposite sides near the edges. so that gas molecules accelerated by the heaters strike the vane, causing it to rotate. The amount of rotation is proportional to the pressure, other conditions remaining constant, and the distance between the vane and heaters being small in comparison to the mean free path of the molecules at the existing pressure. The damping magnets eliminate erratic movement of the vane caused by normal vibration without appreciably affecting its sensitivity.

The equation for calibration of the Knudsen gauge is given by

$$P=\left(\frac{2\pi^2 I}{rAt^2}\right)\left(\frac{D}{d}\right)\left[\frac{1}{\left(\frac{T_1}{T}\right)^{\frac{1}{2}}-1}\right]$$

If T_1 and T are fairly high temperatures on the absolute scale, and if their difference is small,

$$P=\left(\frac{4\pi^2 ID}{rAt^2 d}\right)\left(\frac{T}{T_1-T}\right)\text{dynes per square centimetre}$$

where: I = moment of inertia of moving vane
r = mean radius of moving vane
$2A$ = total area of the vane opposite heaters
t = period of oscillation of the vane
D = scale deflection
d = scale distance

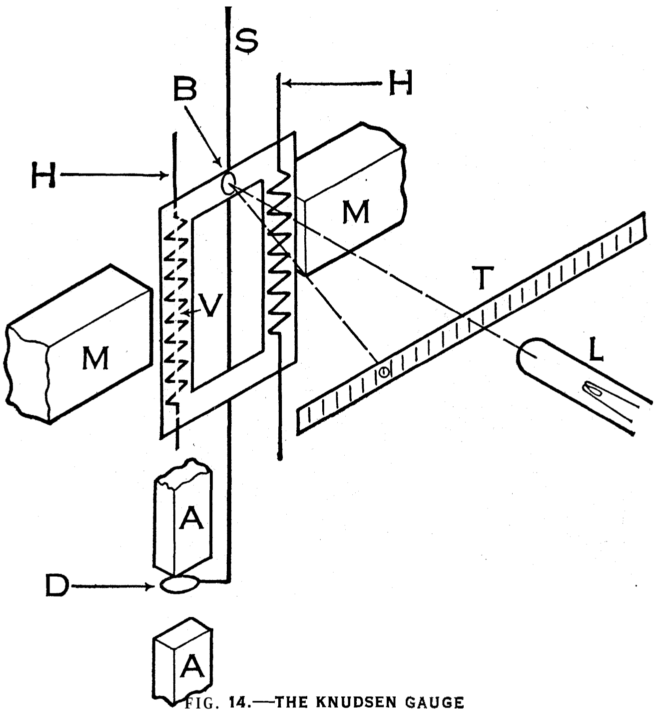

FIG. 14.—THE KNUDSEN GAUGE

S, tungsten wire; H, heater; A, internal damping magnet; B, mirror; D, damping vane; M, external damping magnet; V, impact vane; L, lamp; T, scale

T = absolute temperature of residual gas in gauge
T_1 = absolute temperature of heating elements H.

Since all these quantities can be measured directly, it follows that the device can be used as an absolute manometer, without the necessity of calibrating against any other gauge. It is also evident that the indications of this gauge must be independent of the gas to be measured.

Pumping Speed.—In the preceding discussion three principal types of vacuum pumps—the oil-sealed mechanical pump, the diffusion pump and the booster pump—have been described. Usually some combination of two of these pumps is needed and there are occasions where all three types together constitute the pumping unit for the vacuum system.

One important characteristic of any pump is its pumping speed. The speed of exhaust of a closed vessel may be measured at constant pressure, and defined as the volume of gas pumped from the vessel at that pressure in unit time. Expressed mathematically

$$S_1=-\frac{dV}{dt}$$

where S_1 is the pumping speed and dV is the small change of volume in the short time dt. By applying Boyle's law for a perfect gas this definition may be written as

$$\frac{dp}{dt}=-\frac{S_1}{V}p$$

where p is the instantaneous pressure at the time t in a closed volume V being exhausted by a pump having a speed S_1. In 1913 Gaede published some of his work with vacuum pumps, which indicates that he originated the concept of pumping speed. In 1916 Langmuir introduced the concept of limiting pressure p_0 for a pump which modifies the Gaede equation by substitution of $(p-p_0)$ for p. The equation above then becomes

$$\frac{dp}{dt}=-\frac{S_1}{V}(p-p_0)$$

The solution of this modified equation is

$$t_2-t_1=\frac{2.3V}{S_1}[\log_{10}(p_1-p_0)-\log_{10}(p_2-p_0)]$$

where t_2-t_1 is the time required to reduce the pressure in the volume V from p_1 to p_2 using a pump of speed S. It should be noted that the vessel being evacuated is connected directly to the intake of the pump. Pump speed S_1 is the pumping speed

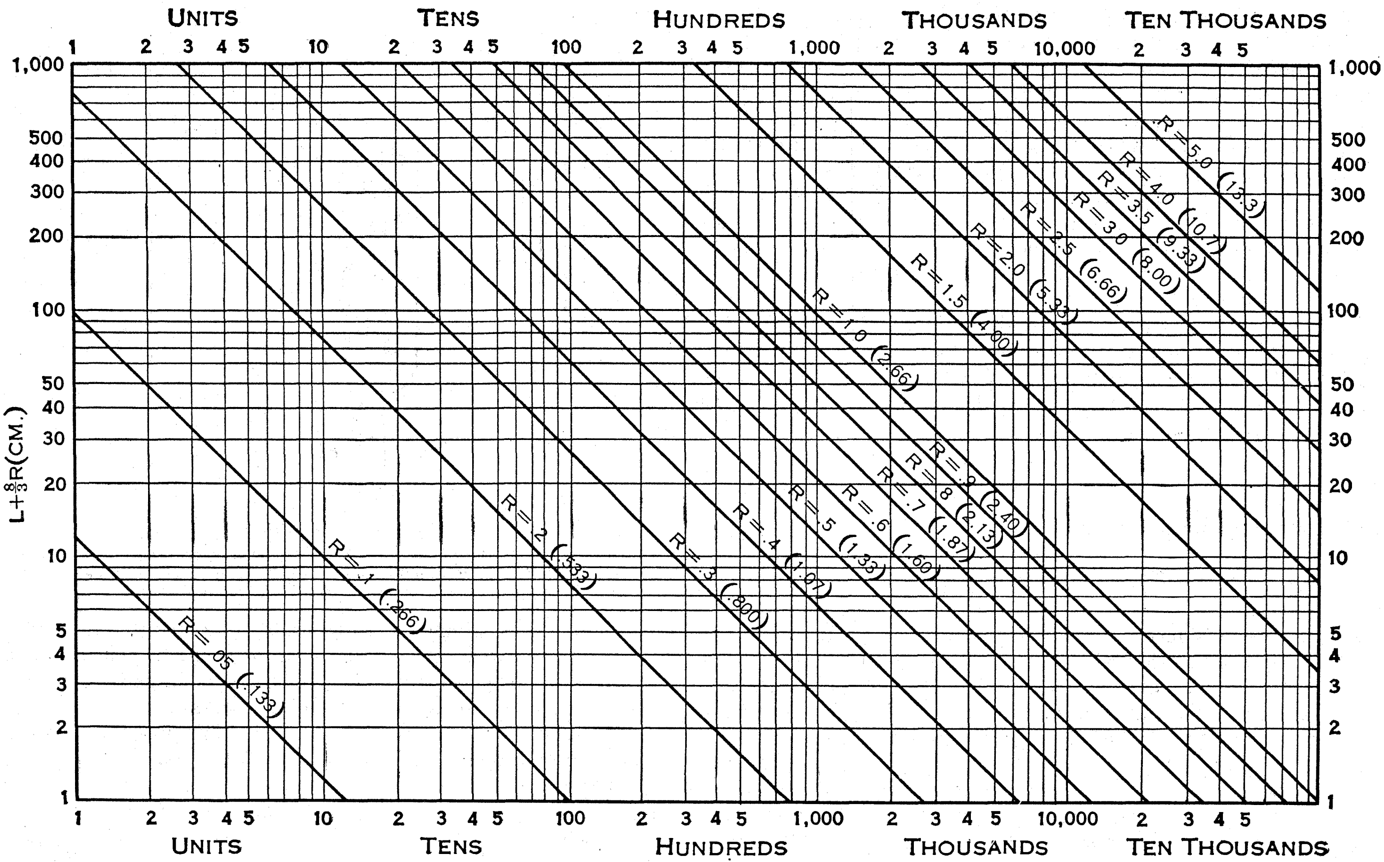

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FIG. 15.— CHART OF CONDUCTANCE OF CONNECTING TUBES FOR AIR AT LOW PRESSURE

at the pump intake.

Usually a connection of some length is required between the pump and the vacuum chamber. Under such circumstances the pump speed S_1 is not the controlling factor. In making "pump-pown" calculations, particularly if pressures below 10^{-2} mm. are involved, the speed of evacuation S rather than pump speed S_1 determines the period of cyclic operations.

When the pump is operating in the high-vacuum range, the flow of gas through a tube is substantially molecular in character. The hydrodynamic component of gas flow, being proportional to pressure, becomes relatively unimportant. In other words, at extremely low pressures the gas removed from the system is largely confined to those molecules which, because of their thermal kinetic energy, happen to wander into the low pressure region created by the pump, and by the action of the pump become trapped and prevented from again entering the chamber being evacuated.

From experiments over a large range of pressures with different gases, Knudsen in 1909 derived the following semiempirical relation which holds at all pressures.

$$Q=\left[aP+Z\frac{(1+\alpha P)}{(1+\beta P)}\right](p_1-p_2)$$

Where $a=\frac{\mathbf{a}R^4}{8\mu L}$ (coefficient of hydrodynamic flow—Poiseuille's constant)

$Z=\frac{\sqrt{2\pi}}{\rho'}\frac{4}{3}\frac{R^3}{L}$ (coefficient of molecular flow)

$\alpha=\frac{2\sqrt{\rho'}R}{\mu}$

$\beta=\frac{2.47\sqrt{\rho'}R}{\mu}$

where Q = volume of gas, measured at pressure P, which flows per second through the tube

p_1-p_2 = difference in pressure at the two ends of the tube

$P=\frac{p_1-p_2}{2}$ = average pressure

R = radius of tube

L = length of tube

μ = coefficient of viscosity of the gas

$\rho'=\frac{p}{P}$ where p = density of the gas

ρ' is a function only of the kind of gas and the temperature.

For ordinary pressures this equation assumes the form commonly known as Poiseuille's law,

$$Q=\frac{\pi R^4}{8\mu L}P(p_1-p_2)$$

while at extremely low pressures it becomes

$$(1)\quad Q=\left[\frac{\sqrt{2\pi}}{\rho'}\frac{4}{3}\frac{R^3}{L}\right](p_1-p_2)$$

The quantity enclosed by brackets in the above equation is a factor applying only in the case where one is considering the quantity of gas, Q, flowing per second through a tube of length L and radius R with a difference of pressure at the ends of p_1-p_2. Effects of the various end conditions that may be applied to the tube have not been considered. Hence where we have a tube of length L and radius R connecting two vessels at low pressures, the quantity of gas Q flowing per second from the vessel at pressure p_1 through the tube into a second vessel at pressure p_2 is given by

$$(2)\quad Q=\left[\frac{4}{3}\left(\frac{\sqrt{2\pi}}{\rho'}\right)\left(\frac{1}{\frac{L}{R^3}+\frac{8}{3R^2}}\right)\right](p_1-p_2)$$

It will be observed that the form of the last two equations is similar to Ohm's law, where Q is similar to a current, (p_1-p_2)

similar to a potential drop and the bracketed term similar to a conductance. It must be remembered that the bracketed term in the equation (1) considers only the gas flowing through a tube, neglecting end effects. For a long tube this is sufficiently accurate in most cases. The bracketed term in equation (2) is for the case of a tube terminating at a thin mall, the circular opening in the wall being of the same diameter as that of the tube. This expression for the conductance has been used in plotting the curves shown in fig. 15. Other types of end configurations would introduce other correction factors into these equations. For different gases the value of the conductance varies as the reciprocal of the square root of p'.

Some of the references given in the bibliography give further discussion to the problem of flow of gases in pipes at low pressures.

The system speed of evacuation S is related to the speed of the pump S_1 and the conductance of the connecting tubing Z by the following relationship:

$$\frac{1}{S}=\frac{1}{Z}+\frac{1}{S_1}$$

On rearranging the terms,

$$S=Z\left[\frac{S_1}{Z+S_1}\right]=S_1\left[\frac{Z}{Z+S_1}\right]$$

These expressions have important significance. The fractional term in either expression is less than 1. Consequently, the speed of evacuation S can never be greater than the conductance Z nor can it be greater than the speed of the pump S_1. The second expression suggests that the speed of evacuation approaches the speed of the pump only when Z is very large in comparison with S_1. This expression shows that the performance of a high-speed pump may be seriously impaired by the use of ill-chosen connections. For a well-designed pipe line, pumping speed (speed of evacuation) S in a system should not be much less than 80% of the speed S_1 at the intake of the pump.

When several lengths of tubes of different diameters are connected in series between the pump and exhaust chamber the conductance Z for the combination is given by

$$\frac{1}{Z}=\frac{1}{b_1}+\frac{1}{b_2}+\frac{1}{b_3}+\ \dots\ +\frac{1}{b_n}$$

where b_1, b_2, etc. are the respective conductances of the tubes.

Traps or Condensers.—A trap is an obstruction placed in a vacuum system for the purpose of collecting solid particles, liquids, vapours or gases. If vapours are involved, the trap must be cooled. The cooling may be done by mechanical refrigeration, by a mixture of solid carbon dioxide (dry ice) and alcohol or acetone, or by liquid air. Typical traps are shown in fig. 16. Certain "permanent" gases may be removed by using a trap of activated charcoal cooled with liquid air.

The conductance of a trap in the vacuum system may be quite important. Hence traps are preferably constructed with large passages to avoid undesirable reduction in pumping speed.

Refrigerated glass traps are commonly used between a McLeod gauge and the vacuum system to prevent contamination of the mercury and the glass parts of the gauge and to prevent diffusion into the vacuum system of mercury vapours from the gauge. Such a trap is also frequently used between the pump and the vacuum system, either to trap vapours which might contaminate the pumping fluids, or to prevent passage of oil vapours from the pump into the vacuum system.

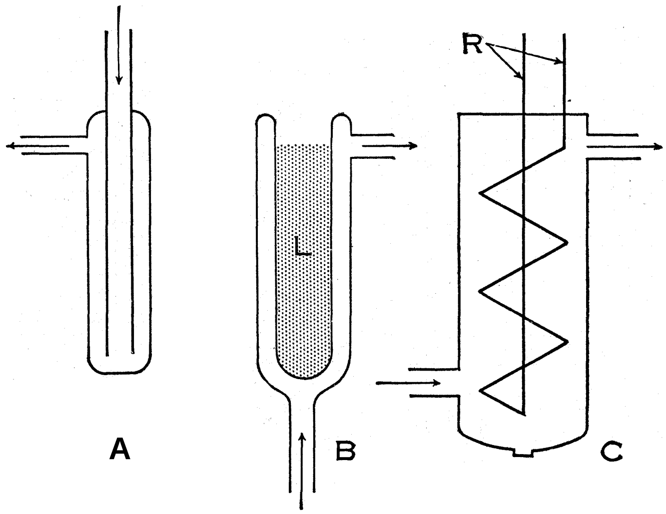

FIG. 16.— COLD TRAPS

Trap A: Refrigerant surrounds outside of trap and is contained in a Dewar flask: Trap B: Refrigerant contained in well, L; Trap C: Refrigerated coils, R, cooled by mechanical refrigeration, afford the cooling surface

MANAGEMENT OF THE VACUUM SYSTEM

In industrial use, high vacuum is considered to begin in the range of pressures corresponding to 1 mm. Probably this would not be considered high vacuum by the experimental or resedrch man working in the laboratory where pressures of the order of 10^{-6} mm. are obtained. Attainment of a good vacuum requires thoughtful selection of equipment, care in assembly and manipulation of the apparatus.

The elements of a vacuum system have been discussed in the preceding sections. They consist of forepump, diffusion pump, cold traps, valves, plumbing, gauges and the apparatus or equipment to be evacuated. A number of factors must be considered in selecting a pumping system. The choice will be largely influenced by the arrangement of the equipment, the volume of the vacuum chamber, the quantity of gas to be handled at low pressures and the importance of time in cyclic operations. One consideration that is generally common to various arrangements is the speed of the forepump. This is directly related to the speed of the diffusion pump and the ratio of pressures at the discharge and intake of the diffusion pump. On the assumption that a particular diffusion pump has a speed of 100 l. per second at 10^{-6} mm. and that the pump operates satisfactorily at a fore-pressure of 10^{-2} mm., the ratio of pressures is 1 to 10,000. This means that a forepump capable of handling 0.0001 of 100 l. per second or 0.01 l. per second is theoretically sufficient for the job. This suggests that a relatively low-speed forepump would be sufficient. However, there are usually other factors that must be considered.

Fluids used in diffusion pumps often deteriorate if their temperatures are elevated when in contact with air at pressures of 0.1 mm. and above. Unless appropriate steps are taken. this means that a certain amount of time is lost in heating and cooling the boiler in a cyclic operation. To avoid this loss of time, various techniques are used. In some instances, two parallel pumping systems are installed. One consists of a high-speed forepump either directly connected or connected through a cold trap to the vacuum chamber and a second independent connection in which a relatively small forepump backs a diffusion pump. During the preliminary pumping period or when air is admitted to the vacuum chamber the intake to the diffusion pump is closed but all the pumps are permitted to opcrate, In operation the high-speed forepump withdraws the air from the chamber to the low millimetre range after which the diffusion pump is opened to the system so that the reduction in pressure continues without interruption. In another arrangement only one forepump is used. More vacuum valves are required because the high-speed forepump is first connected to the vacuum chamber and later placed in series with the diffusion pump.

Valves and plumbing must be free from leaks and of high conductance. The question of system speed (speed of evacuation) has been discussed and the methods for calculating conductance outlined. As part of the steady improvement in vacuum techniques, by which the lower limit of pressure has been pushed steadily downnard, it became increasingly important to detect and locate even the microscopic leak in the walls of the vessels, connecting tubes, junctions of parts, all of which constitute the barrier betn een a region of high vacuum and one of atmospheric pressure. The final vacuum attained in a system is an equilibrium condition between pumping speed, on the one hand, and the rate of leak into or evolution of gas within the system, on the other.

Various methods of leak detection have been employed. With the rapid advances in vacuum techniques made during World War II many new methods were developed. Older methods employ the Tesla coil, discharge tube, Pirani and ionization gauges. Newer methods make use of the differential Pirani gauge and the mass spectrometer. Oddly enough, the most sensitive method is also the most rapid; *i.e.* the mass spectrometer method.

Vacuum systems are constructed from glass and metal. Depending upon the conditions a system may be either all glass or all metal. Glass can be easily cleaned and welded at junctions. It has high electrical insulating quality, may be baked out and sealed off to give a more or less permanent vacuum. Metal systems are made from steel or brass. The parts may be machined and fitted together with rubber gaskets or soft-soldered, silver-soldered or brazed. Glass or metal vacuum valves can be fitted permanently or with tapered joints, into the system.

Where the highest degree of vacuum is desired considerable outgassing of glass and metal parts must be done. Outgassing removes gases adsorbed to the surface of glass and metal. Prolonged heating of glass at 150° C. to 200° C. in vacuum removes most of the gases adsorbed on the surface, metals strongly heated in a vacuum give off adsorbed gases as well as absorbed gases and gas arising from the decomposition of oxides near the surface. Metal parts within the evacuated chamber are outgassed by heating to a high temperature with high frequency induced currents. When an apparatus has been reduced to its lowest pressure by continued pumping and heating and is sealed off from the system, the pressure may be further lowered by a getter. Getters remove gases by chemically combining with them and by absorbing them.

Further detailed information on procedures in the management of high vacuum systems will be found in the references given in the bibliography.

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HIGH-VACUUM COMMERCIAL APPLICATIONS

High vacuum as employed in industry generally falls within two ranges of pressures:

(a) 1 to 1000 μ (1 μ = 0.001 mm. Hg.),

(b) 10^{-8} mm. to 10^{-3} mm. Hg.

The extremely low pressures are found almost exclusively in the electronics industry, while pressures in the micron range find applications throughout the chemical and metallurgical fields. By undertaking processes under an appropriate range of gas pressures, one or more of the following advantages may be gained: (1) oxidation is prevented, (2) distillation temperature is reduced, (3) absorbed and adsorbed gases may be removed, (4) dehydration may be performed at low temperatures, (j) gaseous ionization may be prevented or controlled, (6) thermal conduction of gases may be reduced, (7) radiant energy absorption may be reduced.

Vacuum Metallurgy.—The use of free air pressures below 100 μ has found many applications in the production, purification and treatment of metals.

Thermal Reduction.—Metal oxides may be reduced under vacuum and distilled from the hot reaction zone in highly purified form. Magnesium has been commercially produced from calcined dolomitic limestone by the following reaction:

$$2(MgO.CaO) + \tfrac{1}{6}FeSi_6 \xrightleftharpoons{2{,}150^\circ\ F.} 2Mg\uparrow + (CaO)_2.SiO_2 + \tfrac{1}{6}Fe\ .$$

With appropriate reducing agents other metals such as calcium, lithium, barium, caesium, rubidium, sodium, and potassium may be produced in pure form from their salts.

Distillation of Metals.—Through the use of pressures of 1 to 100 μ the lower melting metals (magnesium, zinc, lead, tin, cadmium, lithium, barium, etc.) may be purified by distillation. Impure magnesium as formed by the carbothermic process has thus been distilled in vertical electrically heated retorts, of several-ton capacity. Separations of lighter melting metals by fractional distillation (*i.e.,* zinc and tin or zinc and aluminum) has also been accomplished.

Vacuum Sintering.—This technique is employed chiefly in the production of tungsten, molybdenum, tantalum and columbium. Bars of the pressed powdered metal are electrically heated in vacuum and after sintering, rolled to size.

Heat Treatment.—Through the use of a vacuum furnace, dies, tools, etc., may be heat-treated without the usual oxidation, the vacuum serving as a true neutral atmosphere.

Vacuum Melting.—Dissolved gases may be removed by maintaining metals above their melting point at low pressure. Gas-free metals, particularly copper and iron, are useful in the electronics industry for the fabrication of parts sealed in vacuum. Copper so treated has greatly increased ductility and improved thermal and electrical conductivity. Highly reactive metals like titanium have been melted and cast at air pressures of 10 μ.

Vacuum Dehydration.—Vacuum evaporation is commonly used in the chemical industry for the removal of water or other solvents from many products. By the use of extremely low air pressures (*i.e.,* less than 10 μ) moisture can be rapidly removed from heat-sensitive materials.

Three pumping methods are normally employed for the removal of water vapour at low temperatures: steam ejectors, refrigerated condensers and chemical absorption systems. In the case of steam ejectors, partial air pressures below 50 μ are feasible on a commercial scale and very large volumes of water vapour may be handled at slightly higher pressures. In other systems, the free air is removed with steam ejectors or mechanical pumps, alone or in combination with oil diffusion pumps. The water vapour is then (a) condensed or (b) absorbed. Free air pressures as low as 1 to 10 μ are possible and under such conditions moisture can be removed at temperatures in the product as low as −75° C.

The possibility of low-temperature drying has been applied for many years to the preservation of biological products on a small scale. It was only after recent advances in vacuum engineering that low-temperature high-vacuum dehydration was applied on a commercial scale.

Blood Plasma.—In order to prevent changes in composition, and to preserve a so-called lyophilic structure capable of rapid rehydration, blood plasma is vacuum dried from the frozen state.

Biologicals, *etc.*—Low-temperature drying has also been applied to penicillin, sera, vaccines, bacteria, nerves, etc.; through the use of the very low temperatures made possible by high vacuum, cellular structure may be preserved throughout the drying cycle and the biological properties maintained after reconstitution even though the product in dried form is stored for long periods.

Foods.—The vacuum dehydration of food products had, by 1951, offered one of the most promising solutions to the production of a high-quality product. The original structure may be maintained, flavour and colour are relatively unimpaired. and sufficiently low moisture content may be produced (0.5% to 1%) to ensure a satisfactory storage life. Because of the relatively high costs involved, vacuum dehydration at air pressures in the micron range has been applied to such relatively expensive materials as orange juice and soluble coffee. The vacuum process for producing a 4:1 concentrate of frozen orange juice had by 1950 become a $100,000,000 a year business. Vacuum drum driers operating at moderate vacuums (10 mm. to 50 mm.) are used for a variety of products such as tomato paste, soups, coffee, etc.

Vacuum Evaporation.—Through the use of pressures below 10^{-4} mm., a variety of metals and salts may be evaporated and their vapours subsequently condensed on a surface.

Low-Reflection Coatings.—So-called low-reflection coatings are produced by evaporating magnesium fluoride, or material of comparable refractive index, in a vacuum system and depositing the vapour to a controlled thickness (one-quarter of a wave length) on a lens or other optical surface.

Reflecting Surfaces.—This same technique may be used to produce front surface mirrors on glass, plastics or other material. Aluminum is commonly employed and evaporated from a heated tungsten filament. Chromium, gold: rhodium, silver, etc., are also used for special applications.

Decorative *Coatings.*—For decorative purposes, plastic sheeting and cloth may be continuously coated with metals by vacuum evaporation. In the case of plastic and paper sheeting, the metal-coated product is used for the manufacture of electrical condensers. Gold leaf may also be made in this manner, by stripping the metal foil after applying to a thin surface.

Other Coatings.—There are many applications for electrically conducting coatings. Piezo quartz crystals are coated with silver in order to improve frequency characteristics and stability. Conducting layers can also be applied to plastic insulated wave guides, quartz fibre suspensions for instruments, etc.

Vacuum **Sputtering.**—Vacuum sputtering involves coating (usually of nonconductors) by means of a gas discharge at 1 mm. to 0.01 mm. The surface to be coated is placed near the Crookes dark space and a cathode formed of the material to be sputtered.

Vacuum Distillation.—At low pressures the boiling point or distillation temperature of all chemical products is materially reduced. In most commercial processes, pressures of 25 mm. to 100 mm. are sufficient. This range is economically attained on a large scale with conventional steam ejectors and the fractionation of petroleum oils is one of the largest operations under such conditions.

High *Vacuum* Distillation.—Through the use of noncondensible gas pressures below 50 microns and vapour paths of low impedance, between evaporating and condensing surface, the distillation point of many high boiling products—waxes, higher alcohols; esters—is sufficiently reduced to permit purification with some fractionation without undue decomposition.

Molecular Distillation.—If the residual gas pressure is reduced to less than 10^{-3} mm. Hg., a point will be reached where any further reduction has substantially no effect on the rate of distillation. If at these pressures the distance between distilling and condensing surface is small and unimpeded, so-called molecular distillation takes place. By such a technique many materials of high molecular weight may be distilled, which otherwise could be handled only with excessive decomposition, if at all.

Commercially, this method has been successfully applied to the production of vitamin concentrates, by direct distillation of vitamin-bearing oils.

Electronics.—The electronics industry has long been concerned with the production of extremely low pressures. With the exception of large continuously pumped systems used with high-voltage X-ray tubes, large magnetrons, etc., high vacuum must be maintained in a closed space for long periods of time. Pressures as low as 10^{-8} mm. to 10^{-5} mm. Hg. are required for many electronic devices, the lowest being necessary to prevent formation of positive ions as in cathode ray and other tubes employing high-voltage electrons. Most electronic devices are now evacuated with oil diffusion pumps. In some cases (*e.g.,* receiving tubes), residual gases are absorbed with "getters" such as barium, magnesium or other reactive metals.

Vacuum Impregnation.—High-vacuum techniques are commonly used as an aid to impregnation processes. Products to be treated are usually placed in a vacuum chamber and the pressure reduced to something less than 1 mm. The chamber is subsequently filled with the impregnation medium which in turn displaces the entire volume previously exhausted. This method of processing finds wide application in the electrical industry where it is a common practice to vacuum impregnate condensers, coils, transformers, cables, etc., with waxes, resins, oils or other materials of appropriate insulating characteristics.

Miscellaneous.—Industries of a wide variety employ high vacuum in one or more stages of product manufacture. In the manufacture of refrigerators it is necessary to remove all traces of water from the entire compressor system, including the small valves, pipes and fittings. This is accomplished by vacuum treatment at pressures of 10 to 200 μ.

A similar procedure is employed in the manufacture of bellows-type barometers and vapour operated thermometers. In the latter case, proper calibration can be achieved only with the complete removal of both condensible and noncondensible gases prior to filling with the operating fluid. (R. S. ME.)

Other applications of vacuum techniques formed the basis for such new industries as the production of citrus juice concentrates. Diffusion pumps of huge size have been employed in the metallurgical industries and the television industry. The low cost of television receivers would be impossible without the routine production of high vacuum by methods which were formerly considered a sophisticated laboratory art. The huge particle accelerators, such as the cyclotrons, the synchro-cyclotrons, the cosmotrons and the linear accelerators: all depend on diffusion pumps having speeds of tens of thousands of litres per second. (P. E. K.)

The manufacture of all vacuum bottles of course depends upon the maintenance of pressures below 10 μ for thermal insulation. Vacuum spectrographs permit industry to carry on spectrographic research and production control operations in the ultra-violet regions of the spectrum. (R. S. ME.)

VACUUM BRAKE, a form of brake utilizing the force exerted on a piston by the pressure of the atmosphere. As long as a vacuum is maintained in the system the brake blocks are kept off the wheels.

However, when air is admitted it presses against one side of the piston and applies the blocks. See BRAKE: *Motorcar* Brakes; *Railroad* Brakes.

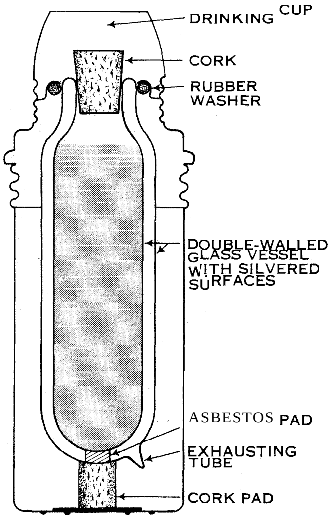
VACUUM CLEANER. An appliance for extracting and removing dust from fabrics, such as carpets, upholstered seats, cushions. etc.. by suction only or by suction and a motor driven brush, designed for the primary purpose of carrying out this operation without the necessity of displacing the articles to be cleansed from the positions which they normally occupy when in use.

It is also used to remove dust from such surfaces as those of floors, shelves, walls, etc. It was so named by H. C. Booth, who made and patented a successful appliance in 1901.

A vacuum cleaner consists essentially of an air suction pump, or exhauster, connected by a pipe or tube or directly to a nozzle having an orifice which is passed over the material being cleansed, the surrounding lip of the orifice being kept in close contact with the material. An air filter which cleanses the air either before or after its entry into the exhauster serves at the same time as a chamber, or receptacle, for collecting the dust, which can be removed therefrom conveniently and without dispersal. In the domestic floor or stick types, this receptacle is often of cloth in the shape of a bag. Tank or cylinder cleaners use other types of receptacles.

In operation, suction from the air exhauster causes air to rush violently into the nozzle through the interstices of the fabric being cleansed and to carry away with it the imprisoned dust. See HOME EQUIPMENT.

(H. C. Bo.; X.)



VACUUM FLASK. EVACUATED SPACE RETARDS TRANSMISSION OF HEAT TO OR FROM CONTAINER

VACUUM DISTILLATION: see DISTILLATION.

VACUUM FLASK, a glass vessel with double walls, the space between which is evacuated. The only junction of the walls is at the neck of the vessel. It is also known as a Dewar vessel after its inventor Sir James Dewar (*q.v.*); Thermos flask is a proprietary name applied to a form protected by a metal casing.

It was invented in the first place to preserve liquefied gases (see LOW-TEJLPERATURE PHYSICS) by preventing the transference of heat from the surroundings to the liquid. The evacuated space between the glass walls is practically a nonconductor of heat, and radiation is reduced to a minimum by silvering the glass. The chief path by which heat can be communicated to the interior of the inner vessel is at the junction of the walls at the vessel's neck, which is consequently made as small as possible. This thermal isolation applies equally to heat, a hot liquid remaining at a high temperature for several hours. Where the flask is subjected to rough usage, metal has been substituted for glass. but the latter is the more efficient material.

VACUUM PUMP: see VACUUM.

VACUUM TUBE: see ELECTRON TUBE.

VACZ or VAC (Ger. WAITZEN), a town in Pest *Megye* (county). Hungary. 20 mi. N. of Budapest on the left bank of an arm of the Danube at the foot of the Cserhát mountains, where the river takes its southward course.

On the hills around the town are large vineyards and viticulture is an important industry. There are also distilleries and textile, soap and shoe factories. The town is the see of a bishop and has an 18th century cathedral and episcopal palace. Vacz has numerous architectural remains as well as a museum of the Roman and medieval relics in which the district is so rich. Pop. (1957 est.) 23,000 (mun.).

VAGA, PERINO DEL (PIETRO BUONACCORSI) (1500–1547), a painter of the Roman school, was born near Florence on June 28, 1500. Perino was first apprenticed to a druggist, but soon came under tutelage of a mediocre painter, Andrea da Ceri, and, when 11 years of age, of Ridolfo Ghirlandajo. The painter, Vaga from Toscanella, undertook to settle the boy in Rome, but first set him to work in Toscanella. Perino, when he at last reached Rome. was poor, and with no clear prospect beyond journeynork for trading decorators He was eventually entrusted with some of the subordinate work undertaken by Raphael in the Vatican.

He assisted Giovanni da Udine in the stucco and arabesque decorations of the *logge* of the Vatican, and executed some of those small scriptural subjects which go by the name of "Raphael's Bible" — Raphael himself furnishing the designs. Perino's examples are: "Abraham About to Sacrifice Isaac." "Jacob Wrestling With the Angel," "Joseph and His Brethren," the "Hebrews Crossing the Jordan," the "Fall and Capture of Jericho," "Joshua Commanding the Sun to Stand Still," the "Birth of Christ," "His Baptism" and the "Last Supper."

Vaga also painted, after Raphael's drawings, the figures of the planets on the ceiling of the great hall of the Appartamenti Borgia.

After Raphael's death in 1520 he executed several works independently in Rome, in the churches of S. Marcello and Trinità de Monti. He then returned to Florence. where his work was much appreciated. On his return to Rome in 1523 he associated himself with Giulio Romano and Penni, whose sister he married. After the sack of Rome in 1527 he settled in Genoa, where he was employed in decorating the Doria palace. He ornamented the palace and frescoed historical and mythological subjects in the apartments, fanciful and graceful arabesque work, sculptural and architectural details. Among the principal works are. the "War Between the Gods and Giants," "Horatius Cocles Defending the Bridge" and the "Fortitude of Mutius Scaevola." He also did some work in Pisa in the *duomo* and elsewhere. Finally he returned to Rome, where Paul III allowed him a regular salary. He worked in the Sala della Segnatura (Vatican) on the monochrome decoration of the basement, to replace Fra Giovanni's woodwork decoration which had been destroyed in the sack of 1527; he was engaged in the decoration of the Sala Reale, begun by Paul III, when his health gave way, and he died on Oct. 19, 1547. Vaga is buried in the Pantheon. (W. M. R.)

VAGRANCY. Since the establishment of settled government in England people wandering from their usual habitations, without visible means of support or socially approved reasons for their movements, have been classed as vagrants. Such persons have been subjected to a series of repressive statutes since the 7th century. though the reasons for their official condemnation have varied. In medieval England the masterless man was a potential criminal. By the 14th century, when declining population had given a scarcity value to labour, escaping serfs or landless labourers, absconding from their communities, were regarded as a threat to the traditional social order. Tudor rulers considered vagrancy as politically dangerous. By the 17th and 18th centuries vagrants had become a social nuisance and an economic liability.

Every kind of punishment has been used to eliminate vagrants. In 1360 fugitive labourers could be branded. The act of 1495 committed vagrants to the stocks for three days on a diet of bread and water. In 1530 they were to be whipped and sent home. A statute of 1547 condemned them to slavery for a year for a first offense, for life for a second and to a felon's death for a third. Three years later this act was repealed and whipping, henceforth the usual punishment, was revived. The act of 1597 ordered vagrants to be whipped until their backs were bloody, then returned to their birthplace. last place of residence or to the house of correction. This act remained the basis of the vagrancy laws until 1714, when it was amended to secure greater efficiency.

In 1744 vagrants were classified as (1) idle and disorderly persons, (2) rogues and vagabonds and (3) incorrigible rogues.

By the 17th century the administration of these laws had become slack, even though to secure stricter execution, rewards were given to constables for apprehending vagrants and the expense of removal was borne by the county (1690). Gradually floggings became less frequent. Though forbidden to do so magistrates gave passes to vagrants without previous punishment as the easiest way of getting rid of them, or regular vagrant contractors undertook for a fixed sum to move them to their place of settlement. It was this breakdown in the vagrancy laws that led to the appointment of a select committee in 1821 to inquire into the problem.

The report of the committee was followed by the repeal of existing legislation and by a new act of 1824, which left vagrancy offenders liable to punishment as idle and disorderly persons. as rogues and vagabonds or as incorrigible rogues. (D. ML.)

Ten years later the reform of the poor law in 1834 modified the general institutional background. The poor lam commissioners recognized in 1837 that all cases of destitution should be relieved irrespective of the fact that applicants might belong to distant parishes. Five years later, by act of parliament. they were ordered to require vagrants to work in return for food and lodging. In 1848 when the poor law board took the place of the poor law commission it urged uniformity in treatment of vagrants, refusal of relief to able-bodied men not actually destitute, and employment of police officers as assistant relieving officers for vagrants.

Poor law reform and growing economic prosperity greatly reduced vagrancy. A small number of vagrants continued to seek temporary work and shelter. To deal with the problem, more casual wards were provided by workhouses! and more private lodginghouses were designed for vagrants. The growth of social legislation in the 20th century further modified the approach to vagrancy. The setting up of labour exchanges in 1909, the provision of unemployment insurance from 1911 onward. the growth of national assistance after 1934 and the welfare policy put into effect by such measures as the National Insurance act of 1946 and the National Assistance act of 1948, reduced vagrancy to manageable proportions.

Twentieth-century trends can be traced back to the departmental committee on vagrancy, 1906, which suggested that the control of casual wards should be transferred to the police with a view to securing uniform treatment throughout the country. By the 1930s it was often necessary for vagrants to apply for tickets at police stations before they could sleep in casual wards. although the police had no final control. By then in many parts of the country vagrancy committees had been set up for counties or larger areas, while in London the Metropolitan Asylums board had unified the London wards, made them cleaner and more efficient and introduced greater uniformity in administration.

Just as the poor law as a whole, however, retained a deterrent element until 1946, so the care of vagrants was influenced by stringent moral considerations. The casual poor relief order, 1925, for example, while requiring poor law authorities to provide for vagrants "a decent and proper provision for sleeping, for the drying and disinfection of clothes, and for personal cleanliness" added that "every opportunity should be afforded to a casual to alter his mode of life, especially if he is an elderly man, by entering the institution." Guardians were told to insure that "children should not be allowed to grow up to a life of vagrancy." The Local Government act, 1929, which transferred responsibility for vagrants from the guardians to the county councils and county boroughs, did not change policy.

In 1935 a new act stated that no unemployed person should be described as a vagrant unless he had been directed to a reasonably accessible place of shelter and failed to apply for or refused accommodation. It also insisted on the criterion of persistence in relation to "wandering abroad."

The National Assistance act (1948) changed both terminology and procedures. The term casual ward was replaced by reception centre, and it became the duty of the National Assistance board, with the support of local authorities, to make provision for "persons without a settled way of life." In the well-managed reception centre the casual was to receive a bath, a clean bed and food. In return he had to do some housework. He was to be urged to stay at the centre until work was found and to be interviewed by social workers who would examine his background. problems and qualifications. Old and ill casuals were to be transferred to hospitals or to rehabilitation centres maintained by voluntary organizations.

The number of vagrants decreased, although by mid-century a hard core still remained. In 1905 there were 9,768; in 1932 at the height of the economic depression. 16,911; in 1949 the post-1945 peak of 2,617. Most of the vagrants were men. nearly two-thirds of them under 50, and a high proportion of them without family responsibilities. Investigation of the conticued causes of vagrancy was becoming associated with psychological inquiry more than with an analysis of prevailing economic conditions. (See also POOR LAW; SOCIAL SECURITY; SOCIAL SERVICE.)

BIBLIOGRAPHY.—There is no modern study of the history of vagrancy. *See* C. J. Ribton-Turner, *History of Vagrants and Vagrancy* (London, 1887); W. H. Dawson, *The Vagrancy Problem* (London, 1910); the Vagrancy acts of 1824, 1935 and the National Assistance act, 1948. (A. BRI.)

Vagrancy in the United States.—Statutes had been passed by the legislatures of about. 40 states by the mid-rqjos to codify and extend the English definitions of vagrancy. Different types of personal condition by "being" certain types of person are included. Almost all of these laws define vagrancy to include living in idleness without any visible means of support; nearly half of them also include being a common prostitute. Other conditions frequently covered include persons who are common drunkards or common gamblers, keepers of gambling houses or keepers of houses of prostitution, associates of knovin thieves and wanton, dissolute or lascivious persons. Many laws also include persons guilty of specific acts of wandering, loitering or begging.

Vagrancy is usually a misdemeanour punishable by a small fine or a jail sentence of a few months. In most states there is no right to trial by jury, since vagrancy was not historically one of the "crimes" for which common constitutional provisions guarantee a jury trial. Conviction of vagrancy based upon personal condition ordinarily requires evidence of a series of acts showing the existence of the forbidden condition. Proof of a bad reputation alone is not enough. Since the crime is committed wherever the defendant may be found, it may be proved by acts evidencing it committed in another jurisdiction. Reformation by the defendant before trial is generally held a bar to conviction.

Vagrancy prosecutions constitute an important method of crime prevention. This is because the overt acts required to prove vagrancy frequently also show an intent to commit offenses in the future. Known criminals may be harassed hy vagrancy prosecutions until they move on, or may be held temporarily during a period of emergency. Drunkards and other derelicts also may be picked up on vagrancy charges, and given a night's lodging in jail and a chance to become sober out of harm's way.

When members of the criminal classes are believed to be involved in some serious crime it is often possible to arrest them legally for vagrancy. This legalizes incidental searches and permits the defendants to be held for a sufficient time to secure evidence of guilt of the serious crime through fingerprint checks and police line-ups for identification. Even if the evidence of the other crime remains too weak for successful prosecution. some punishment may be meted out by pressing the original vagrancy charge.

Prior to the middle 1930s, occasionally it was claimed that vagrancy prosecutions were used against strikers and other labour agitators. The breadth and vagueness of the definition of the crime gave the police an unusually wide discretion in its use. Vagrancy prosecutions were not much used in connection with labour disputes after 1935.

So-called "gangster acts" were passed in several states. imposing drastic penalties on vagrants where the additional element of association with others for criminal purposes could be proved. A New Jersey law of 1935 provided up to 20 years' imprisonment for any person with a prior criminal record, not engaged in any lawful occupation, who was "known to be a member of any gang consisting of two or more persons."

In 1939 the Supreme Court of the United States held this New Jersey law to be "so vague, indefinite and uncertain that it must be condemned as repugnant to the due process clause of the Fourteenth Amendment." (*Lanzetta* v. New Jersey, 306 U.S. reports 451 at 458.) The decision that this law was unconstitutional put an end to the attempt to use such gangster acts in the war on organized crime. This decision did not, however, lessen the effectiveness of vagrancy prosecutions against small-time criminals, persons suspected of serious crime acd potential offenders.

See Forrest *W*. Lacey, "Vagrancy end Other Crimes of Personal Condition," *Harvard Law Review*, vol. 66, p. 1203 (1953). (L. HL.)

VAI (or VEI), a Mandingo-speaking Negro tribe (Mandé-fu subgroup), about 40.000 in number, inhabiting the Pujehun district of Sierra Leone and the neighbouring part of Liberia. They are remarkable for the use of a syllabic script of more than 160 signs invented in the first half of the 19th century by Momolu Doalu Bukere (d. 1850), and unrelated to any other script.

See A. Klingenheben, "The Vai Script," *Ajrica*, vol. vi, pp. 158–171 (London, 1933). (W. B. FC.)

VAIDA-VOEVOD, ALEXANDRE (1871–1950), Rumanian statesman, mas born at Olpret, Transylvania, in 1871. He studied medicine in Vienna and practised for many years at Karlsbad (Karlovy Vary). At the age of 28 he joined the National Rumanian party of Transylvania and from 1906–18 sat in the Hungarian parliament at Budapest, where he waged a permanent fight in defense of the Rumanians in Transylvania. On the collapse of the Central Powers in the autumn of 1918. Vaida-Voevod was instructed by the newly formed "Rumanian National committee," to voice their claims in the Hungarian parliament. Invoking the right of self-determination he denied the right of the Hungarian government to speak in the name of the Rumanians of Transylvania and claimed that the latter should have their own representative at the peace conference. Soon after. the Rumanian National committee took administrative control of Transylvania and delegated Vaida-Voevod to represent the Rumanians of Transylvania and the Banat at the peace conference in Paris.

In 1919 Vaida-Voevod was appointed prime minister and minister for foreign affairs of Rumania and in the latter capacity went to Paris and London early in the following year to negotiate with the French and British governments the recognition of the union of Bessarabia with Rumania. This he succeeded in doing in March 1920 when the rights of Rumania over Bessarabia were recognized by the Supreme Economic council. and afterward ratified by the Treaty of London (Oct. 28, 1920). Vaida-Voevod resigned in the same year and afterward sat in parliament as one of the lenders of the National Rumanian party. from which he later resigned. He was prime minister again from Aug. to Oct.

1932, and from Jan. to Nov. 1933. He died March 19, 1950.

VAIL, THEODORE NEWTON (1845–1920), U.S. businessman, twice president of the American Telegraph and Telephone company, was born in Carrol county, Ohio, July 16, 1845. He began his career as a telegraph operator for the Union Pacific railroad and rose to general superintendent in 1875. In 1878 he became general manager of the American Bell Telegraph company and in 1885 the first president of the newly organized American Telephone and Telegraph company. He resigned two years later because of ill-health.

In 1907 he was re-elected president and upon resigning again in 1919 became chairman of the board. He died in Baltimore, Md., on April 16, 1920.

See A. B. Paine, *Theodore N. Vail, A Biography* (1929).

(J. R. Lt.)

VAILLANT, EDOUARD MARIE (1840–1915), French politician, was born in Vierzon, Cher, on Jan. 28, 1840. He studied science, residing in Heidelberg, Tubingen and Vienna. On his return to Paris he took part in the republic and socialist battle against the Second Empire, becoming a disciple and friend of Louis Blanqui. On March 18, 1871, he took part in the Commune insurrection, and, on the 26th, was elected a member of the Commune. He was a delegate on the executive commission, and his work for public instruction displays his revolutionary audacity and his scientific knowledge.

After the defeat of the Commune he fled to England and became associated with Karl Marx. But, after having been a member of the general committee of the First International, after having participated in 1872 in the congress at The Hague, he induced his friends to abandon this association because it seemed to him to be insufficiently revolutionary. He founded "The Revolutionary Commune" which published the manifesto in which these disciples of Blanqui declared themselves to be atheists, republicans, communists, revolutionaries and partisans of class conflict.

Condemned to death by the war council in 1872, Vaillant only returned to France in 1880 under amnesty. He was a founder of the Socialist Revolutionary party, and in 1884, he became a municipal councillor of Paris, becoming deputy in 1893. Under his direction, the Blanquist party made itself noticeable among the other socialist parties. In Boulangisme (1889), he separated from other blanquists, who, through nationalism, were inclined to accept a plebiscitary dictator.

In 1899, and again in 1905, Vaillant made himself the apostle of socialist unity in France. When in 1905, all the socialist parties united, he became a very close friend of Auguste Jaurbs, and secured with him the majority in all socialist congresses until 1914. He advocated the eight-hour day, security and hygiene for workers, remedies against stoppage of work, and a struggle against war.

In Aug. 1914 Vaillant considered that France was attacked and that it was the duty of the socialists to defend it as in 1870 and 1871. He resumed the formulas of Blanquist socialism and declared himself unreservedly in favour of national defense.

VAILLANT, GEORGE CLAPP (1901–1945), U.S archaeologist, an authority on the ancient civilizations of middle America. nas born on April 5. 1901, in Boston, Mass. Educated at Harvard (Ph D., 1927), his first archaeological field work was undertaken in Arizona for the university's Peabody museum. Later he nent on expeditions to Pecos. N.M., Yucatan and Egypt. While affiliated nith New York's American Museum of Natural History (1927–41), where he became curator of Mexican archaeology, he undertook major excavations in the valley of Mexico, identifying and describing the successive stages that gave rise to the higher civilizations culminating in the Aztec empire His lively and authoritative account. *The* Aztecs of *Mexico* (1944), became a classic.

At the museum he reinstalled collections from Central America and Mexico, skillfully emphasizing their artistic values. He taught at New York and Columbia universities and was director of the university museum of the University of Pennsylvania from 1941 until his death. His relations with Mexican scholars furthered international scientific collaboration. In this, as well as in his research, he was aided by his wife, Suzanna Beck. During World War II he served as cultural officer for the U.S. foreign service in Peru.

Vaillant died May 13, 1945 in Valley Forge, Pa. (A. V. K.)

VAISESHIKA, one of the six schools of thought to which Indian philosophers adhered in the centuries following the Epic period See INDIAN PHILOSOPHY: The Six Systems.

VAISHNAVITES (Bengal). Chaitanya, the founder of the great Vaishnava sect of Bengal, was the son of a high-caste Brahman of Nadiya, the famous Bengal seat of Sanskrit learning, where he was born in 1485, two years after the birth of Martin Luther, the German reformer. Having married in due time, and a second time after the death of his first wife, he lived as a householder (grihastha) till the age of 24, when he renounced his family ties and set out as a religious mendicant (vairagin), visiting during the next six years the principal places of pilgrimage in northern India, and preaching with remarkable success his doctrine of Bhakti, or passionate devotion to Krishna, as the supreme deity.

He subsequently made over to his principal disciples the task of consolidating his community, and passed the last 12 years of his life at Puri in Orissa, the great centre of the worship of Vishnu as Jagannatha, or "lord of the world," which he remodelled in accordance with his doctrine, causing the mystic songs of Jayadeva to be recited before the images in the morning and evening as part of the daily service; and seeking to humanize divine adoration by bringing it into accord with the experience of human love. To this end, music, dancing, singing parties (sankirtan), theatricals—in short anything calculated to produce the desired impression—would prove welcome to him.

His doctrine of Bhakti distinguishes five grades of devotional feeling in the Bhaktas. or faithful adherents: viz., (*santi*) calm contemplation of the deity; (dasye) active servitude; (sakhya) friendship or personal regard; (vatsalya) tender affection as between parents and children; (madhurya) love or passionate attachment, like that which the Gopis felt for Krishna. Chaitanya promoted the celebration on an imposing scale of the great Puri festival of the Rathayatra, or car procession, in the month of Ashadha, when, amidst multitudes of pilgrims, the image of Krishna, together with those of his brother Balarama and his sister Subhadra, is drawn along, in a huge car, by the devotees. This festival was, and is, attended by people from all parts of India, without distinction of caste or sex. All classes, even Mohammedans, were admitted by Chaitanya as members of his sect. The ordinary form of worship is very simple, consisting mainly of the constant repetition of names of Krishna, or Krishna and Radha, which of itself is considered sufficient to ensure future bliss. The partaking of flesh food and spirituous liquor is strictly prohibited. By the followers of this sect, also, an extravagant degree of reverence is habitually paid to their gurus or spiritual heads. Indeed, Chaitanya himself, as well as his immediate disciples, have come to be regarded as complete or partial incarnations of the deity to whom adoration is due, as to Krishna himself; and their modern successors, the Gosains, share to the fullest extent in the devout attentions of the worshippers. Chaitanya's movement was directed against the vile practices of the Saktas (see SAKTISM) then very prevalent in Bengal, but his own doctrine of divine, though all too human, love was by no means free from corruptive tendencies. While in Chaitanya's creed, Krishna, in his relations to Radha, remains at least theoretically the chief partner, an almost inevitable step was taken by some minor sects in attaching the greater importance to the female element, and in this way making Krishna's love for his mistress the guiding sentiment.

VALAIS, a canton of south Switzerland. The region is the old' *Vallis Poenina* (Upper Rhône valley). The former spelling, Vallais, was officially replaced in the early 19th century by Valais.

The modern canton includes the entire basin above St. Maurice, but below this point it consists of the western part only; its lower limits are in the Lake of Geneva. The total area is 2,020.7 sq.mi. (exceeded only by the Grisons and Berne), of which, however, only 55.9% is reckoned as productive; forests cover 282.6 sq.mi.

and vineyards 12.2 sq.mi. Its unproductive area includes the most considerable stretch of glaciers in Switzerland (c. 375 sq.mi.), together with about 5 sq.mi. of lakes. Poor as the canton is, it would be poorer were it not for its excellent wines—the area under vineyards is second only to Vaud (*q.v.*) and is increasing—and for its well-organized tourist traffic. Hotels have been built in nearly every tributary glen, and on the majority of the high pastures. The striking beauty of the scenery of its high glens, and the accessibility (see below) of the most characteristic features, have made the canton unusually popular, chiefly with summer visitors. The Upper Rhône occupies a northeast to southwest gorgelike trench from Gletsch to Brig; below this the valley widens and runs east to west to Leuk; onward it resumes its original course, ever widening until Martigny is reached, where the remarkably sharp bend carries the feature to the northwest; between St. Maurice and the lake is the only low land in the canton. The lowest commune is St. Gingolph (1,266 ft. alt.). The loftiest point is the Dufourspitze summit (15,200 ft.) of Monte Rosa, but the highest mountain wholly within the canton is the Dom (14,942 ft.). (See SWITZERLAND: Physical Geography.)

The chief railway line (about 75 mi.) through the canton is from St. Gingolph, on the Lake of Geneva, to Brig, at the north mouth of the Simplon tunnel (1895–1905—12¼ mi. long); from St. Maurice onward it forms part of the main through line from Lausanne toward Milan. There are also several mountain railways; *e.g.*, from Visp up to Zermatt (thence a branch up to the Gornergrat), from Vernayaz (near Martigny) past Salvan toward Chamonix, and from Leuk to Leukerbad, near the Gemmi pass and noted for its mineral springs. A new tunnel (1906–12) beneath the Lotschen pass, connects Kandersteg, in the Bernese Oberland, with Brig, thus opening up a new direct route from Paris to Italy, via Berne. The lofty alpine barriers of Valais are, as a rule, accessible only by footpaths or mule paths, but there are excellent roads over the Great St. Bernard pass (8,094 ft.) and the Simplon pass (6,591 ft.) to Italy, while at the head of the Rhône valley other excellently engineered roads give access to Uri over the Furka pass (7,992 ft.) and to Berne over the Grimsel pass (7,100 ft.).

In general, the boundaries of the canton run along the summit ridges of the surrounding mountains, but from an early date it has held a valuable part of the southern slope of the Simplon pass to below Gondo, as well as the rich Alpine pastures on the northern slopes between the Gemmi pass (7,641 ft.) and Schwarenbach.

The total population by the census of 1950 was 159,178; in 1930 it was 136,394, of whom 88,498 were French-speaking, 44,275 were German-speaking and 3,269 were Italian-speaking. The Italians decreased in number during the 20th century. The linguistic frontier has shown much oscillation; at present the inhabitants above Leuk generally speak a dialect of German, while below Leuk a Savoyard patois (French dialect) is the prevailing tongue. In general, the history of Valais (from 1810 to 1814 the French department of the Simplon) is a struggle between French and German elements. It is one of the last three admissions to the confederation. In 1930 there were 130,801 Catholics, 4,662 Protestants and 48 Jews.

The canton forms the 4th-century diocese of Sion (created *c.* 580) and has St. Théodule as its patron saint. Since 1513 its bishop has had no superior except the pope. Valais contains the three famous religious houses (all now held by Austin canons) of St. Maurice, of the Great St. Bernard, and of the Simplon. The abbey of St. Maurice (4th century and the oldest Christian foundation among the Alps) has, since 1128, belonged to the Augustinians. Since 1840 its abbot has borne the title of bishop of Bethlehem in partibus.

Good wines, especially muscat and vin du glacier, are produced in the canton, but the chief activity of the main valley below Brig is agriculture, rendered rather precarious in former days by extensive Rhône inundations. In the higher valleys the inhabitants are employed in pastoral occupations. The number of mountain pastures is greater, and they are better stocked in the more congenial Lower Valais than in Upper Valais (the line of division passing near Leuk). The capital is Sion (pop. 10,904). The canton has no large towns. The average density of the population in 1950, 79 per sq.mi., was but little above that of Uri (*q.v.*). Of the larger settlements, Monthey (5,608)—near St. Maurice—with an electric railway up the Val d'Illiez to Champéry, and Brig (3,854) are the most important. Naters, near the latter town, has a prosperous colony of Italian workmen.

Valais is divided into 13 administrative districts, which comprise 170 communes. The cantonal constitution was entirely remodelled in 1907. The legislature (grand conseil) is composed of 119 members elected by the people in the proportion of one for every 1,100 Swiss residents. The executive (*conseil d'état*) is composed of five members. Both councils hold office for four years. The obligatory referendum prevails for all laws and financial resolutions passed by the grand conseil, while 4.000 electors (6,000 in the case of a revision of the cantonal constitution) have the right of initiative as to legislative projects; the latter initiative dates back to 1848. The canton provides two members of the federal *Ständerat* and six members of the federal Nationalrat, elected by a popular vote. The principles of proportional representation are employed in communal elections.

History.—The Vallis Poenina was won by the Romans after a great fight at Octodurus (Martigny) in 57 B.C., and was so thoroughly Romanized that the Celtic aboriginal inhabitants and the Teutonic Burgundian invaders (5th century) became Romance-speaking peoples. Valais formed part of the kingdom of Transjurane Burgundy (888), which fell to the empire in 1032, and later of the duchy of Burgundia Minor, which was held from the emperors by the house of Zahringen (extinct 1218). In 999 Rudolph III of Burgundy gave all temporal rights and privileges to the bishop of Sion, who was later styled "praefect and count of the Valais." About the middle of the 13th century independent communities or tithings (*dizains* or Zehnten) were growing up, these, though seven in number, taking their name most probably from a very ancient division of the bishop's manors for administrative and judicial purposes. In the same century the upper part of the valley was colonized by Germans from Hasli (Bern), who Teutonized it, though many Romance local names still remain. In 1354 the liberties of several of the seven tithings (Sion, Sierre, Leuk, Raron, Visp, Brieg and Conches) were confirmed by the emperor Charles IV. A little later the influence of Savoy became predominant, and the count secured to his family the bishopric of Sion, of which he was already the suzerain. His progress was resisted by the tithings, which in 1375–76 crushed the power of the house of La Tour-Châtillon, and in 1388 utterly defeated the forces of the bishop, the count and the nobles at Visp, this being a victory of the Teutonic over the Romance element in the land.

From 1384 the Morge stream (a little below Sion) was recognized as the boundary between Savoyard or Lower Valais and episcopal or Upper Valais. In 1416–17 the Zehnten of the upper valley made an alliance with Lucerne, Uri and Unterwalden, with a view partly to the conquest of the Val d'Ossola, which was finally lost in 1422, and partly to the successful crushing of the power of the lords of Raron (1420). By the election of Walther von Supersax of Conches as bishop in 1457 the Teutonic element finally won the supremacy. On the outbreak of the Burgundian War, the bishop of Sion and the tithings made a treaty with Bern. In November of the same year (1475) they seized all Savoyard or Lower Valais up to Martigny, and in 1476 (March), after the victory of Grandson, won St. Maurice, Evian, Thonon and Monthey. The last three districts were given up in 1477, but won again in 1536, though finally by the treaty of Thonon in 1569 Monthey, Val d'Illiez and Bouveret alone were permanently annexed to the Valais, these conquests being maintained with the help of their old allies, Uri, Schwyz and Untermalden. These districts (or Lower Valais) were ruled as subject lands by the bishop and tithings of Upper Valais. In 1790–91 Lower Valais rose in revolt; but it was not finally freed till 1798, when the whole of Valais became one of the cantons of the Helvetic republic. Such prolonged resistance, however, was offered to French rule that in 1802 Bonaparte declared Valais an independent state under the name of the "Rhodanic Republic." In 1810, for strategic reasons, he incorporated it with France as the "department of the Simplon," and it was not freed till the Austrians came in 1813. In 1815 a local assembly was created, in which each of the seven tithings of Upper, and each of the six of Lower Valais elected four members, the bishop being given four votes. This constitution was approved by the federal Swiss diet, and the Valais was received as a full member of the Swiss confederation. By the constitution of 1839, the local assembly was to be elected according to population (1 member for every 1,000 inhabitants), and the bishop was given a seat instead of his four votes, while the clergy elected one deputy. By the 1844 constitution the clergy elected a second deputy. In 1844 there was civil war, and the Valais became a member of the Sonderbund. It was the last canton to submit in the Sonderbund War (1847) By the constitution of 1848 all ecclesiastical exemptions from taxation were swept away, and the bishop lost his seat in the assembly. New constitutions were framed in 1852, 1875 and 1907. (See SWITZERLAND: History.)

VALDEMAR I, king of Denmark (1131–1182), the son of Canute Lavard and the Russian princess Ingeborg, was born a week after his father's murder, and was brought up in the religious and relatively enlightened household of Asser Rig, whose sons Absalon and Esbjorn Snare, or "the Swift," were his playmates. On the death of King Eric Lam in 1147 Valdemar came fonvard as one of the three pretenders to the Danish crown, Jutland falling to his portion (compact of Roskilde [1157]). Narrowly escaping assassination at a banquet a few days later, at the hands of his rival, King Sweyn III, he succeeded only with the utmost difficulty in escaping to Jutland, but on Oct. 23 utterly routed Sweyn at the great battle of Grathe Heath, near Viborg, Sweyn perishing in his flight from the field.

Valdemar had no longer a competitor. He was the sole male survivor of the ancient royal line; his valour and ability were universally recognized, and in Absalon, elected bishop of Roskilde in 1158, he possessed a minister of equal genius and patriotism. The first efforts of the new monarch were directed against the Wendish pirates who infested the Baltic and made not merely the political but even the commercial development of the Danish state impossible. What the Northmen were to the western powers in the 8th and 9th centuries the Wends were to the Scandinavian lands in the 11th and 12th centuries. At the beginning of the reign of Valdemar the whole of the Danish eastern coast lay wasted and depopulated. Arkona, the chief sanctuary, and Garz, the political capital of the Wends, in the island of Riigen, were captured in 1169 by a great expedition under the command of Valdemar and Absalon; the hideous colossal idol of Rugievit was chopped into firewood for the Danish caldrons, and the Wends were christened at the point of the sword.

This triumph was only obtained, however, after a fierce struggle of ten years, in which the Danes were much hampered by the uncertain and selfish co-operation of their German allies, chief among whom was Henry the Lion, duke of Saxony and Bavaria, who appropriated the lion's share of the spoil. For at the beginning of his reign Valdemar leaned largely upon the Germans and even went the length, against the advice of Absalon, of acknowledging the overlordship of the emperor Frederick Barbarossa at the diet of Dôle, 1162. Very different was Valdemar's second conference with Barbarossa, on the banks of the Eider in 1182, when the two monarchs met as equals in the presence of their respective armies and a double marriage was arranged between two of Valdemar's daughters and two of the emperor's sons.

The only serious domestic trouble during Valdemar's reign was the rebellion of the Scanian provinces, which objected to the establishment of a strong monarchy inimical to local pretensions and disturbances, and especially to the heavy taxes and tithes necessary to support the new reign of law and order. The rising was ultimately suppressed by Absalon at the battle of Dysiaa, 1181. In the following year King Valdemar died.

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VALDEMAR II, king of Denmark (1170–1241), was the second son of Valdemar I and brother of Canute VI, whom he succeeded on Nov. 12, 1202. Already during his brother's lifetime, as duke of Schleswig, Valdemar had successfully defended Denmark against German aggression. In 1201 he assumed the offensive, conquered Holstein, together with Hamburg, and compelled Count Henry of Schwerin to acknowledge the overlordship of the Danish crown. Immediately after his coronation, he hastened to his newly won territories, and was acknowledged lord of Northalbingia (the district lying between the Eider and the Elbe) at Liibeck, Otto IV, then in difficulties, voluntarily relinquishing all German territory north of the Elbe to Valdemar, who in return recognized Otto as German emperor. Thus the three bishoprics of Liibeck, Ratzeburg and Schwerin, which hitherto had been fief of the Reich, now passed under Danish suzerainty. In 1208, when the emperor Otto felt more secure upon his unstable throne, he would have attempted the recovery of the lost German territory but for the interposition of Pope Innocent III, who threatened to excommunicate any German prince who should attack Valdemar, the equally pious and astute Danish king having undertaken. at the bidding of the holy see, to lead a crusade against the heathen Estonians. Valdemar's position was further strengthened by the accession of Frederick II, who formally renounced all the German lands north of the Elbe and Elde, as well as the Wendish lands on the Baltic, in favour of Valdemar.

Valdemar henceforth turned to the extension of the Danish empire over the eastern Baltic shores. There, however, he had already been forestalled by German colonists established in Gotland and at Riga. In 1206 Valdemar, urged by Archbishop Anders Suneson, had occupied the Isle of Oesel on the Estonian coast. In 1210 Valdemar led a second expedition eastward, this time directed against heathen Prussia and Samland, the chief result of which was the subjection of Mestwin, duke of Pomerania, the leading chieftain in those parts.

In 1218 the German Bishop Albert of Riga was driven to appeal for assistance to King Valdemar. Valdemar cheerfully undertook a new crusade "for the honour of the Blessed Virgin and the remission of my own sins." In 1218 he set sail for Estonia with one of the largest fleets ever seen in northern waters, including a Wendish contingent led by Prince Vitslav. Landing at Lyndantse (the modern Reval) in north Estonia, Valdemar at once received the submission of the inhabitants, but three days later was treacherously attacked in his camp and only saved from utter destruction by his own personal valour and the descent from heaven, at the critical moment, of a red banner with a white cross on it, the Dannebrog (Danes' Cloth), heard of for the first time, and which henceforth was to precede the Danish armies to victory till its capture by the Ditmarshers, three hundred years later. This victory was followed by the foundation of Reval and the occupation of Harrien and Wirland, the northern districts of Estonia, by the Danes.

King Valdemar II was then, after the king of England, the most powerful potentate in the north of Europe. The southwestern Baltic was a Danish sea, and Danish territory extended from the Elbe to Lake Peipus. But this scattered and heterogeneous empire required a large standing army and a strong central government to hold it together. It is doubtful whether even the genius of Valdemar would have proved equal to such a stupendous task. He never had the opportunity of attempting it. In May 1223 he was seized at midnight in his tent on the isle of Lyo, where he had gone to hunt, by his vassal and guest Count Henry of Schwerin, and conveyed with his son and many other valuable hostages to the inaccessible castle of Dannenberg-on-Elbe. In this dungeon he languished for two and a half years, and despite all the efforts of Pope Honorius III on his behalf, he was ultimately forced to pay a heavy ransom and surrender Northalbingia and all his Wendish conquests except Riigen.

On his release he tried to retrieve his position by force, but was defeated at Bornhoved (July 22, 1227), which deserves a place among the decisive battles of history, for it destroyed at once and for ever the Danish dominion of the Baltic and established the independence of Lübeck, to the immense detriment in the future of all the Scandinavian states. On the other hand Valdemar, by prudent diplomacy, contrived to retain the greater portion of Danish Estonia (compact of Stensby, 1238). With rare resignation Valdemar devoted the remainder of his life to the great work of domestic reform. His noblest achievement in this respect is the codification of the Danish laws known as the *Jydske Lov* (Jutland Code), which he lived to see completed a few days before his death at Vordingborg on March 21, 1241. Valdemar was twice married, his first consort being Dragomir (Dagmar) of Bohemia, his second Berengaria of Portugal. All his four sons, Valdemar, Eric, Abel and Christopher, became kings of Denmark.

See *Danmarks Riges Historie*, vol. i, pp. 736–849 (Copenhagen, 1897–1905). (R. N. B.; X.)

VALDEMAR IV, king of Denmark (*c.* 1320–1375), was the youngest son of Christopher II of Denmark. Valdemar was brought up at the court of the German emperor Louis of Bavaria during those miserable years when Denmark was partitioned among Holstein counts and German Ritter, while Scania, the breadbasket of the monarchy, sought deliverance from anarchy under the protection of Magnus of Sweden. Even the Hansa towns, the hereditary enemies of Denmark, regarded the situation with disquietude. "One would gladly have seen a single king in Denmark if only for peace sake," says the contemporary Lubeck chronicle, "for peace was not to be had either at sea or on land." The assassination at Randers of the detested Holstein tyrant Count Gerhard III (1340), who for nine years had held Jutland and Funen and dominated the rest of Denmark, first opened Valdemar's way to the throne, and on midsummer day 1340 he was elected king at a *Lartdsting* held at Viborg, after consenting to espouse Helveg, the sister of his most important confederate, Valdemar, duke of Schleswig.

Valdemar could not have been more than 20 when he became the nominal king of Denmark, though, as a matter of fact, his territory was limited to the northernmost county of Jutland. His precocious maturity is strikingly evident from the first. An energy which never slackened, a doggedness which no adversity could crush, a fiery ambition coupled with the coolest calculation, and a diplomatic unscrupulousness which looked always to the end and never to the means, these were the salient qualities of the reconstructor of the dismembered Danish state. First Valdemar aimed at the recovery of Zealand, which was actually partitioned among a score of Holstein mortgagees who ruled their portions despotically from their strong castles and sucked the people dry. The oppressed clergy and peasantry regarded Valdemar as their natural deliverer; but the work of redemption proved painfully slow.

In Nov. 1343 Valdemar obtained the town and castle of Copenhagen from King hlagnus Smek of Sweden by reconfirming in still more stringent terms the previous surrender of the rich Scanian provinces, and by the end of the following year he had recovered the whole of North Zealand. In 1347 the remainder of Zealand was redeemed, and the southern islands, Laaland, Falster and Mon, also fell into the king's hands. By this time, too, the whole of Jutland (except the province of Ribe) had fallen to him, county by county, as their respective holders mere paid off. In 1349 at the *Landsting* of Ringsted, Valdemar proudly rendered an account of his stewardship to the estates of Zealand, and the bishop of Roskilde congratulated him on having so miraculously delivered his people from foreign thraldom. In Aug. 1346, he prudently rid himself of the distant and useless province of Estonia by selling it very advantageously.

In north German politics Valdemar interfered to protect his brother-in-law the Margrave Louis of Brandenburg against the lords of Mecklenburg and the dukes of Pomerania, with such success that the emperor Charles IV, at the conference of Bautzen, was reconciled to the Brandenburger and allowed Valdemar an annual charge of 16,000 silver marks on the city of Lubeck (1349). Some years later Valdemar even contemplated a descent on England in alliance with the French king John, but the chronic state of rebellion in western Denmark, fomented by the discontented Jutish magnates, lasted with short intervals from 1350 to 1360 and compelled Valdemar to renounce this fantastic design. But he proved more than a match for his domestic rebels, especially after his great victory at Brobjaerg in Funen (1357). Finally, the compact of Kalundborg restored peace to the kingdom.

Valdemar now turned his eyes to the "kingdom of Scania." Valdemar had indeed pledged it solemnly and irrevocably to King Magnus of Sweden, who had held it for 20 years; but profiting by the difficulties of Magnus with his Norwegian subjects, after skilfully securing his own position by negotiations with Albert of Mecklenburg and the Hanseatic league, Valdemar suddenly and irresistibly invaded Scania, and by the end of 1361 all the old Danish lands, except North Holland, were recovered.

By the recovery of Scania Valdemar had become the lord of the great herring-fishery market held every autumn from St. Bartholomew's day (Aug. 24) to St. Denis' day (Oct. 9) on the hammer-shaped peninsula projecting from the southwest corner of Scania containing the towns of Skanor and Falsterbo. This flourishing industry, which fully occupied 40,000 boats and 300,000 fishers assembled from all parts of Europe to catch and salt the favourite Lenten fare of the whole Continent, was the property of the Danish crown, and the innumerable tolls and taxes imposed by the king on the frequenters of the market was one of his most certain and lucrative sources of revenue. Foreign chapmen eagerly competed for special privileges of Skanor and Falsterbo, and the Hanseatic merchants in particular aimed at obtaining a monopoly there. But Valdemar was by no means disposed to submit to their dictation, and political conjunctures brought about actual hostilities between Valdemar and the Hansa, or at least that portion of it known as the Wendish towns[1], whose commercial interests lay principally in the Baltic.

From time immemorial the Isle of Gotland had been the staple of the Baltic trade, and its capital, Visby, whose burgesses were more than half German, the commercial intermediary between east and west, was the wealthiest city in northern Europe. In July 1361 Valdemar set sail from Denmark at the head of a great fleet, defeated a peasant army before Visby, and a few days later the burgesses of Visby made a breach in their walls through which the Danish monarch passed in triumph. The conquest of Gotland at once led to a war between Valdemar and Sweden allied with the Hanseatic towns; but in the spring of 1362 Valdemar repulsed from the fortress of Helsingborg a large Hanseatic fleet provided with "shooting engines" (cannon) and commanded by Johan Wittenburg, the burgomaster of Lubeck. In Sweden proper he was equally successful, and the general pacification which ensued in April 1365, very greatly in his favour, was cemented by the marriage of his daughter Margaret with Haakon VI of Norway.

Valdemar was now at the height of his power. Every political rival had been quelled. With the papal see, since his visit to Avignon in 1364, he had been on the best of terms. His ecclesiastic patronage was immense, and throughout the land he had planted strong castles surely held by the royal bailiffs. But in the winter of 1367–68 a hostile league against him of all his neighbours threatened to destroy the fruits of a long and strenuous lifetime. The impulse came from the Hansa. At a *Hansetag* held at Cologne on Nov. 11, 1367, three groups of the towns, 70 in number, concerted to attack Denmark, and in Jan. 1368 Valdemar's numerous domestic enemies, especially the Jutlanders and the Holstein counts, acceded to the league, with the object of partitioning the realm among them.

And now an astounding and still inexplicable thing happened. At Easter-tide 1368, on the very eve of this general attack, Valdemar departed for three years to Germany, leaving his realm in the capable hands of the earl-marshal Henning Podbusk. Valdemar's skilful diplomacy, reinforced by golden arguments, did indeed induce the dukes of Brunswick, Brandenburg and Pomerania to attack the confederates in the rear; but fortune was persistently unfriendly to the Danish king, and peace was finally concluded with the towns by Podbusk and the Danish council of state at the congress of Stralsund, 1370. The con-

[1] Rostock, Greifswald, Wismar and Stralsund.

ditions of peace were naturally humiliating for Valdemar, though ultimately he contrived to render illusory many of the inordinate privileges he was obliged to concede. He was also able, shortly before his death on Oct. 24, 1375, to recover the greater part of Holstein from the rebels. (R. N. B.)

VALDÉS, JUAN DE (c. 1500–1541), Spanish religious writer, was born about 1500 at Cuenca. He has been confused with his twin brother Alfonso (Latin secretary of state from 1524; d. 1532 at Vienna). Juan probably studied at the University of Alcalá. In fear of the Spanish Inquisition he left Spain for Naples in 1530. In 1531 he moved to Rome, where his criticisms of papal policy were condoned.

From the autumn of 1533 Valdés made Naples his permanent residence, his name being Italianized as Valdesso and Val d'Esso. Valdés' house was the centre of a literary and religious circle; his conversations and writings (circulated in manuscript) stimulated the desire for a spiritual reformation of the church. His first production at Naples was a philological treatise, *Diálogo de la lengua* (1535). His works entitle him to a foremost place among Spanish prose writers. His friends urged him to seek distinction as a humanist, but his bent was toward problems of biblical interpretation in their bearing on the devout life.

Vermigli (Peter Martyr) and Marcantonio Flaminio were leading spirits in his coterie. On Bernardino Ochino, for whose sermons he furnished themes, his influence was great. Pietro Carnesecchi, who had known Valdés at Rome as "a modest and well-bred courtier," found him at Naples (1540) "wholly intent upon the study of Holy Scripture," translating portions into Spanish from Hebrew and Greek, with comments and introductions. Valdés died at Naples in May 1541, and his death scattered his band of associates. Some of Valdés' writings ivere published by degrees, in Italian translations. They combine a delicate vein of semimystical spirituality with the personal charm attributed to their author in all contemporary notices. Juan Llorente traces in Valdés the influence of Johannes Tauler; any such influence must have been at secondhand. The *Aviso* on the interpretation of Scripture, based on Tauler, was probably the work of Alphonso.

The suggestion that Valdés was unsound on the Trinity was first made in 1567 and was adopted by Sand (1684), Robert Wallace (1850) and other anti-Trinitarian writers, and is countenanced by Pierre Bayle. But Valdés never treats of the Trinity, reserving it as a topic for advanced Christians; yet he explicitly affirms the consubstantiality of the Son, whom he unites in doxologies with the Father and the Holy Spirit. Practical theology interested him more than speculative, his aim being the promotion of a healthy and personal piety.

Valdés' writings include *Diálogo de la lengua* (written, 1533; first printed, 1737); *Qual Maniera si devrebbe tenere a informare . . . gli figliuoli de Christiani delle Cose della Religione* (before 1545; Eng. trans., 1882); *Trataditos* (1881; Eng. trans., 1882); *Aliabeto Cristiano* (nritten about 1537; Eng. trans, 1861); *Cento e dieci divine considerazioni* (all copies of the original edition suppressed by the Spanish Inquisition; Eng. trans, 1638, 1865); *Comentario breve . . . sobre la epistola de San Pablo a los Romanos* (1556; Eng. trans, 1883); *Cowentario breve . . . sobre la primera epistola de San Pablo a los Corintios*, no 8 (1557); *El Evangelio de San Mateo* (1881; Eng. trans, 1883).

See B. Wiffen's *Life* of Valdés prefixed to Betts's translation of the *Considerations* (1865); E. Boehmer, *Spanish Reformers of Two Centuries* (1874), *Lives of J. and A. de Valde's* (1882). (*A.* Go.; X.)

VALDÉS LEAL, JUAN DE (1622–1690). Spanish painter and etcher, an unaccomplished draftsman but a subtle and original colourist who added a new note to Spanish painting, was baptized at Seville, May 4, 1622. His father Fernando de Nisa was Portuguese, his mother was Sevillian. He nas influenced first by Bartolomé Esteban Murillo; both artists were officers of the Academy of Draning, Seville. In 1653 Valdés Leal painted six scenes on the life of St. Clara for the convent in Carmona and in 1657. at Seville. a series on St. Jerome and the nuns and monks of Jerome's order. Perhaps his finest altarpiece was that done for the monastery of the Carmelitas Calzados at Córdoba (1658). As an etcher he was especially distinguished. His few portraits reveal skill in that branch of the arts. Paintings of many heads of martyred saints gained him the title of "the painter of the dead," and his *vanitas* motifs are unequaled in Spanish art. "The Hieroglyphs of the End of Our Days" (1672), two paintings on macabre subjects, done for the Hospital de la Caridad, Seville, are considered his masterpieces. His life was spent at Cordoba and Seville except for a brief journey to Madrid. He died at Seville on Oct. 14, 1690.

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VALDEZ, a town of Alaska, U S, farthest north all-$ear-open port in North America, on Prince William sound, about 370 mi. S. of Fairbanks. Selected in 1898 by the U.S war department as a base for exploration. it became the site of a military post, Ft. Liscum, where troops were stationed until 1922. The route of a military telegraph line from Valdez to the settlements of Eagle and Fairbanks became a trail, a wagon road and eventually the principal highway, known as the Richardson highway, open all year between the coast and the interior. Valdez thus became an important port of entry for shipments to Fairbanks, Anchorage and other cities. Gold and copper mining, fish canning and fur farming are important. Pop. (1960) about 600. (J. E. Cl.)

VALDNIA, a province of southern Chile where agriculture, lumbering and tourism flourish. It was one of the eight provinces created in 1826 but modifications have reduced its area, the latest occurring in 1943 when Osorno province (*q.v.*) was created. Valdivia's 8,083 sq mi. area includes coastal range, central valley and cordilleran landscapes. The central valley. its rolling eastern margin, and the westward extending lowlands of the Valdivia and Bueno river systems are agricultural; eastern and western uplands are forested. Vacationist attractions include the Valdivia estuary, and the lakes (Calafquén, Panguipulli. Riñihue, Ranco, Puyehue) and mountains of the east (notably volcanoes Choshuenco and Puyehue). Trout fishing, as in much of southern Chile, is remarkably good. Temperature extremes are moderate but the wmters are very met.

Pop (1952) 232.647. About 45% of the gainfully employed are engaged in agriculture and lumbering. Meat. wheat. lumber, milk, potatoes and fruit are the major products. Valdivia's lumber production is of major importance in Chile and its beef and dairy are also significant. Much of local industry is concerned with processing farm and forest products for domestic consumption but iron and steel smelting (Corral), foundry and metal fabrication, and seafood preserving (Valdivia) have been important. Stimulating all these phases of economic gron th have been German colonizers and their descendants. The first families settled near La Unión in 1846. Government-supported immigration, begun in 1850, developed clusters of Germans in Valdivia (q v.) and on farm land in the vicinity, and near La Unibn and Osorno (*q.v.*). Valdivia, pop. (1952) 45.203, is the provincial and departmental seat; La Unión (9,830) and Río Bueno (6,259) are departmental capitals. All are served by the longitudinal rail system that links Santiago uith Puerto hlontt. (J. T.)

VALDIVIA, a city in southern Chile with important manufacturing, lumbering, commercial and recreation functions, and the capital of Valdivia province (*q.v.*), was founded in 1552 by Pedro de Valdivia. It is located on the Valdivia river, about 12 mi. from the sea. Although a strategically significant outpost to colonial Spanish South America, Valdivia did not flourish until after the mid-19th century when German settlers introduced capital, vigour and fresh skills into local economic life. Pop. (1952) 45.203. Its commercial and administrative heart, on the river's south bank, is flanked by residential districts, railroad shops and factories (foodstuffs, metal fabricating, lumber products, boat yards). Linked to the city by two bridges is a north-bank industrial neighbourhood, the university, airport and fairgrounds. Construction in the 20th century employs modern design and materials but the preponderance of frame and corrugated metal buildings gives an interesting pioneer-city appearance. Almost all of Valdivia's important maritime trade is barged to or from Corral's anchorage. Both the city and the outport were severely damaged during the earthquakes that shook south-central Chile early in 1960.

The Valdivia-Corral area is a popular summer resort; the city is a gateway to Chile's lake district. (J. T.)

VALDOSTA, a city of southern Georgia. U.S., 120 mi. N.W. of Jacksonville, Fla.; the seat of Lowndes county. The area produces well over half of the nation's naval stores of turpentine. Agricultural products include tobacco, cotton, watermelons, peanuts and vegetables; factories in the city produce feed, fertilizer, textiles. and wood and metal products. Cattle raising is the predominant livestock industry.

Valdosta nas settled in 1859. George M. Troup. governor of Georgia, 1823–27, had chosen the name of the Italian province Valle d Aosta ("vale of beauty") for his estate and when the town was incorporated in 1860 the name was adopted in modified form. Chartered as a city in 1901, it established a council-manager form of government in 1958. The chief educational institution is Valdosta State college. a division of the University of Georgia (see GEORGIA: *Education*). Moody air force base, 10 mi. N. of the city, was established in 1941 and reactivated in 1951. Hunting is popular among sportsmen and the 80 lakes in the region provide fishing and uater sports. For comparative population figures see table in GEORGIA: *Population*. (S. B. K.)

VALENCE, a town of France, is on the Rhône Pop (1954) 36,659. Valentia was the capital of the Segalauni, and the seat of a celebrated school before the Roman conquest. a colony under Augustus, and an important tonn of Viennensis Prima under Valentinian The bishopric of Valence dates probably from the 4th century. Valence nas ravaged by the Alani and other barbarians, and fell successively under the power of the Burgundians the Franks. the sovereigns of Arles, the emperors of Germany, the dukes of Valentinois, the counts of Toulouse and its own bishops. The citizens put themselves under the protection of the dauphin, and in 1456 had their rights and privileges confirmed by Louis XI, the bishops recognizing the suzerainty of the dauphin. Valence became the capital of the Protestants of the province in 1563. The toun was fortified by Francis I. It had become the seat of a university in the 15th century, but the revocation of the Edict of Nantes crippled the town's prosperity.

VALENCE (or VALENCY), in chemistry, is the property of an element that determines the number of other atoms with which an atom of the element can combine. The property is not a simple one; the effort to obtain a clear understanding of the nature of valence led to the dissociation of the concept into several new concepts—of ionic valence, covalence, oxidation number, coordination number, metallic valence—corresponding to different modes of interaction of atoms. Some chemists have felt that the word valence might well be allowed to drop into disuse, in favour of these more precise terms. In practice, however, valence continues to be used as a general expression of the combining capacities of the elements or as a synonym for one or another of the more precise terms.

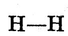
When, toward the middle of the 19th century, the relative weights of atoms and molecules became accurately known, especially through the reintroduction by Stanislao Cannizzaro in 1858 of Amedeo Avogadro's principle (1811) of the relation between the molecular weight and the density of a gas, it became clear that the number of atoms with which a given atom could combine varied with the nature of that atom: that, for example, a fluorine atom could combine with one hydrogen atom, an oxygen atom with two, a nitrogen atom with three and a carbon atom with four, forming the compounds HF, H_2O, H_3N and H_4C. These characteristic combining capacities were shown to extend to more complicated compounds: two of the four hydrogen atoms in methane, CH,, could be replaced by one oxygen atom, or all four by two, or three by one nitrogen atom, as in H_2CO, CO_2, HCN. Thus, it appeared that every atom could combine with or replace a definite number of other atoms of a specified kind, and hydrogen, since it was the lightest atom arid mas never found to combine with more than one atom of another element, was selected as the standard. The term valence, introduced in 1868, is used to express both the power of combination in general, and its numerical value.

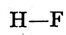
As the examination of the valence of elements was extended there was much dispute as to whether or not it was constant in value for any one element. It soon became evident that the valence of many elements is variable: for a time it was maintained that the variations were always by two units, so that elements could be divided into those of odd and those of even valence; but before long it was recognized that, although this is true of many elements, there are others whose valence must vary by single units at a time.

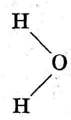
The discovery of the periodic classification of the elements by Dmitri Mendeléyev and Lothar Meyer (1864–69) brought to light a new regularity in the valences of the elements (see PERIODIC LAW). Mendeléyev pointed out that all the elements of a periodic group have the same principal valences, and that these change in value by one unit in passing from one group to the next. In particular, the highest valence of an element, as shown in its oxide, is equal to the ordinal number of the group to which it belongs. On the other hand, the valence in the hydrides seems to rise with that in the oxides from 1 to 4, and then to fall by steps of one unit to unity again.

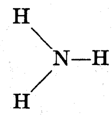
Earlier Theories—All discussions of valence in the 19th century were handicapped by the absence of any satisfactory theory of its cause. J. J. Berzelius, in the earlier part of the century, had assumed atoms to be electrically charged, and to be held together in the molecule by the attraction of opposite charges. This view was supported by the phenomenon of electrolysis, as investigated especially by Sir Humphry Davy and Michael Faraday. Its validity as a general theory of valence was. however, destroyed about 1840 by the discovery that under some conditions "electropositive" atoms could be replaced by "electronegative" atoms without any fundamental modification of the properties of the molecule: thus, part of the hydrogen in acetic acid can be replaced by chlorine, and the product resembles the original acid in many ways, and obviously must have a similar structure. The attempts of Berzelius to stretch his theory to explain such phenomena led to its falling into discredit, and it was in part replaced by what ultimately became the theory of structural chemistry.

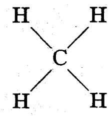
In this new theory no assumptions were made as to the nature of the forces connecting the atoms in a molecule, and hence no opposition in character between the atoms was required. Every atom was regarded as having a certain number of units of combining power, and every atomic link as involving the utilization of one of these units by each of the atoms concerned. Double and triple links, in which each of two atoms used up two or three of these units in combining with one another, were also recognized. The valence of an atom in the numerical sense was the number of such units that it possessed. On paper, the links were represented by lines, giving such formulas as

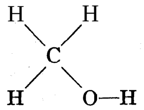

Hydrogen

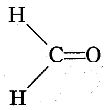

Hydrogen fluoride

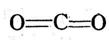

Water

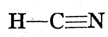

Ammonia


Methane


Methyl alcohol


Formaldehyde


Carbon dioxide


Hydrogen cyanide

This theory had an astounding success in its application to organic chemistry. It was found possible to determine from the reactions of a substance the order in which the constituent atoms are linked in the molecule and thus to assign to the vast hordes of organic compounds "structural formulas" that account for their existence and to a large extent also for their properties. For a discussion of further extensions of this theory, which made it possible to determine the approximate relative positions in space of the various atoms and groups in a molecule, see STEREOCHEMISTRY. The electrical theory again became prominent in and after 1887, with the rise of the Svante Arrhenius theory of salt solutions, which showed that a solution of a salt in water contains oppositely charged ions (a solution of sodium chloride, for example, contains positive sodium and negative chlorine ions) that have to a great extent the properties of free molecules.

(N. V. S.; L. C. P.)

Werner's Co-ordination Theory.—A new concept in chemistry was developed in 1893 by Alfred Werner. It had been recognized that many metallic salts have the power of combining with other salts or with water or ammonia or other molecules. The compounds formed in this way had not been fitted into any theory of valence, however, and their existence had been attributed to the action of weak residual forces, inferior to the forces of true valence. By the study of an immense number of these compounds, Werner showed that their compositions and properties could be systematized on the basis of a new assumption. This assumption, which was later completely verified by X-ray investigations of the structure of complex crystals (R. W. G. Wyckoff and R. G. Dickinson. 1920), is that a metal atom has the power of combining with a definite number (usually 4 or 6) of other atoms. ions or molecules, and "co-ordinating" them into a definite geometrical arrangement about itself. Werner was able to present sound evidence) consisting mainly' of the existence of isomers, to support his proposal that most complexes with "co-ordination number" 6, such as the hexachloroplatinate ion, $[PtCl_6]^{2-}$, and the cobaltic hexammine ion, $[Co(NH_3)_6]^{3+}$, have an octahedral configuration, the six attached groups being arranged at the corners of a regular octahedron about the central atom. He also showed that some complexes with co-ordination number 4 have a tetrahedral configuration (such as $[Zn(NH_3)_4]^{2+}$) and some have a square, planar configuration ($[PtCl_4]^{2-}$ and other complexes of bivalent palladium and platinum). General acceptance of Werner's co-ordination theory came in 1911, after his prediction and the experimental verification of the existence of the optical isomerism of some octahedral co-ordination complexes. See CO-ORDINATION COMPOUNDS; STEREOCHEMISTRY.

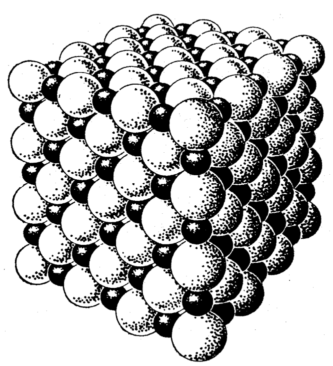
The Development of the Electronic Theory of Valence.—The modern electronic theory provides a detailed and thoroughly sound explanation of valence and chemical combination in terms of the electrostatic forces operating between electrons and atomic nuclei. The first great step in the development of this theory was made by G. N. Lewis (1916): the identification of the valence bond of organic chemistry with a pair of electrons held jointly by two atoms, and serving to hold them together. Lewis also discussed the relation between the electronic structure of atoms and the valence of elements, including their power to form ions. In the same year, the electronic structure of ions was discussed by W. Kossel; and after the development of the detailed electronic theory of the periodic system of the elements (see PERIODIC LAW) further progress in the formulation of the electronic theory of valence was rapidly made through the efforts of I. Langmuir. N. V Sidgwick and many other chemists.

Within two years after the development of quantum mechanics (*q.v.*) by W. Heisenberg, E. Schrodinger and P. A. M. Dirac, the fundamental nature of the shared-electron-pair chemical bond was elucidated by the quantum-mechanical treatment of the hydrogen molecule, carried out by W. Heitler and F. London in 1927. During the next few years many workers contributed to the application of quantum mechanics to the problem of chemical combination and valence, and rapid progress was made in the discovery of the principles determining the formation of shared-electron-pair bonds, the relation of the nature of bonds to the character of bond orbitals and the significance of quantum-mechanical resonance to molecular structure. As a result of this progress. and the great progress that has been made in the determination of the detailed atomic structures of molecules and crystals by methods of spectroscopy and the diffraction of X-rays and electrons, the theory of chemical valence is no longer a discussion of empirical rules but is in large part a precise discussion of electronic structures and interatomic forces firmly based on the modern knowledge of electrons and atomic nuclei and their interactions.

Ionic Valence.—Molten sodium chloride is a good conductor of electricity. This molten salt consists of monatomic ions (positive sodium ions, Na^+, and negative chloride ions. Cl^-) in a moderately compact aggregate in which because of thermal agitation. each ion is free to move slowly around. Under the influence of the applied electrical field the sodium ions move toward the negative electrode and the chloride ions toaard the positive electrode. and this motion of the ions carries the electric current through the region between the electrodes.

A sodium ion is a sodium atom that has lost one electron, and has thus acquired an electric charge $+e$ (or $+1$, with use of the magnitude of the electronic charge as unity). Since sodium is one greater in atomic number than neon, the sodium ion contains the same number of electrons as the neon atom. The chloride ion is a chlorine atom that has gained one electron, and has thus assumed a negative charge $-e$ (or -1) and the same number of electrons as argon. It is not accidental that these ions have the same electron numbers as the noble (inert) gases neon and argon. The noble gases are shown by their extreme chemical inertness to have especially stable electronic structures. This stability is shown by the fact that the ionization energy (the energy required to remove one electron from the atom: $X \rightarrow X^+ + e^-$) is greater for the noble gases than for any other atoms. Similarly, the electron affinity (the energy liberated in picking up an additional electron, according to the reaction $X + e^- \rightarrow X^-$) is smaller for the noble-gas atoms than for other atoms. An atom with an atomic number near that of a noble gas tends to achieve the noble-gas structure by the loss or gain of electrons. One electron of a neutral sodium atom is loosely held and can be removed by a rather small amount of work; the ionization energy of the sodium atom is small. The chlorine atom has the power of adding an electron. When metallic sodium and gaseous chlorine react, an electron is transferred from each sodium atom to a chlorine atom, forming the ions Na^+ and Cl^-. Sodium chloride is an aggregate of these ions. The necessity of electrical neutrality requires that the substance contain equal numbers of singly charged cations and singly charged anions—hence, its formula is Na^+Cl^- (usually NaCl); only a minute excess of ions of one sign would cause the sample of salt to have a high electrical potential.

The coulomb forces between the ions cause each ion to attract neighbouring ions of opposite sign, and to tend to co-ordinate them about itself. This leads to a stable spatial arrangement, shown by the sodium chloride crystal (see figure), in which each ion has 6 nearest neighbours of the opposite sign and 12 neighbours of the same sign at a distance $\sqrt{2}$ larger. The total coulomb energy for this arrangement is found by summation over pairs of ions to be $-1.7476\frac{e^2}{R}$ per Na^+Cl^- ion pair, in which R is the distance between the centre of one ion and the centre of one of its six nearest neighbours. The crystal is hence stabilized by this coulomb attraction by an energy quantity 75% greater than the coulomb energy of a positive and a negative charge the distance R apart. This coulomb energy of the crystal is large: it amounts to -205 kg.cal. per mole for sodium chloride and is large enough (with the help of the electron affinity of chlorine) to provide the energy to sublime sodium metal to separate atoms, to ionize these atoms and to dissociate chlorine molecules into chlorine atoms, all with 98 kg.cal. per mole to spare—evolved as the heat of formation of sodium chloride from the elements.



BY COURTESY OF LINUS PAULING

THE ATOMIC ARRANGEMENT IN THE SODIUM CHLORIDE CRYSTAL: SMALL SPHERES ARE SODIUM IONS; LARGE SPHERES. CHLORIDE IONS

The forces of attraction of ions of opposite charge are called "ionic valence forces," and the charge of an ion is called its "ionic valence." Sodium and the other alkali metals, with atomic numbers one greater than the noble gases, tend to form ionic compounds in which they have ionic valence 1+ (are "unipositive"). Chlorine and the other halogens form compounds in which they have ionic valence 1− (are "uninegative"). The alkaline-earth metals lose two electrons per atom to form the bipositive ions Be^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+} and Ra^{2+}, in compounds such as $Ca^{2+}Cl^{-}_{2}$, $Ca^{2+}O^{2-}$, etc. The elements of Group VI of the periodic table may be formed into binegative ions O^{2-}, S^{2-}, Se^{2-} and Te^{2-}.

The metals of Groups Ib and IIb (*see* PERIODIC LAW) tend to form cations (Cu^{+}, Ag^{+}, Zn^{2+}, Cd^{2+}, Hg^{2+}) in which they have ten electrons more than a noble gas. The transition elements also form cations with other electron numbers. Usually these ions are bipositive or terpositive: the electron affinity of electronegative elements and the stabilizing effect of interionic attraction seem to be sufficient to remove two or three electrons from a transition atom, but not more. Examples of stable ions are Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+} and Cu^{2+}. The rare-earth metals usually form terpositive ions; a few, such as cerium, also form quadripositive ions, and a few others, such as europium, form bipositive ions.

Covalence.—Another kind of valence of great importance is "covalence," which results from the sharing of two electrons by two atoms. The bond that consists of a pair of shared electrons is called a "covalent bond"; it is essentially the bond of the organic chemist, represented by a dash in structural formulas, such as

$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & - & C & - & O-H \\ & & | & & | & & \\ & & H & & H & & \end{array} \quad \text{for ethyl alcohol.}$$

Whereas in an ionic compound the individual ions retain some independence of one another, and under certain conditions (as in the molten salt or in solution in a solvent of high dielectric constant) can move about rather freely, the atoms that are bonded together by covalent bonds are held tightly to one another and form a rather rigid molecule.

The simplest example of a covalent molecule is the hydrogen molecule, H_2, for which the structure H:H or H—H can be written. This molecule has been found by experiment to be rigid, with the equilibrium internuclear distance 0.740 Å.; the frequency of nuclear vibration 4,318 cm.$^{-1}$ (corresponding to a large restoring force to the equilibrium configuration); and the energy of dissociation of the molecule in its normal state into atoms 102,700 cal. per mole. The quantum-mechanical treatment of this molecule, carried out by Heitler and London and relined by H. M. James and A. S. Coolidge. has given complete agreement with these experimental values, leaving no doubt that the chemical bond in this molecule is the shared-electron-pair bond postulated by Lewis and formulated mathematically by the theory of quantum mechanics.

The rules that determine the formation and properties of covalent bonds may be stated as follows: A covalent bond between two atoms consists of two electrons (with opposed spins—see ELECTRON) occupying one orbital for each atom. The strength of the bond is determined by the stability of the atomic orbitals and also by their nature, a good bond orbital of an atom being a stable orbital that extends in the direction of the atom with which the bond is formed.

The requirement of stability of bond orbitals (as well as of atomic orbitals occupied by electron pairs not shared with other atoms) causes the covalence of atoms to be related to certain stable electronic configurations, especially those of the noble gases. Since an atomic orbital can be occupied by either an unshared electron pair or a shared electron pair, a noble-gas configuration can be achieved by an atom by the formation of covalent bonds as well as by the transfer of electrons (ionic valence). The normal covalences 4, 3, 2 and 1, respectively, for carbon, nitrogen, oxygen and fluorine correspond to the achievement of the neon structure by the sharing of electrons:

$$\begin{array}{c} H \\ H{:}\ddot{C}{:}H \\ H \end{array} \qquad \begin{array}{c} H \\ {:}\ddot{N}{:}H \\ H \end{array} \qquad \begin{array}{c} H \\ {:}\ddot{O}{:}H \\ \end{array} \qquad {:}\ddot{F}{:}H$$

A double bond between two atoms involves two electron pairs and two orbitals for each atom, as in ethylene,

$$\begin{array}{ccc} H & & H \\ & C{::}C & \\ H & & H \end{array}.$$

A triple bond involves three electron pairs and three orbitals for each atom, as in hydrogen cyanide (H:C:::N:). In each of these molecules the hydrogen atom achieves the helium configuration by forming one shared pair, and the carbon and nitrogen atoms achieve the neon configuration. An atom may form covalent bonds in number different from the normal number and complete its stable electronic configuration by the transfer of electrons. An example is nitrogen in the ammonium ion,

$$\left[\begin{array}{c} H \\ H\ {:}\ddot{N}{:}H \\ \ddot{H} \end{array}\right]^{+}$$

When uncertainty arises as to the most satisfactory electronic structure for a molecule, the question may usually be resolved by assigning to a molecule a hybrid structure, corresponding to resonance among the likely alternative structures (*see* RESONANCE, THEORY OF). Thus, hydrogen chloride may be assigned the structure {$H^{+}Cl^{-}$, H—$\ddot{C}l$:}, a hybrid of the structure involving an extreme ionic bond and that involving a normal covalent bond; nitrous oxide may be assigned the structure {:N=N=O:, :N≡N—O:}, a hybrid of the two most reasonable valence-bond structures. Some progress has been made in the rough quantitative assignment of hybrid structures, with use of experimental values of energy of formation, interatomic distances and other molecular properties.

For some purposes it is convenient to make use of the concept of formal charge. The formal charge of an atom is the electrical charge that the atom would have if it retained all its unshared electrons and one-half the electrons that it shares with atoms to which it is bonded. For example! in the ammonium ion, with the structure shown above, the formal charge of the hydrogen atoms is 0, and that of the nitrogen atom is +1.

Co-ordination Number.—The "co-ordination number" of an atom is the number of atoms, ions or molecules that the atom holds as its nearest neighbours in a complex or a crystal. Thus, the metal atom has co-ordination number 8 in the Werner co-ordination complexes $[Mo(CN)_8]^{4-}$ and $[Sr(H_2O)_8]^{2+}$; 7 in the complex $[ZrF_7]^{3-}$; 6 in the complexes $[SnCl_6]^{2-}$, $[PtBr_6]^{2-}$, $[FeF_6]^{3-}$; $[Co(NH_3)_6]^{3+}$ and $[Al(H_2O)_6]^{3+}$; 4 in the complexes $[Zn(CN)_4]^{2-}$, $[Cu(CN)_4]^{3-}$, $[Ni(CN)_4]^{4-}$, $[Ni(CN)_4]^{2-}$, $[Be(H_2O)_4]^{2+}$, $[BF_4]^{-}$ and $[Pt(CN)_4]^{2-}$, and 2 in the complexes $[Ag(NH_3)_2]^{+}$, $[AuCl_2]^{-}$ and $[HgCl_2]$.

The forces which hold the atoms together in these complexes, and which lead to the observed co-ordination numbers. are of different kinds. The bonds to the highly electronegative fluorine atoms in the fluoride complexes are essentially ionic, and the increase in co-ordination number, with fluoride ion, from 4 to 6 to 7 for B^{3+}, Fe^{3+} and Zr^{4+} is the result mainly of the increase in size of the cation, which permits a successively larger number of fluoride ions F^{-} to be packed about the central ion. The influence of the relative size of the co-ordinated molecule and the central ion is important in hydrated cations. in which the co-ordinating bond is mainly the electrostatic attraction of the central cation and the negative end (oxygen atom) of the water molecule.

In many Werner complexes—including those formed by the cyanide ion, thr nitrite ion or nitro group, the thiocyanate ion, the halide ions (other than fluoride), the ammonia molecule and the carbon monoxide molecule—the bonds between the attached atom or group and the central atom are essentially covalent, and the co-ordination number is determined by the nature of the bond orbitals of the central atom. Thus. Zn^{2+} and Cu^{+} have their five 3d orbitals occupied by unshared pairs of electrons, leaving as stable orbitals suited to bond formation the one 4s and the three 4p orbitals These can hybridize to form four bond orbitals directed toward the corners of a regular tetrahedron; accordingly, these ions form cyanide complexes $[Zn(CN)_4]^{2-}$ and $[Cu(CN)_4]^{3-}$, with co-ordination number 4 and the tetrahedral configuration.

The neutral nickel atom similarly forms tetrahedral complexes $[Ni(CN)_4]^{4-}$ and $[Ni(CO)_4]$. However. the bipositive nickel ion Ni^{2+}, behaves differently It may use one 3d orbital for bond formation: this orbital can hybridize with the 4s orbital and two 4p orbitals to form four bond orbitals directed toward the four corners of a square that is coplanar with the central ion. It was discovered by Werner that bivalent palladium and platinum form these square planar complexes, and this configuration has been verified for the covalent complexes of bivalent nickel also.

The octahedral covalent complexes, such as the ferrocyanide ion, $[Fe(CN)_6]^{4-}$, involve six covalent bond orbitals formed by hybridization of two 3d orbitals with the 4s and 4p orbitals.

Some heavy-metal atoms tend to assume co-ordination number 2 and to form two oppositely directed covalent bonds. Examples of such linear complexes are: $[:N{\equiv}C{-}Cu{-}C{\equiv}N]^{-}$, $[N{\equiv}C{-}Ag{-}C{\equiv}N.]^{-}$, $[Cl{-}Au{-}Cl]^{-}$. $[Cl{-}Hg{-}Cl]$.

Oxidation Number.—After the concepts of ionic valence and covalence had been introduced. and detailed electronic structures of molecules began to be written, it was recognized that a simple representation of the oxidation states of elements in a compound is needed, especially as an aid in balancing equations for oxidation-reduction reactions. The "oxidation number" came into use for this purpose.

The oxidation number of an element in a substance is the electrical charge assigned to the atoms of fhe element according to certain rules. These rules are simple, but are not completely unambiguous, and their application requires some chemical insight. The rules, as generally accepted, are the following:

1 The oxidation number of a monatomic ion in an ionic substance is equal to its electrical charge.

2. The oxidation number of atoms in an elementary substance is zero.

3 In a covalent compound of known structure, the oxidation number of each atom is the charge remaining on the atom when each shared electron pair is assigned completely to the more electronegative of the two atoms sharing it (*see* PERIODIC LAW). A pair shared by two atoms of the same element is usually split between them.

4 The oxidation number of one element in a compound of uncertain structure may be calculated from a reasonable assignment of oxidation numbers to the other elements in the compound.

For example, in the permanganate ion, MnO_4^{-}, oxygen is assigned its usual oxidation number -2; manganese, hence, has oxidation number $7. In acidic solution this ion can be reduced to manganous ion, Mn^{2+}, by a suitable reducing agent. Hydrogen peroxide can serve as the reducing agent for this purpose. The oxidation number of oxygen in hydrogen peroxide, H_2O_2, is -1, that of hydrogen being $+1$, and on oxidation of hydrogen peroxide free oxygen is formed, with increase in oxidation number of oxygen from -1 to 0. Hence, two manganese atoms can oxidize ten oxygen atoms and the equation for the oxidation of hydrogen peroxide by permanganate ion in acidic solution is easily written. $2MnO_4^{-} + 5H_2O_2 + 6H^{+} \rightarrow 2Mn^{++} + 5O_2 + 8H_2O$.

The word valence when used in the field of inorganic chemistry ordinarily refers to the state of oxidation of an element as expressed by its oxidation number, whereas in organic chemistry it ordinarily refers to the covalence of the element.

The Hydrogen Bond.—A structural feature that has an important effect on the properties of many substances is the "hydrogen bond" A hydrogen atom bonded to an electronegative atom can attract another electronegative atom and form with it a weak bond (with bond energy 5 or 10 kg cal per mole). This bond is not a second covalent bond—hydrogen, with only one stable orbital, can form only one covalent bond—but is the result of the attraction of the residual positive charge of the hydrogen atom bonded to one electronegative atom for an unshared electron pair of the other atom.

The strongest hydrogen bonds are formed by fluorine ($[FHF]^{-}$, polymers of HF). The hydrogen bonds formed by water molecules are responsible for the surprisingly high melting point of ice and boiling point of water, for the existence of a maximum density of water and for the expansion of water on freezing (*see* ICE). Many special properties of inorganic and organic molecules. such as the dimerization of fatty acids, are caused by hydrogen-bond formation.

Metallic Valence.—The nature of the valence forces operating in metals, and especially in intermetallic compounds, had not been completely elucidated by the early 1960s. It seems certain. however, that metals and intermetallic compounds can be described as aggregates of metal cations bound together by valence electrons, which have considerable freedom of motion through the specimen, and it is reasonable to call the number of electrons of an atom that help to bind the metallic crystal together the "metallic valence" of the atom.

It is likely that the metallic valence of the alkali metals is 1, and that that of the alkaline-earth metals is 2. Values for the transition metals are uncertain, but their strength and hardness suggest values increasing from 3 for scandium to about 6 for chromium and succeeding elements, and then decreasing for copper and zinc. The magnetic properties of the rare-earth metals provide evidence that the metallic valence is 3 for all the rare-earth metals except europium and ytterbium, for which it is 2; the paramagnetic susceptibility of these two metals is the same as for their bivalent salts. whereas for the other rare-earth metals it is the same as for their tervalent salts.

Some progress has been made in systematizing the often complex formulas of intsrmetallic compounds such as y-brass, Cu_5Zn_8, and the compounds $Cu_{31}Sn_8$, Cu_9Al_4, Fe_5Zn_{21}, etc., which are related to it (*see* ALLOYS). It was pointed out (by A. Westgren and W. Hume-Rothery) that if the valences 1, 2, 3 and 4 are assigned to Cu. Zn, Ga and Sn, respectively, the formulas Cu_5Zn_8, Cu_9Ga_4 and $Cu_{31}Sn_8$ all correspond to the same ratio, $\frac{21}{13}$, of valence electrons to atoms; and a quantum-mechanical theory of the stability of these alloys in terms of electron waves was developed by H. Jones. An equivalent theory was formulated (by L. Pauling) with the use of another set of metallic valences, originally deduced from the ferromagnetic properties of the transition metals. These valences (5.44, 4.44, 3.44 and 2.44 for Cu, Zn, Ga and Sn, respectively) also lead to a constant value, $62\frac{7}{13}$, for the ratio of valence electrons to atoms in the y-alloys. with the formulas given above. Further progress toward a penetrating understanding of the nature of metals was needed before a firm choice between the metallic valences 1 and 5.44 for copper (and similar pairs of values for other transition elements) could be justified.

It is clear that valence does not play as great a part in determining the compositions of intermetallic compounds as it does for salts and organic compounds. Among the other factors of significan'ce for intermetallic compounds the relative sizes of atoms of different kinds is of greatest importance; many intermetallic compounds have compositions corresponding to modes of filling space with atoms of different sizes in such a way as to give each atom the maximum number of neighbours.

From the consideration of interatomic distances V. M. Goldschmidt was led to conclude that the metallic bond is closely related to the covalent bond. Gsually the number of neighbours of an atom in a metal or alloy is greater than its metallic valence, and the covalent bonds formed by the atom are considered to resonate among the interatomic positions.

See also references under "Valence" in the Index volume.

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VALENCIA, a maritime province of eastern Spain. Pop. (1960 est.) 1,440,761. Area. 4,156 sq.mi. When the ancient kingdom of Valencia was incorporated into Aragon in 1238, it included the provinces of Castellón de la Plana (*q.v.*) and Alicante. It was bounded on the north by Catalonia, west by Aragon and New Castile, and south by Murcia.

The inhabitants are of very mixed origin. because of the successive occupation of the country by Iberians. Greeks. Carthaginians, Romans. Visigoths and Moors. Their dialect resembles Catalan but is softer, and contains a larger percentage of Arabic words.

The elaborate irrigation works and the system of intensive agriculture which have rendered the *huertas* or gardens of Valencia celebrated were initiated by the Moors as were the Elche date groves, the Alicante vineyards and the Valencia orange plantations.

With the decline of the caliphate of Cordova early in the 11th century, Valencia became an independent kingdom which passed successively into the power of the Almoravides and Almohades.

In 1609, 200,000 Moriscos, or Moors who outwardly professed Christianity, were banished from the country. In 1833 Valencia was divided into the three provinces already named

The coast is skirted by considerable stretches of sand dune, and by a series of these the lagoon called the Albufera de Valencia is separated irom the Mediterranean. The principal rivers are the Guadalaviar or Turia and the Júcar (*q.v.*). Irrigation disputes are settled by the peasants' Tribunal de las Aguas.

The *vegas* ("cultivated plains") have an exceptionally fine, almost subtropical climate. In their low-lying portions rice is the favourite crop; elsewhere wheat, maize and all kinds of iruit; the mulberry is cultivated for silk; and wine and oil are produced. Esparto grass is grown in the less fertile areas. The fishing industry is considerable, and there are manufactures of silk, carpets and tapestry, woolen, hemp and linen fabrics, glass, pottery and leather; there are also iron foundries, distilleries, cooperages and oil refineries. The coast railway from Barcelona traverses the province.

Besides Valencia, the capital and principal seaport, some of the more important towns of the province are Sagunto, Alcira, Sueca, Játiva, Gandia, Carcagenta and Cullera. Other towns (mun. pops.) are Algemesi (17,789), Catarroja (11,296). Oliva (13,472), Liria (9,327), Tabernes de Valldigna (12,212) and Torrente (16,123).

VALENCIA, a town of Spain and the capital of the province of the same name. is situated on both banks of the river Turia, near the eastern coast, 3 mi. from the Mediterranean. The city has a temperate climate with mild winters. Pop. (1960 est.) 571,452.

All around the city stretches the Huerta de Valencia. a fertile plain with groves of oranges, lemons and mulberries. At the mouth of the Turia is the port of Villanueva del Grao, accessible by road and rail from Valencia. and along the coast are small villages and beautiful beaches. Separated from the sea by a narrow, pine-forested belt of land and 7 mi. S. of Valencia is the Albufera, Spain's biggest lake. Until 1871 Valencia was enclosed by a Roman wall rebuilt in 1356 by Pedro IV; two gateways, the Serranos and Cuarte towers; remain.

At the heart of the city, Caudillo square lies a little to the north of the northern station and the bull ring. On opposite sides of the square are the main post office and the town hall, which houses the municipal museum. The baroque-style building of the flower market is in the Caudillo square. A little farther to the north. the Plaza del Mercado is the site of the central market; with more than 1,000 market stalls, this is one of the biggest in Europe. St. John's church in the same square is typical of many Valencian baroque buildings and has frescoes by A. Palomino in the vault. The most beautiful building on the Plaza del Mercado, however, and classified as a national monument, is La Lonja. a Gothic building which was the silk exchange in the 15th century.

To the northeast stands,the cathedral called La Seo. This building. in various styles. was begun in 1262; the campanile (el hliguelete). an isolated octagonal Gothic tower, is 152 ft. in height. The cathedral has rich treasures including examples of 15th-century sculpture and a collection of paintings by Don Sebastián Llanos. Fernando Yáñez de la Almedina, Juan de Juanes (Vicente Juan Macip), Orente, and two large canvases by Goya. What is traditionally believed to be the chalice used at the Last Supper is the most precious treasure of the cathedral and has been kept there since the 15th century. In the vicinity of the cathedral stand the archbishop's palace, the basilica of the Virgin of the Desamparados and the palace of the Generalidad, with its fine Renaissance paneled ceilings.

To the east lies the Cruz de los Caldas, a circular plaza almost surrounded by gardens, one of which extends to the riverbank. The palace of justice, a neoclassic building of the 18th century erected originally as a customhouse, is to the south. Several roads radiate from the Cruz de Ios Caldas; of these, three lead directly to bridges over the river and one, the Calle de la Nave, leads to the Gniversity of Valencia and to the church and college of Corpus Christi which are close by. The university, which has a magnificent library including a valuable collection of manuscripts, was iounded about 1500. The Patriarca museum, which has some beautiful 15th-century Brussels tapestries and one of the finest collections of paintings in the city, is housed in the Royal College of Corpus Christi.

There are beautiful private gardens in the city as well as the public gardens of Yiveros, Moniortc, la Alameda, la Glorieta and Parterre. The Alameda is where the July fair and the iamous battle of the flowers are held. The botanic gardens on the river bank to the west were the first in Spain. Valencia is famous for its many colouriul festivals; the *fallas*, when bonfires are lit, takes place in March, and the procession of the Virgin of the Desamparados, during which flowers are thrown along the route, in May.

Communications **and Industry.**—Valencia is a centre of road anti rail communications for eastern Spain. Regular sea services operate between the town and other ports on the mainland and also between i'alencia and the Balearic Islands. There is an airport at hlanises, $7\frac{1}{2}$ mi. W. of the city. The industries of Valencia are many and varied, but the principal manufacture is silk for which the city has been famous from the 15th century. Other fabrics including linen and rayon are made. In addition to the big shipyards, Valencia has several heavy industries for the manuiacture of machinery and railway equipment; there are chemical and printing works. Fruit, rice and vegetables produced in the region are processed. Typically Spanish articles, such as fans and lace, are made for export, but Valencia is more particularly famous for its coloured tiles.

History.—The earliest mention of Valencia (I'alentia) is by Livy who states that the consul Decimus Junius Brutus settled the soldiers of Viriathus there in 138 B.C. Valencia sided with Quintus Sertorius. the Roman general, in his war against Pompey but was partially destroyed by Pompey in 75 B.C. It seems to have recovered speedily irom this setback for it was prosperous again under Augustus and was mentioned by Pliny as being a colony in the region of the Edetani. Yalencia was taken by the Yisigoths in A.D. 413. Three hundred years later (714) it was captured by the Moors and in 1021 it became the seat of the newly established independent Moorish kingdom oi Valencia which extended from Almería to the Ehro estuary. From 1089 until the final capitulation of the city in 1094 the kingdom was being fought for by the Cid (*q.v.*) who eventually secured it irom the Almoravides. It remained in the hands of the Cid, after whom the city is sometimes called Yalencia del Cid. He died there in 1099. The Moors recovered possession of the city in 1101. In 1238 James I of Aragon added Valencia to his dominions. In 1479 the kingdom of Valencia together with the thrones of Aragon, Catalonia and Majorca passed to Ferdinand II. son oi John II. king of Castile.

A long period of peace followed during which the city developed rapidly and the arts prospered. The first Spanish printing press is said to have been set up there in 1474 and during the next two centuries the city was the seat of the Valencian school of painting. In the War of the Spanish Succession the city took a stand in favour of the archduke Charles of Austria. It was captured by the French in 1812 and held till 1813. During the Spanish civil war Valencia was made the loyalist capital in Nov. 1936, but was captured by the nationalists in 1939. Industries have increased in number and importance during the 20th century. A mark oi the city's prosperity is the annual holding of an international samples fair during the first two weeks oi May.

VALENCIA, a city of Venezuela and capital of the state of Carabobo. is situated in a large basin between parallel ranges of the Central highlands. Lying at an elevation of 1.600 ft. above sea level, it has a generally pleasant and healthy climate. with an average temperature of 76° F. Valencia was founded in 1555. At the beginning of the war of independence the city was made the capital of Venezuela; it served as capital again in 1830 and in 1858 but each time the seat of national government returned to Caracas. The city came into its own only after 1910, following the eradication of malaria. It is strategically located as a converging point of highways for the states of Yaracuy, Falcón, Lara, Zulia. Cojedes, Portuguesa, Aragua, Barinas. and the Federal District. Accordingly, it has become one of the country's leading industrial centres. Despite much modern construction Valencia still retains the features of a Spanish city. Through the centuries it has survived sacking, fires, earthquakes, epidemics and economic upheavals. Valencia is the centre of the country's most developed agricultural region and of its cattle business.

Not far from the city is the 100 sq.mi. Lake Valencia, a shallow lake bordered by a marshy lacustrine plain which provides fattening pastures for cattle from the Llanos. Pop. (1961) 161,313. (L. WE.)

VALENCIA or VALENTIA, an island in County Kerry. Ire., forming the southern horn of Dingle bay. It is 7 mi. long and 3 mi. broad. with hills to the west and north. The channel separating it from the mainland forms a fine natural harbour with narrow entrances and a depth of about 40 ft. at low tide. A ferry connects Knightstown on the island with the railway terminus on the mainland. The harbour is used only by fishing boats. Peasant farming and fishing are the main occupations. An important meteorological station is maintained on the island and it is the terminus for transatlantic cables. Pop. (1956) 971. (T. HER.)

VALENCIENNES, a town of northern France. Population (1954) 42,214. Valenciennes is said to owe its name and foundation to one of the three Roman emperors named Yalentinian. In the middle ages it was the seat of a countship which in the 11th century was united to that of Hainaut. In the 16th century Valenciennes became the stronghold of Protestantism in Hainaut, but was conquered by the Spaniards. In 1656 the Spaniards under the prince of Condé made a successful defense against the French under Vicomte de Turenne; but. in 1677 Louis XIV took the town and Vauban constructed the citadel. Valenciennes, which then became the capital of Hainaut, has since always belonged to France. In 1793, after 43 days' bombardment, the garrison surrendered to the allied forces. In 181j it defended itself successfully.

The Scheldt there divides into two branches, one of which flows through the town, while the other, canalized and forming a port, skirts it on the west. The Tour de la Dodenne (13th and 15th centuries) and the citadel (17th century) are the chief remains of the old fortifications. The town hall is early 17th century, with a 19th-century façade. The museum contains a good collection of paintings. Valenciennes is the centre of the rich Anzin coal field. There are important ioundries, forges, rolling mills, wireworks and machine shops. There is also an extensive sugar-beet cultivation, with attendant sugarworks and distilleries, and glass, starch, chemicals and soap are produced. Hosiery, trimmings and handkerchiefs are manuiactured and cotton weaving and printing are carried on, though little of the iamous lace is now made.

VALENCY: see VALENCE.

VALENS, East Roman emperor from 364 to 378, owed his elevation in the 36th year of his age to his brother, Valentinian. who chose him to be his associate in the empire. Valens had been attached to Julian's bodyguard. but he did not inherit the military ability of his father. Gratian of Pannonia. A revolt headed by Procopius in the second year of his reign was quelled by the ability of his generals. In the year 366 Valens at one stroke reduced the taxes of the empire by one-fourth, a very popular measure. though one of questionable policy in the' face of the threatening attitude of the Goths on the lower Danube. Before venturing on a campaign against them, Valens received baptism from Eudoxus, the Arian bishop of Constantinople. After some small successes over the Goths. won by his generals (367–369), Valens concluded a peace with them. which lasted six years, on a general understanding that the Danube was to be the boundary betn-een Goths and Romans. On his return to Constantinople in 369–370 Valens began to persecute his orthodox and Catholic subjects, but he lacked the energy to carry out his edicts.

In the years 371 to 377 Valens was in Asia Minor, most of the time at the Syrian Antioch. Though anxious to avoid an Eastern war, because of danger nearer home from the Goths, he was compelled to take the field against Shapur II. Valens crossed the Euphrates in 373, and drove back the king of Persia to the iarther bank of the Tigris. But the Roman success n-as by no means decisive, and no definite understanding as to boundaries was come to with Persia. Valens returned to Antioch, where in the winter of 373–374 he instituted a persecution of magicians. Between 374 and 377 we read of grievous complaints of injustice and extortion perpetrated under legal forms. Although preparations were made for following up the war with Persia and securing the frontier, a truce was patched up, rather to the disadvantage of the empire, Armenia and the adjacent country being half conquered and annesed by Shapur. The armies of Rome, in fact, were wanted in another quarter. The Huns, of whom me now hear for the first time. were beginning in 376 to press the Goths from the north, and the latter asked leave of the emperor to cross the Danube into Roman territory. This they were allowed to do, on the condition that they came unarmed, and their children were transported to Asia as hostages. The conditions, however, were not observed by the imperial generals. Accordingly, the enraged Goths, under their chief Fritigern, streamed across the Balkans into Thrace and the country round Adrianople, plundering, burning and slaughtering as they went. They were driven back for a time, but returned in the spring of 378 in greater force! with a contingent of Huns and Alans and penetrated to the neighbourhood of Adrianople. Valens left Constantinople in May 378 with a strong and well-officered army. Without awaiting the arrival of his nephew Gratian, emperor of the West, who had just won a great victory over the Alamanni, Valens attacked the enemy at once. The battle, which was fought on confined ground in a valley, was decided by a cavalry charge of the Alans and Sarmatians, which threw the Roman infantry into confusion and hemmed it in so closely that the men could scarcely draw their swords. The slaughter, which completely destroyed the Roman army, was one of the greatest recorded in antiquity. Valens perished either on the field or, as some said, in a cottage fired by the enemy. From the battle of Adrianople the Goths permanently established themselves south of the Danube.

VALENTIN, LE (JEAN DE BOULOGNE) (1594–1632), French painter. who settled in Rome as a young man and became one of the followers of Caravaggio, was born at Coulommiers in 1594. The works of the Caravaggesque artists were very popular with private collectors during the first two decades of the 17th century, but Yalentin was one of the few who continued the manner in Rome after 1620. when the Bolognese and full baroque styles came into favour. He chose to exploit the more obvious aspects of Caravaggio's style and subject matter; that is to say, the picaresque figures, the scenes of gaming, feasting and violence, the strong, dramatic lighting with its heavy shadows and the coarse realism. But he lacked Caravaggio's depth of feeling and his economy and concentration. as well as his range of subject matter.

Like other Caravaggesque painters, Valentin worked exclusively in oil colours on canvas. never in fresco. He rarely painted pictures for churches. so that most of his output is now in museums or in private hands. He died in Rome on Aug. 20, 1632.

See H. Voss, *Die Malerei des Barock in Rom* (1924); R. Longhi; "Apropos de Valentin," *Revue des Arts,* 8:58–66 (1958). (M. W. L. K.)

VALENTINE, SAINT. The feast of St. Valentine on Feb. 14 seems to be intended to commemorate two saints of the same name. According to legend, one was a Roman priest who suffered martyrdom during the persecution of the emperor Claudius and was buried on the Flaminian way, and the other a bishop of Interamna (Terni), who was martyred apparently also in Rome, and whose relics were later translated to Terni.

In their present form the acts of both martyrdoms are legendary, but they seem to be based on a historical foundation. It is possible that they may actually be different developments of the same original account and refer only to one person. St. Yalentine's day as a lovers' festival, the choice of a valentine and the modern development of sending valentine cards has no relation to the saint or to any incident in his life. These customs seem rather to be connected either with the pagan Roman festival of the Lupercalia which took place in the middle of February, or with the spring season in general.

See E. M. Fusciardi, *Vita di S. Valentino* (1936). (H. C. G.)

VALENTINIAN I, Roman emperor of the West from A.D. 364 to 375, was born at Cibalis, in Pannonia. He had been an officer of the guard under Julian and Jovian, and had risen high in the imperial service. He was chosen emperor in his forty-third year by the officers of the army at Nicaea in Bithynia in 364, and shortly afterwards named his brother Valens (*q.v.*) colleague with him in the empire. As emperor of the West, Valentinian took Italy, Illyricum, Spain, the Gauls, Britain and Africa, leaving to Valens the eastern half of the Balkan Peninsula, Greece, Egypt, Syria and Asia Minor as far as Persia. During the short reign of Valentinian there were wars in Africa, in Germany and in Britain, and Rome came into collision with the Burgundians, Saxons and Alamanni. The emperor's chief work was guarding the frontiers and establishing military positions. Milan was at first his headquarters for settling the affairs of northern Italy; next year (365) he was at Paris, and then at Reims, to direct the operations of his generals against the Alamanni who were driven back to the German bank of the Rhine, and checked for a while by a chain of military posts and fortresses. At the close of 367, however, they suddenly crossed the Rhine, and sacked Moguntiacum (Mainz). Valentinian attacked them at Solicinium (Sulz in the Neckar valley or Schwetzingen) with a large army, and defeated them with considerable loss on his own part. (Later, in 374, he made peace with their king, Macrianus.) The next three years he spent at Trier, which he chiefly made his headquarters, organizing the defence of the Rhine frontier.

During his reign the coasts of Gaul were harassed by the Saxon pirates, with whom the Picts and Scots of northern Britain joined hands, and ravaged the island from the wall of Antoninus to the shores of Kent. In 368 Theodosius was sent to drive back the invaders; in this he was completely successful, and established a new British province, called Valentia. In Africa the Moorish prince, Firmus, raised the standard of revolt against Count Romanus, the military governor. The services of Theodosius were again requisitioned. He landed in Africa with a small band of veterans, and Firmus, to avoid being taken prisoner, committed suicide. In 374 the Quadi, a German tribe in what is now Moravia and Hungary, resenting the erection of Roman forts to the north of the Danube, and further exasperated by the treacherous murder of their king, Gabinius, crossed the river and laid waste the province of Pannonia. The emperor, in April of the following year, entered Illyricum with a powerful army, but during an audience to an embassy from the Quadi at Brigetio on the Danube (near Pressburg) died in a fit of apoplexy.

Valentinian's general administration seems to have been thoroughly honest and able, in some respects beneficent. If he was hard and exacting in the matter of taxes, he spent them in the defence and improvement of his dominions. Though himself a plain and almost illiterate soldier, he was a founder of schools, and he also provided medical attendance for the poor of Rome, by appointing a physician for each of the fourteen districts of the city. He was an orthodox Catholic, but he permitted absolute religious freedom to all his subjects. The great blot on his memory is his cruelty, which at times was frightful.

VALENTINIAN II., son of the above, an infant of four in 375 with his half-brother Gratian (*q.v.*) a lad of about seventeen, became the emperors of the West. They made Milan their home; and the empire was nominally divided between them, Gratian taking the trans-Alpine provinces, whilst Italy, Illyricum in part, and Africa were to be under the rule of Valentinian, or rather of his mother, Justina. In 387 Magnus Maximus (*q.v.*), who had in 383 overthrown Gratian and made himself master of the northern provinces, crossed the Alps and threatened Milan. The emperor and his mother fled to Theodosius, the emperor of the East. Valentinian was restored in 388 by Theodosius. Four years later he was murdered at Vienne in Gaul, probably at the instigation of his Frankish general Arbogast.

VALENTINIAN III., emperor of the West from 425 to 455, the son of Constantius and Placidia. He was only six years of age when he ascended the throne, and during his minority the conduct of affairs was in the hands of his mother. His reign is marked by the dismemberment of the Western Empire; the conquest of the province of Africa by the Vandals in 439; the loss of great portions of Spain and Gaul, in which the barbarians had established themselves; and the ravaging of Sicily and of the western coasts of the Mediterranean by the fleets of Genseric. As a set-off against these calamities there was the great victory of Aetius over Attila in 451 near Châlons, and his successful campaigns against the Visigoths in southern Gaul (426, 429, 436), and against various invaders on the Rhine and Danube (428–31). Ravenna was Valentinian's usual residence; but he fled to Rome on the approach of Attila, who ravaged North Italy in 452. In 454 Aetius was treacherously murdered by Valentinian. Next year, however, the emperor himself was assassinated by two of the barbarian followers of Aëtius. He was self-indulgent, incompetent, and vindictive.

VALENTINO, RUDOLPH (RODOLPHO ALFONZO RAFFAELO PIERRE FILIBERT GUGLIELMI DI VALENTINA D'ANTONGUOLLA) (1895–1926), motion-picture actor, was born in Italy on May 6, 1895. He went to the United States in 1913 and worked there for a time as a landscape gardener and dishwasher, later becoming established as a professional dancer in vaudeville. In 1918 he went to Hollynood, where he played small parts in films but with little success. Through the intervention of June Mathis, scenario writer, he was given the role of Julio in *The Four Horsemen of the Apocalypse* (1921). He immediately became a star. Darkly handsome in appearance, he received enormous acclaim for his romantic portrayals. As Frederick Lewis Allen commented (in *Only Yesterday*, New York: Harper & Brothers, 1931), "With his sideburns and his passionate air, [Valentino] ... set the standard for masculine sex appeal."

His films included *The Sheik* (1921), *Blood and Sand* (1922), *The Young Rajah* (1922), *Moran of the Lady Letty* (1922), *Monsieur Beaucaire* (1924), *A Sainted Devil* (1924), *Cobra* (1925), *The Eagle* (1925) and *The Son of the Sheik* (1926).

Valentino died in New York city, on Aug. 23, 1926; his lying in state, managed by skillful press agents, attracted an 11-block-long crowd. (M. S. BY.)

VALENTINUS (d. 827) was pope for about 40 days in Aug. and Sept. 827, between Eugenius II and Gregory IV. A Roman by birth, he had become archdeacon under Paschal I, and was beloved for his goodness. Nothing is known of his pontificate.

VALENTINUS and **THE VALENTINIANS.** Valentinus, the most prominent leader of the Gnostic movement, was born, according to Epiphanius (*Haer.* 31, 2), near the coast in Lower Egypt, and was brought up and educated in Alexandria. Valentinus came to Rome (c. 135–160) during the episcopate of Hyginus, flourished under Pius and stayed till the time of Anicetus. According to Irenaeus iii. 3, 4, Polycarp, during his sojourn in Rome under the episcopate of Anicetus, converted a few adherents of the Valentinian sect. Tertullian (*Adv. Valentin.* cap. 4) declares that Valentinus came to Rome as an adherent of the orthodox Church, and was a candidate for the bishopric of Rome, but he abandoned the Church because a confessor was preferred to him for this office. The credibility of this statement may be questioned. Great uncertainty attaches to the residence of Valentinus in Cyprus, recorded by Epiphanius (*loc. cit.*), who places it after his stay in Rome, adding that it was here that he definitely accomplished his secession from the Church. But it seems to be clear that Valentinus did not, like Marcion, break with the Church from the very beginning, but endeavoured to maintain his standing within it.

Justin's *Syntagma*, which treats of Valentinus, is unfortunately lost. Irenaeus, *Adversus Haereses*, i. 11, 1–3, as in every other article where named, has preserved what is obviously an older document, possibly from Justin, dealing with Valentinus's own teaching and that of two of his disciples. The sketch which he gives is the best guide for the original form of Valentinianism. For Valentinus himself we have also to consider the fragments of his writings preserved by Clement of Alexandria. The best edition of and commentary on them is Hilgenfeld's *Ketzergeschichte des Urchristentums* (pp. 293–307). Irenaeus also gives a detailed account of the two chief schools following Valentinus, the school of Ptolemaeus (i. 1–10), and Marcus and the Marcosians (i. 13–21). For his account of the Ptolemaeans, Irenaeus seems to have used various writings and expositions of the school, especially prominent being a collection of Scripture proofs which may have once had a separate literary existence (i. 1, 3; 3, 1–5 [6]; 8, 2–4). To this is appended in a somewhat disconnected fashion a commentary on the prologue to the fourth Gospel (i. 8, 5). Irenaeus himself twice prefaces his remarks by saying he is indebted to other authorities for his exposition (i. 2, 3–4; 7, 2–5). *Excerpta ex Theodoto* which are to be found in the works of Clement and may be looked upon as a collection made by the author with a view to the unfinished eighth book of his *Stromateis*. The lost *Syntagma* of Hippolytus, which can be partially reconstructed from Philaster (*Haereses*) and from pseudo-Tertullian (*Adversus Valentini anos*), seems to furnish us with valuable information as to the earlier doctrines of the sect; and in his second treatise against heretics, the so-called *Philosophumena* (6, 29 *seq.*), Hippolytus gives a homogeneous and continuous exposition of a later Valentinian system, possibly connected with the school of Ptolemaeus. Important, too, are Hippolytus' references to an Italic and an Anatolian branch of the Valentinian sect (6, 35). Tertullian gives at the beginning of his treatise against the Valentinians a few separate notices of the life and disciples of Valentinus, but his further argument is closely dependent upon Irenaeus' exposition of the Ptolemaean system, which he embellishes in his usual fashion with bitterly sarcastic comments. Epiphanius deals with Valentinus and his school in sections 31–36 of his work. He has preserved a valuable letter of Ptolemaeus to Flora, which is of the highest importance for the understanding of Gnosticism.

Valentinus is the only one of the Gnostics who had a whole series of disciples who are known by name—indeed, in the accounts of the Church Fathers his own system and views are almost entirely obscured by the accounts of those of his disciples. The most important disciples are the two dealt with at length by Irenaeus, Ptolemaeus and Marcus, who both seem to have had a numerous following. Also, there was Herakleon, of whose commentary on the gospel of St. John extensive fragments are preserved by Origen. Ptolemaeus and Herakleon are counted by Hippolytus (6, 35) among the Italic branch of Valentinianism. There was also the Anatolian branch, as representative of which Hippolytus mentions Axionicus, who is also referred to by Tertullian as having actually been taught in Antioch. The *Excerpta ex Theodoto* in Clement are also, according to the superscription, fragments from the Anatolian Gnosticism. It is, however, an error when Hippolytus speaks of Bardesanes as representative of this branch, for he had an entirely distinct position. Valentinianism was based on primitive gnosticism (*q.v.*), with the doctrines of which Valentinus may have become acquainted in Egypt. The mother goddess stands at the centre of the system. The main doctrines are outlined below.

(1) Valentinus has a system of thirty aeons, but the quite shadowy plurality of ten and twelve aeons (the *Dekas* and the *Dodekas)* of the Valentinian system we may at once set aside as mere fantastical accretions. We have left only a group of eight celestial beings, the so-called Ogdoas, and of these eight figures four again are peculiar to this system.

(2) The first pair of aeons, *Bythos* and *Sige,* is an original innovation of the Valentinian school, and clearly betrays a monistic tendency. According to Irenaeus's account of the "Gnostics" (i. 29), their theory was that *Sophia* casts herself into the primal substratum of matter *(Bythos)* to be found outside the celestial world of aeons. But in the Valentinian system matter is not originally and irretrievably separated from the higher celestial world, but the latter originally exists for itself alone; the fall or disturbance is accomplished within the celestial world, and the material world first comes into existence through the fall.

(3) There remain a double pair of aeons, the Father and Truth, the *Anthropos* and the *Ekklesia.* With the celestial Primal Man—of whom the myth originally relates that he has sunk into matter and then raised himself up from it again—is associated the community of the faithful and the redeemed, who are to share the same fate with him.

(4) In the true Valentinian system the so-called *Christos* is the son of the fallen Aeon, who is thus conceived as an individual. *Sophia,* who in a frenzy of love had sought to draw near to the unattainable *Bythos,* brings forth, through her longing for that higher being, an aeon who is higher and purer than herself, and at once rises into the celestial worlds. Among the Gnostics of Irenaeus we find a kindred conception, but with a slight difference. Here *Christos* and *Sophia* appear as brother and sister, *Christos* representing the higher and *Sophia* the lower element. In the enigmatic figure of *Christos* we again find hidden the original conception of the Primal Man, who sinks down into matter but rises again. (In the later Valentinian systems this origin of the *Christos* is entirely obscured, and Christ, together with the Holy Spirit, becomes a later offspring of the celestial world of aeons; this may be looked upon as an approximation to the Christian dogma)

(5) A figure entirely peculiar to Valentinian Gnosticism is that of *Horos* (the Limiter). The name is perhaps an echo of the Egyptian *Horus.* The peculiar task of *Horos* is to separate the fallen aeons from the upper world of aeons. He becomes a kind of world-creative power, who in this capacity helps to construct an ordered world out of *Sophia* and her passions. He is also called, curiously enough, *Stauros* (cross), and we frequently meet with references to the figure of *Stauros.* But we must not be in too great a hurry to assume that this is a Christian figure. A Platonic conception may have been at work here. The cross can also stand for the wondrous aeon on whom depends the ordering and life of the world, and thus *Horos-Stauros* appears here as the first redeemer of *Sophia* from her passions, and as the orderer of the creation of the world which now begins. The figure of *Horos-Stauros* was often assimilated to that of the Christian Redeemer.

(6) The dualism of the two separate worlds of light and darkness was thus overcome. This derivation of the material world from the passions of the fallen *Sophia* is, however, affected by an older theory according to which the son of *Sophia,* whom she forms on the model of the *Christos* who has disappeared in the higher heavens, becomes the *Demiourgos,* who with his angels now appears as the real world-creative power. These two conceptions had now to be combined at all costs. And it is interesting to observe here what efforts were made to give the *Demiourgos* a better position. According to the older conception, he was an imperfect, ignorant, half-evil and malicious offspring of his mother, who has already been deprived of any particle of light (Irenaeus i. *29,* 30). In the Valentinian systems he appears as the fruit of *Sophia's* repentance and conversion. He is no longer called *Jaldabaoth,* but has been assigned the better name, drawn from the philosophy of Plato, of *Demiourgos.* The *Demiourgos* of the Gnostic corresponded to the God of the Old Testament, which again suggests a compromise with the Christian faith

(7) With the doctrine of the creation of the world is connected the subject of the creation of man. We fortunately know, from a fragment preserved by Clement, that Valentinus here preserved the old Gnostic myth practically unaltered in his system. According to it, the world-creating angels—not one, but many—create man, but the seed of the spirit comes into their creature without their knowledge, by the agency of a higher celestial aeon, and they are then terrified by the faculty of speech by which their creature rises above them, and try to destroy him. A definite Valentinian idea is here added in that of the threefold nature of man, who is represented as at once spiritual, psychical and material. In accordance with this there also arise three classes of men, the *pneumatici,* the *psychici* and the *hylici* (ὕλη, matter). All the other Gnostic systems recognize only a dual division, the children of light and the children of darkness. That the Valentinians should have placed the *psychici* between the *pneumatici* and *hylici* signifies a certain recognition of the Christian Church and its adherents who are not treated as outcasts.

(8) At the centre of the whole Valentinian system naturally stands the idea of redemption, and so we find here developed particularly clearly the myth of the heavenly marriage already known from Irenaeus i. 30 to be Gnostic. Redemption is essentially accomplished through the union of the heavenly *Soter* with the fallen *Sophia.* This myth of the redeemer is of significance for the practical piety of the Valentinian Gnostics. It is the chief idea of their pious practices mystically to repeat the experience of this celestial union of the *Soter* with *Sophia.* In this respect, consequently, the myth underwent yet wider development. Just as the *Soter* is the bridegroom of *Sophia,* so the heavenly angels, who sometimes appear as the sons of the *Soter* and *Sophia,* sometimes as the escort of the *Soter,* are the males betrothed to the souls of the Gnostics, which are looked upon as feminine. Thus every Gnostic had his angel standing in the presence of God, and the object of a pious life was to bring about and experience this inner union with the celestial abstract personage. This leads us straight to the sacramental ideas of this branch of Gnosticism.

(9) With this celestial *Soter* of the Valentinians and the redemption of *Sophia* is connected the figure of Jesus of Nazareth and the historical redemption connected with his name. The *Soter,* the bridegroom of Sophia, and the earthly Jesus answer to each other as in some way identical. Here again we recognize the artificial compromise between Gnosticism and Christianity.

(10) The Valentinians laid down that even the Redeemer has a threefold nature; from his mother, Sophia, he derived his

nature as a *pneumaticos,* in the world of the Demiourgos he was united with the Christos, and finally a wonderful bodily nature was formed for him from celestial elements, which was yet not of earthly material. As such he was miraculously born of the Virgin. The compromises with the Catholic Church are here obvious. Also, there was the idea that upon this Jesus, so constituted, yet another celestial nature, the Christos or the Soter, has descended at his baptism.

The first survey of these confused speculations, these myths gathered together and preserved from the ancient world, this marshalling together of the most varied traditions, and above all, these artificial attempts at compromise, makes us inclined to doubt whether it was possible for any true piety to coexist with all this. Yet such piety existed; indeed we have here a set of regular mystics. It is not, indeed, a purely spiritual and mystical piety, but a mysticism much distorted and over-grown with sacramental additions and a mysterious cult. But all this is not without an inner value and an attractive atmosphere. In a letter in Clement ii. 20, 114, Valentinus sets forth that the soul of man is like an inn, which is inhabited by many evil spirits. "But when the Father, who alone is good, looks down and around him, then the soul is hallowed and lies in full light, and so he who has such a heart as this is to be called happy, for he shall behold God."

But with this mysticism is connected the mystery and cult of the sacrament. The lofty spirituality of the Gnostic degenerates over and over again into a distinctly material and sensual attitude, in which all kinds of efforts are made actually to assimilate to oneself the divine through external means.

The chief sacrament of the Valentinians seems to have been that of the bridal chamber. Just as the apostle Paul represented his Christianity as a living, dying and rising again with Christ, so the first concern of the pious Valentinian was the experience of the divine marriage feast of Sophia. As Sophia was united with the Soter, her bridegroom, so the faithful would experience a union with their angel in heaven. Through a fortunate chance, a liturgical formula which was used at this sacrament appears to be preserved. It runs: "I will confer my favour upon thee, for the father of all sees thine angel ever before his face . . . we must now become as one; receive now this grace from me and through me; deck thyself as a bride who awaits her bridegroom, that thou mayest become as I am, and I as thou art. Let the seed of light descend into thy bridal chamber; receive the bridegroom and give place to him, and open thine arms to embrace him. Behold, grace has descended upon thee."

Besides this the Gnostics already practised baptism, using the same form in all essentials as that of the Christian Church. The name given to baptism was *apolytrosis* (liberation). In one of the formulae occur the words: "I would enjoy thy name, Saviour of Truth" The concluding formula of the baptismal ceremony is: "Peace over all upon whom the Name rests" (Irenaeus i. 21, 3). This name pronounced at baptism over the faithful has above all the significance that the name will protect the soul in its ascent through the heavens, conduct it safely through all hostile powers to the lower heavens, and procure it access to Horos, who frightens back the lower souls by his magic word.

Here and there a reaction took place against the absurdity of this sacramental superstition. Thus Irenaeus (i. 21, 4) tells us of certain Gnostics who would admit no external holy practices as efficacious. A pure piety breathes in the words of the Gnostics preserved in *excerpta ex Theodofo,* 78, 2: "But not baptism alone sets us free, but knowledge *(gnosis)*: who we were, what we have become, where we were, whither we have sunk, whither we hasten, whence we are redeemed, what is birth and what rebirth."

We have seen that Valentinian Gnosticism affected the nearest approach of all the Gnostic sects to the Catholic Church. Valentinus's own life indicates that he for a long time sought to remain within the official Church, and had at first no idea of founding a community of his own.

And yet this reconciliation of Gnosticism was a fruitless and henceforward a purposeless undertaking. Oriental dualism and wildly intemperate Oriental mythology had grown into so radical and essential a part of Gnosticism that they could not be separated from it to make way for a purer and more spiritual view of religion. And at a time when the prevailing tendency of Christianity was a struggle out of the darkness of Oriental mythology and eschatology into clearness, and an effort towards union with the lucid simplicity of the Hellenic spirit, these Gnostics, for all their efforts, and even the most noble of them, had come too late. They are not the men of a forward movement, but they are, and remain, in spite of all clearer insight, the rear-guard of piety.

See Bibliography to article GNOSTICISM.

VALENZUELA, FERNANDO DE (1636–1692), Spanish royal favourite, was born at Naples where he was baptized on Jan. 17, 1636. He gained influence at the Spanish court by his marriage with a lady in waiting to Mariana, Philip IV's second wife. When he was appointed introducer of ambassadors (Oct. 12, 1671), it became notorious that whoever had a petition to present must apply to him. He became popularly known as the *duende*, the fairy or brownie of the palace, and was believed to be the lover of the queen. Dismissed (1675) from court by intrigue, he was made marquis of Villa Sierra by the queen and ambassador to Venice. He exchanged the embassy for the governorship of Granada, organized a counterintrigue and returned to court. The queen-regent appointed him prime minister and made him a grandee, to the profound indignation of the other grandees. At the palace revolution of Jan. 1678, Valenzuela fled to the Escorial, was captured, degraded from the grandeeship, exiled to the Philippines and his property confiscated. He died in Mexico on Feb. 7, 1692.

See *Documentos inditos para la historia de España,* vol. lxvii *(1842 et seq.).*

VALERA Y ALCALA GALIANO, JUAN (1824–1905), Spanish novelist, entered diplomacy in 1847 and became unpaid attaché to the Spanish embassy at Naples under the famous duke de Rivas. He held various other diplomatic posts until 1858 when he returned to Spain and entered the House of Deputies, taking his place with the Liberal opposition. On the flight of Isabella II. in 1868 he was elected deputy for Montilla in the province of Cordova, became under-secretary of state for foreign affairs, and was one of the deputation who offered the crown to Amadeus of Savoy in the Pitti Palace at Florence. Though he always called himself a Moderate Liberal, Valera invariably voted for what are considered Radical measures in Spain, and a speech delivered by him in Feb. 1863 against the temporal power of the pope created a profound sensation. However, though a member of the revolutionary party, he steadily opposed organic constitutional changes, and therefore he retired from public life during the period of republican government. After the Bourbon restoration he acted as minister at Lisbon (1881–83), at Washington (1885), at Brussels (1886) and as ambassador at Vienna (1893–95), retiring from the diplomatic service on March 5, 1896. During his last ten years he took no active part in politics.

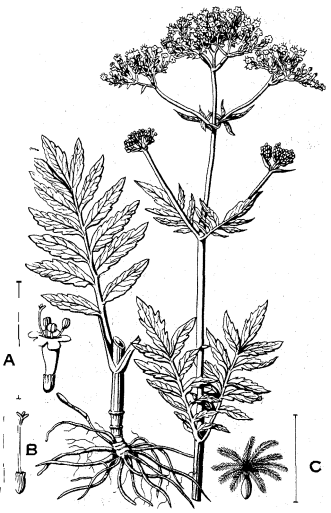
Valera's *Poesias* (1858) are imitative exercises rather than original poetry. His criticism in the *Estudios criticos sobre literatura* (1864), in the *Disertaciones* y *juicios literarios* (1878) and in the *Nuevos estudios criticos* (1888) show penetration and taste, but also an excessive amiability. He said a hundred incisive, wise, witty, subtle and suggestive things concerning the mysticism of St. Theresa, the art of novel-writing, *Faust*, the Inquisition, *Don Quixote,* Shakespeare, the psychology of love in literature; but, to do himself justice, it was an almost indispensable condition that he should deal with the past. In the presence of a living author Valera was disarmed

When in his 50th year, he published *Pepita Jiménez* (1874) a recital of the fall of Luis de Vargas, a seminarist who conceived himself to be a mystic and a potential saint, and whose aspirations dissolve at the first contact with reality. It is easy to point out blemishes: the story is not well constructed, and it has pauses during which the writer's fantasy plays at pleasure over a hundred subjects not very germane to the matter; but its characters are as real as any in fiction, the love story is told with the most refined subtlety and malicious truth, while page upon page is written in such Spanish as would do credit to the best writers of the 16th and 17th centuries. A second novel, *Las ilusiones del Doctor Faustino* (1875), was received with marked disfavour, and has the faults of over-refinement and of cruelty; yet in keen analysis and in humour it surpasses *Pepita Jiménez.* The *Comendador Mendoza* (1877) is more pathetic and of a profounder significance; and if *Doña Luz* (1879) repeats the situation and the general idea already used in *Pepita Jiménez* it strikes a deeper and more tragic note, which came as a surprise to those familiar only with the lighter side of Valera's genius. Besides these elaborate psychological studies, Valera issued a volume of *Cuentos* (1887), some of these short tales and dialogues being marvels of art and of insight.

At the close of the 19th century Valera was recognized as the most eminent man of letters in Spain. He had not Pereda's force nor his energetic realism; he had not the copious invention nor the reforming purpose of Pérez Galdós; yet he was as realistic as the former and as innovating as the latter. And. for all his cosmopolitan spirit, he fortunately remained intensely and incorrigibly Spanish. His aristocratic scepticism, his strange elusiveness, his incomparable charm are his own; his humour, his flashing irony, his urbanity are eminently the gifts of his land and race. He is by no means an impersonal artist; in almost every story there is at least one character who talks and thinks and subtilizes and refines as Valera himself wrote in his most brilliant essays. This may be a fault in art; but, if so, it is a fault which many great artists have committed. (J. F.-K.)

VALERIAN, common name of any of the genus *Valeriana,* herbaceous perennial plants of the family Valerianaceae, widely distributed in temperate regions of North America, Europe and Asia. The genus comprises about 175 species. native to Europe or Asia; two species, *Valeriana officianalis* and *V. dioica,* are indigenous to Britain. Common valerian (*V. officianalis*), or garden heliotrope, is cultivated in the United States! Britain and western Europe for the medicinal uses of the root, which acts as a sedative and carminative.

The valerians have opposite leaves and small, very fragrant flowers! usually white or reddish, and arranged in terminal cymes. The limb of the calyx is remarkable for being at first inrolled and afterward expanding in the form of a feathery pappus which aids in the dissemination of the fruit. The dried root or rhizome consists of a short, central, erect portion, about the thickness of the little finger, surrounded by numerous rootlets about 0.1 in. in diameter, the whole being of a dull brown colour. When first taken from the ground it has no distinctive smell, but on drying it acquires a powerful odour of valeric acid.



VALERIAN (VALERIANA OFFICINALIS) ONE-THIRD NATURAL SIZE
(A) Flower; (B) flower after removal of corolla; (C) fruit crowned by the feathery pappus (A,B, & C enlarged)

This odour, which is now regarded as offensive, was in the 16th century considered to be fragrant, the root being placed among clothes as a perfume. just as V. *celtica* and other species are still used in the east.

The ornamental Jupiter's beard or red valerian of gardens is *Centranthus ruber,* also belonging to the Valerianaceae; but Greek valerian or Jacob's-ladder is *Polemonium caeruleum,* belonging to the family Polemoniaceae. and introduced from Eurasia to the northeastern C.S. and southern Canada. Cats are fond or' the smell of this plant. as they are of the true valerian. and will frequently roll on the plant and injure it. Valerian thrives in a rich, loamy, moist soil.

The chief constituent of valerian is a volatile oil, which is present in the dried root to the extent of 1% to 2% and is responsible for its medicinal properties.

The oil is of complex composition, containing valeric (valerianic), formic and acetic acids combined with terpene; the alcohol known as borneol; and pinene.

VALERIANUS, PUBLIUS LICINIUS, Roman emperor from A.D. 253 to 260. He was of noble family, and in 238 was *princeps senatus.* In 251, when Decius revived the censorship with practically supreme civil authority, Valerian filled the post. Gallus, the successor of Decius, summoned him from the upper Rhine in 253 when threatened by the rebellion of Acmilianus. The soldiers, however, proclaimed Valerian emperor, and marching slowly towards Rome he found both his rivals dead, slain by their own soldiers. Trouble on the frontiers east and west was complicated by something near national bankruptcy. Valerian left his son, Gallienus, in charge of the wars in Europe; and took the offensive against the Goths, recaptured Antioch and marched to relieve Edessa.

He was defeated and taken prisoner, and disappears from history (258).

VALERIUS FLACCUS, GAIUS (fl. 1st century A.D.), Latin epic poet, was the author of an *Argonautica.* Very little is known of his life, but he must have died about A.D. 90 since he is mentioned by Quintilian who says of him in his *Institutio oratoria,* published between 93 and 95, that his recent death was a great loss. Valerius' own reference to the Jewish war of Titus shows that he was writing after A.D. 70, and as he also mentions the eruption of Vesuvius he must have been alive after A.D. 79.

The *Argonautica* is the only work of his that survives. It is an epic poem in hexameter verse, and is dedicated to the emperor Vespasian. It describes the famous voyage of the ship "Argo" in which Jason and other heroes sailed to Colchis to bring back the golden fleece to Thessaly. The first four books deal with the adventures of the Argonauts on their voyage, the story of the Lemnian women, the battle at Cyzicus, the loss of Hylas and departure of Hercules, and others. In the fifth book they arrive at Colchis and Jason meets Medea. She falls in love with him and helps him to sow the dragon's teeth and steal the fleece. He then takes her off with him on the "Argo." Soon after this the poem breaks off abruptly. in the eighth book.

Valerius clearly borrowed material from the *Argonautica* of the Alexandrian poet Apollonius Rhodius (fl. *c.* 200 B.C.); and for his style and treatment he was deeply indebted to Virgil, though his Medea is a much gentler and less passionate figure than Dido. His work is free from some of the vices of Silver Latin epic poetry, such as display of erudition and exaggerated rhetoric, and the great 17th-century scholar, Nikolaes Heinsius, admired it. To the modern reader it seems less poetic than the best of Statius and less powerful than the best of Lucan, but it is a good narrative, in simple and direct language, which shows distinct dramatic talent.

The *Argonautica* was unknown until the first four and a half books were discovered by Poggio at St. Gall in 1417. The first edition was published in 1474. Later editions include P. Langen in *Berliner Studien fur klassische Philologie,* new series, vol. 1 (1896–97), and O. Kramer in the Teubner series (1913).

See W. C. Summers, *A Study of the Argonautica of Valerius Flaccus* (1894); J. W. Duff, *A Literary History of Rome in the Silver Age,* pp. 433–451 (1927). (An. K.)

VALERIUS MAXIMUS (fl. *c.* A.D. 20), was the Latin author of a book of historical anecdotes. His family was poor, and he owed everything to Sextus Pompeius (consul A.D. 14, and proconsul of Asia), a kind of minor Maecenas, whom he accompanied to the east *c.* A.D. 27. His book, *Factorum et dictorum memorabilium libri ix* ("Nine Books of Memorable Deeds and Sayings," *c.* A.D. 31), was intended for use in the schools of rhetoric. The anecdotes are drawn chiefly from Roman history, but include extracts from the annals of other peoples, principally the Greeks. The arrangement is loose and irregular, the style turgid, artificial and showy, but Valerius can sometimes produce an effective and well-placed pointed expression, an ingenious transition or a clever piece of fancy. In spite of its contradictions and errors this varied collection proved very popular, especially in the middle ages. There is an edition in the Teubner series with two later epitomes (the second surviving incomplete) by C. Kempf (1888) and an English translation by S. Speed (1678).

It is not easy to determine Valerius' sources. He made considerable use of Cicero. He also used Pompeius Trogus, Livy, an earlier historian and probably Varro. It has not been proved that he used Sallust or Caesar. Valerius was a champion of Caesarism, and reproduced the general feeling of the empire that the Romans of his day were inferior to their ancestors but greatly superior to the rest of the world.

See J. W. Duff, 4 Literary History of Rome in the Silver Age, pp 65–81 (1927); R. Helm in Pauly-Wissowa, Real-Encyclopadie der classischen Altertumswissenschaft, 2nd series, vol. 8, col 90–116 (1955). (G. B. A. F.)

VALÉRY, PAUL (1871–1945), French poet, was born at Cette on Oct. 30, 1871. He first became known as the author of several apocalyptic poems of remarkable beauty and form, which appeared in such reviews as *L'Ermitage,* Le Centuure, etc., and were issued later in a collection entitled Album de Vers *anciens* (1920). From 1900 to 1917 Valéry lived in strict retirement and published nothing. During this period, however, his ideas matured, and he accumulated material later given to the public in Cahier *B,* Rhumbs and *Analecta.* It was not until 1917 that he published his first great poem La Jeune Parque, dedicated to André Gide. Then came Aurore (1917), Le *Cimitière marin* (1920), La *Platane, L'Ebauche* d'un Serpent, etc., which appeared in a collection entitled Les *Charmes* (1922).

Valéry also wrote critical essays (on Stendhal, Poe, etc.) and philosophical treatises (Introduction *à* la mdthode de *Léonard* de *Vinci, Soirée* avec *M. Teste*) of which some were collected under the title *Variétés* (1924), *Eupalinos* and *Ame et la Danse* (1923), two Platonic dialogues.

Valéry initiated a new movement in French poetry. Influenced by Mallarmé, especially in his sense of verbal music, he believed with the symbolists that pure poetry must have value in itself apart from any reference to the accidents of being. Interested in philosophy and mathematics, he was a poet-mathematician trying to set his subtle analysis to music.

Valéry was a member of the Académie française from 1926. He died July 20, 1945, at Paris.

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VALHALLA (Old Norse VALHÖLL), in Norse mythology was the hall of slain warriors, who lived there blissfully under the leadership of the god Odin. Valhalla is depicted as a splendid palace, roofed with shields, where the warriors feast on the flesh of a boar slaughtered dally and made whole again each evening. They drink liquor which flows from the udders of a goat, and their sport is to fight one another every day.

Thus they will live until the Ragnarök (Doomsday), when they will march out the 640 doors of the palace to fight at the side of Odin against the giants. When heroes fall in battle it is said that Odin needs them to strengthen his forces for the Ragnarok.

Early Norse poets frequently allude to Valhalla and its splendors, but it is improbable that the belief in it was ever widespread among the common people. (G. T.-P.)

VALKYRIES, generally represented in Northern mythology as divine maidens who, sent by Odin, ride through the air to determine the course of battles and to select brave warriors for Valhalla (*q.v.*).

Beings with the same name (*waelcyrgean*) were in England associated with witches.

VALLA, LORENZO (LAURENTIUS) (c. 1407–1457), Italian humanist, was born at Rome about 1406, his father, Luca delle Vallea, being an advocate. He was educated at Rome, became a priest in 1431, and wandered from one university to another lecturing. About 1437 he became private secretary to Alphonso V of Aragon, who ever afterwards protected him, and later helped him to open a school at Naples. Valla by now had achieved a great reputation by the De Voluptate and the *De Elegantiis* Linguae Latinae. The first is a remarkable dialogue presenting in turn the Stoic, Epicurean and Christian ethical systems. Christianity is allowed to prevail, but Epicurus is very favourably treated. The De Elegantiis is a scientific analysis of the rules of Latin grammar and style. In 1440 appeared his famous exposure of the Donation of Constantine (*q.v.*), followed by other attacks on spurious documents. He was compelled to appear before an inquisitory tribunal composed of his enemies, and he escaped only by the special intervention of Alphonso. He was not, however, silenced; he ridiculed the Latin of the Vulgate and accused St. Augustine of heresy. In 1446 he visited Rome, but in this city also his enemies were numerous and powerful, and he saved his life only by flying in disguise to Barcelona, whence he returned to Naples. After the death of Eugenius IV in 1447 he went again to Rome, where he was welcomed by the new pope, Nicholas V, who made him an apostolic secretary, and this entrance of Valla into the Roman Curia has been justly called "the triumph of humanism over orthodoxy and tradition." Valla also enjoyed the favour of Pope Calixtus III. His most famous dispute was with Poggio (*q.v.*). He died in Rome on Aug. 1, 1457.

Over Valla's private life, the most obscene language was employed. He appears as a vain, jealous and quarrelsome man, but an elegant humanist, an acute critic and a venomous writer, who had committed himself to a violent polemic against the temporal power of Rome. In him posterity honours the man who initiated a bold criticism, which he applied to language, to historical documents and to ethical opinions. Luther had a high opinion of him, and Cardinal Bellarmine calls him *praecursor Lutheri,* while Sir Richard Jebb says that his *De Elegantiis* "marked the highest level that had yet been reached in the critical study of Latin."

Collected, but not quite complete, editions of Valla's works were published at Basle in 1540 and at Venice in 1592 *seq.,* and De *Elegantiis* was reprinted nearly 60 times between 1471 and 1536. For detailed accounts of Valla's life and work see G. Voigt, Die *Wiederbelebung* des *classischen* Alterthunzs (1880–81); J. A. Symonds, *Renaissance in Italy* (1897–99), G. Mancini, *Vita di* Lorenzo Valla (Florence, 1891); M. von Wolff, Lorenzo Valla (Leipzig, 1893); J. Burckhardt, Kultur der Renazssance (1860); J. Vahlen, *Laurentius* Valla (1870); L. Pastor, Geschichte der Papste, Band ii. Eng. trans. by F. I. Antrobus (1892); the article in Herzog-Hauck's *Realencyklopadze,* Band xx (Leipzig, 1908); J. E. Sandys, Hzst. of Class. Schol. ii. (1908), pp. 66–70; and V. Rossi, *Il* Quattrocento, 2nd ed. (1933).

VALLADOLID, an inland province of Spain, one of the eight into which Old Castile was divided in 1833. Population (1950 census) 348,185; area, 3,155 sq.mi.

The province belongs to the basin of the river Duero (Douro). It is for the most part flat and exceedingly fertile, the only part that can be called hilly being in the northwest, where the low Montes de Torozos occur. Valladolid shares with the Tierra de Campos in Palencia the title of granary of the Peninsula.

Besides wheat, maize, barley and oats, the province produces hemp, flax, various fruits, red and white wine, oil and madder. Honey, wax and silk are also produced. The woollen fabrics of Valladolid were once highly esteemed, but this industry later greatly declined, although in the larger towns there are still linen and cloth factories, besides iron foundries, tanneries, saw-mills and flour-mills. Trade is facilitated by the Canal de Castilla, connecting Valladolid, on the Pisuerga, with Alar del Rey, in Palencia. Valladolid is traversed from north to south by the railway from Madrid to France. Apart from the capital Valladolid (*q.v.*), Medina del Campo (13,242) is the only large town. The province was captured by nationalist troops in 1936, during the early stages of the civil war of 1936–39.

VALLADOLID, the capital of the Spanish province of Valladolid, 2,228 ft. above sea-level, at the confluence of the river Pisuerga with the Esgueva Pop. (1950) 115,157.

Valladolid is sometimes identified with the ancient Pintia of Ptolemy. Its Roman origin is uncertain. The present name is undoubtedly Moorish. Valladolid was recovered from the Moors in the 10th century, but is first named by Sancho II of León in 1072. The cortes of Castile frequently met here in the following centuries. and in the beginning of the 15th century John II made it his principal residence. After the removal of the capital to Madrid by Philip II in 1560 it began rapidly to decay. Columbus died

(1506) and Philip II was born (1527) at Valladolid. The cathedral was begun in 1585 by Juan de Herrera in the Renaissance style. The interior contains pictures by Luca Giordano (1632–1705) and the celebrated silver monstrance wrought by Juan de Arphe. Other buildings are the church of Santa Maria la Antigua (1200); the church of San Pablo (1286); San Gregorio (15th century); and San Benito (end of the 14th century). The Plateresque college of Santa Cruz, built by Enrique de Egas in 1479–92, contains three pictures by Rubens, and some remarkable wooden statues by Alonso Berruguete (d 1561), Gregorio Hernández (1566–1636) and others. The university, originally founded at Palencia early in the 13th century, was transferred to Valladolid before 1250. The house in which Cervantes lived (1603–06) has been preserved. Manufactures include textiles, pottery, gold and silver work, flour, wine, beer, chocolate, leather and ironware.

VALLANDIGHAM, CLEMENT LAIRD (1820–1871), U.S. politician who was exiled for his opposition to the American Civil War, was born in New Lisbon, O., on July 29, 1820. He attended Jefferson college, Canonsburg, Pa., but left before graduating. He then studied law and was admitted to the bar in Ohio in 1842. He soon turned to politics and was elected to the Ohio house of representatives in 1845. From 1857 to 1863 he was in the U.S. house of representatives, where he was noted for his strong opposition to the principles and policies of the new Republican party. He became a leader of the midwestern Democrats or "copperheads." who were opposed to the prosecution of the Civil War for the benefit of eastern interests. He bitterly attacked the Lincoln administration, charging that it was destroying the constitution and would end by destroying civil liberty in the north. In 1863 he made vigorous speeches in Ohio against the war and the administration, and for these he was arrested by the military authorities, tried by a military commission in Cincinnati and sentenced to imprisonment. President Lincoln commuted his sentence to banishment, and Vallandigham was sent into the Confederate lines, whence he made his way to Canada. His case was appealed to the U.S. supreme court, which decided in Ex *parte Vallandigham* (1 Wallace 243) that it had no jurisdiction. While in exile he received the Democratic nomination for governor of Ohio, but was defeated. In 1864, in spite of the order for his banishment, he returned to Ohio and took active part in the campaign of that year. He wrote part of the national Democratic platform in which the war, as carried on by the Lincoln administration, was denounced as a failure. After the war he criticized the reconstruction policy of the Republicans as unconstitutional and tyrannical, but in 1870, seeing the uselessness of further opposition, he advised his party to accept the situation and adopt a "new departure" emphasizing financial issues. Vallandigham was an able lawyer and a popular politician. He died in Lebanon, O., on June 17, 1871, after accidentally shooting himself with a firearm that was an exhibit in a murder trial.

See F. L. Klement, *Copperheads in the Middle West* (1960); H. S. Merrill, *Bourbon Democracy of the Middle West* (1953).

(W. B. HE.)

VALLE, PIETRO DELLA (1586–1652), Italian traveler in the east, was born on April 11, 1586, in the family palace built by Cardinal Andrea. He served against the Moors of Barbary, but also became a member of the Roman academy of the Umoristi, and acquired some reputation as a versifier and rhetorician. Sailing from Venice in 1614, he reached Constantinople, where he remained for more than a year. In Sept. 1615 he sailed for Alexandria. From Alexandria he went on to Cairo, and, after an excursion to Mount Sinai, left Cairo for the holy land in March 1616. Having visited the holy sites, he journeyed by Damascus to Aleppo, and thence to Baghdad, where he married a Syrian Christian named Maani. He now desired to visit Persia; but, as that country was then at war with Turkey, he had to leave Baghdad by stealth in Jan. 1617. Accompanied by his wife he joined Shah Abbas in a campaign in northern Persia, in the summer of 1618. On his return to Isfahan he began to think of returning by India; but the state of his health, and the war between Persia and the Portuguese at Ormuz, created difficulties.

In Oct. 1621 he started from Isfahan, visited Persepolis and Shiraz, went on to the coast and in Jan. 1623 found passage for Surat. In India he remained till Nov. 1624, his headquarters being Surat and Goa. He was at Muscat in Jan. 1625, and at Basra in March. In May he started by the desert route for Aleppo, and took ship at Alexandretta. Touching at Cyprus, he reached Rome on March 28, 1626. He died at Rome on April 21, 1652.

VALLE, a small department in southern Honduras, bordering the Gulf of Fonseca and El Salvador. Pop. (1961) 80,924, of which 77% was rural. Population is evenly distributed within the department. Nacaome, the departmental capital, pop. (1961) 3,715, is on the Inter-American highway and is connected by Inter-Ocean highway with Tegucigalpa. Amapala, a port on Tigre Island, handles nearly as much cargo as Puerto Cortés. Most of the department consists of coastal and low alluvial plains. About 55% of the land is used for farms; 28% is cultivated and 20% is in pasture. Important products are cotton, swine, cattle, sesame, corn and beans. (C. F. J.)

VALLE D'AOSTA, the upper basin of the Dora Baltea river, from its source near Mont Blanc to just above Ivrea. Geographically and historically part of Piedmont, it formed from 1948 an autonomous region within the Republic of Italy. Pop. (1961) 99,754. Area 1,260 sq mi. Through it runs the important highway from the Po valley to the Great and Little St. Bernard passes. The capital and episcopal see is Aosta (anc. Augusta Praetoria Salassorum), 1,920 ft. above sea level and 80 mi. N N W. by rail (48 mi direct) from Turin, at the junction of the two Alpine routes. Pop. (1957 est.) 28,446 (commune). It was the birthplace of Saint Anselm (1033–1109), archbishop of Canterbury. The valley is economically important for its dairy products and as a tourist centre, and has valuable hydroelectric resources. The local dialect has strong Franco-Provençal affinities.

Originally the territory of the Salassi (a Celtic tribe), the valley was annexed and Aosta, the capital, was founded in 25 B.C. After the fall of the western Roman empire Valle D'Aosta passed through many hands until in the 11th century it came into, and thereafter remained in, the hands of the house of Savoy. Aosta has preserved the walls, two gates and the street-plan of its Roman predecessor, as well as a fine triumphal arch in honour of Augustus, the vaulted substructures of a large rectangular temple-precinct, one complete wall of the theatre, and elements of the amphitheatre and public baths. The plan, a strict rectangle of 792 by 625 yd., bisected longitudinally by the main valley road and crossed at right angles by another road, is laid out on a basis of 64 equal *insulae* and is an outstanding example of Roman formal city planning. Of later monuments the cathedral is notable for its treasury and 12th-century floor mosaics, and the church of St. Orso for its Romanesque cloisters and Gothic choir stalls. A feature of the valley is its magnificent series of medieval castles.

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VALLE DEL CAUCA, a department of the republic of Colombia that encompasses the flat-floored valley of the upper Cauca river (elevation 3,100–3,300 ft.). Area 7,888 sq.mi. Pop. (1961 est.) 1,743,320. The department is a leading producer of sugar, rice, tobacco and coffee. Buenaventura (*q.v.*) on the Pacific ocean, connected with the capital city of Cali (*q.v.*) by both rail and highway, has become a leading port of the country. Through it moves the major portion of Colombia's coffee exports. The ambitious Cauca Valley Development project, a 20-year plan, was modeled on the Tennessee river project in the U.S. (Js. J. P.)

VALLE-INCLÁN, RAMÓN DEL (1866–1936), Spanish novelist, dramatist and poet, outstanding as a stylist, was born at Villanueva de Arosa (Pontevedra), on Oct. 28, 1866. After a childhood and youth in Galicia and a sojourn in Mexico in 1892, he settled in Madrid, where he became renowned for his colourful personality. Coming under French "decadent" and Symbolist influences, he was early preoccupied with style. His first notable work, *Sonata de otoño* (1902), is the story of a latter-day Don Juan, the marquis of Bradomin, told in evocative, cadenced prose of great beauty. Bradomin, also the protagonist of three more *Sonatas* (1903–1905; Eng. trans. of all four, 1924), remains one of the memorable characters of Spanish literature. In other works Valle-Inclán developed a style rich in popular as well as literary elements, as in the prose *Comedias bárbaras* (*Aguila de blasón,* 1907; *Romance de Zobos,* 1908; *Cara de plata,* 1923'1. about the patriarchal Don Juan Manuel de Montenegro and his brood of wild sons. Later, with a growing social and political consciousness, Valle-Inclán wrote plays, novels and verse in a tone of burlesque tragedy and a style superbly adapted to his grotesque, satirical, Goyalike vision, calling the new genre *esperpento* ("an ugly, ridiculous person or thing"). In this vein are his last novels, *Tivano Banderas* (1926; Eng. trans. 1929), with its vivid portrayal of a Latin-American despot, and the unfinished series. El *ruedo ibérico: La corte de los milagros* (1927), *Viva mi dueño* (1928) and the posthumous *Baza de espadas* (1958), dealing with the political degradation of 19th-century Spain. Valle-Inclán died at Santiago de Compostela on Jan. 5, 1936.

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(W. L. Fi.)

VALLEJO, a city of Solano county, Calif., U.S., on San Pablo bay at the mouth of the Napa river north of the Carquinez straits, is at the head of deep water with a 35-ft. channel to San Francisco, 25 mi. S.W. Vallejo is within the San Francisco-Oakland standard metropolitan statistical area; *see* SAN FRANCISCO. Its population in 1960 was 60,877; for comparative population figures *see* table in CALIFORNIA: *Population.*

It was named for the Mexican soldier and pioneer, Gen. Mariano Guadalupe Vallejo, who explored the area in 1830. In Jan. 1851. a few months after California's admission to the United States. Generai Vallejo offered the legislature 156 ac. of land for a state capital on San Pablo bay. Although the offer was accepted and the legislature moved from San Jose. Vallejo served as the state capital for only seven days in Jan. 1852 and for a month in 1853. The establishment of the Mare Island naval shipyard in 1854 permitted the town to survive and prosper.

The rapid growth of Vallejo's population and economy after 1940 was due largely to varied military operations in the area, of which the most important continued to be Mare Island. Important civilian industries include flour milling and meat packing. The city is the economic hub of the agriculturally rich Solano county, noted for its production of sheep and wool, field crops such as tomatoes and sugar beets, and a large variety of fruit and nut crops. The public school system of the city includes a junior college. Vallejo is the home of the California Maritime academy, a special institute conferring the bachelor's degree based on an accelerated program. (M. H. Mo.)

VALLÈS, JULES (1832–1885), French journalist and author, was born at Puys, France, on June 10, 1832. Coming to Paris, he joined the staff of the *Figaro* and became a constant contributor to the other leading journals. He was in Paris during the siege of 1870 and after the capitulation was a member of the Commune and founded *Le Cri du Peuple.* He took a conspicuous part in the fighting in the Paris streets but finally made his escape to London, whence he contributed anonymously to the French press. In 1878 he began in the *Siècle* the serial publication of his principal work, *Jacques Vingtras,* a long autobiographical romance. He died in Paris on Feb. 14. 1885.

VALLETTA or VALETTA, the capital of Malta (since 1570), was built after the great siege of 1565 and named after the grand master Jean Parisot de La Valette who had led the knights of the Order of the Hospital of St. John of Jerusalem to victory against the Turks; it is a major British naval and air base. The nucleus of the city is built on the promontory of Mt. Sceberras that runs like a tongue into the middle of a bay which it thus divides into two harbours, Grand harbour to the east and Marsamuscetto (Marsamxett) to the west; these are subdivided again into creeks by three smaller peninsulas. On two of these peninsulas on the east side of Grand harbour; and at their bases, are built the aggregate of towns called the Three Cities—Vittoriosa, Cospicua and Senglea. On the main promontory, with Valletta. is the suburb Floriana and, on the extremity of this promontory, Fort St. Elmo. The suburb Sliema lies on the western point which encloses Marsamuscetto harbour; Fort Ricasoli is on the eastern point, enclosing Grand harbour. Pop. excluding suburbs (1957) 18,202.

The most interesting building in the town is St. John's co-cathedral, formerly the conventual church of the Order of St. John, but now equal in rank with the bishop's cathedral in Notabile (hence its title of co-cathedral). It was designed by the Maltese architect Girolamo Cassar and built by the grand master Jean Lévesque de la Cassière between 1573 and 1577. In 1661 Mattia Preti (1613–99) was invited from Rome to Malta to decorate the ceiling of the church; he also painted some of the altarpieces for the side chapels. Though the church was despoiled by Napoleon, it still contains many art treasures such as the magnificent set of Flemish tapestries executed by Judocus de Vos from Preti's designs and presented to the church by the grand master Ramon Perellos in 1697. Other important buildings by Cassar are the palace of the grand masters (1573–77), now shared by the British governor and the Maltese legislative assembly and containing the armoury of the Order of St. John; the Auberge d'Aragon, now the seat of the prime minister; and the Auberge de Provence, now a national museum. Of the other *auberges* (lodges of the knights of Malta) by Cassar those of France and Auvergne were destroyed during World War II. The Auberge de Castille. originally built by Cassar, was completely remodeled in the 18th century by Domenico Cachia; it is used for military offices, clubrooms and other purposes. The Royal Malta library (containing 300.000 volumes and 1,450 manuscripts) was constructed by Stafano Ittar at the end of the 18th century. The Royal University of Malta, in St. Paul street, was founded by the grand master Emmanuel Pinto in 1769. After the British occupation of Malta in 1799, Valletta became a naval and military station of the first importance. The naval dockyards, arsenal and provisions stores occupy the shores of the two main creeks within Grand harbour. The large transit trade and the local trade of the island is also centred in the city. Valletta has no industries but it is the shopping town. All the main government departments are there and it is the administrative centre of Malta and Gozo. Transport is by bus, taxi or the local horse-drawn vehicle called the *karrozzin.* Valletta was the principal objective of bombing raids on Malta by German aircraft, which commenced on June 11, 1940, and continued for nearly three years on a scale unequaled elsewhere in the world. *See* also MALTA. (*P.* J. Ni.)

VALLEYFIELD (SALABERRY-DE-), a city in Beauharnois county. Que., Can.. 25 mi. S.W. of Montreal, at the eastern end of Lake St. Francis—a widening of the St. Lawrence river—and at head of the Beauharnois canal section of the St. Lawrence seaway. Pop. (1956) 23,584. of which 90% are French-speaking. It is the seat of a Roman Catholic bishopric and serves as an administrative and cultural centre for the surrounding agricultural areas. Industry has been attracted to the area because of available hydroelectric power and a large labour force. Important products are cotton and silk yarns, paper, bronze, drugs, canned goods and wood products. (W. F. Ss.)

VALLEY FORGE, an area about 20 mi. N.W. of Philadelphia, Pa., U.S., where the American Revolutionary army of about 11,000 men under George Washington spent the winter of 1777–78. Their sufferings there from cold, starvation and sickness hallowed the historic site for Americans. The troops wintered in log huts and received little food or clothing. On Dec. 23, 1777, Washington wrote: "We have this day no less than 2,873 men in camp unfit for duty because they are barefooted and otherwise naked. . . . Numbers are still obliged to sit all night by fires." There were many desertions and occasional symptoms of mutiny, but for the most part the soldiers bore their sufferings with heroic fortitude. In Feb. 1778 the winter encampment became the first training camp of any United States armed forces. Under the drillmaster. Baron Frederick von Steuben (*q.v.*) the army was reorganized, and left Valley Forge June 19, 1778, an efficient fighting unit. Of the original encampment 2,033 ac. are owned, maintained and preserved by the commonwealth of Pennsylvania and known nationally as Valley Forge park. Washington headquarters, Varnum quarters, commissary quarters and much of the military works used by the Continental army was restored. The ruins of the valley forge, an iron plant which gave name to the area and which the British burned in Sept. 1777, have been excavated. Statues of Anthony Wayne and Von Steuben and the National Memorial arch, erected as a tribute to all the men, are outstanding monuments.

The locations of troop units from each of the 13 original colonies are indicated by granite markers. One memorial to Washington is the magnificent Washington Memorial chapel with its carillon of 49 bells. (G. S. J.)

VALLEY OF TEN THOUSAND SMOKES, a volcanic region in Alaska, which came into being at the time of the eruption of Mt. Katmai on the Alaskan peninsula on June 6, 1912. An ancient trail led through the valley, so that it was well known to have been rich in plant and animal life, a favourite hunting ground of the natives. One of the first events in the Katmai eruption was the bursting forth of a new volcano, Novarupta, in the floor of one arm of the valley. Probably from this vent, and other smaller ones, issued the great flow of incandescent sand which filled the floor of the valley, 17 mi. in length and 4 mi. in width, utterly consuming everything in its path until it reached the lower end of the valley, where the trees were merely turned to charcoal. At the time of its discovery not ten thousand but millions of jets of steam were issuing from the floor of the valley from vents ranging in size from a tiny crack to pits or craters 150 ft. in diameter. In temperature they ranged up to 1,200° F., hot enough to melt zinc and to set ablaze a stick held in the steam. Immediately following the hot sand flow Mt. Katmai 'exploded. Its three-peaked snow-covered crown was blown to bits, leaving a crater 3 mi. wide, containing a lake 3,700 ft. below the crater rim. Kodiak Island, 100 mi. away. was covered with a blanket of volcanic ash a foot deep. Acid rains fell in Cordova, 360 mi. distant, while the fumes tarnished brass in Victoria, B.C., 1,500 mi. away. The haze was noted in Virginia and at the bureau of standards in Washington, D.C. The dust from Katmai thrown into the higher layers of atmosphere robbed the north temperate zone of 10% of the sun's heat in the summer of 1912. Because Katmai is located in a region almost uninhabited, not a human being lost his life, though this eruption nas one of the largest ever known.

The Valley of Ten Thousand Smokes and its neighbouring wonders mere discovered by Robert F. Griggs, director of the National Geographic society's expeditions of 1915–16–17–18–19, This region proved to be so stupendous a volcanic laboratory as well as so rich in scenic value that in Sept. 1918 Pres. Woodrow Wilson set aside the whole district, comprising 2,697,590 ac., as the Katmai National monument. (L. T. G.)

VALLEY STREAM, a village of New York, U.S., in Nassau county, about 16 mi. from Manhattan, is the first suburban community outside of the political limits of New York city on the south shore of Long Island. The village was first settled in 1647 on open, flat, farm country. It was incorporated in 1925.

Valley Stream is almost entirely suburban in character; between 60% and 70% of its working population commutes to New York city. After World War II its population steadily increased until practically no land was available for new housing. The community has long been regarded as an ideal suburban residence because of its convenience to Manhattan and also to Long Island's beaches and recreational facilities. For comparative population figures see table in NEW YORK: Population. (WI. M. D.)

VALLOMBROSA, a summer resort of Tuscany, Italy, in the province of Florence, reached by road (9 mi.) from the station of Saint Ellero (which is 16 mi. S.E. of Florence) and 328 ft. above sea level, on the northwest slope of the Prato Magno chain. The former monastery was suppressed in 1866. A number of hotels have been built. Similar summer resorts are situated among the woods above the Casentino or upper valley of the Arno to the east, such as Camaldoli, Badia di Prataglia, etc. Camaldoli was the original headquarters of the Camaldulensian order, now partly occupied by a hotel. Five hours' journey to the south of the last on foot and 7½ mi. to the east of Bibbiena by road is the monastery of La Verna, 3,660 ft. above sea level, founded by St. Francis in 1215 on an isolated limestone peak. There he received the stigmata in 1224. The small Church of the Angels, erected by him, and the Chiesa Maggiore (begun in 1348) contain some fine terracotta reliefs by the Della Robbia family.

VALLOMBROSIANS, an order of monks under the Benedictine rule, founded by St. John Gualbert, who, about 1030, withdrew to Vallombrosa, a shady dale on the side of a mountain in the Apennines, 10 mi. from Florence, and for several years led a completely solitary life. Disciples, however, gathered around him, and he formed them into an order in which the cenobitical and the eremitical lives should be combined. The Benedictine rule was the basis of the life; but every element of Benedictine life was eliminated that could interrupt the attention of the mind to God—even manual labour.

The Vallombrosians spread in Italy and France, but they never had more than 60 houses.

VALMY, a small village on the main road between Verdun and Paris, just west of Ste. Menehould, famous for the French victory of Sept. 20, 1792. Pop. (1954) 255. Eastward of Valmy lies, roughly north and south, the long barrier of the forest of Argonne. Dumouriez. with the belated assistance of Kellermann, was attempting to hold this in September against the advance of the duke of Brunswick's German troops. The duke's forces broke through to the north by a pass known as the Cross in the Woods. In great haste, on the 19th, Dumouriez was able to withdraw under the cover of darkness the forces guarding the northern portions of the Argonne, which would otherwise have been cut off, and to complete his junction with Kellermann. By the morning of Sept. 20 his army was on the flank of Brunswick's advance and was facing toward Paris, with its back to the Argonne.

As soon as the heavy mist lifted on the morning of Sept. 20, the duke commenced an attack on the French by heavy artillery preparation. The French artillery was the sole important arm which had not been disorganized, and was able to reply effectively to the Prussian cannonade. Early in the afternoon, however, the Prussian guns did tremendous damage by a lucky shot which blew up the French ammunition reserves. A German mercenary brigade in the French service broke, and Brunswick decided the moment had come for an attack, and gave the signal.

The Prussians advanced en *échelon* under a severe fire, but steadily, about two-thirds of the intervening distance. The shaky ranks of the French were rallied by Kellermann, and were more or less prepared to meet the attack, when the Prussians hesitated, and, still apparently without disorder, retreated to their original position. Some mystery surrounds this, the central event of the battle: it seems probable that the Prussian advance was impeded by unsuspected thick mud at the foot of the hill, as well as by the accurate French gunnery—the support of their own guns necessarily ceasing as they approached the French lines. The cannonade continued till nightfall. Brunswick, having failed to defeat his enemy, realized that his position was strategically untenable and retreated.

See FRENCH REVOLUTIONARY WARS.

VALQIS, COUNTS AND DUKES OF. The French countship of Valois (*pagus Vadensis*) takes its name from Vez (Lat. Vadum), its early capital, a town in the *département* of the Oise. From the 10th to the 12th century it was owned by the counts of Vermandois and of Vexin; but on the death of Eleanor, sister and heiress of Count Raoul V (d. 1167), it was united to the crown by King Philip Augustus. Soon detached from the royal domain, Valois was the property of Blanche of Castile, uidow of Louis VIII, from 1240 to 1252, and of Jean Tristan, a younger son of Louis IX, from 1268 to 1270. In 1285 Philip III gave the county to his son Charles (d. 1325), whose son and successor, Philip, count of Valois, became king of France as Philip VI in 1328. Sixteen years later Valois was granted to Philip's son, Philip, duke of Orléans; then passing with the duchy of Orléans in 1392 to Louis (d. 1407), a son of Charles V, it was erected into a duchy in 1406 and remained the property of the dukes of Orléans until Duke Louis became king of France as Louis XII in 1498, when it was united with the royal domain. After this the duchy of Valois was held by Jeanne, countess of Taillebourg (d. 1520), from 1516 to 1517, and by Marie, countess of Vendôme, from 1530 until her death in 1546; it was given to Catherine de Medici, the widow of Henry II, in 1562, and in 1582 to her daughter, Margaret of Valois, the wife of Henry of Navarre. In 1630 Louis XIII granted Valois to his brother Gaston, duke of Orléans, and the duchy formed part of the lands and titles of the dukes of Orléans until the Revolution.

The house of Valois, a branch of the great Capetian family, is thus descended from Charles, a son of Philip III, and has been divided into several lines, three of which have reigned in France. These are: (1) the direct line (reigned 1328–1498) beginning with Philip VI; (2) the Orléans branch (reigned 1498–1515), descended from Louis, duke of Orléans, a son of Charles V; (3) the Angoulême branch (reigned 1515–89), descendants of John, another son of the same duke.

VALOIS, anciently a district of Picardy, part of the government of the Ile-de-France, bounded on the north by Soissonnais, on the east by Champagne, on the south by the Ile-de-France proper, and on the west by Beauvaisis. It included the towns of Crépy (capital), Morienval, Pierrefonds, Compiègne, Verberie, Pont-Sainte-Maxence, Senlis, Chantilly, Villers-Cotterets. Under the Roman domination it belonged to the Suessiones but it is now a small area in the departments of the Oise and the Aisne.

At first governed by its own independent counts, Valois in 1214 was joined to the kingdom of France by Philip Augustus. It has given its name to three lines of the second branch of the Capetian kings. See VALOIS, COUNTS AND DUKES OF.

VALPARAISO, coastal range province of central Chile, the smallest (1.860 sq.mi.) and second most populated. Pop. (1960) 613,405. The province is administered from the city of Valparaíso (*q.v.*). Adjacent is Viña del Mar, a luxurious beach resort. The province embraces the lower Aconcagua basin and such westward draining lowlands as the Limache and Casablanca valleys. Dairy pastures, the vine. orchard, truck and grain crops are common to all lowlands. Near Limache (pop. [1960] 27,563 [mun.]), Quillota (41.910 [mun.]) and La Calera 121,750 [mun.]) farming is most intensive. The province, second to Santiago in industrial development, produces over 15% (in value) of Chile's manufactured goods. Leading manufactures are food and tobacco products, textiles, chemicals, cement and clothing. The Concón petroleum refinery and Quintero and Viiia del Mar tank farms are Chile's most important. All-year roads and highways and an electrified railway link the urban centres with each other and with Santiago. La Calera and Llay-Llay, respectively, are junctions for the railway to north Chile and the trans-Andean railway route. A branch of the Valparaíso-Santiago railway serves Quintero. Quintero, Maitencillo, Algarrobo and El Quisco are popular coast resorts. The Juan Fernández Islands (*q.v.*) and Easter Island (*q.v.*) are administered from Valparaiso province. (J. T.)

VALPARAÍSO, the second city and first seaport of Chile. capital of the province of the same name, lies on the south side of a broad open bay of the Pacific, 115 mi. N W. by rail of Santiago. Pop. (1960) 259,241 (mun.). The city stands on the slopes of a great semicircular spur of the coastal plateau which ends in the rocky peninsula of Punta Xngeles. This point affords good shelter to the bay from southerly and westerly storms, but leaves it open to those from the north.

The commercial quarter with its port works, warehouses, banks, shopping centre and railway to Santiago occupies reclaimed land adjacent to the crescent-shaped bay, as do the administrative buildings grouped around Plaza Sotomayor. The cathedral, parks, boulevards, theatres, cafes and a few surviving colonial building;, notably the church of La Matriz, are also concentrated in the lower part of the city, of which other principal streets are Calle Esmeraldas and Avenida Pedro Montt. The naval academy buildings and residential quarters are located on the steep slopes and valleys of encircling hills, many of the poorer dwellings occupying the highest parts. Funicular railways, elevators, steps and zigzag roads connect the upper and lower city. The population grew relatively slowly in the middle decades of the 20th century, for the tourist resort of Viña del Mar, adjacent to Valparaiso on the west, increasingly acted as a residential suburb.

Communications.— The state railways connect the city with Santiago by electrified line, and by steam lines nith all the important cities and ports of Chile from Pisagua in the north to Puerto Montt in the south. Valparaiso is the western terminus of the Transandine railway, and thus has direct overland connection with Buenos Aires. Good highways run to the resort towns north and south and to the capital. Internal airlines link the city with other parts of Chile.

Commerce and **Industry.**—Valparaíso is pre-eminently commercial and industrial. There are foundries, and factories producing chemicals, textiles, sugar, paints, clothing, leather goods and vegetable oils. About 60% of Chilean imports enter the country through the port, and although its exports are but 5% by value of the Chilean total, its significance in internal maritime communications is paramount, 1,000,000 tons of shipping using the port annually. It is a terminal and major port of call for several international shipping lines, and its dock facilities, sheltered by a great breakwater, 3,000 ft. long, are modern, well-equipped and capable of accommodating the largest liners afloat.

History.—Valparaíso was founded in 1536 by Juan de Saavedra, who named it after his birthplace near Cuenca in Spain. In 1578 it was captured by Sir Francis Drake, in 1596 by Sir John Hawkins, and in 1600 it was sacked by the Dutch under Oliver van Noort. The port and town were of little note during the colonial period, for free commercial intercourse with the colony was forbidden. In 1819, near the end of its war of independence. its population barely reached 5.000. The relaxation and final breaking of the Spanish mercantile monopoly. the birth of the Chilean navy and its supremacy along the Pacific coast of South America, and the linking of Yalparaiso with Europe by steamship services were powerful factors in the transformation of the little town into a great port. Other factors were British investment in the commerce of the new republic, the function of Valparaiso as a refueling and provisioning port for those coming from Europe via Magellan's strait to the gold fields of California, and the governmental support provided, particularly by Diego Portales, in the 1830–40 period. This expansion mas checked in 1866 by a bombardment by the Spanish fleet which demolished a large part of the town. It was also partially sacked during the civil war of 1891 when congressional troops entered the city after their victory over President Balmaceda's forces. In 1906 an earthquake, the worst Yalparaiso ever experienced, destroyed much of the city but permitted its rebuilding in its present modern form. From ashes and debris streets were widened and paved; better business premises arose and a modern water supply and sewerage system were provided.

The growth of Santiago and the centralization of commerce in the capital have caused many businesses to move from Valparaíso, and the city has thus declined relatively in importance. It retains, however, a marked individuality and character reminiscent of older European ports; and the influence of its strong British connections is still evident. (G. J. B.)

VALTELLINA (Ger. VELTLIN; the name comes from the former capital, Teglio). properly the name of the upper valley of Adda, in north Italy. Historically, it also comprises the Italian Liro or San Giacomo valley, now the province of Sondrio.

Today the whole valley belongs to Italy, except the side valley of Poschiavo (Puschlav), which belongs to the Swiss canton of the Grisons (Graubiinden). The chief town is Sondrio (pop. [1957 est.] 16.471 (commune]). Near Bormio there are some frequented mineral springs (sulfur and lime), known in Pliny's time.

The highest points in the ranges enclosing the valley are the Piz Zupo (13,117 ft.) in the Bernina group and the Gran Zebrù (Konigsspitze) (12,661 ft.) in the Ortler district; the Monte della Disgrazia (12,067 ft.) is the highest peak comprised entirely within the water basin of the valley. Four well-marked Alpine passes are traversed by good roads—the Stelvio pass (9,052 ft.) from Bormio to Spondigna in the Adige valley; the Bernina pass (7.316 ft.) from Tirano to Samaden in the Upper Engadine; and the Aprica pass (3,875 ft.) from Tirano'to the Val Camonica and the Lake of Iseo; while from near the top of the Stelvio a fourth road leads over the Umbrail pass (8,209 ft., the highest in Switzerland) to the Swiss valley of Münster, which is reached at the village of Santa Maria.

The population is wholly Italian-speaking and Roman Catholic, the valley being in the diocese of Como. The shrine of the Madonna of Tirano (founded 1520) attracts large numbers of pilgrims. The valley, particularly in its lower portion, is extremely fertile; and of late years vigorous measures have been taken to prevent the damage caused by the frequent inundations of the Adda. Chestnuts, vines, mulberry trees and fig trees abound; and there are many picturesquely situated churches, castles and villages. The chief articles exported are wine and honey. Large quantities of honey are annually sent abroad. The Valtellina has now become important for its hydroelectric plants.

History.—After the defeat of the Lombards (774) the Valtellina was given (775) by Charlemagne to the abbey of St. Denis near Paris, which never seems to have exercised its rights. In 824 Lothair I., confirming an earlier donation (803) made by Charlemagne, gave the churches of Poschiavo and Bormio to the bishop of Como. Bormio was in 1205 won by the men of Como, who in 1006 had received one-half of Valtellina from the emperor, and by 1214 they were masters of the entire valley. They retained Bormio till 1300, when it freed itself; but in 1336 it belonged to the bishop of Chur. In 1335 the Visconti of Milan became lords of Como, and therefore of Valtellina. As early as 1360 the men of Rhaetia made incursions into Valtellina on the pretext that it had formed part of ancient Rhaetia. This idea was confirmed in 1404, when, in return for kind treatment received during his exile, Mastino Visconti (son of Barnabò) gave to the bishop of Chur his share of the Milanese, including Poschiavo, Bormio and Valtellina. Relying on this donation, the men of the Three Leagues of Rhaetia (best known by the name of Graubiinden) invaded the valley in 1486–87, Poschiavo becoming in 1486 permanently a member (not a subject land) of the Gotteshausbund. In 1512 Chiavenna, Bormio and Valtellina were also seized and harshly ruled. Mastino Visconti's donation was solemnly confirmed in 1516 by the emperor Maximilian I. In 1530 the bishop of Chur was forced to sell to the Three Leagues his title to these two districts. At the time of the Reformation Poschiavo became Protestant. The other two districts clung to the old faith and came under the influence of Carlo Borromeo. Valtellina was extremely important to the Habsburgs as affording the direct route between their possessions of the Milanese and Tirol. Hence a great struggle took place between Austria and Spain on one side and France and Venice on the other. The religious conflicts in Graubdnden led to reprisals in the "subject land" of Valtellina. In 1620 (July 19–Aug. 4) the Spanish and Catholic faction (headed by the Planta family) massacred from 350 to 600 Protestants in the valley, according to different accounts (*Veltliner* Mord or *Sacro Macello*). For the next 20 years the valley was the scene of great strife, being held by the Spaniards (1621–23, 1629–31, 1637–39), by the French (1624–27, 1635–37) and by the pope (1623, 1627). At length Georg Jenatsch, a former pastor, who had been the active and unscrupulous leader of the Protestant party, became a Catholic (1635) in order to free the land from the French by aid of the Spaniards (1637), who finally (1639) gave it back to its old masters on condition that the Protestants were excluded from the valley. In this way the local struggles of Valtellina came to be mixed up with the Thirty Years' War. In 1797 Bormio and Valtellina were annexed to the Cisalpine republic, in 1805 to the Napoleonic kingdom of Italy and in 1815 (despite the remonstrances of the Rhetian leagues) to the kingdom of Lombardo-Venetia, held by the emperor of Austria. In 1859 they became, like the rest of Lombardy, part of the kingdom of united Italy. Poschiavo followed the fortunes of the "Gotteshausbund." It became (after 1798) part of the canton Rhetia of the Helvetic republic, and in 1803 of the canton of the Graubiinden or Grisons, which was then first received a full member of the Swiss Confederation. (See SWITZERLAND.)

VALUATION. In English law a valuation may be said to be an opinion of the value of goods or of an interest in land or in land and buildings. Valuations, particularly of land or of land and buildings, can be made for various purposes. including sale, purchase, mortgage, insurance, compensation of different kinds and for purposes of taxation including rating, income tax and death duties. The opinion may be of capital or of rental value and the valuer's opinion of the same interest in a property may vary according to the purpose of his valuation, because of the statutory provisions under which the valuation is made or because of considerations which in the valuer's opinion are involved.

The usual methods of valuation employed include: (1) direct comparison of capital value between the property to be valued and other similar properties, either as entities or by means of a suitable unit; for example, farm land is often valued at so many pounds per acre; (2) cost of construction of buildings; (3) profits, in the case of certain types of business premises; for example, licensed premises; (4) residual basis, usually applied to properties upon which it is necessary to expend capital in carrying out improvements in order to realize the full potentialities of the property; (5) investment basis, which consists of applying a rate of interest to an actual or to an estimated income to arrive at capital value. In connection with the last method, valuers often employ various tables of compound interest.

Where a contract has been made for the sale of property at a valuation, a valuation made in accordance with its terms will be conclusive as between the parties, in the absence of fraud, collusion or mistake. Where there has been an agreement to sell goods on the terms that the price is to be fixed by the valuation of a third party and such third party cannot or does not make spch valuation, the agreement is voided; but if the goods or any part thereof have been delivered to and appropriated by the buyer, he must pay a reasonable price therefor. Where the third party is prevented from making the valuation by the fault of the seller or buyer. the party not in fault may maintain an action for damages against the party in fault. Where the fixing of a value by valuers is not of the essence of an agreement, but is wholly subsidiary to it, the courts will, if justice requires it, ascertain the value in order to carry the agreement into effect. In a case nhere an agreement had been entered into for the sale of a house at a fixed price and of the fixtures and furniture therein at a valuation by a person named by both parties, and he was refused permission by the vendor to enter the premises for that purpose, the vendor was ordered to allow the entry. A valuer is liable to the person who has employed him for the consequences of negligence or want of due care on his part, but to that person only and not to any other. If his services are thereby rendered worthless he will not be able to recover anything by way of remuneration. He is not, as a rule, liable for a mistaken opinion of value. (*See* AUCTIONS AND AUCTIONEERS; ESTATE AND HOUSE AGENTS.) (X.)

UNITED STATES

Valuation under U.S. law has assumed great importance particularly in three fields: taxation, corporate reorganization and public utility rate regulation. This discussion does not encompass valuation problems presented in the guise of damages for injury to person or property or for property taken. which arise frequently in damage suits, eminent domain cases and under insurance policies. (See COMPENSATION; DAMAGES; TORT; etc.)

Although essentially the same terms, value, market value and fair value, recur in various branches of the law, valuation methods and the results reached vary markedly with the circumstances and purposes of the valuation. While the traditional legal definition of value—the price at which property would change hands between a willing seller and a willing buyer with neither under compulsion to act—is regularly repeated by the courts, it contributes little to the solution of valuation problems. Realistic valuation requires a recognition that value is a term which is not, in Justice Oliver Wendell Holmes's words, "a crystal transparent and unchanged" but instead "the skin of a living thought and may vary greatly according to the circumstances and the time in which it is used" (Towne v. Eisner, 245 U.S. 418, 425, 38 S. Ct. 158, 62 L. Ed. 372, 376 [1918]).

Taxation.—The constitutions or statutes of most states require real property, and in some states personal property, to be assessed, for tax purposes, at full value, cash value, fair value or by a similar standard. While the terms used by the statute vary, there is no discernible difference in assessments made by reason of the particular language used. Three principal methods of valuing real property are used in administering property tax statutes: (1) analysis of market data, with particular emphasis on current sales and bids and offers affecting the property being valued and comparable property; (2) consideration of cost of reproduction of the property, reduced by accrued depreciation; and (3) capitalization of the earnings of the property. Evidence of sales prices of comparable property, made on an arm's length basis by vendor and vendee not labouring under undue pressure to sell or to buy is ordinarily the best evidence of value. Indeed this is the very essence of the value being sought. Such evidence is rarely available, for the sales each year are comparatively few in relation to the vast number of properties required to be assessed. Because the very definition of value assumes a free and steady market, it has been suggested that just as in income tax cases where the statutes typically tax the receipt of property at its market value, no tax should be imposed where no market exists. Such a rule would exempt from property taxation large blocks of property and in depressed times would play havoc with state and local tax revenues. It is, accordingly, well established that the terms value, full value and cash value, or other ad valorem statutory phrases are not synonymous with market value. A whole host of cases arising during the depression of the 1930s produced judicial decisions (and in some cases statutory modifications) requiring properties to be valued by reference to a nonexistent normal market. Where evidence of sales does not exist, bona fide offers to buy and sell may be used. In dealing with such evidence, a major obstacle lies in establishing that the properties sold or bid or offered are in fact comparable in character, location and other qualities.

The capitalized earnings method lends itself best to the appraisal of commercial rental property and apartment houses. It is based on the premise that future income capabilities determine the present value of the property. Actually the future income, the prediction of which is a hazardous undertaking, is normally ascertained by reference to past earnings, and the capitalization rate is determined by reference to the expected return from real estate in the community. Many difficulties arise in determining the net income from the property, once gross rents have been ascertained. Depreciation, adequacy of the use of and improvements in the property, the appropriate capitalization rate and other factors give rise to much controversy in using the earnings method.

The courts have placed a good deal of reliance on reproduction cost, less depreciation, particularly where market price data are unavailable, as a method of valuation in property tax cases. In some states, assessed values of improvements may not exceed reproduction cost, less depreciation, on the theory that no buyer would in ordinary circumstances pay more than the replacement value of the property. The techniques of estimating replacement costs have greatly advanced in the 20th century. Elaborate tables giving the cost per cubic foot of erecting buildings of various types have been prepared and are published in assessors' manuals; they are kept up-to-date by price indexes and current market costs. Depreciation is typically determined on a straight line basis, and obsolescence must also be taken into account.

In practice, it is seldom possible for the assessor to find adequate sales data, or to determine the replacement cost or to compute the capitalized income for more than a small proportion of the properties to be assessed. Consequently, the practical solution adopted by assessors is to utilize a comparative mass appraisal approach derived from the three methods of valuation. By the use of sales and income data, various types of land are reduced to front or square footage rates for standard parcels. These standard units become the base for valuing land. adjusted for special features, such as corners, depth, terrain and so forth. Similarly, various types of buildings are reduced to standard unit cubic footage costs for each classification of improvement; once a structure is assigned to a particular classification, replacement cost new is determined and adjustment is made for depreciation.

In the second half of the 20th century there was a growing recognition that assessment methods had failed to achieve equality among property owners, both because of inadequacies in the assessing staffs and the dislocatians in values produced by wide price fluctuations, rapid and large scale movements of population and industry and new technological developments in construction. A 1957 study made by the Assessment Advisory committee of the New York State Board of Equalization and Assessment found that over half the sample parcels of properties studied in cities were assessed at more than 25% above or below the average for the assessment roll, and that about one-third the properties in towns and villages showed at least a 25% variation from the over-all level. While extensive revisions have been made in assessment methods and procedures, including the making of periodic reassessments of property, improvement in the calibre and training of assessing personnel and vesting of greater control and supervision of assessments in state equalization or taxing boards, significant developments have been taking place in the courts to achieve greater equality among property owners. The extent of judicial review of ad valorem assessments varies markedly among the states. Thus, in some states — California, Illinois and Texas are among them — assessed valuations will not be set aside by the courts unless they are "arbitrary," "capricious," or are so excessive as to be "constructively fraudulent" or involve "an error of law." In such states taxpayers are virtually denied judicial relief from overassessment or inequality in assessment except in the most flagrant cases, or the application of methods or rules of assessment regarded as erroneous by the courts. These courts proceed on the theory that the assessing function has been vested in the assessor and that his judgment as to valuation, erroneous though it may be, is not subject to judicial review unless tainted by fraud, caprice or error of law. In other states, among them Alabama. Iowa, New York and Pennsylvania, the courts have gone to the opposite extreme, allowing a very broad scope for judicial review. While these courts pay lip service to the rule that the action of the assessor is prima facie correct, once the taxpayer introduces valuation testimony attacking the assessments, the courts essentially take over the assessment function and make their own determinations as to assessed values. The result of this approach is not only a usurpation of an executive function by the courts, but it has also produced an unending flow of property tax litigation to clog the courts. Thus, in New York city alone about 10,000 property tax cases per year were filed.

The scope of judicial review should depend on the character of the administrative review. If the taxpayer is given a fair hearing to review the action of the assessor before a competent, impartial and independent review board, the courts ought to be limited to considering problems of laws, errors of method and impropriety in procedure. However, if the administrative review is a perfunctory, rubber-stamp type of hearing conducted by the taxing agency itself or by other personnel in the executive branch of the government, then there is considerable justification for broad judicial review.

An intermediate view of the place of judicial review in property tax assessments has been adopted by the courts of other states, notably, Massachusetts and Ohio. In those states, the courts respect the valuations made by the assessing officers, without paying the slavish deference accorded to their action in states such as California, Illinois and Texas. Only "errors of law" are reviewable, but the absence of substantial evidence to support the assessor's action is regarded as an error of law. Here the courts are following the principles of judicial review of action of administrative officers which have been developed in the law generally.

A virtual revolution in property tax assessments took place in several states as a result of a series of landmark decisions by the highest state courts in New Jersey dealing with inequality of assessment, a requirement emphasized by the mandate embodied in all but two or three state constitutions that assessments must be equal and uniform. It is notorious that despite statutory requirements of full value assessments, few taxing authorities seek even to approximate full value. The key, therefore, to an equitable distribution of property taxes is equality of treatment of various property owners. Effective relief from inequality in assessment was, however, barred by the rule long followed in New Jersey and other states, that so long as a taxpayer could not show that his property was assessed at more than its full value, he could not have his assessment reduced in the courts, despite a showing that other properties were assessed at a lower percentage of full value than his property. Although the United States supreme court had held as early as 1923 in the landmark case of *Sioux City Bridge Co.* v. *Dakota county* (260 U.S. 441 [1923]) that such a rule violated the taxpayer's federal constitutional right to equal protection of the laws, a number of state courts continued to deny reductions in the complaining taxpayer's assessment and to offer him instead the expensive and impracticable procedure of starting proceedings to have all other assessments brought up to the level of his assessment. Such decisions helped perpetuate the single most striking characteristic feature of U.S. ad valorem taxation, namely, that the statutory mandate to tax all property at uniform full value has been consistently ignored for at least many decades. When a group of taxpayers in Essex county, New Jersey, indignantly challenged an upward reassessment of a selected group of properties, while property in the county generally remained at the old level, the New Jersey court in 1954 held that the property owners were entitled to have their assessments reduced (*Baldwin Construction Co.* v. *Essex County Board of Taxation*, 16 N.J. 329, 108 A. 2d 598 [1954]). This decision initiated a development in the New Jersey courts which resulted in holding that assessments at anything less than full value are illegal (*Switz* v. *Township of Middletown*, 23 N.J. 580, 130 A. 2d 15 [1957]). This was a highly salutary development, for so long as assessors flout the legal requirement of assessing all properties at full value (or at a lower fixed statutory percentage), inequalities and unfairnesses will be rife. Legislation was introduced in New Jersey, and was in force in some other states, requiring assessment at a fixed percentage for all properties but at values less than 100%. Whether substantial uniformity and equality would be achieved under such legislation was uncertain.

Intangibles present a host of troublesome valuation problems in death and income taxation. The statutory standard is typically fair market value. Securities traded on stock exchanges or other public markets are ordinarily valued by reference to market quotations. However, where a large block of securities is involved, the courts have generally accepted so-called blockage valuation. Here testimony of experts as to the price which can be obtained for the block of stock being valued and the costs of marketing the stock typically result in lower valuations than market quotations involving small blocks.

The valuation of a substantial business, with its fixed and current assets and its tangibles and intangibles, is a considerable undertaking. Many states are confronted with the even more difficult task of determining, particularly for purposes of property taxes on public utilities and capital stock taxes on corporations generally, the value of a portion of a business which is conducted in more than one state. Under the federal constitution a state may ordinarily tax only the portion of the corporation's business or assets located within its borders. Apportionment formulas have been developed which admittedly do not accurately measure the value of the portion of the corporation's assets, business or capital stock employed in the state but which are acceptable handy tools for solving an extraordinarily difficult valuation problem. The most nidely used formula for apportioning the assets (or the net or gross income where that is the base of the tax) of an interstate business among the states is the so-called Massachusetts formula, which averages the ratios of (1) the value of real property and tangible personal property within the state to the total wherever located; (2) business receipts from business done in the state to total business receipts; and (3) payroll within the state to total payroll. Because the United States supreme court has sustained virtually every apportionment formula which has been challenged before it—and properly so under the federal constitution—the multistate business is at times subject to a myriad of formulas which sometimes produce aggregate valuations exceeding the total value of the enterprise.

Corporate Reorganization.—In corporate reorganizations which stem from insolvency, or in the case of solvent corporations reorganized under the Public Utility Holding Company act of 1935 or other regulatory statutes, valuation is required to establish (1) the extent and nature of the securities which can soundly be issued by the reorganized company on the basis of its assets; and (2) the degree to which existing security holders are entitled to participate in the reorganized enterprise. In contrast with valuations in other areas in which the courts lean heavily on asset values and on past earnings, the law in insolvency reorganizations has developed toward acceptance of the principle that values are determined primarily by reference to estimated future normal earning power, giving weight to past earnings adjusted to reflect actual and expected changes in conditions. These earnings are capitalized at the rates at which the market for securities of comparable enterprises reflects the capitalization of the earnings of those enterprises. Asset values are ordinarily significant only where they exceed the earnings valuation, in which case liquidation of the enterprise is indicated.

An important doctrinal development took place in reorganizations under the Public Utility Holding Company act which affected the results. In administering the act, the Securities and Exchange commission (SEC) utilized the investment-value doctrine under which the claims of securities surrendered were determined by "the value of the securities on the basis of a going business and not as though a liquidation were taking place" (15 SEC Ann. Rep. 124 [1949]; *Electric Bond and Share Co.*, 21 SEC 191, 197, 210, 21 SEC 309. 21 SEC 457, enforcement granted S D N.Y. [1945]; compare *Otis & Co.* v. *SEC*, 323 U.S. 624 [1945], *SEC* v. *Central Illinois Securities Corp.*, 338 U.S. 96 [1949]). The bundle of rights embodied in the surrendered security determined the scope or magnitude of the claim, not as it stated obligations to be fulfilled, but only to the extent that these obligations were in fact reflected by the value of the business as a going concern. The effect of the application of this doctrine was to entitle security holders to receive at times less and at other times more than the contractual liquidation value of the claim. Nevertheless, because most holding companies' reorganizations were carried out in the 1940s and 1950s, when the national economy was expanding rapidly and the utility industry in particular experienced a phenomenal growth, in point of fact, frequently the new securities issued turned out to have a market value far in excess of the apparent investment value of the old securities surrendered. At the same time, participation and values were preserved for common stock and other junior securities.

The investment value doctrine is held by the supreme court, as well as by the Securities and Exchange commission, to be inapplicable to bankruptcies, cases under chapter X of the Bankruptcy act and other insolvency reorganizations, where the courts deal with enterprises that have failed. In such circumstances, under the so-called absolute priority principle, the security holder is entitled to measure his claim by liquidation standards. Nevertheless, even in insolvency cases, this does not mean that he is entitled to the immediate cash liquidation value of his claim, but only to a security that will, within a reasonable time, sell at prices equivalent to the claims they replace. In actual operation. however, the market prices of securities issued under this rule particularly in railroad insolvency reorganizations, often failed to reach the claims of senior security holders within a few years after the reorganization. These results reflect weaknesses in applying the doctrine and excessive optimism in determining value, as well as an unarticulated effort to prevent the wiping out of junior claims. While the wisdom of applying liquidation standards and the propriety of sticking to the absolute priority rule in insolvency reorganizations has long been the subject of dispute in the literature, the differences in the nature, origin and objectives of insolvency reorganizations as compared with Public Utility Holding Company act reorganizations justify the rejection of the investment company doctrine in the former type of cases.

In mergers and similar combinations of corporations, dissenting stockholders are generally entitled to be paid the value of their stock Unlike insolvency reorganizations and reorganizations under the aegis of regulatory commissions, primary weight has been placed on market quotations of the stock being appraised, and in some states consideration is also given to past earnings and asset valuations. In only a few jurisdictions do stockholders receive liquidating value (*i.e.*, asset value), when it can be established that such value exceeds the amounts determined by reference to market quotations, capitalization of past earnings or other methods employed.

Public Utility Valuations.—The United States constitution, as interpreted by the courts. requires the states and the federal government. in regulating rates of public utilities, to permit a reasonable return on the property dedicated to the public service. In 1898, in the momentous case of *Smyth* v *Antes,* the supreme court held that utilities nere entitled to a reasonable return on the fair value of their properties and that in ascertaining fair value the original cost of construction, the cost of reproduction and the amount and market values of the utility's stocks and bonds were to be taken into account. The first two decades of the 20th century witnessed a struggle in which utilities typically sought to have their properties valued by reference to original cost to protect their historical investments, while state rate commissions found it advantageous to give greater weight to cost of reproduction (in both cases with adjustments for depreciation). With the sharply rising costs of production brought on by World War I the tables were largely turned, and the utilities sought values measured by reproduction costs; they succeeded by the middle 1920s in obtaining reversals by the supreme court of decisions of state regulatory commissions for failure to give adequate weight to reproduction costs. Justice Louis Brandeis dissented from these holdings and advanced the theory that the rate base should be determined by the "amount prudently invested" in the property dedicated to public service. In the 1940s the supreme court largely abandoned the role of safeguarding to utilities a fair return on the present value of the properties, took the position that the valuation function belongs to regulatory agencies and limited its review of rate orders to a determination as to whether "reasonable rates" had been allowed. While the contours of the conception "reasonable rates" had not yet been rounded out in the second half of the 20th century, it was clear that the revenues must be sufficient to enable the utility to meet its operating expenses and interest and dividend requirements and to maintain proper credit and market standing.

Valuation for utility rate purposes was thus lodged essentially in the administrative agencies. Each of the valuation methods available to such agencies has its defects and shortcomings. The use of original cost often involves proof of costs incurred many decades previously, with records that are inadequate or that have been destroyed or lost; padded costs and unwarranted expenditures must be squeezed out. Reproduction costs involve estimates and speculation as to costs of labour, materials and money; and every major fluctuation in costs requires a revised valuation. The prudent investment theory eliminates some of the defects of original cost and reproduction cost valuations, but, as is true in other fields. valuation by a single yardstick or by formula seldom produces acceptable results. A consideration of all these methods appears to be required, but the soundness of the judgment of value to be reached will depend on the expert knowledge, the integrity and the economic predilections of the valuers, for public utility valuations have their roots in the political and social attitudes of the day; it is not surprising, therefore, that utility valuations tend to fluctuate with the temper of the times. See also AGRICULTURAL ECONOMICS: *Farm Appraisal.*

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VALUE. In economics the value of a good is measured by the quantity of other goods for which it will exchange. As this depends on the relative prices of the goods in question, the phrase "the theory of value" has come to be applied by economists to that branch of their science which is concerned with the forces governing the relative prices of different goods and services. Changes in the price of any particular good are measured by comparing its money price with that of another good or with an index number measuring prices in general. The price of a good may be influenced by a number of transient factors; *e.g.,* by good or bad harvests (in the case of agricultural products), by changes in fashion or by temporary gluts or shortages arising because producers have misjudged the extent of demand. These factors have been regarded as causing fluctuations about a normal price determined by more fundamental forces, and the study of these fundamental determinants of economic value has always occupied a large part of the attention of economists.

One of the oldest theories on this matter is the labour theory of value. Adam Smith said that "Labour alone, therefore, never varying in its own value, is alone the ultimate and real standard by which the value of all commodities can at all times be estimated and compared"; though he goes on to say that account must be taken of the rent of land and of the profits of "stock" or capital. The theory was presented in its purest form by David Ricardo. He showed that the rent of land was not a causal factor in value, since the value of a good had to be high enough to cover its cost of production on the worst land in use, which would be earning no rent. He regarded capital as stored-up labour and assumed that the proportion of capital to labour was roughly the same for all goods. He was thus able to ignore interest on capital and to maintain that the normal prices of goods tended to be proportional to the amount of labour required to produce them.

The labour theory was taken up by Karl Marx and a number of socialist writers, but it is unsatisfactory in several ways: it does not deal adequately with differences between various types of labour; it eliminates interest on capital only by means of an arbitrary and unreal assumption; and it affords no recognition of the part played by organization and by risk bearing in the productive process. In seeking a way out of these difficulties, some writers, including John Stuart Mill, turned to a cost-of-production theory of value, asserting that normal prices tended to be proportional to the costs of production.

A good can obviously have no value (and so will not be produced) unless someone has a use for it. Smith, Ricardo and Mill had all distinguished between value in use and value in exchange, but they did not carry the idea of value in use very far. During the second half of the 19th century, however, it was raised to a central position in value theory as a result of the writings of W. S. Jevons, of Carl Menger and of M E. L. Walras. They showed that, other things being equal, the utility per unit of a good declines with an increase in a consumer's rate of purchases. A rational consumer will adjust his purchases so that the utility that he gets from the last unit bought is just equal to that which he could get by spending his money in some other way. The utility of this last unit, which is only just worth buying, is known as the marginal utility of a good, and it follows from this reasoning that the prices of different goods will tend to be proportional to their marginal utilities.

The synthesis of the cost-of-production and marginal-utility theories owes much to the work of Alfred Marshall. Marshall distinguished between four "agents of production": land, labour, capital and organization. He accepted and extended the Ricardian view of rent but maintained that the normal reward of the other three factors must be-included in cost of production. The "normal" reward, in this sense, would be that which was necessary to maintain a given supply of a factor engaged in the production of a particular good. being neither high enough to attract additional supplies from other industries. nor low enough to cause factors to be lost to other industries. Marshall analyzed the way in ahich cost of production varied with changes in the rate of output and developed the concept of marginal cost. analogous to that of marginal utility. He was thus able to show that, given time for adjustments to take place. a change in either the demand for or the cost of production of a good would lead to a change in its rate of production such as to keep both marginal cost and marginal utility equa! to price. Hence. he says, "We might as reasonably dispute whether it is the upper or the under blade of a pair of scissors that cuts a piece of paper as whether value is governed by utility or cost of production ··

Since the cost of production of any good depends on the prices of the factors of production, any theory of value which uses cost of production must study factor prices as well as goods prices. Factor prices, like goods prices. are determined by supply and demand. but the supply of many factors is determined by forces outside the scope of economics (*e.g.,* by the size of the working-age population). When the supply of a good or a factor is given, its price must be such that the given supply will just satisfy the demand. This led later writers to give demand (determined by utility) a rather more prominent place in the theory of value than Marshall had given it.

The price which must be paid for a factor used in the production of any one good depends partly on the demand for that factor for the production of other goods. This, in turn. depends on the demand for those goods and on the cost of other factors used in their production. Hence no one price can be strictly determined except in relation to all others, and the logical extension of the marginal-utility and cost-of-production theories is the "general equilibrium" analysis, used by most modern value theorists. in which these relationships are all expressed as mathematical functions from which relative prices can be determined by the solution of a number of simultaneous equations.

Marshall generally assumed a state of free and perfect competition, though he discussed monopoly briefly as a special case. There are. however, many types of market structure intermediate between pure competition and simple monopoly. A market may be imperfect because people are prevented from buying from the cheapest seller. whether through ignorance or by prejudice or costs of transport. An industry may be dominated not by a single monopolist but by a few large firms: or competition may be deliberately restricted either by actual agreement or by tacit understanding between firms. Much of the work in value theory after Marshall's death was devoted to one or other of these situations.

Another controversial change was that which by the middle of the 20th century had come about in the treatment of marginal utility While some economists still maintained that marginal utility is intrinsically measurable and that it can actually be measured in some situations (though not in all) by the amount of money that a consumer is prepared to pay for a marginal unit of a good. others, asserting that the cardinal measurement of utility is impossible, adopted a system in which the consumer is supposed to have only an ordinal scale on which various combinations of goods can be ranked in order of preference; the consumer is then supposed to choose the combination of goods which gives him the maximum utility attainable in any given situation, but no attempt is made to measure utility. Yet other economists rejected the idea of utility altogether and attempted to reconstruct a theory of demand on purely behaviourist lines, simply assuming that the consumer makes a series of consistent choices but without saying anything of what lies behind them.

These changes made value theory in some ways more realistic; but they rohhed it of some of its generality and took economists further than ever from the acceptance of any absolute standard of value. Value came to be equated with relative price, and the word price to displace the word value in much of the contemporary literature.

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VALUE, THEORY OF. Until comparatively recently there was no general theory of value. Value has long been a fundamental notion of political economy, and various theories of its nature have been developed, but it was not until the 19th century that it came to be universally recognized as one of the great philosophical topics. Its discovery has been held by some to be "the greatest philosophical achievement of the 19th century," and its development as a special field of psychological and philosophical study has gone so far that a special name has been created for it. namely "axiology."

The development of such a theory requires the consideration of the following problems: (1) What is the nature of values (definition)> (2) What are the fundamental values and how are they to be classified? (3) How may we determine the relative values of things and what is the ultimate standard of value? (4) Are values merely subjective. satisfying merely subjective desires, or are they objective, in some sense other than objects of desire, and giving some law or norm to desire? (5) What is the relation of values to things or of value to existence and reality>

History of the Value Notion. — A brief sketch of the history of the idea of value in philosophy will help to make clear the meaning of these problems. The Greeks did not have the term value as now understood, but in the light of subsequent developments it may be seen that they had the notion and were aware of these problems. Plato conceived the good or value as the culmination of the world of ideas and the constructive principle of the world which organizes all its forms or laws. Aristotle. in proposing to view all things teleologically and to make the relation of a thing to its end or value essential to its very being, affirmed not only the objective reality of value qualities but also their supremacy over all the other attributes of things. Neither Plato nor Aristotle developed this line of reflection fully, nor did succeeding philosophers investigate the subtle and perplexing problems involved in it. Plato himself called this the most difficult question of all science. Nevertheless, the general principle enunciated by Greek philosophy continued to be the rule throughout the middle ages, and the objectivity of value the key to all thinking.

The modern developments of the subject proceed directly from Immanuel Kant, who here, as elsewhere, represents a crisis in philosophic thought The classical conception of the objectivity of the good or value had been abandoned by empirical thought. If the "secondary" qualities. such as colour. taste, sound, etc., are made dependent upon the percipient subject. all the more must the "tertiary" qualities such as beauty. goodness, etc , be made dependent upon human desire and feeling. This extrusion of all values from the objective world seemed to Kant to be the necessary consequence of the assumptions of "science." But he could not accept it as the whole story of values. By a well-known line of reasoning which cannot be repeated here. he restored their objectivity in a new form. Though not "existent" in the same sense as physical things their reality must be postulated and acknowledged if life and action are to be possible They have. in his terms, "validity" and "practical reality." With this an entirely new line of thought was set in motion, raising new problems of fact and value. value and validity, value and existence. A large part of modern axiology or general theory of value has developed under the inspiration of neo-Kantianism. But it is to R. H Lotze (1817–81) more than any other man perhaps except Nietzsche that the popularity of the term value is attributable, and certainly he more than any other is responsible for the prevalence of the idea of value as an ultimate notion in philosophy Albrecht Ritschl (1822–89), Lotze's theological colleague at Göttingen made the value notion central in the discussions of religion and theology and furnished modernist tendencies in theology with a large part of their inspiration and much of their terminology. He agrees with Kant that the objects of religion are objects of faith as distinct from knowledge in the scientific sense, but he develops much further the notion that they are matters of value judgment as distinct from theoretical judgment, although equally capable of certainty and validity. It is mainly to Ritschl that is due the current distinction between judgments of value and judgments of fact and the subordination of judgments of fact to judgments of value. From Ritschl's position it was easy to pass to that of W. Windelband (1848–1915). who, together with H. Rickert and Hugo Mdnsterberg (1863–1916), developed the neo-Kantian axiology to which reference has been made.

The chief stimulus to the development of the general theory of value as a distinct field of psychological and philosophical study came, honever, from the work of **A.** Meinong (1853–1920) and C. von Ehrenfels (1859–1932). A fresh analysis of value in the economic sense had been undertaken by the Austrian economists Eugen Bohm von Bawerk and Friedrich von Wieser which resulted, among other things, in raising many problems of psychological and even philosophical importance. Under their influence, Meinong and Ehrenfels investigated values other than economic, and first undertook a systematic study of the entire field of value. The more philosophical developments of the subject were largely the work of Meinong. Starting with the psychological concept of the economists, he gradually came to the view of values as objective and independent of their being experienced. At this point the problems of the two modern movements described tended to coalesce. No history of value theory would, however, be complete that did not note the influence of Nietzsche, with his "transvaluation of all values," and the pragmatic movement in philosophy. for which knowledge is subordinated to practice and truth becomes a form of value.

Nature of Value.- he fundamental problem of a general theory of value is the question of the nature of all determinations of value; in other words. of so defining it as to include all the forms of value. The immediate and natural answer to this question is to say that value is a determination or quality of an object which involves *any sort* of *appreciation or interest.* Such appreciation, however, involves feeling and ultimately desires or tendencies underlying the feeling. Therefore value *is* the feeling. Value and feeling of value are the same thing. This is the psychological notion of value, and the theory of value developed on this basis is the psychological theory of value. For many this seems to tell the whole story The economic theory of value made its first scientific steps by abandoning the notion of value, whether in use or exchange, as an objective quality inherent in the thing, and conceiving it as the function of the relation of the object to satisfaction of desire. Following this lead. the general theory of value was in the first place a psychological theory of value. Even in economic theory, however, it is realized that this is only part of the story. Back of desire and feeling lie certain biological tendencies or instincts presupposed by the desire and its satisfaction. So that value becomes. in the words of Orestano, "a biological phenomenon appearing in psychological form." A theory of value that shall be not merely a theory of *price* must relate the *instrumental* values of economics to life. Unless we consider these tendencies merely in their aspect of determinants of price, we must have a quite different notion of value to include them. If this is true of the limited field of economic goods or values, it is all the more true of the *intrinsic* values which a more general theory of value recognizes. Psychological theories of value thus tend to become biological theories in the broader sense of the term. Value is defined in terms of survival and enhancement of life. and the biological tendencies are graded according to some standard of value-for-life. It is at this point, however, that the specifically philosophical theories of value arise. We wish to explain and ultimately validate these values by carrying them back to life. But in this it is already assumed that life and its continuance have value. If values get their significance from their teleological relation to life and its enhancement, then surely life must get its significance from "absolute" values which it embodies; otherwise life and its relative values lose all genuine meaning. From a more ultimate point of view a knowledge of value is presupposed in any concept of a valuable life. As the result of reflections of this type, two main positions have emerged in the general philosophical theory of value. Either value is conceived of as a "logically primitive" concept. and therefore as ultimately indefinable, as are certain other ultimate concepts in philosophy, or else it is conceived of as function of the coherent organization of life or experience as a whole.

It may be said without hesitation that value theory is today predominantly philosophical rather than psychological. This does not mean, however, that the psychological study of the processes of valuation is not an important part of the general theory. The psychological question is what goes on in consciousness when we value, and while an answer to this question will neither tell us what value ultimately is, nor afford us a standard of value which will enable us to form a system or scale of values, it nevertheless throws light on many questions. The most important contributions here are, perhaps, the studies of the mutations or transvaluations of values. The popular interest aroused by Nietzsche in his *Genealogy of Morals* found a scientific echo in the study of the phenomena, causes and laws of the mutations of values. A notable feature of modern value theory is the interpretation of history as a value science, or part of a philosophy of values.

Classes and Standards of Value.—It is generally admitted that distinct species of value exist, although there is no complete agreement as to what they are or how they are to be classified. It is clear, however, that there are sciences which deal with values, and special sciences have been developed to deal uith special classes of value. Thus economic value has long been recognized as a fundamental notion of political economy, which ever since Adam Smith divided it into value in use and value in exchange has been defined thus. the former as the utility of objects for human purposes and the latter the power to induce or compel persons to pay other valuables for the use of them. That ethics also deals with values is generally agreed, although there is dispute as to just what these values are and how they are related. It is now generally recognized that ethical value is not identical with pleasure or happiness, although pleasure is one of the values. Aesthetic values are also generally, although not universally, admitted, many pragmatists holding that, since valuation is always judgmental. and the aesthetic "has no logical function, it must be denied the name of value " From the philosophical standpoint, the most important group of values distinguished is perhaps the logical or theoretical values. Several schools of thought hold that logic is the science of cognitive values and that truth is a positive and error a negative value Indeed this view is quite generally implied, although it is not always explicitly avowed. "Religious values" are quite commonly talked about, although whether they constitute a special group or represent rather a fusion of, or a reaction to, the other values is a matter of dispute. It may be argued that they do not constitute a distinct class, because there is no specific biological tendency or instinct to which they correspond, or that they represent merely the reaction on the fate of the other values in the universe. But the tendency to recognize the value of the "holy" as a distinct type, as developed by the neo-Kantians. is very strong: it found expression in a much-read book, *The* Holy, by Rudolf Otto. Some writers speak of distinct classes of social and political values, but the general tendency, perhaps, is to view these as subforms of the ethical.

Despite such differences of opinion, incidental to any developing theory, there is substantial agreement as to the existence of these five outstanding classes of values. There is, unfortunately, not the same consensus regarding their relations; *i.e.*, the ordering of these values in a system or in a scale of relative value and importance There are in general three accepted ways of classifying them. There is the psychological, which, assuming values to be the functions of interests or desire, divides them according to modes of this interest and tends to become ultimately biological and genetic, the outstanding classes being connected with some fundamental "instinct" or tendency. A more historical mode of classification accepts as units those values, or groups of values, which have acquired an institutional form, such as economic, moral. cognitive, political, aesthetic, religious. A third, which has been called the axiological, accepts in the main the trinity or tetrad of the good, the beautiful and the true, to which it adds the higher unity of God. Such classifications or systems of value all have their uses, but it is generally felt that the first two are not sufficient. A large body of opinion, accepting the axiological classification, holds that while the economic values are clearly instrumental and relative to the others, the other groups are intrinsic and absolute, and as such ultimately co-ordinate. Others hold that they may be put in relations of subordination in a comprehensive scale of values. There are, however, some things that may be said with a certain degree of assurance. The ethical, aesthetic and logical values are self-sufficient and co-ordinate in the sense that they are irreducible the one to the other. All attempts at such reduction, whether. for instance, of the aesthetic to the ethical, of the ethical to the logical or of the logical to the ethical, have proved unsatisfactory. On the other hand, it seems clear that they are all intimately related. No intrinsic value can stand alone. This is equally true whether we consider the question from the standpoint of the realization of values in the individual life or from the more objective point of view of their logical relations. It is impossible to define any one type of value alone or apart from the others. The ancient view that values are subsumable under the heads of goodness, beauty and truth, "a threefold cord, not lightly broken," is in general strengthened rather than weakened by modern value theory.

The idea that these ultimate values are co-ordinate in the sense described does not, however, as might at first appear, exclude the notion of an ultimate standard of value in the light of which some hierarchical principle or scale of value might be developed and the classes-of values be subordinated to each other. On the general question of the commensurability of value as such. there is a large measure of agreement. For the opinion. held by a fen, that they are incommensurable. there is indeed something to be said. It may be objected that an economic satisfaction and an aesthetic experience are of such different inner qualitative content that it is absurd to compare them with each other. The fact remains that we do actually compare them constantly. Not only do we compare values within the same class. as when we choose one economic good rather than another; but we also choose between types and classes. The standpoint of the incommensurability of values can be admitted only in the sense that the different values cannot he expressed in quantitative units and measured in this sense. But there are few that hold this idea at the present day. For the merely psychological or biological theories, the standard of value is found in such conceptions as intensity of feeling. the strength of the desire, or ultimately in the importance for life of the biological tendencies presupposed. For the more philosophical theories, on the other hand, that recognize the limitations of these notions of value, a different conception of the ultimate standard is also necessary. In general such a standard is found in the notion of *inclusiveness*, in some functional conception such as the totality of life or experience, that value being highest which contributes most to the coherent functioning and organization of experience as a whole. Such a standard may be formulated in terms that seem to avoid metaphysical implications, but in general it may he said that the highness or lowness of an experience of value is held to be determined by its metaphysical content. From this point of view a very common table or scale of values is that which puts the economic values as the lowest and the religious (in the broadest sense) as the highest. the ethical, the logical and the aesthetic being arranged in various ways in between. The standard here employed is, in the last analysis. some form of the principle of inclusiveness, the different values being arranged either in accord with the degree of integration of our interests or tendencies, or in accord with the range of the metaphysical content to which they correspond.

Logical or Theoretical Values — Validity. — Theinclusion of logical or theoretical values in the general theory of value is undoubtedly the main reason for the outstanding place which axiology has in modern thought. Such an inclusion obviously involves a radical revision of our entire notion of values and of the relation of value to fact and truth. It is pointed out by the value philosophers that for an ultimate analysis, logic is also a science of values. The pragmatists insist that theoretical values "presuppose purposes, selections. choices," and that "judgments are acts which do not differ in kind from those which are openly practical." The neo-Kantian axiologists point out that the desire for truth and rationality, the demand for logical consistency or validity, is itself a craving for what *ought to be,* and that here too we are moved by an ideal and directed by a norm, as surely as in the realms of ethical and aesthetic values. In either case validity becomes a form of value and logical rules instruments of the will to truth. The development of this notion involves difficult problems which cannot be gone into here. Whether the "value" of truth is relative or absolute; whether truth is the ultimate value upon which all the others in some way depend, or merely subordinate and instrumental to the other values. or. finally, in some way co-ordinate with them—all these are debated questions which, as we have seen. in turn affect the problems both of classification and order of values. In any case, the notion of validity as a form of value brought about in many quarters a radical revision of the notion of the relation of value to fact and truth. Against purely intellectualistic views it is contended not only that every statement of fact is ultimately an evaluation but also that the logical impulse ought not to have the primacy over the other demands of our nature, and that no philosophical system can he adequate which fails to do justice to all our values. Philosophic system tends to become, from this point of view, a system of values. or at least to presuppose such a system.

Value and **Reality.**—Whatever differences of opinion there may be among the various theories of value, there is substantial agreement that values are not subjective in the sense that they are merely matters of opinion and exist only for the persons who appreciate or feel them. Even for the psychological-biological theory. while they are dependent upon interest (desire and feeling), they are independent of judgment and opinion. The "objectivity" thus universally accorded values is indeed given different meanings, but in any case it is generally agreed that values cannot be denied existence or reality in any world that can exist for man. They must, it would seem, exist in several senses.

Values "exist" in the sense that they are operative and effective in and on human minds and in human action, and find embodiment in the objective institutions of society. They are "real" in the sense that they are valid, that is they claim to be true ideals as opposed to false ideals or fictions. They must, however, be real in a still more ultimate sense (metaphysical), in that they are part of the nature of things, and not something merely added to existences. For values to be real in either of the first two senses they must be real in the third. For both must be so related to real existence that they constitute the key to the nature of the real. Otherwise they become false ideals and futile fictions. The question of just how values may be said to exist (to be part of the nature of things) is a difficult and debated question that cannot be gone into here. It is possible, however, to state a general proposition to which almost all theories of value would subscribe. Values are not mere subjective incidents, more or less gratuitously superadded to fact, but are inherent in the structure of reality. Reality in its fullness contains and exhibits values. and they can be extruded from it only by a process of abstraction that is relative to restricted purposes (of special sciences) and that is never quite successful. This reinstatement of the objective reality of values (in its essentials the Greek notion) is attributable partly to developments within value theory itself and partly to a larger movement in philosophy as a whole. In any case, it is now widely felt that in the answer to the problems of value is to he found the key to the philosophical interpretation of reality as a whole.

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VALVE (MECHANICAL), a device used to control the flow of some fluid (liquid, gas or vapour) in a line of pipe. The word preceding the term valve may indicate the type of valve or the purpose for which the valve is used; for example, the term gate valve indicates a type of valve, whereas the term relief valve indicates the purpose of the valve. The size of a valve, in inches

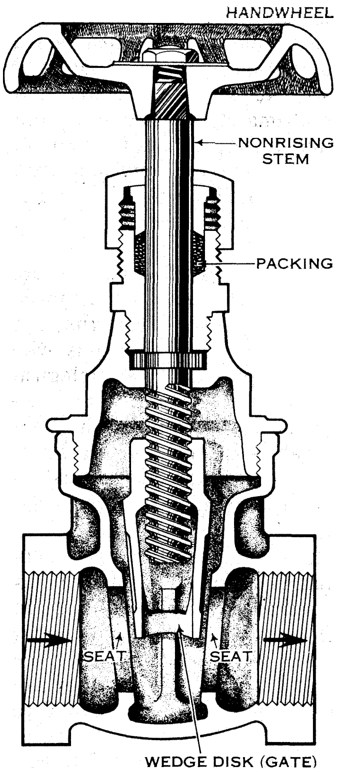


FIG. 1.—SCHEMATIC DIAGRAM OF GATE VALVE. FULLY OPENED

or feet, is the nominal size of the pipe in which the valve is installed.

Common types of simple control valves are the gate valve, globe valve, needle valve and butterfly valve. As illustrated in fig. 1, fluid flows through a gate valve in a straight line; this path minimizes resistance to flow. A gatelike disk, actuated by a stem (with screw threads) and a handwheel, moves up and down at right angles to the flow direction; the wedge gate seats against two seat faces to shut off the flow. The gate valve is suited for starting and stopping flow, but it is not ideal for regulating or throttling flom. It is best applied for services in which the valve is kept fully closed or fully opened.

Fig. 2 illustrates a globe valve, so-called because of the globular form of the valve body or casing. The globe valve is somewhat similar in action to that of the gate valve.

Horzever, it may have a tapered plug, a ball, a plug with a 45° seat or a disk in the upper movable section which fits a corresponding seat in the lower part of the fixed valve body. The disk is moved up and down by the valve stem (with screw threads) and a handwheel. The fluid must change direction in flowing through a globe valve and thus the resistance to flow is increased, but this construction permits better regulation or throttling of the flow. The valve disk and seat usually can be replaced or repaired quickly and conveniently.

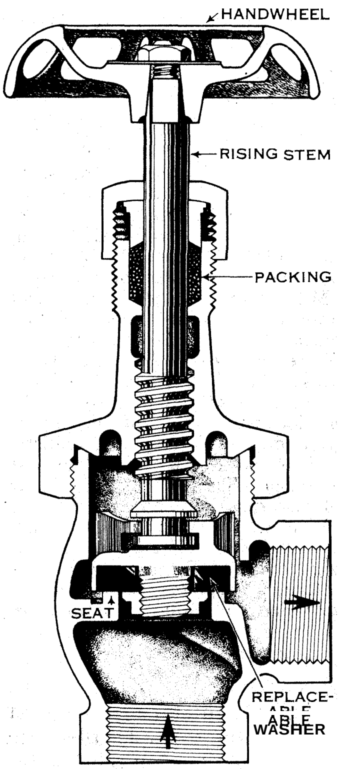
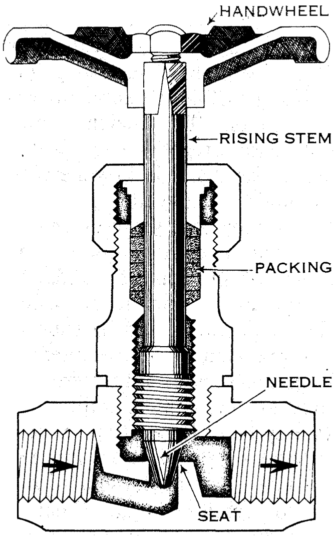


FIG. 2.—SCHEMATIC DIAGRAM OF BALL VALVE. CLOSED

The structure surrounding the valve stem is sometimes called a bonnet. Packing is placed in the upper part of the bonnet, around the stem, in order to prevent leakage of fluid past the stem. In some valves, called diaphragm valves, a circular diaphragm is installed to seal the bonnet without packing. The outer edge of the diaphragm is fastened to the bonnet, and the stem passes through a leakproof joint at its centre.

Fig. 3 shows a needle valve, in which there is a long tapered or conical piece or needle in place of a gate or disk. There is a tapered or conical seat in the valve body to mate with the movable needle. The needle is moved up and down by the valve stem (with screw threads) and handwheel, permitting a very gradual opening and closing of the passage. The volume of liquid flowing through the valve is controlled by the clearance between the needle and the seat. Fig. 3 also illustrates the design of the angle valve, in which the inlet opening is turned 90° from the outlet opening. When used in making a 90° turn in a pipeline, an angle valve reduces the number of joints and the labour in assembly. It also gives less resistance to flow than the combination of elbow and straight-run valve that it replaces.



BY COURTESY OF THE WILLIAM POWELL COMPANY

FIG. 3.—SCHEMATIC DIAGRAM OF ANGLE NEEDLE VALVE

Fig. 4 shows the operation of a butterfly valve, which is essentially a circular disk, pivoted along one diameter. The damper used in stovepipes and warm-air heating systems is of this type, and butterfly valves also are used in the intake systems of automobile engines.

On hydraulic turbine installations, such valves may be 12 ft. or more in diameter.

Check valves are installed to prevent reversal of flow in piping, and they are available in several types. In each type, flom in one direction keeps the valve open, whereas reversal of flow or gravity, or both, closes the valve automatically. Fig. 5 shows a swing check valve; fluid moves through this valve in approximately a straight line from left to right. A swing disk, pivoted at its upper side, is held open by the flom; however, if the flow reverses, the weight of the disk and the movement of the fluid force the disk to seat on the valve seat. In the lift check valve, the construction is similar to that of the globe valve (except that there is no valve stem or handwheel), with the flow coming from under the valve disk and lifting it up. If the flow reverses, the fluid and weight of the valve disk block the reverse flow. In the gravity ball check valve, a ball rests on a spherical seat in the valve body. Flow in the upward direction lifts the ball off the seat; flow in the downward direction is blocked by the ball resting on its seat, A spring may be used to assure positive seating of the ball.

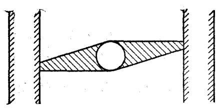


FIG. 4.—DIAGRAM OF BUTTERFLY VALVE

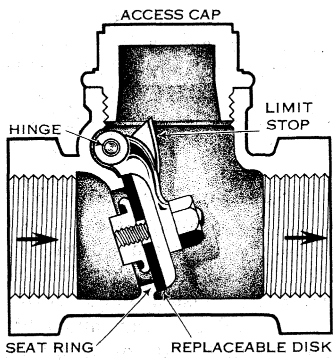


FIG. 5.—SCHEMATIC DIAGRAM OF SWING CHECK VALVE. CLOSED TO PREVENT REVERSE FLOW

Fig. 6 illustrates a cock. In the body is a tapered or conical seat; a conical plug with a hole fits into this seat. By turning the plug. the hole in it is lined up with the pipe or turned so that the pipe passage is blocked.

Pressure-reducing valves are used to lower the pressure in a particular section of a piping system. Fig. 7 illustrates such a valve, which has a cylindrical body holding a fixed valve seat; a valve disk (at one end of the stem) can move toward or away from the valve seat. The outlet pressure acts on the upper side of the movable piston, while a spring (which may be adjustable) acts on the lower side of the piston. The position of the piston, therefore, depends on the net effect of the spring force and the force of the outlet pressure. The piston, in turn, moves the valve disk upward as the outlet pressure is reduced (thus increasing the outlet pressure), or downward as the outlet pressure is increased (thus reducing the outlet pressure). In one type of valve, the piston is replaced by a circular diaphragm, fixed at its outer edge to the valve body and at its

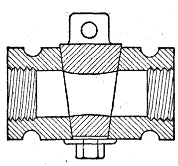


FIG. 6.—DIAGRAM OF COCK, SIMPLE FORM OF ROTARY VALVE

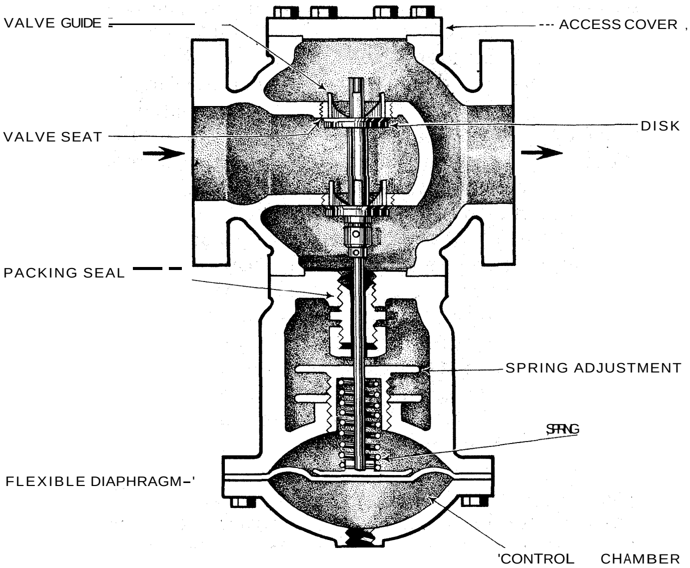


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FIG. 7.— SCHEMATIC DIAGRAM OF PRESSURE-REDUCING VALVE

inner edge to the valve stem.

In hydraulic power and control systems, the spool or piston valve is common. This consists of a cylindrical spool arrangement sliding inside a cylindrical bore. In the valve shown in fig. 8, fluid enters port A; port C is covered, but port B is not; thus, fluid passes from port A through the valve body and out port B. Various arrangements of ports and spools can be devised to achieve different types of flow control. (See POWER TRANSMISSION: Hydraulic Power Transmission.)

Boilers and other mechanical equipment subject to possible damage by excessive pressures are normally equipped with safety

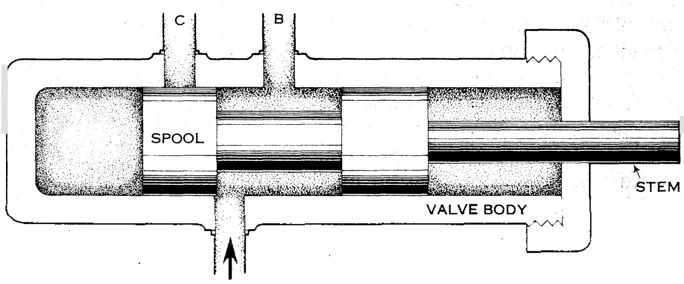

FIG. 8.— DIAGRAM OF PISTON OR SPOOL VALVE. (*See* TEXT)

or relief valves. These valves can be loaded with a spring so that they open automatically when the pressure exceeds a certain value. (R. C. BR.)

VALVE, ELECTRON: *see* ELECTRON TUBE.

VAMPIRE, a term originally applied to bloodsucking ghosts, later transferred to blood-eating bats inhabiting South America and north to southern Mexico.

In its original meaning a vampire is supposed to be the soul of a dead man which quits the dead body at night to suck the blood of living persons. Hence, nhen the grave is opened, the corpse is found to be fresh. To put a stop to his ravages the commonest method is to drive a stake through the body. The belief in vampires is still prevalent among Slavonic peoples. (*See* also DEMON.)

The blood-eating bats comprise two genera (*Desmodus,* the best knonn, and Diphylla) from the forest of tropical America. Their attacks upon men and warm-blooded animals, generally while asleep or at rest, were noticed by writers in the 19th century, but for many years the bats themselves were not identified and the large fruit-eating *Glossophaga* soricana and the carnivorous *Vampyrus* spectrum were mistaken for the true blood-eating species. *Desmodus rotundus* is the most abundant species; it is a small bat, about 3 in. in length, with reddish-brown fur and peculiar teeth adapted to its mode of feeding. They are said to be able to pierce the skin and lap up blood with the tongue without awakening their victim. Diphylla *ecaudata* is less abundant, being confined to Brazil, and differs in the details of the teeth. Since the vampire bats, like some others, carry rabies and other diseases. the bite can be dangerous.

See also BAT: *Classification.*

VAN, the chief town of an il of the same name in Asiatic Turkey; altitude 5,400 ft. Pop (1960) 22 018 It is situated about a mile from the eastern shore of Lake Van. and built along the south side of the citadel rock, an isolated rocky ridge 1.300 yd long, rising 360 ft. out of a plain which extends up to the sharply defined rocky mass of the Varak range. 8 mi. distant. On the gently sloping ground east of the citadel are the gardens, covering an area of 5 by 3 mi. and containing several suburbs and detached houses, along central avenues fringed with trees, and having channels of running water by the sides for irrigation.

The town itself is a poor place with flat-roofed mud houses, narrow winding streets, and surrounded by a ruinous mud wall; but it still contains the business quarter, the government offices and the principal bazaars. Water comes from *karez* or underground channels and streams from Varak. fed from the Sikhe lake. an ancient reservoir which preserves the snow waters on the summit of the mountain. For the southern quarter there is the Shemiram canal. also of very ancient construction, which derives its supply from a large spring 19 mi. distant. near Meshingird. The climate is generally healthful, extremely cold in minter, with 2 to 3 ft. of snow from December to March, nhile the summer heat is not excessive. The Persian trade of Van has declined; European goods. with which the bazaars are fairly well supplied, come from Trebizond through Erzerum. There is a fair local trade in wheat and agricultural produce. as well as sheep and cattle, wool, hides and furs for export.

The cuneiform inscriptions of Van are very numerous, the town having been the capital of the Vannic kingdom of the Assyrian period (see URARTU).

In the 6th century B C. Van passed into the hands of the Persians, and shortly before it fell to Alexander the Great it was rebuilt. according to Armenian historians. by a native prince called Van. In 149 B.C. Valarsaces or Vagharshag, the first Armenian king of the Arsacidae, rebuilt the town, and a colony of Jews was settled in it by Tigranes (94–56 B.C.). In the middle of the 4th century A.D. it was taken by Sapor (Shapur) II, and became the capital of an autonomous province of the Sassanian empire, until it fell into the hands of the Arabs (c. 640), under whom it regained its autonomy. About 908 the governor of Van or Vaspuragan was crowned king by the caliph Moktadir. and in 1021 his descendant Senekherim was persuaded by Basil II to exchange his kingdom for the viceroyalty of the Sebasteian theme. After having formed part of the possessions of the Seljuks, Mongols, Tatars and Persians, Van passed in 1514, after the defeat of Shah Ismail by Selim I at the battle of Kalderan, to the Osmanlis, who did not occupy the town until 1543. In 1636 it nas taken by the Persians, but soon recovered. In 1845 the town was held for a time by the Kurd chief Khan Mahmud.

The *il* of VAN lies along the Iranian frontier between the *ils* of Bayazid and Hekkiari Pop (1960) 211.362 The mineral wealth of the *il* is brlieved to be great.

LAKE VAN, called Arsissa Palus and also Thospitis from its Armenian names, is roughly rectangular, 78 mi. long nith an area of 1,453 sq mi. It stands about 5.643 ft. above sea level. It is without an outlet, and its greatest depth is along the southern shore. It has constant steady fluctuations, rising and falling about eight feet in a periodic movement of five years. In the middle of the 19th century a sudden rise submerged several places on the banks, including Arjish Kale, and the naters did not subside. The northeastern arm is much shallower than the rest. The water is bitter and undrinkable. being largely impregnated with carbonate and sulfate of soda with some borax. The salts are evaporated in pans, and called perek, being sold for washing purposes. There is, however, good water along the coast from springs and streams.

The lake has been navigated from the earliest times, and sailing boats, carrying about 20 tons burden, now ply it, chiefly with wheat and firewood. Severe storms make navigation dangerous in winter. The southern shore is fringed by a steep range of mountains, with several thriving villages along the coast. The hills have been almost denuded of trees. At the southeastern corner is the island of Akhtamar with its ancient church, erected (c. 928) by Gagig, first king of the Ardzrunian dynasty. The catholicos of Akhtamar was one of the highest offices in the Armenian church, and dated from 1113. Large numbers of darekh, a kind of herring, exist in the lake, and are caught in nets from boats or when they enter the shallow lagoons in the spring and summer.

VANADINITE, a mineral consisting of a lead chloride vanadate, is a source of vanadium for the manufacture of vanadium steel. It occurs as crystals, which are usually six-sided prisms terminated by the basal planes, often skeletal and sometimes rounded; they may also be compact, globular or in crusts. The colour is usually brown to yellow, but crystals from Arizona are brilliant red. The hardness is 3. The formula is $Pb_5Cl(VO_4)_3$. It crystallizes in the hexagonal system, and is isomorphous with pyromorphite and mimetite (*qq.v.*). Because of isomorphous replacement of vanadium by phosphorus and arsenic, the specific gravity varies from 6.6 to 7.2. A variety containing much arsenic is called endlichite. Vanadinite is a secondary mineral, forming in the oxidized zones of lead deposits. It occurs in the Urals, Carinthia, Morocco, southwest Africa. Northern Rhodesia, Mexico, Argentina and New Mexico and Arizona. (L. S. RL.)

VANADIUM is a metallic element whose most important use is as an alloy to improve certain qualities of steel and cast iron. For example, vanadium is used in making high-speed tool steel, high-strength structural steel and wear-resistant cast iron. The following article discusses the history, occurrence, extraction, production, physical properties, chemical properties, uses and analysis of vanadium in that order.

History.—Andrés Manuel del Rio (1801) reported the discovery of a new element in vanadinite from Zimapán, Mex., which he named erythronium because of the red colour acquired by its salts on heating. On re-examination a few years later he concluded that he was mistaken and that the brown ore from Zimapán was merely a basic lead chromate. For a quarter of a century no more was heard of the new element erythronium. In 1830 N. G. Sefstrom became interested in an extremely soft iron obtained from Taberg, Swed., iron ore and on examination discovered in the ore, as well as in the wrought iron and slag. a new element which he named vanadium, from Vanadis, the Scandinavian goddess of beauty and youth—a name suggested by the beautiful colours of its compounds in solution. A short time before this, F. Wöhler had undertaken a re-examination of the vanadinite ore from Zimapán and found (1830) that the new element, surmised and abandoned by Del Rio, was identical with the vanadium of Sefstrom. Because of illness contracted as a consequence of poisoning by hydrogen fluoride vapour, Wöhler failed to report his findings and thus did not receive credit for the discovery of the new element. J. J. Berzelius (1831) prepared a number of compounds of vanadium and concluded that the element belonged in the same family as chromium and molybdenum.

H. E. Roscoe then showed (1867–70) that Berzelius was in error in this conclusion since the substance, which Berzelius had assumed to be the free metal, was really the oxide, VO, and that therefore most of the compounds studied by Berzelius had contained oxygen. Roscoe established the position of vanadium in the fifth group (subgroup V) of the periodic system by showing that it forms a number of compounds analogous in composition to those of phosphorus and also that a number of vanadates are isomorphous with the corresponding phosphates. Roscoe (1869) was the first to obtain metallic vanadium, 95.8% pure, by reduction of vanadous chloride, VCl_2, with hydrogen. Metallic vanadium has been one of the metals most difficult to isolate in highly pure state because of the great stability of its lowest oxide, its nitride and its carbide. J. W. Marden and M. N. Rich (1927) succeeded in obtaining metallic vanadium, 99.7% pure, by heating a mixture of vanadium pentoxide, calcium metal and calcium chloride for one hour at 900° to 950° C. At mid-20th century pure vanadium was being produced in limited quantities.

Occurrence.—Vanadium is widely distributed in various minerals. coal and petroleum. Although it is estimated to comprise betneen 0.02% and 0.03% of the earth's crust, ores of commercial value occur in only a few places. The principal commercial ores are patronite, roscoelite, vanadinite and carnotite. Patronite, not a well-defined mineral, occurs in coal deposits at Mina Ragra, Peru (elevation 16,000 ft.). It is essentially a sulfide of vanadium, is associated with free sulfur and iron pyrites, and contains 10% or more of vanadium. On preliminary roasting the vanadium content is increased to 20% with almost complete elimination of sulfur. These deposits have been materially depleted. Roscoelite, $K_2(Mg,Fe)(Al,V)_4Si_{12}O_{32}.4H_2O$, one of the micas, occurs in Colorado and other western states. This mineral and carnotite, $K_2O.2U_2O_3.V_2O_5.3H_2O$ (Utah and Colorado), are the ore types which heretofore have been the source of most of the domestic U.S. vanadium. Vanadinite, $PbCl_2.3Pb_3(VO_4)_2$, with arsenic and phosphorus replacing vanadium in some cases, occurs in Arizona, New Mexico, southwest Africa and Northern Rhodesia (also in the Crals, Mexico, Spain and Argentina). Potential vanadium reserves in extensive phosphate beds of the Wyoming-Utah area were disclosed as a result of studies begun by the U.S. geological survey in 1939. Results of laboratory and field work indicated the possibility of obtaining both vanadium pentoxide and phosphate fertilizer at costs not greatly different from those for other ores. Vanadium-bearing magnetite mined in northern New Tork contains an average of 0.6% V_2O_5. Generally, vanadium-poor iron ores can be used in steelmaking processes directly. Vanadium is a common constituent of coals, asphalts, bitumens and oil. Flue dust from smokestacks and boilers of ships burning certain Venezuelan and Mexican oils contains 12% to 15% V_2O_5 and has become a commercial source of vanadium.

Extraction.—The methods of extraction vary widely depending on the nature and richness of the ore and the value of the by-products (such as uranium and radium from carnotite). The difficulties encountered are connected with the separation of the vanadium from uranium, aluminum, iron and silica. The methods fall into two general types: (1) acid extraction, in which soluble pervanadyl compounds, $(VO_2)_2SO_4$ or VO_2Cl, are formed; and (2) alkali extraction, in which soluble alkali vanadates, $NaVO_3$ and Na_3VO_4, are produced. Crude vanadium pentoxide may be obtained from the acid leach by evaporation and ignition. Or the acid leach may be nearly neutralized, other constituents precipitated and the resulting solution treated with excess sodium carbonate (soda ash), thereby converting the vanadium to soluble vanadates. The precipitate containing iron, aluminum and calcium is discarded and the vanadium is then precipitated as ferrous vanadate on addition of ferrous sulfate to the neutralized solution. From an alkaline leach, vanadium may be precipitated as ammonium metavanadate on addition of excess ammonium chloride; as ferrous vanadate or as hydrated vanadium pentoxide by proper acidification. Although wet processes are more common, dry processes involving initial fusion with sodium carbonate are used.

Various modifications of these more general procedures were developed.

Production of Vanadium and Its Alloys.—Four methods of preparing vanadium metal are known, but production of the pure metal on a tonnage basis had not been accomplished by 1960. The four methods, listed below, generally involve chemical reduction. (1) A reaction known as the alumino-thermic process has been used to produce vanadium of 98% purity. 'The reaction mixture that has been used contains vanadium pentoxide, aluminum and sodium carbonate in the proportions of 150, 60 and 18 g. respectively. (2) Reduction of vanadium pentoxide (V_2O_5) with calcium metal is the most popular method of producing vanadium metal. In this method a calcium chloride ($CaCl_2$) flux is often used, and the reaction is carried out in a constant volume steel bomb. Sample proportions of 175 g. of V_2O_5 and 300 g. each of Ca and $CaCl_2$ are reacted at 900° C.; massive pieces of metal can be produced. This method is capable of producing 99.7% purity metal with satisfactory ductility if the oxygen content is kept below 0.05% by weight. Commercial vanadium has a typical purity of 0.05% carbon, 0.07% oxygen, 0.003% hydrogen and 0 08% nitrogen. (3) Thermal decomposition of vanadium di-iodide has produced ductile metal. This method is similar in principle to the methods used for the production of zirconium or titanium but suffers because of the low vapour pressure of vanadium di-iodide. Temperatures of 900° to 1,000" C. are generally employed (4) Hydrogen reduction of chlorides at temperatures near 1,000" C. is another way of producing ductile vanadium. Nitrogen-free hydrogen should also be used in order to prevent the formation of vanadium nitride during the reduction process. Care must be taken to anneal the final metal of approximately 99.9% purity in vacuum since hydrogen tends to embrittle the metal.

Alloying of vanadium or remelting of stock is carried out by arc-melting the metals in an argon atmosphere in a water-cooled copper mold with a tungsten tipped electrode. Ceramic crucibles cannot be used because vanadium reduces or dissolves stable oxides. carbides and borides. For alloys containing 50 atomic per cent vanadium or less the use of thoria-lined recrystallized alumina crucibles has been reported as satisfactory. Hot working vanadium and vanadium-rich alloys is a questionable operation, but it is possible to roll, swage and extrude alloys by jacketing them in mild steel. In this way atmospheric contamination is prevented, and the mild steel jacket can be pickled off in hydrochloric acid. After such pickling, vanadium is likely to be embrittled with hydrogen, and vacuum annealing is called for. Since vanadium sheets one-quarter of an inch thick can be cold rolled to 0.001 in. sheets without intermediate annealing, the amount of strain hardening is very small. Cold worked vanadium can be recrystallized at approximately 800° C.

Physical Properties. — Vanadium, whose symbol is V, has the atomic number 23 and an atomic weight of 50.95.

Vanadium metal has a bright silver-white colour and does not tarnish readily. Compared with other metals at their respective melting points it is one of the least volatile (melting point, 1,950" C.). Its density (cold-worked) is 6.0 g. per millilitre at 22° C. as determined from X-ray data obtained with the powdered metal. Since cold-working increases the density, this value is somewhat higher than that usually given (approximately 5.9).

When heated in the presence of hydrogen, vanadium becomes very brittle. Malleability may be restored by heating in a vacuum. Other physical properties of the metal are:

Boiling point, 3,600" C.
Specific gravity, 5.87 at 15° C.
Index of reiraction, 3.03.
Specific resistance at 20° C., 26 × 10^{-6} ohm-centimetre.
Temperature coefficient of resistance, R, between 20° and 150" C. is given by the relation $R = R_o(1 + at)$, in which a = 0.0028.
Specific heat between 20" and 100" C.. 0.120 cal. per gram per C°.
Specific heat oi fusion, 8.0 cal. per gram:
Estimated heat of sublimation at 25° C., 121.9 Kcal. per gram atom.
Ionization potential of gaseous atoms, 6.71 v.
Crystal structure, body centred cubic system, a, = 3.0258 Å
Radius of ion, V^{+5}, in crystals, 0.59 × 10^{-8} cm. (0.59 Å)
Coefficient of linear thermal expansion, 200°–1,000° C., 9.7 × 10^{-6}/° C.
Recrystallization temperature for 70% cold-rolled sheet, 700"–800" C.

Vanadium alloys with a large number of elements including aluminum, cobalt, copper, iron, manganese, molybdenum, nickel, platinum. tin and silicon. It is infinitesimally soluble in mercury.

Naturally occurring vanadium consists of two isotopes (mass numbers 50 and 51). Four artificial radioactive isotopes have been produced with mass numbers 47, 48, 49 and 52 and half-lives of 33 min.. 16 days, 600 days and 3.74 min. respectively.

Metallic vanadium may be cold-worked into wire and other forms. It resembles tantalum in these respects and also in its crystal form, which belongs to the body-centred cubic system.

Chemical Properties; Compounds. — Vanadium is the first member of subgroup V of the periodic system, which also includes niobium and tantalum in order of increasing atomic weight. Like its congeners in the subgroup, vanadium may be described as seminoble. When heated with oxygen, nitrogen, carbon and sulfur it forms the oxides V_2O_3, VO, VO_2 and V_2O_5; the nitride VN; the carbides, VC and V_4C_3, and the sulfides, VS_2 and V_2S_5. The three metals of subgroup V form compounds in which their maximum oxidation state (valence) is plus five. The other oxidation states possessed by vanadium in its compounds are two, three or four. Vanadium dissolves in nitric acid and is oxidized by other moderate oxidizing agents in acid solution. It is not dissolved by hydrochloric or dilute sulfuric acid even though its oxidation by hydrogen ion in these acid solutions is thermodynamically possible. Fusion of vanadium with alkalies produces soluble vanadates and hydrogen.

The basicity of the hydrogen-oxygen compounds of vanadium varies with the oxidation state. In the two lower oxidation states. two and three, these compounds are basic; in oxidation states four and five they are amphoteric, being much more basic than acidic in state four and more acidic than basic in state five. The formulas. names and colours of the ions of vanadium in the different oxidation states in acid and basic solutions, respectively, are given in the following table:

Oxidation state	Acid solution	Basic solution
+2	V^{++}, vanadous, lavender	—
+3	V^{+++}, vanadic, lavender-blue	—
+4	VO^{++}, vanadyl, blue	$V_4O_9^{--}$, vanadite, brown
+5	$V(OH)_4^{+}$, $V(OH)_3^{++}$, $V(OH)_2^{+++}$ tetra-, tri-, di-hydroxypervanadyl, greenish-yellow	$V_3O_9^{---}$, metavanadate, colourless VO_4^{---}, orthovanadate, colourless $V_2O_7^{----}$, divanadate, colourless

The molal electromotive forces at 25° C. and the half-cell reactions involving various oxidation states of vanadium in acid solution are as follows:

$$V = V^{++}\ 2e^- \qquad +1.18\ v\ \text{(estimated)}$$
$$V^{++} = V^{+++} + e^- \qquad +0.255\ v$$
$$V^{+++} + H_2O = VO^{++} + 2H^+ + e^- \qquad -0361\ v$$
$$VO^{++} + 3H_2O = V(OH)_4^+ + 2H^+ + e^- \qquad -1.00\ v$$

As these values indicate, pentavalent vanadium in acid solution may be reduced to the tetravalent state, VO^{++}, by mild reducing agents such as iodine, ferrous ion, sulfur dioxide and mercury (in sulfuric acid). Stronger reducing agents cause further reductions, e g., iron, magnesium and stannous tin give trivalent vanadium. V^{+++}, and zinc and cadmium give the vanadous state.

Intermetallic compounds have been identified in a number of binary and ternary metallurgical systems. In the iron-vanadium (Fe-V) system only a single intermediate phase corresponding to FeV but having a range of vanadium content between 30% and 60% has been reported. The solubility of carbon in austenite is increased by vanadium additions to iron-carbon alloys; however, in steels iron carbide (Fe_3C) and V_4C_3 are precipitated separately and not as complex double carbides. The existence of a spinel FeV_2O_4 has been reported.

Uses. — Vanadium metal. as such, has small commercial use and is therefore produced in very limited quantity. Ductile vanadium, 99.8% pure, was made available in 1950 About 90% of the vanadium used is consumed as ferrovanadium in the manufacture of tool steels, engineering steels, high-strength structural steels, non-aging rimming steels and special wear-resistant cast irons. (See VANADIUM STEEL.) A satisfactory ferrovanadium alloy must contain 30% to 40% of vanadium and not more than 0.5% carbon, 1.0% silicon, 2.0% aluminum, 0.1% phosphorus and 0.1% sulfur. In steel fabrication, vanadium functions in three ways: it (1) increases the strength and durability by partially dissolving in the ferrite; (2) produces a finer and more uniform grain size and minimizes the tendency to grain growth during heat treatment; and (3) forms very stable carbides that add to the strength and hardness and show little tendency to segregate or to form large masses at elevated temperatures. Quantities of vanadium for 0.15% to 0.25% are sufficient. Although vanadium is a powerful deoxidizer, it is too expensive to be used in steels for this purpose alone. High-speed tool steel contains 0.50% to 2.50% vanadium along with about 0.70% carbon, 0.20% silicon, 18.0% tungsten, 0.25% manganese and 4.0% chromium. Vanadium steels date from the discovery of the Peruvian deposits in 1905. Certain alloys of vanadium with other metals, such as copper and aluminum, have found industrial uses.

The largest uses of vanadium pentoxide and ammonium metavanadate at mid-20th century were as catalysts, in colouring glass and ceramic glazes, for driers in paints and inks and for laboratory research. After 1927 the use of vanadium catalysts in the contact process for manufacturing sulfuric acid revolutionized this industry. These catalysts are not susceptible to poisoning as are platinum catalysts and compare favourably with the best platinum catalysts in their effectiveness. The active agent is vanadium pentoxide or sodium metavanadate. The catalytic action is attributed to the alternate oxidation and reduction of the vanadium between the tri- and pentavalent states. Vanadium pentoxide and vanadates are likewise efficient catalysts for the oxidation by oxygen of a large number of organic substances. Among the more important of such oxidations are the following: naphthalene to phthalic anhydride, benzene to maleic acid, aniline to aniline black, toluene to benzaldehyde and benzoic acid, anthracene to anthraquinone and methyl alcohol to formaldehyde.

Analytical. — Qualitatively the presence of vanadium pentoxide in a mixture of oxides may be shown by the violet-red colour of ammonium thiovanadate, $(NH_4)_3VS_4$, which is produced on treating the solution of the oxides in hydrofluoric acid with excess ammonium sulfide. The presence of pentavalent vanadium in acid solution — present as $V(OH)_4^+$ — may be shown by the red colour produced on addition of hydrogen peroxide. The intensity of this red colour has been used in the quantitative determination of vanadium.

Gravimetric procedures depend upon the weight of vanadium pentoxide, the formation of which has been indicated under methods of extraction. Two of the simpler volumetric methods of determining vanadium are based on (1) reduction of pentavalent vanadium in hot acid solutions to the tetravalent state (vanadyl) with sulfur dioxide, removal of excess sulfur dioxide and titration of the hot solution with standard potassium permanganate solution; and (2) reduction of pentavalent vanadium in acid solution to the tetravalent state with iodide ion in the absence of oxygen, and titration with standard sodium thiosulfate solution. See also Index references under "Vanadium" in the Index volume.

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VANADIUM **STEEL.** The advantages inherent in adding vanadium to steel first became a matter of industrial knowledge at the end of the 19th century. Widespread use of alloy steels after World War I reflected on vanadium, which came to be used for many types of steels both alone and in association with other alloying elements.

Vanadium and iron are mutually soluble in the liquid state in all proportions but form a compound containing 48% vanadium below 1,250" C. In steels, vanadium principally strengthens the matrix. if both vanadium and carbon are kept very low. But as either of them is proportionally increased, vanadium will be increasingly present as a very hard and stable carbide.

Vanadium has essentially two effects upon the steel: it refines the grain of the steel matrix, and it increases strength and hardness by forming free carbides. Fine grain is developed in the steel by the action of small, dispersed vanadium carbides possibly with assistance from other vanadium compounds formed in the steel. Vanadium steels retain their fine grain over the full range of heat treating temperatures. These features are applied in the production of heavy castings and forgings. In special cases, namely, for easier machining and also for maximum high temperature strength, the fine grain of vanadium steels can be coarsened by holding them above normal quenching or annealing temperatures. The grain grows, as the carbides increasingly dissolve in the austenite. Fine grain returns with renewed heat-treating in the quenching or annealing range.

Vanadium is added to constructional steels to improve elastic properties, toughness and yield to tensile strength ratios. Medium carbon steels containing 0.6% to 1.0% manganese and 0.1% to 0.2% vanadium are used for heavy railroad equipment, namely, connecting rods, driving axles and crank pins; a similar steel with 1.23% to 1.75% manganese serves under more severe conditions. This type of steel with low carbon and 1.0% to 1.25% manganese is used for rivets and bolts and as plate in marine and other transportation equipment. Numerous products such as gears, camshafts, springs, shafting, ball bearings and wearing plates are made from a low-vanadium analysis with chromium and carbon in the ranges of 0.4% to 1.2% and 0.4% to 1.0%, respectively, according to application. For very heavy forgings, such as turbine rotors, complex vanadium steels are specified, principally nickel-vanadium, nickel-molybdenum-vanadium, nickel-chromium-vanadium types.

Additions of the metal to steel are usually made with ferrovanadium containing between 35% and 80% vanadium. Since the metal is chemically very active, the steel is first deoxidized. Where cheaper deoxidizers have a deleterious effect, the metal is employed to combine with both oxygen and nitrogen. However, in so-called nonaging rimming steels, vanadium combines with nitrogen while permitting a mild rimming action (reaction of iron oxides with carbon prior to solidification, causing development of carbon monoxide and permitting a better yield of metal from the ingot), thus combining the advantages of rimming steel with the nonaging characteristics of "killed" steels (which do not contain any oxides free to react with carbon and do not materially change their properties in time — do not age).

Tool steels. either the carbon-vanadium or more complex low-alloy types, are produced in large variety, usually with not more than 0.25% vanadium. These steels generally ensure controlled shallow hardening, and this feature is applied in the heat treatment of tools designed to have a hard exterior and a tough core. Also, in tools of varying cross section the surface of the heaviest part can be fully hardened without danger of grain coarsening in the lightest. When the vanadium content is increased to about 0.5%, the depth of hardening can be finely adjusted by raising the quenching temperature to take more or less vanadium-rich carbide into solution.

The greater stability of the vanadium carbides permits higher tempering temperatures and thus improves shock resistance combined with a relatively high hardness. It also allows higher cutting-edge operating temperatures, leading to better performance at high speeds or wear resistance at greater pressures or higher temperatures in forming operations.

In these carbon and low-alloy tool steels, vanadium ranges between 0.1% and 1.3% and is used to develop optimum properties in virtually all types ranging from razor and knife blades, taps and dies, chisels, lathe tools and milling cutters to drop-forging, die casting and extrusion dies. In high-speed tool steels, which are used for all types of heavy-duty cutting. drilling, forging, extruding, etc., the great hardness of the vanadium carbides is utilized to the fullest possible extent. Among these steels a type designated as 18–4–1 (tungsten-chromium-vanadium) was outstanding for many years. During the 1940s and 1950s a lower tungsten, 6–6–4–2, tungsten-molybdenum-chromium-vanadium composition came to the fore along with a 9–4–2, molybdenum-chromium-vanadium analysis with or without 2% tungsten.

Carbon in high-speed steels generally ranges between 0.65% and 0.85% but is lower where severe impact loads apply. Later developments tended toward higher wear resistance and also greater hardness by raising carbon and vanadium contents which may lie between 1 5% and 4.0%, and between 4% and 12%, respectively.

In vanadium-bearing high-temperature steels, special properties are frequently produced by heat treatments to dissolve practically all the carbide Steels for power-generating units often contain carbon, vanadium, molybdenum and chromium with sometimes tungsten all at a medium alloy level. An excellent performance record has been established by a 1% chromium, 1% molybdenum, 0.25% vanadium tube steel in steam power service up to 1,100° F.

Vanadium-bearing cast steels and cast irons generally contain *0.05%* to *0.20%* vanadium with one or more of *0.50%* to 1.50% chromium. 0.15% to *0.35%* molybdenum (with occasionally higher molybdenum in iron) and normal *(0.7%)* or high *(1.0%* to *1 75%)* manganese in steel. Vanadium limits the growth of dendrites in the solidification of steel castings; in cast irons it helps to produce a uniiorm distribution of graphite in the form of moderate-size flakes In steel castings vanadium is included to engender improved impact resistance and to raise the ratio of the yield strength to the ultimate tensile strength; in cast irons the stability and hardness of vanadium carbides increase wear resistance and strength. (C. M. C.)

VAN ALLEN RADIATION BELTS. In May *1958,* J. A. Van Allen interpreted the response of a Geiger counter he had installed in the first U.S. artificial satellite. Explorer I, as an indication of an intense belt of particulate radiation surrounding the earth. Subsequent experiments by Van Allen and others, undertaken with other satellites and space probes, confirmed this discovery, established many properties of the radiation and revealed that there are two huge zones of trapped charged particles encircling the earth. The trapped particles in these Van Allen radiation belts, as the zones soon came to be called, were found to be protons and electrons. The Van Allen belts, especially the outer one, play an important role in a number of geophysical phenomena such as auroras. geomagnetic storms (i e., large disturbances in the earth's magnetic field), airglow and atmospheric heating. Studies of the belts have revealed much concerning the intensity of cosmic rays (*q.v.*) in interplanetary space.

Particle Motion in Earth's Magnetic Field.—An analysis of the motion of charged particles in the earth's magnetic field will explain how these belts can contain such an extraordinary flux of high-speed particles. Consider a particle of charge e, velocity **v** and momentum **p** that is moving at an angle a relative to the direction of a magnetic field of uniform flux density B. The magnetic force on the particle is perpendicular to both of the vectors **B** and **v** (or **p**). Hence the magnitude of the velocity and of its component along the direction of **B** remain constant, while the component of velocity normal to B is continually modified in direction by the force. The resulting motion of the particle is along a spiral with pitch angle equal to a. Equating the magnetic force, Bev sin a. to the centripetal force $mv^2 \sin^2 \alpha/\rho$ required for the circular motion normal to B shows that p, the radius of the spiral, is equal to $p \sin \alpha/Be$.

For the high-energy cosmic rays that are not stored in the Van Allen belts, the radius of gyration, p, is comparable with or greater than that of the earth; hence the change of the magnetic field along the paths of these particles is very important. Indeed. as they approach the earth from interplanetary space, these high-energy cosmic rays execute in most cases less than one revolution about the lines of force of the earth's field. But the particles found in the Van Allen zones have comparatively low momentum and their radii of gyration are so small compared with the distance from the centre of the earth that to a first approximation their motion is a tight spiral about the lines of force, as though the particles were moving in a uniform field.

The gas density at the altitudes where these particles are found is so low that atomic collisions are very rare, and the particles can travel for distances hundreds of times the diameter of the earth without experiencing deflections other than those due to the earth's magnetism.

The magnetic field of the earth at high altitudes is approximately that of a dipole (*i.e.*, a short bar magnet) of strength $M = 8.1 \times 10^{25}$) gauss-cubic centimetre, displaced *342* km. from the centre of the earth toward latitude 6.5° north, longitude 162° east and tilted 11.5° relative to the geographic axis in the plane of the meridian 69° west of Greenwich (see GEOMAGNETISM). It is convenient to describe the field in terms of co-ordinates centred on the dipole instead of on the geographic centre of the earth. The dipole field has a northward component, $B_\lambda = M \cos \lambda/r^3$, and a radial component, $B_r = -2\ M \sin \lambda/r^3$, where λ is the geomagnetic latitude and r the distance from the centre. The lines of force are represented by the family of curves $r = r_0 \cos^2 \lambda$, where r_0 is the radius at which a line crosses the magnetic equator. The strength of the field varies along a line of force according to $B = (M/r_0{}^3) \sec^6 \lambda\ (1 + 3 \sin^2 \lambda)^{\frac{1}{2}}$. Near the surface of the earth the true field is more complicated, but the dipole approximation is adequate for the present discussion.

As a charged particle follows its spiral path northward or southward from the equator along the lines of force, the particle approaches closer to the atmosphere, since the radius of a line of force decreases according to $r = r_0 \cos^2 \lambda$. For instance, particles that cross the equator at an altitude of $3\ R_e$ (R_e being the radius of the earth, about *6,470* km.) would strike the earth at a latitude of about ± 60°.

However, as the spiral proceeds northward or southward the field lines do not remain parallel, but converge. In a convergent field the force, which remains perpendicular to the field lines, has a component along the axis of the spiral. decelerating this component of motion and making the pitch of the spiral grow steeper according to $\sin^2\alpha = (B/B_0) \sin^2\alpha_0 = \sec^6\lambda\ (1 + 3 \sin^2\lambda)^{\frac{1}{2}} \sin^2\alpha_0$, where α_0 is the pitch and B_0 is the field strength where the spiral crosses the equator. Somewhere between the equator and the latitude where the spiral would enter the atmosphere, the condition $\sin^2\alpha = 1$ is reached for those particles having a sufficient pitch angle at the equator. At such latitudes, the particles are reflected in their north–south motion and retrace their paths to a similar latitude in the opposite hemisphere, where they are reflected again. Particles traveling along paths with smaller pitch angles enter the atmosphere and are absorbed.

Thus. a magnetic-dipole field constitutes a trap or "magnetic bottle" for charged particles moving in a vacuum, confining many of the particles between certain limits of latitude and altitude. If the field is static and no scattering by atomic collisions occurs, particles trapped in the field cannot get out. and particles capable of entering the region from outside cannot get trapped in it.

The spiral motion, viewed along the axis, is not quite circular, because at the points of lowest altitude the field strength, and hence the curvature, is slightly greater than at the points of highest altitude. **As** a result, the particles drift in longitude at a rate given by

$$\frac{\text{drift velocity}}{\text{total transverse velocity}} = \frac{3}{2}\ \frac{\text{radius of spiral}}{\text{distance from magnetic center}}$$

The positive particles (protons) drift from east to west and the negative particles (electrons) from west to east, in either case generating a westward electric current. Consider a typical trapped electron of *20* Kev energy at a distance of $4\ R_e$ from the centre and having a pitch angle of 30° at the equator. The radius of gyration is about ½ km. and the particle executes *14,000* oscillations per second. Meanwhile it travels north and south bet een reflection points at latitudes of ±33° about once a second, and drifts eastward around the earth about once a day. Although the drift velocity is slow. the number of particles in the Van Allen zones is so large that they constitute a ring current exceeding a million amperes. This causes an appreciable modification in the earth's magnetic field—as much as the normal dipole field itself at a distance of about $10\ R_e$. The field due to the ring current reduces the total field inside the ring and adds to the field outside.

Magnetometer measurements in Soviet and American space vehicles have verified the existence of such ring currents. The location and strength of the principal current appear to be variable: that found by Soviet workers in *1959* was at *3* to $4\ R_e$, while that found by the U.S. satellite Explorer VI six months later, and by the space probe Pioneer V in *1960* (a current of about *5* million amperes), occupied a toroidal volume between radii of 7 and 13 R_e.

Proton Distribution.— Two kinds of particles, protons and electrons, are trapped in abundance around the earth, the protons being much less numerous but individually more energetic than the electrons. The protons are found only in the innermost radiation belt, which has a kidney-shaped cross-sectional contour about 2.000 km. in radial thickness, tapering off rapidly in intensity at latitudes in excess of 30". Because of the eccentricity of the magnetic dipole with respect to the earth's centre, the altitude of the equatorial lower edge of this belt varies from 400 km. on one side of the earth to 1,200 km. on the other. The lower edge occurs at altitudes where the magnetic field is equally strong on all sides of the earth.

The peak intensity of the protons with energy exceeding 40 Mev is about 20,000 particles per second crossing a sphere of 1 cm.^{2} area in all directions—10,000 times the intensity of cosmic rays in interplanetary space in 1959. The spectrum of these protons is rather hard, the number with kinetic energy above E being approximately proportional to $E^{-1.8}$, at least up to 700 Mev. Thus, many of the protons can traverse shields of lead several inches thick.

The average energy of the trapped protons decreases with distance from the earth. This variation in the spectrum, as well as the absence of protons in the outer reaches of the earth's field, are explained by the fact that the magnetic bottle is quite "leaky" unless the radius of gyration of the particle is very small compared with the distance from the centre of the field. The magnetic field strength decreases with the cube of this distance; hence the maximum momentum of containable protons decreases as the square of the distance, and the kinetic energy decreases as the fourth power. Protons of very low energy would probably be found at distances of several earth radii, were it not for the presence of a rare atmosphere of neutral hydrogen there. When a proton of energy that is small compared with an Mev passes near a neutral hydrogen atom, the proton is likely to capture the electron from the neutral atom. Thereupon the faster moving particle escapes, since it is no longer deflected by the magnetic field; and the remaining, nearly stationary proton is soon neutralized by combining with a free electron from the surrounding plasma (ionized gas).

This restriction of the proton belt to low altitudes also explains its confinement between low latitudes. The lines of force which cross the equator at altitudes less than one earth radius all meet the top of the atmosphere at latitudes less than 44°, and those that cross the equator at 1 km. altitude meet the atmosphere at about 20°. The particles having pitch angles at the equator large enough to lead to reflection points above the atmosphere are the only ones that can be stored; the others plunge into the atmosphere and are absorbed.

Electron Distribution.— The trapped electrons are subject to the same limitations on momentum as the protons, but because they are 1,837 times lighter, the electrons have much higher velocity and kinetic energy than protons of the same momentum; furthermore, electrons are not lost by a neutralization process, as are the low-energy protons. This explains the occurrence of many low-energy trapped electrons, which are distributed over a much broader region of space than is the proton belt.

Many electrons of moderately high energy, extending up to at least several Mev and capable of making very penetrating X-rays when they strike a space vehicle, exist along with the protons in the inner radiation belt; and electrons of energy in the Kev region are trapped as far out as 14 R_e. Here the lines of force of the earth's field merge with those in interplanetary space, and at larger radii no particles can be confined because the field lines do not connect with the earth.

With instruments sensitive to electrons of energy above 20 Kev. the maximum recorded flux is about 10^{11} particles per second crossing one square centimetre in all directions. This intensity was found near the equator at a height of between 2 and 3 R_e above the surface. The energy spectrum of these particles was found to be very steep, less than 1 in 1,000 having energy above 200 Kev. There is indirect evidence from the association of this band of radiation with the aurora borealis that the number of electrons continues to increase with decreasing energy below the threshold of the above-mentioned instruments, reaching at least 10^{13} per square centimetre per second at 4 or 5 Kev. (By direct detection of the particles with more sensitive instruments that were carried aboard rockets fired into auroral arcs, it was found that the major part of the auroral light is caused by electrons of energy of this order of magnitude.)

The distribution of the electrons in space is complex and also varies with time. With rockets fired outward from the earth at the equator, it was found that the intensity rises sharply at altitudes above 1 km., reaches a maximum at 1 to 1.5 R_e from the surface, decreases, then increases again to the principal maximum at 2.5 to 3 R_e. The decrease beyond this maximum is irregular, and at distances between 7 and 13 R_e large variations were found in small intervals of time or space, indicating strong bunching or waves of electrons. Magnetometers also detected sharp-crested waves in the magnetic field, supporting the picture of this outer region as being strongly disturbed by the impact of streams of plasma from the sun. Beyond about 14 R_e no trapped particles are found—there is only the normal flux of high-energy cosmic rays.

Thus, over the equator the electrons are distributed in a broad and highly structured belt extending from about 1 km. above the earth's surface to 90,000 km., with a peak intensity at about 20,000 km. The north-south spiral paths of these electrons converge as the paths approach the earth at high northern and southern latitudes, mostly between 50° and 70°. Hence the outer radiation zone has a cross section resembling a crescent, with horns reaching down toward the earth in the auroral zones.

Argus Experiments.— The theories of the motion of particles in the exosphere (*i.e.*, the outermost layer of the atmosphere) were put to test in Aug. and Sept. 1958 by the Argus experiments, in which three nuclear explosions were set off in rockets at high altitude over the South Atlantic. The explosions released large numbers of beta ray electrons into the altitude region of the "slot"; *i.e.*, the space between the inner and outer radiation zones where there is ordinarily a minimum density of particles. The electrons spiraled back and forth between northern and southern latitudes as predicted, causing artificial auroras and atmospheric electrical disturbances. The particles having paths of sufficient pitch angle to be reflected before entering the atmosphere were detected with instruments in an artificial satellite; these particles were found to circle about the earth as expected, and to remain trapped for at least two weeks. Solar emissions then caused a disturbance in the earth's field which apparently precipitated the loss of the remaining artificial radiation.

Injection Processes.—As long as the earth's field is undisturbed, purely magnetic deflections can neither make particles escape from the trapped orbits nor conduct any particles into them. The static field merely acts as a bank: deposits and withdrawals require other mechanisms.

Neutron Albedo.—One mechanism of injection is neutron albedo; *i.e.*, the high-energy cosmic rays of galactic origin colliding with atoms in the atmosphere produce secondary neutrons, some of which are ejected backward and leave the atmosphere. These neutrons have been measured outside the atmosphere and found to number about one per square centimetre per second, as predicted from earlier measurements inside the atmosphere. Neutrons have a natural half life of 12 min., and as they travel through the radiation zones at speeds on the order of 30.000 km./sec. some of them (a small proportion) decay into protons and electrons. The calculated energies of particles produced by this mechanism fit the observations in the inner radiation belt. However, both the neutron flux and decay probability are so small that, to account for the number of particles in this zone. the mean storage time has to be on the order of 10 years. In 1963 it was not yet clear whether the various loss mechanisms (atomic scattering into orbits that lead into the atmosphere. neutralization by charge exchange and perturbations of the earth's field by solar disturbances) would permit such long storage.

It is clear that this injection mechanism does not supply the particles in the outer zone, since the electrons there are much more transient, and their spectrum does not fit that of the beta rays arising from decay of albedo neutrons.

Solar Plasma Streams.—Following solar flares, both the content and spatial distribution of particles in the outer zone are observed to undergo major changes. The initial phase, occurring about a day after the flare (when the emitted plasma stream first reaches the earth), is a decrease in the stored radiation; this is often associated with a visible aurora. Apparently the stream of ionized gas disturbs the earth's field in such a way that many of the stored particles are released into the atmosphere at latitudes between 50° and 70°, causing auroras, atmospheric heating and expansion, enhanced ionization and consequent changes in radio transmission. These effects are accompanied by measurable alterations in the magnetic field at the surface of the earth (*i.e.*, a geomagnetic storm) and by major changes in the ring current and the magnetic field in the outer radiation zone. The second phase, occurring in the next few days, involves a gradual recovery of the inner magnetic field and, simultaneously, a build-up of the radiation in the outer zone to a level much higher than the value preceding the disturbance. It appears that the solar stream leaves behind many charged particles and excites violent magnetohydrodynamic oscillations in the exosphere. These oscillations expend themselves gradually in accelerating the electrons to energies above the threshold for detection.

In such an event, the radiation density has been observed to accumulate to the point where the energy per unit volume in the radiation was as much as in the quiescent magnetic field; the field cannot hold a larger amount of energy. Following such an injection process, the particle density dies down comparatively slowly as particles are gradually scattered out of the trapped orbits, until another solar flare causes a repetition of the sequence of events.

The details of the above process were not well established in 1963, but it was clear that the electron acceleration occurs in the earth's field after the arrival of the solar streams, because space rockets did not encounter such dense concentrations of energetic electrons far from the earth.

It was suspected that a process of the same type might be more important than neutron albedo in supplying the particles of the inner band; however, the field close to the earth is too strong to be greatly affected by the solar streams, and the changes in content of the inner radiation belt, produced in geomagnetic storms, were too small to permit a test of this supposition by 1963.

See also SPACE EXPLORATION. (K. GN.)

VANBRUGH, SIR JOHN (1664–1726), British dramatist and architect, was born in the parish of St. Kicolas Acons in the City of London, and christened on Jan. 24, 1664. His father was a sugar baker, and his grandfather, Gillis van Brugg, came to England from Ghent in James I's reign. The Vanbrughs left London during the Plague and went to Chester. After a few years at the King's school, Chester, John at 19 was sent to France to study the arts; after two years' absence he returned to take up a commission in the regiment soon to be known as the 13th Foot. In the early autumn of 1690 Vanbrugh was arrested at Calais on a charge of espionage, on the information of a lady. He was imprisoned at Vincennes, but on Feb. 1, 1692, by a *lettre de cachet,* he was removed to the Bastille. His enforced leisure was responsible for the first draft of the *Provok'd Wife*. For a time after his return he resumed his commission.

The production of Cibber's *Love's Last Shift* at the Theatre Royal in Jan. 1696 kindled afresh his attachment to the comic muse. He thought it would be interesting to develop the situation upon which Cibber had rung down the curtain, and the result was *The Relapse*, "got, conceived and born in six weeks' space." It was given on Boxing day 1696, with Cibber as Foppington, one of the three parts borrowed from the preceding comedy. The Sir Novelty Fashion of Cibber was developed in this play into Lord Foppington, who has been pronounced "the best fop ever brought upon the stage." Foppington, Tunbelly Clumsy and Miss Hoyden are as fine a trio of comic characters as any play can show. *Aesop* at Drury Lane followed. This ran for a week only, but the success of *The Relapse* was so triumphant that Montague, afterward Lord Halifax, asked at once for the *Provok'd Wife* for the theatre in Lincoln's Inn Fields, and it was produced at that theatre in May 1697. Sir John Brute, the husband, is Vanbrugh's masterpiece, and as usual the servants' characters are well drawn. The play was a complete triumph, and Brute was one of Garrick's great parts. Vanbrugh was fiercely attacked by Jeremy Collier for immorality in 1698, and wrote nothing more for the stage until 1700, when an adaptation of the *Pilgrim* of Beaumont and Fletcher was produced at Drury Lane. In this play, in the part of Alinda, Anne Oldfield scored her first success. Two years later appeared *The False Friend,* a version of Le Sage's *Traître puni.* Other adaptations from the French were *A Country House*, from Dancourt's *Maison de campagne; Confederacy* (1705), from the same author's *Bourgeoises à la mode; Squire Trelooby* (1704), a version of Molière's *Monsieur de Pourceaugnac;* and *The Mistake* (1705). from Moliere's *Dépit amoureux.* As a dramatist Vanbrugh is less polished than Congreve and less remorseless than Wycherley. He was not primarily a man of letters, and, as Cibber said, his dialogue is "common conversation committed to paper." No one would trouble to defend his dramatic morality, but his worst efforts are less repulsive than Wycherley, because there is less ruthless realism and more fun in his attitude. His plays are farce, very often, rather than strict comedy, and warmed with humour.

Collier's attack and the resulting movement must have been responsible in part for "Van" turning his attention to architecture. The demand for splendid country seats in the new Palladian style was steadily increasing, and his reputation as a modern wit was an introduction in itself. In 1702 he was entered as comptroller of the Royal Works (now the board of works, where several of his designs may still be seen). In 1703 he wrote to ask his friend Jacob Tonson to procure him a "Palladio," and in the same year he was a commissioner at Greenwich. In the meantime, Vanbrugh had been appointed architect to the earl of Carlisle, and the result. completed in 1714, was the Corinthian mansion of Castle Howard. The work is an extension of the Palladian plan introduced by Inigo Jones, with the addition of immense corridors in segmental colonnades leading from the main entrance to the wing blocks. From a scenic artist's point of view, it is a magnificent (and certainly his best) piece of work. The earl procured for Vanbrugh a high place in the College of Arms. In March 1704 he was actually promoted Clarenceux, though he not only knew nothing of heraldry but had openly ridiculed that grave science in *Aesop*. His next work was to prepare designs for Kneller hall near Hounslow. But the success of Castle Howard now caused him to entertain the rash project of building a theatre in the Haymarket, from his own design, for the acting of his own plays. Congreve joined in the venture. The magnitude of Vanbrugh's architectural ideas grew as the work went on, and with the ideas the structure grew till a theatre meant for the delicate *bijouterie* work of polite comedy seemed growing to the proportions of the Roman Colosseum.

When at length the time came to test the acoustics of the pile, they were found to be sadly defective. What changes were made to rectify the errors of structure does not appear. The theatre was opened to the public with an Italian opera, which was followed by three of Molière's comedies, and these by the *Confederacy,* Vanbrugh's masterpiece.

Vanbrugh at last withdrew from the disastrous speculation; Congreve had already withdrawn. But a man to whom fortune had been so kind as she had been to Vanbrugh could hardly be depressed by any of her passing frowns. Queen Anne at once sent him abroad on an important state errand, and afterward he was commissioned to build Blenheim. Upon the merits and demerits of this famous "hollowed quarry" there has been much conflict of opinion. Blenheim palace is probably the largest domestic building in England, and consists of three blocks, the centre containing the private living rooms, one wing the stables and the other the kitchens and storehouses. It is planned on a colossal scale. Vanbrugh considered a building and the parts of a building as simply so much material for effect, without regard to their reasonable use and the necessary limitations of design. Personal comfort was sacrificed to perspective. Windows were to adorn the elevation, not to light the interior, and, as Voltaire said, if the rooms had only been as wide as the walls were thick, the château would have been convenient enough. After Blenheim and Castle Howard, his next largest palace was probably Fleurs, near Kelso. Blenheim, however, was a source of great sorrow to the kindly dramatist. Though parliament had voted for the building of it, no provision had been made for the supplies. The queen while she lived paid them, and then Vanbrugh was left to the meanness of the duke of Marlborough, and afterward to the insolence of the "wicked woman," who did her best to embitter his life. Besides Castle Howard and Blenheim, he built many other country mansions, such as Grimsthorpe and Duncombe hall in Yorkshire, Eastbury in Dorsetshire.

In Jan. 1719 Vanbrugh married Henrietta Maria, daughter of Colonel Yarborough of Heslington, and four years afterward, at the accession of George I, he was knighted. He afterward wrote again for the stage, and the unfinished fragment of the *Journey to London* (completed by Cibber as *The Provok'd Husband* in 1728) shows that his powers remained to the last as fine as ever. His married life was mostly spent at Blackheath, very probably in "Bastile house" on Maze hill, repaired in 1904 and now known as Vanbrugh castle. His wife died there at a great age in 1776, but "Van" himself died on March 26, 1726, in his modest town house in Whitehall. The site is occupied today by the war office.

The famous epitaph, "Lie heavy on him, earth," is attributed to Abel Evans.

Vanbrugh's works were edited in 2 vol., 1893, by W. C. Ward (portraits). *Select Plays* were issued in the "Mermaid Series" (ed. A. E. H. Swaen) in 1896. *See* G. H. Lovegrove's *Life, Works and Influence of Sir John Vanbrugh* (1902), Max Dametz's *Vanbrughs Leben und Werke* (1898), and *Swift's Works* (Bohn), xii. 80 sq. *The Complete Works of Sir John Vanbrugh* (Plays and Letters) edited by B. Dobree and G. Webb with introduction by B. Dobree (1928).

VAN BUREN, MARTIN (1782–1862), 8th president of the United States, mas known as the "Little Magician" because of his reputed cunning and skill as a politician. He was the third of five children, born in Kinderhook, N.Y., on Dec. 5, 1782, to Abraham and Maria (Hoes) Van Buren, both of Dutch descent. His father, a small farmer and tavern keeper, fought in the American Revolution, engaged in local politics and served as town clerk. Van Buren acquired considerable knowledge of human nature by working in his father's tavern; his formal education was conducted in the Kinderhook schoolhouse and later the village academy. In 1796 he took up the study of law in the office of Francis Silvester and later completed his legal studies in New York city under the tutelage of William P. Van Ness. He was admitted to the bar in 1803 and returned to Kinderhook where he began a long and highly successful law practice. On Feb. 21, 1807, he married Hannah Hoes, by whom he had four sons: Abraham, John, Martin and Smith Thompson. His wife died of consumption in 1819 and he never remarried.

Van Buren entered politics about the same time he began his law practice. In 1808 he was appointed surrogate of Columbia county. His talents as an industrious lawyer and astute politician were quickly recognized and he was elected in 1812 to the state senate over Edward P. Livingston on an antilandlord, antibank ticket. He served t o terms (1812–1820) and during his tenure was appointed state attorney general. He prosecuted Gen. William Hull for treason resulting from the surrender of Detroit to the British during the War of 1812. Hull was found guilty but the sentence of execution was remitted by Pres. James Madison. As senator, Van Buren actively supported the war, favoured the construction of the Erie canal and helped sponsor a convention in 1821 to revise the constitution of the state of New York. He was a delegate to the convention and succeeded in resolving differences between the conservative and radical members on several important issues, notably suffrage and qualifications for holding office. Because of his skill as an organizer, his ability to execute political schemes which weakened his opponents, and his engaging personality as a leader of men, he won command of the Bucktail faction (those Republicans opposed to Gov. De Witt Clinton and his policies) of the state Republican party. Over a period of 15 years he battled Clinton for political control of New York; the struggle did not end until Clinton died in 1828. After his election to the U.S. senate in 1821 Van Buren created the Albany regency (*q.v.*), a political organization to govern the state during his absence in Washington. His name became closely linked with machine politics and his reputation as a statesman suffered accordingly.

Van Buren regarded himself as a disciple of Thomas Jefferson. He supported the doctrine of states' rights, opposed a strong central government in Washington and disapproved federally sponsored internal improvements. He voted for the tariff bill of 1824 but later became a free trader. Above all, he insisted the party system of government was the best means of advancing democratic ideals. In the presidential election of 1824 he managed the campaign of William H. Crawford against John Q. Adams, Andrew Jackson and Henry Clay. He called the last congressional caucus for the purpose of nominating a presidential candidate. After the election of Adams he recognized the necessity of adjusting his political thinking to the changing times. The Crawford, Jackson and Calhoun factions of the Republican party were joined; the popularity of Jackson was exploited; and the political principles of Thomas Jefferson were reasserted. Out of this union an organization gradually emerged which became known as the Democratic party.

To promote Jackson's election to the presidency in 1828 Van Buren skillfully maneuvered passage of the Tariff of Abominations; to assist Jackson's victory in New York, which had been menaced by the sudden rise of the anti-Masonic party (*q.v.*), he successfully ran for the office of governor, and resigned his senate seat. After two and a half months he resigned the governorship to accept appointment as Jackson's secretary of state. Before resigning, however, he introduced the safety fund, an improved banking system to provide New York with more dependable financial institutions.

As the leading member of Jackson's cabinet, Van Buren was criticized for extending the spoils system throughout the federal government, but the criticism was exaggerated. Van Buren did not introduce the system, nor was he as ruthless a spoilsman as his opponents claimed. He was, on the other hand, responsible for initiating effective co-operation between the president and party leaders in congress. His tact and good judgment in the social situation involving Mrs. John H. Eaton (("Peggy O'Neill"), wife of the secretary of war who had been maligned by the wives of the other cabinet members, earned Jackson's confidence and respect. As secretary of state he helped resolve the dispute between Great Britain and the United States over West Indian trade; he was instrumental in securing agreement from the French for subsequent payment of spoliation claims originating during the Napoleonic wars; and he negotiated the first treaty with Turkey providing American access to the Black sea and a reciprocal most-favoured-nation commerce agreement. He drafted Jackson's message vetoing the Maysville road bill and approved the president's decision not to recharter the Second National Bank of the United States. He resigned in 1831 to permit the reorganization of the cabinet and was appointed minister to Great Britain.

Four months after arriving in England, Van Buren learned that his nomination had been defeated in the senate by the tie-breaking vote of Vice-Pres. John C. Calhoun. The jealousy and rivalry between the two men went back to the beginning of Jackson's administration. Calhoun's action ensured Van Buren's nomination for the vice-presidency on the Jackson ticket in 1832 by the first national convention of the Democratic party. (*See* NATIONAL CONVENTION). He was elected with Jackson on an antibank ticket and he endorsed the president's handling of the nullification controversy. In 1835 he became Jackson's choice for the presidency and was unanimously nominated in the Baltimore convention. Van Buren received 170 electoral votes against 73 for William Henry Harrison, 26 for Hugh L. White, 14 for Daniel Webster and 11 for Willie P. Mangum.

Van Buren's presidency began as the financial panic of 1837 spread throughout the nation. He called a special session of congress and proposed removing government funds from state banks and putting them in an "independent treasury." After a prolonged congressional battle the bill passed (1840) but many conservative Democrats deserted to the Whig party. Although Van Buren displayed statesmanlike courage and firmness during the struggle, hostility and bitterness born of the panic continued to mount against him. A costly war with the Seminole Indians in Florida and his failure to support the proposed annexation of Texas also lessened his popularity. In foreign affairs he had difficulties with Great Britain arising out of the U.S.S. "Caroline" incident. The U.S.S. "Caroline" was a U.S. steamer which had been transporting supplies to Canadian insurgents and had been set afire and sunk by Canadian troops. One American was killed in the melee and Alexander McLeod, a participant, was subsequently arrested in New York and charged with murder and arson. Great Britain threatened war but in time the disputes were settled peaceably. The question of the northeast boundary of the United States provoked conflict between the inhabitants of Maine and their Canadian neighbours bordering the Aroostook river. Armed clashes over rights to the territory were halted by Van Buren and a permanent settlement was later negotiated in the U'ebster-Ashburton treaty of 1842. One of his last acts in office was to order that no person should labour more than ten hours a day on federal public works.

Van Buren was unanimously renominated in 1840 by the Democrats and was opposed by the Whig candidate, William Henry Harrison. Songs, ballyhoo and slogans were the devices employed by both parties to solicit votes during this "log cabin and hard cider campaign," as it was called, and the popular expression "O.K." (meaning Old Kinderhook) is said to have originated during the election. Van Buren was decisively defeated, winning only 60 electoral votes to Harrison's 234.

Four years later Van Buren was a contender for the Democratic nomination but failed to obtain the required two-thirds vote because of his opposition to the annexation of Texas. In 1848 he was nominated by the antislavery Democrats (Barnburners) and then by the Free-Soilers with whom the Barnburners and "conscience" Whigs coalesced. Failing of election, Van Buren retired to his estate "Lindenwald" in Kinderhook and spent several years traveling in Europe. He continued an active interest in politics until his death in Kinderhook on July 24, 1862. *(See* also UNITED STATES [OF AMERICA], THE: *History.)*

Van Buren wrote his memoirs to 1833, which were published in 1920 under the title *The Autobiography of Martin Van Buren.* He also wrote an *Inquiry into the Origin and Course of Political Parties in the United States* (1867). *See* also Index references under "Van Buren, Martin" in vol. 24.

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VANCOUVER, GEORGE (1757–1798), English navigator, was born at King's Lynn on June 22, 1757. He entered the navy at the age of 13, and accompanied James Cook on his second (1772–75) and third (1776–80) voyages of discovery. After nine years' service in the West Indies, Vancouver, on Sir Alan Gardner's recommendation, was appointed to command an expedition to the northwest coast of North America, to take over from the Spaniards the territorial right they had claimed (and later relinquished) at Nootka Sound, to explore the coast from 30° N. round to Cook's river (or inlet), to search for an eastward passage to Hudson bay and to ascertain the true character of Juan de Fuca strait. Vancouver in the sloop "Discovery" (not Cook's old ship) accompanied by the "Chatham" under Lieut. W. R. Broughton, left Falmouth on April 1, 1791, and proceeded by way of the Cape of Good Hope to Australia, where he surveyed part of the southwest coast, especially King George's sound. He next made for Dusky bay, New Zealand, then sailing northeast, discovered Oparo islet (27° 36' S.; 144° 1' 30" W.), and on Dec. 30 reached Tahiti, where he was rejoined by Broughton, who had discovered Chatham Island.

After staying at Tahiti and at the Hawaiian Islands, Vancouver, on April 17, 1792, sighted the west coast of North America at 39° 27' N. He examined the coast up to 52° 18' N., with minute care, surveying all the intricate inlets and channels in the region of Vancouver Island, and naming (among others) Puget sound and the Gulf of Georgia. By August he was negotiating with the Spanish at Nootka; and he refitted at Monterey.

After another visit (Feb.–March 1793) to the Hawaiian Islands, Vancouver resumed his exploration of the North American coast in April, surveying north to 56° 44' N., and south (past the Spanish Californian settlements) to 35° N. In the autumn he was again at Nootka and Monterey. Refreshing at the Hawaiian Islands (Jan.–March 1794), Vancouver accepted their submission to Great Britain, but his annexation seems never to have been officially ratified. On his third season's work, in 1794, Vancouver sailed to Cook's inlet, which was proved to be no river. After a fresh survey of much of the coast north of San Francisco, he set homeward via Cape Horn and St. Helena reaching the Thames on Oct. 20, 1794. By this great voyage of four and one-half years, on which only one man was lost by disease, Vancouver "had completed perhaps the most arduous survey that it had fallen to any navigator to undertake" (E. Heawood, *A History of Geographical Discovery in the 17th and 18th Centuries*, p. 297, University Press, Cambridge [1912]); and he had effectively disproved the existence of any channels between the Pacific and Hudson bay.

Vancouver immediately set about the preparation of his narrative; but he died at Richmond in Surrey on May 10, 1798, before he had completed his task. His brother John assisted by Capt. Peter Puget, who commanded the "Chatham" in 1793–94, published the complete record in 1798.

See *A Voyage of Discovery to the North Pacific Ocean and Round the World . . . 1790–95,* 3 vol. (1798), with an atlas of maps and plates; G. S. Godwin, *Vancozrver: a Life* (1930). (R. A. SN.)

VANCOUVER, a city of British Columbia, Can., the most important Canadian seaport on the Pacific coast, has a superb site facing the sea and mountains: on the north there is the deep fiord, Burrard inlet, and its backdrop of forested slopes culminating in peaks 5,000 ft. high; southward the large urban area stretches to the delta of the Fraser river. Pop. (1961), city of Vancouver, 384,522; metropolitan area (which includes the adjacent cities of New Westminster [*q.v.*], North Vancouver, Port Coquitlam and Port Moody as well as eight district municipalities), 790,165.

Vancouver has one of the mildest climates in Canada. Essentially maritime conditions prevail, with temperatures for January averaging 37° F. and for July, 64° F. Two-thirds of the precipitation of about 60 in. occurs between October and March.

The city takes its name from Capt. George Vancouver of the Royal Navy, who explored Burrard inlet in 1792. For many years thereafter no white men visited the area, but by 1865 there was a small settlement on the inlet around the Hastings sawmill. Construction of the Canadian Pacific railway across Canada in the 1880s led to the founding of Vancouver and it was incorporated as a city in 1886. In the same year a disastrous fire burned most of the 800 business establishments and homes of its 2,000 citizens. They vigorously rebuilt their city, which soon had an assured prosperity when it became the railway terminus (originally planned to be in Port Moody, 12 mi. E. of Vancouver) and the port for many ships trading with the orient. The first Canadian Pacific train arrived on May 23, 1887. Settlers poured in and by 1910 the population had jumped to 100,000. The city became firmly established as a great seaport after the completion of the Panama canal in 1915, by which prairie grain could be shipped via Vancouver to Europe.

Vancouver is the industrial and commercial heart of British Columbia. Trade and transportation are basic functions and one-third of the labour force is engaged in these activities. Another third is in service industries and finance, and one fifth in a number of extremely diversified manufacturing industries. Wood processing, based on the extensive forest resources of coastal British Columbia, is an important industry; it includes sawmilling, plywood and pulp and paper manufacturing. Iron and steel fabrication, oil refining, food processing and chemical manufacturing are also important. Hydroelectric developments near the coast and oil and natural gas pipelines from the east side of the Rocky mountains provide ample supplies of power.

Ships of any size can be accommodated in Vancouver's harbour, which has a depth of 40 ft. The port is particularly active when eastern Canadian ports are closed by ice. Its general-cargo, deep-water docks are used by freighters from all parts of the world and Vancouver is also home port for a large fleet of fishing vessels. Auto ferries ply between Vancouver and Nanaimo and Victoria on Vancouver Island.

Vancouver is the terminus for four railways: the Canadian Pacific and Canadian National, which are transcontinental lines; the Pacific Great Eastern, extending to north-central British Columbia; and the Great Northern to Seattle and other U.S. cities. Vancouver International airport at the mouth of the Fraser river is one of the major air centres in North America.

The commercial and industrial core of the city adjoins the port facilities along the shores of Burrard inlet and False creek. Large residential suburbs with their own shopping districts extend from the downtown area. There are relatively few tall buildings because ground space has been plentiful. Few of the buildings exhibit impressive architecture, but the face of the city was given a special character by the thousands of beautifully landscaped homes built during the rapid post-World War II expansion.

The Lions Gate bridge, a splendid suspension structure, links the city of Vancouver to North and West Vancouver at the First narrows of Burrard inlet, and two bridges cross the Second narrows. The north shore communities cover the lower mountain slopes. North Vancouver has some industry of its own, mainly shipbuilding and sawmilling.

Among the outstanding amenities of the city is Stanley park, which occupies a seagirt promontory forming the entrance to Vancouver harbour. Although there are gardens, an aquarium and zoo. a large proportion of the 1.000 ac of the park has been left in a natural forest of Douglas fir and Western Red cedar.

The campus of the University of British Columbia, founded in 1908, has a scenic location overlooking the ocean at the tip of Point Grey. Faculties include arts and science, applied science, agriculture, law, pharmacy, medicine, forestry, commerce and business administration, education and graduate studies.

Golf and tennis are year-round games in Vancouver. Three subalpine areas have been developed extensively for skiing. Boating enthusiasts cruise and fish in the waters of Burrard inlet and neighbouring Howe sound. A unique feature of Vancouver is that it is possible to hunt for ducks and geese on the Fraser delta, practically within the city limits, and to fish for steelhead trout in Capilano creek only four miles from the city centre. In the juxtaposition of mountains and sea nature has endowed Vancouver with particular advantages for outdoor recreation. (G. A. W.)

VANCOUVER, the seat of Clark county in southwestern Washington, U.S.. 8 mi. N. of Portland, Ore., located at the head of deep-water navigation on the Columbia river. It is the oldest permanent settlement in the Pacific northwest, having been established in 1824 as a post of the Hudson's Bay company. Its location at the confluence of the northwest's principal natural travel routes accounted for its selection as headquarters for all the company's operations west of the continental divide until the area was taken over by the U.S. in 1846.

Fort Vancouver was the scene of the Pacific northwest's first farming, horticulture, dairying and wool growing; its first gristmill, sawmill and brickyard; and its first school. The first seagoing craft constructed in the northwestern United States was built there in 1829. There, too, in 1836, the U.S S. "Beaver," first steamboat to enter the Pacific, made its first trip under steam. Built on the Thames in England, it arrived under sail with engines and paddle wheels as deck cargo, to be installed at Fort Vancouver. The fort became a U.S. military reservation in 1848, adjoining the town which had formed about the trading post. Washington's first post office and first hospital were located there. Incorporated as a city in 1857 it has a council-manager form of government, in effect since 1952. Its growth has been steady except during the 1940s, when the population more than doubled as a result of war industries. For comparative population figures ***see*** table in WASHINGTON. *Population.*

Vancouver is the Bonneville Power administration's distribution centre for all hydroelectric energy produced in the Columbia river drainage basin. Availability of ample electric power accounts for local production of aluminum, abrasives and chemicals. Other manufactures include lumber, wood products, paper, beer, malt and canned fruits. The city is a major grain shipping point. Intensive agriculture, horticulture, dairying and poultry raising in the surrounding area are aided by a 208-day growing season.

Among the U.S. army officers stationed at the military post at Vancouver were Ulysses S. Grant, "Phil" Sheridan, George B. McClellan, George E. Pickett, William S. Harney, O. O. Howard, Nelson A. Miles, Frederick Funston and George C. Marshall. In 1948 the old stockade site became Fort Vancouver National monument. Grant House museum occupies a building erected by the U.S. army in 1849. Clark college, a public junior college organized in 1933, and the state schools for the deaf and the blind are in Vancouver. (H. J. Bu.)

VANCOUVER ISLAND, British Columbia, the largest of innumerable islands which fringe the Pacific coast of Canada, and the largest island on the west coast of North America. It is 282 mi. long, averages 50 mi. wide and has an area of 12,408 sq mi. It extends in a northwest-southeast direction and is separated from the state of Washington to the south by Juan de Fuca strait, and from the mainland to the east by the Strait of Georgia and Queen Charlotte strait. The island was made a British crown colony in 1849 (having previously been held under grant by the Hudson's Bay company), and in 1866 it was united with British Columbia, which had become a crown colony in 1858; the enlarged crown colony of British Columbia entered the Dominion of Canada as a province in 1871.

Vancouver Island has a deeply dissected, mountainous interior averaging 2,000 ft.–4,000 ft. above sea level (highest point, 7,250 ft.), flanked on the east by a coastal plain and on the west by deep fiords and numerous rocky islets. Alberni Inlet, at the head of which lie the twin cities of Alberni and Port Alberni, nearly bisects southern Vancouver Island and provides an excellent 20-mi.-long waterway for deep-sea vessels. Softwood forests clothe much of the island and logging, sawmilling and other wood processing are the most important industries. A variety of minerals is present and considerable quantities of coal, iron ore and copper are produced. Fishing, agriculture and tourism are also significant, agriculture (primarily dairying, poultry raising, and the growing of small fruits and vegetables) being confined to the favourable soils and topography of the east coastal plain. Population and road and rail transport facilities are also concentrated along the east coast. the main cities being Victoria. Duncan, Nanaimo, Port Alberni, Courtenay and Campbell River. Victoria (*q.v.*), about 60 mi. S. across the Strait of Georgia from the city of Vancouver on the mainland. is the capital and second largest city in the province (1961 population, city proper 54,941; metropolitan area, 154,152). Esquimault, a municipality within the Victoria metropolitan area, has long been a naval and garrison centre. As early as 1854 a small Royal Navy hospital was built near the entrance to its harbour. some 3 mi. W. of Victoria, and in 1865 an official base was established there. Since 1905 Esquimault has been Pacific coast headquarters of the Royal Canadian navy. The army garrison is at Work Point, facing Victoria harbour. See also BRITISH COLUMBIA. (A. L. FY.)

VANDALS, a term used by early writers only as a collective designation for a group of Teutonic tribes including, according to Pliny, the Burgundians and the Goths. The Vandals as a separate people figure in the earliest legends both of the Goths and the Lombards, and first came into contact with the Romans during the Marcomannic War. In the time of Aurelian they invaded Pannonia, and during the reign of Probus we find them fighting in Dacia. In the time of Constantine I, according to Jordanes, they suffered a great defeat at the hands of Geberich, king of the Goths, their own king Visimar being killed, and the survivors were allowed by the Romans to settle in Pannonia.

Invasions. — In AD. 406 they moved westward, according to some writers at the instigation of Stilicho, who is himself said to have been of Vandal origin, and crossing the Rhine at Mainz proceeded towards Gaul.

Owing to defeat at the hands of the Franks the Vandals could not settle in Gaul and in 409 their king Gunderic led them across the Pyrenees. They appear to have settled in Spain in two detachments. One, the Asdingian Vandals, occupied Galicia, the other, the Silingian, Andalusia. The Silingian Vandals were almost exterminated during the next 20 years but their Asdingian brethren marched across Spain and took possession of Andalusia. In 428 or 429 the whole nation set sail for Africa, upon an invitation received by their king from Bonifacius, count of Africa, who had fallen into disgrace with the court of Ravenna. Gunderic was now dead, and supreme power was in the hands of his bastard brother Gaiseric who was for 50 years the terror of Constantinople and Rome. Probably in the month of May 428, he assembled all his people on the shore of Andalusia, and numbering the males among them from the greybeard down to the newborn infant found them to amount to 80,000 souls. The nation was transported to Africa in ships supplied by Bonifacius. Although he soon returned to the Imperial allegiance only three cities of Roman Africa—Carthage, Hippo and Cirta—remained untaken by the Vandals by May 430. At length (Jan. 30, 435) peace was made between the emperor Valentinian III. and Gaiseric. The emperor was to retain Carthage and the small but rich proconsular province in which it was situated, while Hippo and the other six provinces of Africa were abandoned to the Vandal. Gaiseric observed this treaty no longer than suited his purpose. On Oct. 19, 439, he suddenly attacked and took Carthage. The Vandal occupation of this great city, the third among the cities of the Roman empire, lasted for 94 years. Gaiseric seems to have counted the years of his sovereignty from the date of its capture. Henceforward he made of Carthage a pirate's stronghold, whence he issued forth, like the Barbary pirates of a later day, to attack, as he himself said, "the dwellings of the men with whom God is angry," leaving the question who those men might be to the decision of the elements. Almost alone among the Teutonic invaders of the empire he set himself to form a powerful fleet, and was probably for 30 years the leading maritime power in the Mediterranean. Gaiseric's celebrated expedition against Rome (455), undertaken in response to the call of Eudocia, widow of Valentinian, was only the greatest of his marauding exploits. He took the city without difficulty, and for 14 days, in a calm and business-like manner, emptied it of all its movable wealth. Eudocia and her two daughters were carried into captivity.

Empire and Defeat. — There does not seem to be in the story of the capture of Rome by the Vandals any justification for the charge of wilful and objectless destruction of public buildings which is implied in the word "vandalism." It is probable that this charge grew out of the fierce persecution which was carried on by Gaiseric and his son against the Catholic Christians. The bishops were almost universally banished, and the congregations were forbidden to elect their successors, so that the greater part of the churches of Africa remained "widowed" for a whole generation. In 476, at the very close of Gaiseric's life, by a treaty concluded with the Eastern emperor, the bishops were permitted to return. There was then a short lull in the persecution; but on the death of Gaiseric (477) and the accession of Hunneric it broke out again with greater violence than ever.

On the death of Hunneric (484) he was succeeded by his cousin Gunthamund, Gaiseric having established seniority among his own descendants as the law of succession to his throne. Gunthamund (484–96) and his brother Thrasamund (496–523), though Arians, abated some of the rigour of the persecution, and maintained the external credit of the monarchy. On the death of Thrasamund, Hilderic (523–31), the son of Hunneric and Eudocia, at length succeeded to the throne. He adhered to the creed of his mother rather than to that of his father; and, in spite of a solemn oath sworn to his predecessor that he would not restore the Catholic churches to their owners, he at once proceeded to do so and to recall the bishops. Hilderic, elderly, Catholic and timid, was very unpopular with his subjects, and after a reign of eight years he was thrust into prison by his cousin Gelimer (531–534).

The wrongs of Hilderic, a Catholic, with the blood of the emperor Theodosius in his veins, afforded to Justinian a long-coveted pretext for overthrowing the Vandal dominion. A great expedition under the command of Belisarius reached Africa in the beginning of Sept. 533. A large force of Vandals was then occupied in Sardinia under Gelimer's brother Tzazo, and the landing of Belisarius was entirely unopposed. He marched rapidly towards Carthage and on Sept. 13, defeated Gelimer at Ad Decimum, 10 m. from Carthage. Next day he entered Carthage and ate the feast prepared in Gelimer's palace for its lord. Belisarius, however, was too late to save the life of Hilderic, who had been slain by his rival's orders as soon as the news came of the landing of the imperial army. On the return of Tzazo from Sardinia a force was collected considerably larger than the imperial army, but the Vandals were defeated and Gelimer took to flight. He took refuge in a mountain fortress called Pappua on the Numidian frontier, and there, after enduring great bardships in the squalid dwellings of the Moors, surrendered to his pursuers in March 534. The well-known stories of his laughter when he was introduced to Belisarius, and his chant, "Vanitas vanitaturn," when he walked before the triumphal car of his conqueror through the streets of Constantinople, probably point to an intellect disordered by his reverses and hardships. The Vandals who were carried captive to Constantinople were enlisted in five squadrons of cavalry and sent to serve against the Parthians under the title "Justiniani Vandali." Four hundred escaped to Africa and took part in a mutiny of the imperial troops, which was with difficulty quelled by Belisarius (536). After this the Vandals disappeared from history. The overthrow of their kingdom undoubtedly rendered easier the spread of Saracen conquest along the northern shore of Africa in the following century. (F. G. M. B.; T. H.)

VANDAMME, DOMINIQUE RENÉ, Count (1770–1830), French soldier, was born at Cassel, near Dunkirk, on Nov. 5, 1770. He enlisted in the army in 1786, served in Martinique in 1788 and on returning to France entered into the Revolutionary movement, raising a company of light infantry. He was promoted and after Hondschoote he was made general of brigade. serving in the Low Countries (1794), on the Rhine (1795) and in Germany (1796). In 1799 he was promoted general of division, and served in Holland, Germany and Switzerland. He was a devoted servant of Napoleon. In 1805, for his leadership at Austerlitz, he was given the Grand Eagle of the Legion of Honour, and in 1806–07 he commanded a small corps of the *Grande Armée* which reduced the Silesian fortresses. In 1808 he was made count of Unebourg. In 1809 he served in the Eckmühl campaign, but in 1812, while commanding the Westphalian contingent he quarrelled with King Jerome Bonaparte and returned to France. He returned to the army in 1813, but his corps, sent against the line of retreat of the Allies at the battle of Dresden, surrendered at Kulm. (*See* Napoleonic Campaigns.) At the end of the war he was forbidden to enter Paris. When Napoleon returned Vandamme joined him and was made a peer of France and placed at the head of the 3rd corps in the army of the north. (*See* Waterloo Campaign, 1815.) The Restoration first imprisoned and then exiled him. He died at Cassel on July 15, 1830.

VANDEGRIFT, ALEXANDER ARCHER (1887–), U.S. marine corps officer who commanded the 1st marine division in one of the most outstanding actions of World War II in the Pacific, the capture and holding of Guadalcanal, was born at Charlottesville, Va., March 13, 1887. After attending the University of Virginia, Charlottesville, he received a commission in the marine corps in 1909, advancing to the rank of major general in 1942. Vandegrift led the 1st marine division on Aug. 7, 1942, in the assault on Guadalcanal, the first large-scale U.S. offensive action against the Japanese, and held the island against repeated counterattacks, being aided later by other marine and army units. He also commanded the 1st marine amphibious corps in the Bougainville landing in the autumn of 1943. Appointed the 18th commandant of the U.S. marine corps on Jan. 1, 1944, he became the first marine officer to hold the rank of general, to which he was advanced in March 1945. Vandegrift retired Jan. 1, 1948. (J. B. Hn.)

VANDERBILT, a U.S. family whose fortune was founded on steamship and railway lines. Cornelius Vanderbilt (1794–1877), nicknamed "Commodore," was born at Stapleton, N.Y., May 27, 1794, and when 16 bought a sailboat, in which he carried farm produce and passengers between Staten Island and New York city. He successfully established his fortune in the shipping business, particularly through his reduction of the route from New York to San Francisco following the Gold Rush of 1849 By 1855–61 he also operated a freight and passenger line between New York and Le Havre

In 1857–62, houever, he sold his steamships and turned his attention to railways. He purchased the New York and Harlem railroad stock in 1362 at a low price and later that of the Harlem's competitors, the Hudson River railroad, and the New York Central railroad running from Albany to Buffalo. In all three cases he thnarted attempts by financial opponents to prevent his success. In 1868 he sought control of the rival Erie railway by buying stock. Honever, Daniel Drew, Jay Gould (*q.v.*) and James Fisk (*q.v.*) who controlled the Erie, placed fraudulent stock on the market to prevent Vanderbilt's purchase. Although he lost millions in the abortive attempt to control the Erie, Vanderbilt continued his railroad expansion by acquiring the Lake Shore and Michigan Southern in 1873 to establish a through route bet een New York and Chicago At the time of his death he controlled many railroads and his fortune was estimated at more than $100,000,000. He endomed Vanderbilt university.

His eldest son, WILLIAM HENRY VANDERBILT (1821–1885) was born in New Brunswick, N J , May 8, 1821. After a career as receiver and president of several railroads he succeeded his father as president of the Lake Shore and Michigan Southern, the Canada Southern. and the Michigan Central railways.

William Henry's son, GEORGE WASHINGTON (1862–1914) was an outstanding agriculturist and forester. He established the vast Biltmore estate near Asheville, N.C., and devoted considerable money and time to the advance of scientific farming and forestry. Another son, WILLIAM KISSAM (1849–1920) was active in the Vanderbilt railroad empire and was an enthusiastic yachtsman and race horse owner. His eldest son, CORNELIUS (1843–1899) was also active in managing the Vanderbilt fortunes. Of his sons, the eldest, CORNELIUS III (1873–1942) was devoted to numerous financial interests, while the other two sons, ALFRED GWYNNE (1877–1915) and REGINALD CLAYPOOL (1890–1925) were noted for their interests in show horses.

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(W H. D)

VANDERLYN, JOHN (1775–1852), the first U.S. painter to study in Paris, where he was much influenced by J. L. David, was born at Kingston, N.Y., on Oct. 15, 1775. While still very young he copied some of Gilbert Stuart's portraits, including one of Aaron Burr, and Burr was so impressed that he placed him under Stuart as a pupil and later employed Vanderlyn to paint his portrait and that of his daughter, Theodosia. In 1796 Vanderlyn went to Paris, and in 1805 to Rome, where he painted his "Marius Amid the Ruins of Carthage"; this was shown in Paris, and obtained a gold medal there; it is now in the New York Public library. Vanderlyn remained in Paris for seven years, during which time he prospered greatly. In 1812 he showed a nude "Ariadne" (engraved by Durand, and now in the Pennsylvania Academy of the Fine Arts, Philadelphia), which increased his fame. When Aaron Burr fled to Paris, Vanderlyn was for a time his only support. Vanderlyn returned to America in 1815, but did not meet with success. In 1842, through friendly influences, he was commissioned by congress to paint "The Landing of Columbus" for one of the panels in the rotunda of the Capitol at Washington, D.C. Going to Paris, he employed as assistant a French artist, who, it was said, did most of the work; though this was common practice, it led to his being charged with fraud. Vanderlyn was in actual want when he died at Kingston, N.Y., on Sept. 23, 1852.

VAN DER ROHE, LUDWIG MIES: *see* MIES VAN DER ROHE, LUDWIG.

VANDERVELDE, EMILE (1866–1938), Belgian statesman, was born on Jan. 25, 1866 at Ixelles near Brussels. He studied law at Brussels university and in 1885 took his doctorate in social science. In the following year he joined the Belgian Labour party and soon became its acknowledged leader. He first entered parliament in 1894 as Socialist member for the Charleroi constituency. but after 1900 was returned continuously by Brussels. In the chamber he achieved both influence and prestige and played a prominent part in the struggle to attain universal suffrage, a struggle which resulted in more than one national general strike. On the outbreak of World War I, Vandervelde devoted himself to the problems of national defence, the liberation of his invaded country, and in Aug. 1914 was summoned to join the government as minister of state, later becoming member of the cabinet. At the time of peace negotiations and the signing of the Versailles treaty, he used his influence to obtain the insertion of labour clauses, relating especially to the eight-hour day. As minister of justice in the Liberal-Catholic-Socialist cabinet formed after the war, Vandervelde effected great humanitarian and scientific reforms in the prison system. After the important successes achieved by the Labour party in the general elections of 1925 he entered the Socialist-Catholic coalition cabinet as minister for foreign affairs and played an important part in negotiating the Locarno pact in 1925, which he signed on behalf of Belgium. He retained the portfolio of foreign affairs on Jaspar's ministry of "national unity" He came to be regarded abroad as well as in Belgium as essential in Belgian foreign policy, partly because of his success at Locarno and the high esteem in which he was held by his foreign colleagues at Geneva. But he was constantly subjected to criticism because of his genuine internationalism, and early in 1927 he had some difficulty in soothing his non-Socialist critics. In internal politics he fought for a reduction of the term of military service to six months and thorough reorganization of the army system. This attitude of the Socialist members of the Jaspar cabinet was the immediate cause of its fall. Vandervelde was minister without portfolio, 1935–36, and minister of public health, 1936–37. Considered by some to be the most powerful Socialist orator in the French language since Jaurès, Vandervelde played a conspicuous role in the modern international Socialist congresses.

VAN DE VELDE: *see* VELDE, VAN DE.

VAN DOREN, CARL CLINTON (1885–1950), U S. author, editor and critic, was born on a farm near Hope, Ill., Sept. 10, 1885. He graduated from the University of Illinois in 1907 and received his Ph.D. from Columbia university in 1911. His first book, a biography of Thomas Love Peacock, was also published in 1911. He taught English at Columbia from 1911 to 1930. From 1917 to 1921 he was managing editor of the *Cambridge History of American Literature*. He was literary editor of the *Nation* (1919–22) and of *Century Magazine* (1922–25).

His writings ranged through surveys of literature to novels, biography and criticism. In 1939 he received a Pulitzer prize for his biography *Benjamin Franklin* (1938). His works included *The American Novel* (1921; revised 1940); *Contemporary American Novelists* (1922); *American and British Literature Since 1890* (1925), in collaboration with his brother, Mark Van Doren, and revised in 1939; *American Literature: An Introduction* (1933), reissued as *What Is American Literature?* (1935). Some of his other important works were *James Branch Cabell* (1925); *Swift* (1930); *Sinclair Lewis* (1933); and his autobiography, *Three Worlds* (1936).

VAN DYCK (VANDYKE), **SIR ANTHONY** (1599–1641), after Rubens, the most prominent Flemish painter of the 17th century. He was a prolific painter of portraits, of which about 500 are extant, aside from many repetitions, copies, imitations and forgeries that go under the artist's name. He also painted many religious and mythological subjects and ranks high as a draftsman and etcher.

LIFE

Van Dyck was born in Antwerp on March 22, 1599, the seventh of 12 children of Frans Van Dyck, a well-to-do silk merchant. When Anthony was eight years old the family moved from the house "Den Berendans" ("To the Bears' Dance"), which had belonged to Van Dyck's grandfather, into a very stately dwelling called "To the City of Ghent." At the age of ten, Van Dyck was apprenticed to Hendrik van Balen, a successful Antwerp painter specializing in small religious and mythological pictures. Van Dyck soon must have come under the influence of Rubens who after his return from Italy in 1608 quickly assumed undisputed leadership of art in Antwerp. Some scholars believe that the youthful Van Dyck was also in close contact with Jacob Jordaens, whose vigorous first manner dated from 1612.

1613–21.—Van Dyck's first surviving work, the portrait of a man, is dated 1613; a self-portrait (Academy, Vienna) cannot have been done much later. His precociousness showed also in other ways. When only 18, he acted as family representative in a lawsuit; before he mas 19 his father declared him legally of age. On Feb. 19. 1618, Van Dyck was inscribed as master in the Antwerp guild. It is uncertain when he entered the studio of Rubens, but on July 17, 1620, a correspondent of the earl of Arundel reported that "van Dyck is still staying with Rubens and his works begin to be appreciated as much as those of his master." In March 1620 Rubens had received a large commission permitting him to use the assistance of "Van Dyck and some other disciples." It is generally believed that Rubens referred to Van Dyck when he described a painting he offered in April 1618 to the English ambassador at The Hague as having been painted "by my best pupil." Thus there must have been a close association of the two men even before 1618. In view of Van Dyck's fully developed personal style in these years. however. it is probably more accurate to call him Rubens' collaborator rather than his pupil.

Although the relationship between Rubens and Van Dyck became strained after 1630, there is no evidence for the belief that Rubens tried to hamper the career of the young rival. On the contrary, he probably helped him with recommendations on his first trip to England (Nov. 1620 to Feb. 1621) where Rubens' admirer the earl of Arundel was also Van Dyck's protector.

1621–27.—Apparently unwilling to remain at the court of King James I, despite an annual salary of £100 sterling, Van Dyck returned to Antwerp and in Oct. 1621 set out for Italy. There, too, Rubens' recommendations paved his way. His first goal was Genoa. where in 1606/7 Rubens had been employed as a painter of portraits, and where Van Dyck was immediately patronized by the same group of aristocratic families for whom Rubens had been active. At the end of the 18th century there were still 99 paintings by Van Dyck in Genoa, 72 of which were portraits.

Genoa remained his headquarters, but he is known to have visited Rome, Venice, Padua Mantua, Milan and Turin. In 1624 he spent some time in Palermo, where he painted the Spanish viceroy Emanuel Philibert of Savoy (Dulwich), who in the same year died of the plague; Van Dyck also made a drawing of Sofonisba Anguisciola. a 96-year-old, blind woman painter (Chatsworth house, Derbyshire, Eng.). In 162j he is said to have visited Nicolas Peiresc, the great scholar and friend of Rubens, in Aix-en-Provence Although every here employed with commissions. Van Dyck used the opportunity of his Italian years to study the works of the great Italian painters. A sketchbook at Chatsworth house testifies to his attraction to the Venetian masters. above all Titian. He made many rapid sketches of their compositions, occasionally adding notes about colour and spontaneous words of praise.

1627–32.—In July 1627, Van Dyck was again in Antwerp, where he remained until 1632. The frequent absence of Rubens between 1626 and 1630 on diplomatic missions may have induced many patrons to turn to Van Dyck. He received numerous commissions for altarpieces and for portraits, which forced him to employ assistants. During this period Van Dyck also began to make small monochrome portraits in oil and drawings in chalk of princes, soldiers. scholars, art patrons and especially of fellow artists, with the view of having them engraved and published. At least 15 of these portraits were etched by Van Dyck himself. The others were engraved, primarily by Lucas Vorsterman and Paul Pontius. The series. popularly knoan as Van Dyck's "Iconography," was first published in 1645–46.

After 1632.—After a brief trip to Holland in Feb. 1632. Van Dyck again went to England and succeeded brilliantly. King Charles I appointed him "principalle Paynter in ordinary of their Majesties" and knighted him. He gave him a golden chain and settled upon him an annual salary of £200 sterling. Yet in March 1634 Van Dyck returned once again to Antwerp, ostensibly to settle matters connected with his family estate, but probably also to establish contacts with the new Spanish governor, Cardinal Infante Ferdinand, expected in the fall of that year. While in Belgium Van Dyck painted a huge portrait of the 23 members of the Brussels magistracy which unfortunately perished in the French bombardment of 1695. The Antwerp guild of artists appointed him "honorary dean," a title which had been bestowed before only on Rubens. In 1635 Van Dyck was again in England, after about a year's absence.

He had been settled in Blackfriars, outside the jurisdiction of the local guild. Charles I liked to visit him there and in 1635 had the approaches to the house improved. During the summer Van Dyck was given a place in Eltham castle, Kent. His work now consisted almost exclusively of painting portraits. He organized it in an efficient manner designed also to increase his prestige. He gave hourly appointments to his sitters, leaving the execution of accessories to his assistants who also had to prepare for him a new palette at the beginning of each session. While the king paid slowly and at times was even forced to reduce the artist s demands, Van Dyck derived a comfortable income from his many portraits. His life matched in luxury that of his clients.

He must have realized, however, that the political fortunes of the Stuart monarchy were declining. He had failed in an ambitious plan to decorate the banqueting hall at Whitehall with a "Procession of the Knights of the Garter" in tapestry (sketch at Belvoir castle, Leicestershire). In Sept. 1640 he again left England, induced possibly by the hope of taking Rubens' place. since Rubens had died in May. In nervous haste he went from Antwerp (October) to Paris (Jan. 1641). thence back to London (May) and again to Paris (November). At the end of that month he returned to London, sick and beaten, having failed in all his projects. He died on Dec. 9, 1641, and was buried in St. Paul's, London, in accordance with his own wishes. His tomb, located next to John of Gaunt's, was destroyed in the Great Fire of 1666.

He was survived by his wife, Mary Ruthven, whom he had married in 1639, and an infant daughter,Justina Anna (Justiniana). born Dec. 1, 1640. An illegitimate daughter, Maria Theresia, born in 1620, was brought up by one of his sisters, a *béguine*, or lay sister, in Antwerp. He bequeathed most of his continental possessions to this sister for the benefit of Maria Theresia. Whatever assets he had in England went to his widow and daughter in equal shares, but all was lost in the Great Rebellion. A pension of £200 sterling granted by Charles II to Justiniana in 1662 was paid irregularly. Justiniana herself acquired a modest reputation as a painter. At the age of 12 she married Sir John Baptist Stepney by whom she had four children; the line died out in 1825. Maria Theresia, married to Gabriel Essers, had seven children.

Van Dyck was a handsome man, but his features lacked strength and he was rather short. Although socially ambitious, he remained devoted to the members of his family and on cordial terms with fellow artists. His manners were suave and ingratiating. Legend has it that he inclined to licentiousness and extravagance, but the evidence is inconclusive. Whatever the faults of his character, he certainly was never idle. Only by cbmbining facility of execution with great industry could a man who died at the age of 42 have painted a body of nork as large as his.

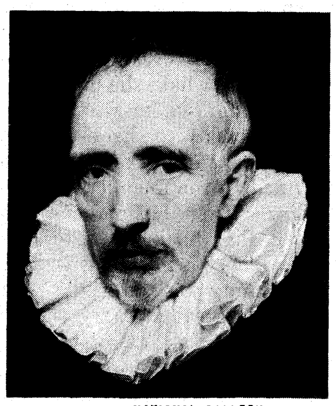
WORK

Development.— For the sake of convenience one generally distinguishes four periods in Van Dyck's activity. In the figural compositions of his first period (1613–21), the emulation of Rubens' melodramatic style is obvious, but there are distinctly personal aspects. Instead of using Rubens' technique of enamel-like glazes. Van Dyck painted directly and with a rather coarse texture. His colour scale is darker and warmer than Rubens', his lights and shades are more abrupt, his figures more angular in their gestures and less harmoniously proportioned. As if to outdo Rubens, he exaggerated the expression of his figures, from the fierce fanaticism or feverish ecstasy of saints and the brutality of executioners to the voluptuous smiles of satyrs and the drunken stupor of Silenus (Brussels, Madrid, Munich, Ottawa, Dulwich).

The few figural compositions of Van Dyck's second period (1621–27) betray a trend towards colouristic and expressive refinement under the influence of the Venetian school. Recollections of Rubens and of Bolognese masters may be seen in his most accomplished religious work done in Italy, the "Madonna of the Rosary" (Palermo). The tendencies first manifested in works done in Italy carry over into Van Dyck's third period (1627–32). He, as well as his patrons, appear to have realized that his talent was better suited to themes involving tender emotion than violent action. The happiest works of that period show the Virgin as the affectionate mother with the infant Jesus in her arms, or as the Mater Dolorosa in Lamentation scenes (Munich, Buckingham palace, Paris, Berlin and Antwerp); equally appealing are pictures showing saints in religious transport (Antwerp, Church of the Augustinians, and Vienna). In memory of his father Van Dyck painted in 1629 the crucified Christ with St. Dominic and St. Catherine of Siena, one of his noblest works and a prime example of the spiritual intensity fostered by the Counter-Reformation. Some of Van Dyck's most enchanting stories from mythology or fable were done during these years (Paris, Vienna and Baltimore). His manner of painting was now quite economical The pigments were put on thinly, in delicate combinations of blue, gray, pink, ochre and sienna. The emphasis is on mellonness, in colour and tone. Although he continued to give an almost sensuous appeal to textures like silk, hair and human skin, his paintings became increasingly cool and artificial. Narrative painting practically disappears in his last period (1632–41).

Portraits. — The enduring fame of Van Dyck rests on his portraits. Whether he painted the patricians and artists of Antwerp, the nobles of Genoa or the court of Charles I, Van Dyck succeeded in idealizing his models without sacrificing any of their individuality. He adopted patterns of portraiture that had been formulated before, chiefly by Hans Holbein, Antonio Moro, Titian and Rubens, but he invented innumerable variations, never losing sight of the fundamental necessity to retain an impeccable formality no matter how exact the likeness.

The Belgian patricians and their wives of his first period generally are rendered in bust- or knee-length; their hands hold gloves, books, handkerchiefs, feathers, flowers or golden chains, or fall idly over the back or armrest of a heavy baroque chair. When married couples or parents and their children appear on one canvas they often hold or touch each other's hands. His earliest portraits had neutral backgrounds but under Rubens' influence he introduced columns, curtains, balustrades and flower vases to enrich the setting. With consummate skill he rendered details of costume and décor, making — perhaps not quite inadvertently — propaganda for Antwerp's celebrated silk and lace.



BY COURTESY OF NATIONAL GALLERY, LONDON

"CORNELIS VAN DER GEEST" BY SIR ANTHONY VAN DYCK. IN THE NATIONAL GALLERY, LONDON

Always convincing as likenesses, his portraits show the models calm, dignified and reserved. In contrast to the ebullient Dutch burghers Frans Hals was painting at the same time, Van Dyck's sitters are genteel and wary. Their expressions are quizzical rather than self-revealing, guarded rather than warm. Among the finest are a father and his son (Paris), Frans Snyders and his wife (New York, Frick collection), a family group (Leningrad) and Isabella Brant (Washington).

The portraits done in Italy stress grandeur and aristocratic refinement. Many are in full-length, like Rubens' Genoese portraits of 1606/7. There he also did his first equestrian portraits. While in earlier portraits the sitters generally look at the beholder, now they often are turned away as if concerned with weightier matters. Some of his Genoese ladies, portrayed in glitter and silk, have a condescending look. An outstanding group of such portraits is in Washington (the Marchese Brignole-Sale, Grimaldi-Cattaneo and Balbi). The seignorial portrait of Cardinal Bentivoglio (Florence) and the unknown elderly couple (Berlin) are equally stunning and psychologically more penetrating.

In his third period, bust- and half-length figures were again in the majority. Among his models were many members of the great princely houses of Europe but some of the finest pictures are of collectors and art patrons (Cornelis van der Geest. Peter Stevens, Everard Jabach), as well as scholars, churchmen and a great many Antwerp artists. To this group should be added the portraits done during his visit to the continent in 1634–35, among them that of the Abbé Scaglia. the skillful diplomat, for whom Van Dyck also painted one of his last religious pictures, a Lamentation (Antwerp). In these portraits a new predilection for rhetorical poses is noticeable. With agile hands, some figures seem to address an audience. Caught in momentary and dramatic actions, Van Dyck's figures represent well the baroque taste in portraiture.

Van Dyck's English portraits are his most popular. Our visual image of English society prior to the revolution of 1648 has forever been shaped by Van Dyck. The Cavalier king himself was frequently portrayed by the master, and nowhere perhaps more revealingly than in the beautiful canvas in Paris where he appears "as he would have wished to live in history: a figure of matchless elegance, of unquestioned authority and high culture, the patron of the arts and the upholder of the divine right of kings" (Ernst H. J. Gombrich, The Story of Art, Phaidon Publishers Inc., Oxford University Press, New York, 1950). (See PORTRAIT PAINTING: Baroque and Rococo) A portrait showing three views of the king was made to serve for a bust to be made by Gianlorenzo Bernini; the sculpture perished, however, in 1697.

As in his Italian portraits, full-length renderings prevail, but his English patrons seem more rigid and as a rule more prosaic than their Latin counterparts. An unusual feature, reflecting a literary vogue, are allegorical attributes and mythological disguises. Ladies often point at, touch, or pick roses, or hold a hand under water running from an urn. Portraying himself with a sunflower, Van Dyck expresses emblematically his devotion to the king. In portraits, now lost, he painted ladies as "Pallas" or "Venus." Still preserved are the countess of Southampton as "Fortuna," Lady Digby as "Prudence" and the so-called Margaret Lemon as "Flora."

Van Dyck's gift for combining formality and casualness shows up particularly well in portrait commissions involving groups of people. In Genoa he had painted the Lomellini family (Edinburgh) and the delightful Balbi children (London, Lady Lucas). To his last decade belong the little-known family of John, count of Nassau-Siegen (Panshanger), and the largest of all of Van Dyck's extant paintings (more than 19 ft. wide), the family of the earl of Pembroke (Wilton house). In his several versions of the children of Charles I (Windsor castle, Turin) and the unidentified group of seven children (Detroit), he gives to his models all their youthful innocence no matter how gravely dignified their pose. An equally celebrated picture of William II, prince of Orange, and his little bride Mary (Amsterdam) is generally attributed to Sir Peter Lely (Pieter van der Faes), though it may have been begun by Van Dyck.

Influence. — Van Dyck's influence was pervasive and lasting. Many of the younger Flemish painters (such as Willeboirts, Boeyermans, Thys, the two Franchoys and Gonzales Coques) owe more to him than to Rubens. Dutch and German portraitists, especially those active in London, continued his manner (Cornelis Janssens van Ceulen, Hannemann, Gerard van Honthorst. Lely and Sir Godfrey Kneller), as did several native Englishmen (William Dobson, Robert Walker). The style of the great 18th-century English portrait painters, above all that of Thomas Gainsborough, was deeply indebted to Van Dyck; and Spanish painters who appear to have known Van Dyck's works mainly from engravings (Antonio Pereda, Don Juan de Miranda Carreiio. Mateo Cerezo, etc.) imitated and occasionally copied the religious compositions of the Flemish artist.

Van Dyck's fame was always high, but whereas formerly the works of his last period were most admired, those of his youth and his Genoese period have been favoured in the 20th century for their freshness and spontaneity. The interest of scholars has turned toward works neglected before, such as the oil sketches and the many drawings in chalk, pen and wash, and watercolour. Particularly sensitive and delightful are some of his sketches of landscapes (*e.g.*, the "View of Rye," dated Aug. 27. 1633; New York, Pierpont Morgan library). *See* also **PAINTING**: *Rise of European Schools: Flanders.*

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VANE, SIR HENRY (1589–1654), English secretary of state. was born at Hadlow, Kent, on Feb. 18, 1589, was educated at Brasenose college, Oxford, entered Gray's Inn in 1606, and was knighted in 1611. He purchased various court offices, and sat in parliament for various constituencies from 1614 onward. Vane was sent on many foreign missions, and in 1630 became one of the king's chief advisers. He was made a commissioner of the admiralty in 1632 and for the colonies in 1636. He was one of the eight privy councillors appointed to manage affairs in Scotland on the outbreak of the troubles there, and on Feb. 3, 1640, through the influence of the queen and of the marquis of Hamilton and in opposition to the wishes of the earl of Strafford, he was made secretary of state in the room of Sir John Coke.

In the Short parliament, which assembled in April, it fell to Vane to demand supplies. He proposed that the king should give up ship money and receive in return 12 subsidies. Parliament proved intractable and was dissolved on May 5 to prevent a vote against the continuance of the war with the Scots. In the impeachment of Strafford, Vane asserted that Strafford had advised the king at a meeting of the privy council to employ the Irish army against England. He was on bad terms with Strafford, who had opposed his appointment to office. Vane was accused of collusion and treachery, and there is no doubt that he desired Strafford's removal, believing that his sacrifice would satisfy the demands of the parliament. Nevertheless, the charge that he deliberately compassed his destruction is not proved. Suspicions of his fidelity, however, increased, and after accompanying the king to Scotland in Aug. 1641, he was dismissed from all his appointments on Nov. 4, on Charles I's return.

Vane immediately joined the parliament; he was placed on the committee for Irish affairs on Dec. 13, was made lord lieutenant of Durham on Feb. 10, 1642, became a member of the committee of both kingdoms on Feb. 7, 1644, and in this capacity attended the Scots army in 1645, while the parliament in the treaty of Uxbridge demanded for him from Charles a barony and the repayment of his losses. He adhered to the parliament after the king's death, and in the first parliament of the Protectorate he was returned for Kent, but the house refused to appoint him a member of the council of state in Feb. 1650. He died in 1654.

VANE, SIR HENRY (1613–1662), English statesman and author, known as "the younger" to distinguish him from his father, Sir Henry Vane (*q.v.*), was baptized on May 26, 1613, at Debden, Essex. After an education at Westminster and at Magdalen hall, Oxford, he spent some time at Geneva or Leyden and in 1631 joined the suite of the ambassador to Vienna. He had already acquired strong Puritan views, and, in 1635, in order to obtain the free exercise of his religion, he emigrated to Massachusetts, where he was elected governor in 1636. His actions in supporting a certain measure of religious toleration brought him into collision with a more rigid and influential group headed by John Winthrop the elder, who in 1637 succeeded him as governor.

Vane returned to England in Aug. 1637. He was made joint treasurer of the navy with Sir William Russell in Jan. 1639, was knighted on June 23, 1640, and was elected for Hull in the Short and Long parliaments. He at once became a prominent opponent of royal policy and by allowing John Pym to copy a transcript which he had made of his father's notes on the privy council meeting of May 5, 1640, he helped to bring the earl of Strafford to the scaffold. In 1643 he was the leading man among the commissioners sent to treat for a league with the Scots. Vane, who was bitterly opposed to the tyranny of the Presbyterian system, succeeded in getting the proposed bond between the parties termed the Solemn League and Covenant, and further in substituting the whole expression "*according to the word of God* and the example of the best Reformed churches" for the latter part alone. He succeeded to the leadership of the war party on Pym's death and was engaged in all the principal negotiations which followed. His leadership ended when the Presbyterian party obtained the supremacy in parliament in 1646. During the subsequent struggle he was one of the six commissioners appointed to treat with the army by the parliament, but failed to effect a compromise because he was distrusted by both the Levellers and the Presbyterians. His views of government may be studied in *The People's Case Stated.*

In spite, however, of these free opinions, Vane still desired the maintenance of the monarchy and the constitution. He supported the renewal of negotiations with the king and mas appointed in 1648 one of the commissioners for the treaty of Newport. He showed a desire to come to terms on the foundation of toleration and a "moderate episcopacy," of which Oliver Cromwell greatly disapproved, and opposed the shaking off of the conferences. He withdrew from the commons after Pride's Purge and remained absent until after Charles I's death. On Feb. 14, 1649, he was placed on the council of state, though he refused to take the oath approving the king's execution. Vane served on innumerable committees of importance. He furnished the supplies for Cromwell's expedition to Scotland and was one of the commissioners to negotiate a union between the two countries (1651–52). He was a leading member of the committee dealing with foreign affairs and in 1651 went on a secret mission to negotiate with Cardinal de Retz. To Vane, as chief commissioner of the navy, belongs largely the credit of the victories obtained against Tromp.

In domestic politics Vane continued to urge his views of toleration and his opposition to a state church. On Jan. 9, 1650, he brought forward as chairman the report of a committee advocating reform of the franchise on a property basis, the disfranchisement of certain existing boroughs and increased representation to the large towns; the sitting members, however, were to retain their seats. But Cromwell and the army desired an entirely new parliament. On April 20, 1653. Cromwell forcibly dissolved the Long parliament while it was in the act of passing Vane's bill. Hitherto they had lived on intimate terms of friendship, but Vane's protests and the ensuing argument created a permanent breach. In his retirement Vane wrote the *Retired Man's Meditations* (1655). In 1656 he proposed in *A Healing Question* (reprinted in vol. vi of Lord Somers, *A Collection of Scarce and Valuable Tracts*, 2nd ed., rev. by W. Scott, 13 vol. [1809–15]) a new form of government, insisting as before upon a Puritan parliament supreme over the army. The seditious movements of the Anabaptists were attributed to his influence, and on July 29, 1656, he was summoned before the council. Refusing to give security, he was imprisoned at Carisbrooke castle from September to the end of the year. In the parliament of Richard Cromwell he sat for Whitchurch in Hampshire and urged that the protector's power be limited.

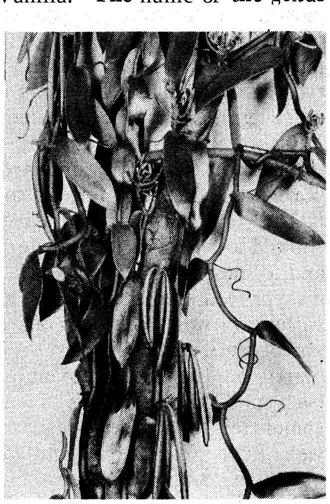
He allied himself with the officers in setting aside the protectorate and in restoring the Rump parliament. On Richard Cromwell's abdication he became a member of the committee of safety and of its successor, the council of state (May 1659). He was a member of all the principal commissions and had the virtual management of foreign affairs. When John Lambert turned out the Rump in October, Vane remained in office. He endeavoured to reconcile the factions in the army and sought by negotiation to prevent the defection of the navy. In consequence, at the restoration of the Rump (December) he was expelled from the house and ordered to retire to Raby.

At the Restoration Vane was imprisoned in the Tower and later in the Scilly Isles. After several conferences between the houses of parliament, it was agreed that he should be excepted from the indemnity bill, but that a petition should be sent to Charles II asking that his life might be spared. The petition was granted. But the new parliament of 1661 demanded his trial on the capital charge. He was found guilty and was executed on June 14, 1662.

VAN EYCK: see EYCK, VAN.

VAN GOGH: see GOGH, VINCENT WILLEM VAN.

VANILLA, a genus of tropical herbs and the extract made from any of several of its species. The flavouring agent is largely used in the manufacture of chocolate, in confectionery and in perfumery. Like cacao. it was first cultivated by the Indians, who, however, never combined the two to make sweet chocolate. Vanilla consists of the fermented and dried pods of several species of orchids belonging to the genus Vanilla. The name of the genus comes from the Spanish *vainilla,* a diminutive of vaina ("a pod"). The great bulk of the commercial article is the produce of V. *planifolia,* a native of southeastern Mexico, also cultivated in several tropical countries, especially on Réunion, the Seychelles and Madagascar in the Indian ocean; and in Tahiti and Java.



BY CO''RTESY OF CHICAGO NATURAL HISTORY MUSEUM

VANILLA WITH PODS

The plant has a long fleshy stem and attaches itself by its aerial rootlets to trees; the roots also penetrate the soil. The leaves are alternate, oval-lanceolate and fleshy; the light-greenish flowers form axillary spikes. The fruit is a pod from 6 to 10 in. long, when mature, and about ½ in. in diameter. The wild plant yields a smaller and less aromatic fruit, distinguished in Mexico as *Baynilla* cimarona; the cultivated vanilla is B. *corriente*.

Mexican vanilla is principally consumed in the United States. On Réunion large areas are under cultivation; the crop, which is called Bourbon vanilla. is sent to Bordeaux, the chief centre of the trade in France. Its odour differs from that of the Mexican variety in having a suggestion of tonka bean. The best varieties of vanilla pods are of a very dark chocolate brown or nearly black colour, and are covered with a crystalline efflorescence technically known as givre, the presence of which is taken as a criterion of quality. The peculiar fragrance of vanilla is due to vanillin, $C_8H_8O_3$, which forms this efflorescence. Chemically speaking. it is the aldehyde of methyl-protocatechuic acid. It is not naturally present in the fleshy exterior of the pod. but is secreted by hairlike papillae lining its three internal angles, and ultimately becomes diffused through the viscid, oily liquid surrounding the seeds. Besides vanillin, the pods contain vanillic acid (odourless), about 11% fixed oil, 2.3% soft resin, sugar, gum and oxalate of lime.

Vanillin forms crystalline needles, melting at 81° C. and soluble in alcohol, ether and oils, hardly soluble in cold, but more so in boiling water. Vanillin has been found in Siam benzoin and in ram sugar, and has been prepared artificially from coniferin, a glucoside found in the sapwood of fir trees, from asafetida and from a constituent of oil of cloves named eugenol. It is prepared synthetically on a commercial scale in Germany.

See also FLAVOURINGS ; ORCHIDS.

See "Vanilla, Its Botany, History, Cultivation and Economic Import," *Econ. Bot.,* 7:291–358 (1953).

VANINI, LUCILIO, or, as he styled himself in his works, GIULIO CESARE (1585–1619), Italian freethinker, was born at Taurisano, near Naples. He studied at Rome, Naples, and at Padua, and was ordained priest. Subsequently he led a roving life in France. Switzerland and the Low Countries.

Vanini was obliged to flee from Lyons to England in 1614, but was imprisoned in London for some reason for 49 days. Returning to Italy he made an attempt to teach in Genoa. but was driven once more to France, where he tried to clear himself of suspicion by publishing a book against atheists. *Ampitheatrum* aeternae providentiae *divino-magicum* (1615). Though the definitions of God are somewhat pantheistic, the book is sufficiently orthodox, but the arguments are largely ironical, and cannot be taken as expounding his real views. Vanini expressly tells us so in his second (and only other published) work, De admirandis naturae reginae deaeque *mortalium arcanis* (Paris, 1616), which, originally certified by two doctors of the Sorbonne, was afterward reexamined and condemned. Vanini then left Paris, where he had been staying as chaplain to the maréchal de Bassompierre, and began to teach in Toulouse. In Nov. 1618 he was arrested, and after a prolonged trial was condemned as an atheist. He was burned on Feb. 9, 1619.

VAN LOO (VANLOO), **CHARLES ANDRÉ** (CARLE) (1705–1765), French painter, whose works, more than those of any of his contemporaries. typify rococo painting, was born in Nice on Feb. 15, 1705, of a noted family of artists of Flemish origin. His elder brother, Jean Baptiste Van Loo, brought him up, taught him his profession and took him to Rome. Back in Paris, he worked with his brother and in 1724 won first prize in the Academy competition. He went back to Rome in 1727 and was awarded various distinctions. On his way home to Paris he stopped in Turin where his nephew had died and painted works for the king of Sardinia's palaces. After his return to Paris in 1734, he became the most popular painter of the time, and was in 1763 elected director of the Academy. Van Loo was also appointed first painter to the king and shared with François Boucher the favour of Paris society and foreign courts. Mme. de Pompadour commissioned the artist to work for her at her chhteau at Bellevue. A horn painter with almost excessive facility. he influenced many pupils. He died in Paris on July 15, 1765. His portraits and genre scenes are most appreciated.

See Emilia Frances Dilke, French *Painters* of the Eighteenth Century (1899). (M. N. B.)

VANNES, a town of western France, capital of the *département* of Morbihan, 84 mi. N.W. of Nantes on the railway to Brest. Pop. (1954) 23,377. Vannes (Dariorigum), the capital of the Veneti (whence *Gwenea,* the Breton name of the town), led the Armorican league against Julius Caesar, who in 56 B.C. overcame their fleet and opened up their country by six roads. St. Paternus, the first bishop, was consecrated in A.D. 465. In the 5th century Vannes was ruled for a time by independent counts, but soon came under the yoke of the Franks. Nomenoé, the lieutenant of Louis I, the Pious, in Brittany, assumed the title of king in 843, and one of his brothers was the founder of a line of counts who resisted the Normans in the 9th and 10th centuries. Vannes became part of the duchy of Brittany at the end of the 10th century. The estates of Brittany met there for the first time in 1203. In the course of the War of Succession the town was besieged in 1342. Duke John IV built here the castle of L'Hermine and made it his habitual residence. In 1487 the town was for a year in the hands of Charles VIII of France. In 1532 Brittany was definitively united to France.

Vannes is 10 mi. from the open sea, at the confluence of two streams forming the Vannes river, which opens into the landlocked gulf of Morbihan about a mile below the town. The old town, lying on a hill facing the south, is surrounded by fortifications of the 14th, 15th and 17th centuries. The modern suburbs surround the old town. The archaeological museum includes one of the richest collections of prehistoric remains in Europe. The cathedral of St. Peter, burned by the Normans in the 10th century, was rebuilt in the 13th, 15th and 18th centuries. Among the industries are tanning and cotton weaving. The port of Vannes, south of the town, is accessible only to small vessels.

VAN RENSSELAER, STEPHEN (1764–1839), U.S. political leader and soldier, "last of the patroons," was born at New York city. Nov. 1, 1764. He was fifth in descent from Killian van Rensselaer, original patroon of Rensselaerwyk, N.Y. He was a member of the New York assembly 1789–90, 1808–10, and in 1818; a member of the state senate 1791–95 and of the national house of representatives 1822–29. He served as a major-general in the second war with Great Britain, commanding the first division of the detached militia of the state of New York, and on Oct. 13, 1812 was defeated at the battle of Queenston Heights. Because he was a Federalist he mas severely criticized and censured for this defeat and resigned from the army. At the close of the war the Erie Canal project was renewed, and from 1816 until his death he was a member of the board of canal commissioners, and for nearly

15 years was its president. In 1818 he was again elected to the assembly; in 1819 he became a regent of the state university of which he was for a time chancellor. From 1822 to 1829 he was a member of the national house of representatives, and there voted for John Quincy Adams for the presidency. He died at Alhany (N.Y.), Jan. 26, 1839.

VAN'T HOFF, JACOBUS HENDRICUS (1852–1911), Dutch physical chemist who was named the first Nobel laureate in chemistry (1901) for his work on chemical dynamics and osmotic pressure in solutions. was born in Rotterdam on Aug. 30, 1852. He studied at the Polytechnic at Delft, at the University of Leiden, then under Friedrich A. Kekulé van Stradonitz at Bonn, Charles A. Wurtz at Paris in the Ecole de Medecine and with G. J. Mulder at Utrecht, where he obtained his doctorate in 1874. He was lecturer in physics at the veterinary school. Utrecht (1876); professor of chemistry, mineralogy and geology in Amsterdam university (1878); and professor to the Prussian academy of sciences in Berlin (1896), accepting an honorary professorship in the university so that he might lecture if he wished. He was elected a foreign member of the Royal society in 1897 and awarded its Davy medal in 1893. He died March 1, 1911, at Berlin.

Van't Hoff's earliest important contribution to science was made in 1874. Starting with the results of the work of Johannes Wislicenus (*q.v.*) on the lactic acids (1873), he showed that the four valencies of the carbon atom were probably directed in space toward the four corners of a regular tetrahedron. In this way optical activity, shown to be always associated with an asymmetric carbon atom could readily be explained. An identical idea was put forward two months later (Nov. 1874), quite independently, by Joseph A. le Bel (*q.v.*), whose name is generally linked with that of van't Hoff in connection with the theory of asymmetric carbon. Though van't Hoff and Le Bel had been fellow students under Wurtz, they "never exchanged a word about the carbon tetrahedron, though perhaps both of us cherished the idea in secret." The concept was attacked by Hermann Kolbe (*q.v.*), but its value was soon universally realized and it laid the foundation stone of the science of stereochemistry (*q.v.*). In 1877 van't Hoff published his *Ansichten über die organischen Chemie*, the second part of which contains the beginnings of his studies in chemical thermodynamics and affinity. In his *Études de dynamique chimique* (1884) he developed the principles of chemical kinetics, described a new method of determining the order of a reaction, and applied thermodynamics to chemical equilibriums. He deduced the connection between the equilibrium constant of a reaction and the temperature. in the form of an equation known as the "van't Hoff isochor." which he generalized in the form of the "principle of mobile equilibrium," a special case of the principle developed by Henry Louis le Châtelier (*q.v.*) at the same time (1884). He also introduced the modern concept of chemical affinity as the maximum work obtainable as the result of a reaction and showed how it may be calculated from measurements of osmotic pressure, gas pressure and the electromotive force of reversible galvanic cells. In 1886 he published the results of his study of dilute solutions and showed the analogy existing between them and gases, since both obey equations of the type $pv = RT$. During the next nine years he developed this work in connection with the theory of electrolytic dissociation enunciated by Svante A. Arrhenius (*q.v.*) in 1887. The abnormality in the case of electrolytes was explained by the equation $pv = iRT$, in which the factor i was a measure of the deviation from the simple expression. With Wilhelm Ostwald (*q.v.*) he started the important *Zeitschrift für physikalische Chemie* in 1887, the first volume of which contained the famous paper by Arrhenius on electrolytic dissociation, along with the fundamental paper of van't Hoff.,

VAN TIEGHEM, PHILIPPE EDOUARD LÉON (1839–1914), French botanist, the dominant figure in French botany for almost half a century, was born April 19, 1839, at Bailleul. After graduating from the College of Bailleul, he entered the Sorbonne where Pasteur influenced him to take a degree in chemistry, but, still determined to work in botany, he prepared a second doctorate. In 1864 he was appointed professor at the École Normale Supérieure, a post he held until 1879 when he was made professor of botany at the Museum of Natural History, Paris. In 1898 he became professor at the National Institute of Agronomy. occupying this position until he died April 28, 1914.

Van Tieghem's more than 600 publications ranged throughout the plant kingdom, but he is best known for his studies on bacteria, blue-green algae, the mucors and. particularly, on plant anatomy.

See *Revue Générale de Botanique*, 26:353–440 (1914); *Ann. Sci. Nat.* (Bot.), vol. xix. series 9, pp. i–viii (1914). (J. N. C.)

VAPHIO, an ancient site in Laconia. Greece, on the right bank of the Eurotas, some. 5 mi. S. of Sparta, famous for its "beehive" tomb, excavated in 1889 by Dr. Tsountas. A walled approach, about 97 ft. long, leads to a corbel-vaulted chamber 33 ft. in diameter, in the floor of which the grave was cut. The tomb, which probably belonged to Amyclae, is now almost entirely destroyed. Its contents are typical of the "First Late Minoan" period (about 1500 B.C.) and include engraved gems and amethyst beads, articles in gold, silver, bronze. lead, amber and crystal; also an iron ring, unusual at this early date.

VAPORIZATION is the general term denoting the change in state of a pure substance from a solid or a liquid to a vapour. The converse change from a vapour to a solid or a liquid is called condensation. The term sublimation refers specifically to the vaporization of a solid. In a more extended sense the term vaporization is applied to the change in state whereby one or more substances pass from a condensed complex consisting of any number of solid and liquid phases to a vapour phase, and the term condensation is applied to the converse change. Certain aspects of vaporization are discussed in the articles on THERMODYNAMICS: DISTILLATION; LOW-TEMPERATURE PHYSICS; CALORIMETRY; HEAT and SOLUTIONS.

Definitions and the Phase Rule.—The number of discrete parts. each of uniform chemical composition and physical structure. into which a thermodynamic system can be divided is the number of phases, s, in the system. The minimum number of pure substances required to produce a system in all of its equilibrium states that are considered possible is the number of components, e, of the system. The number of intensive variables whose values can and must be specified in order to fix the intensive properties (those properties that are independent of the quantity of material) of every phase of a system is the variance, v, of the system. Examples of intensive variables are pressure, temperature, specific volume and mole fraction of a component in a phase. The phase rule of J. Willard Gibbs states that

$$v = c + 2 - s \tag{1}$$

in a system which is in equilibrium and is uninfluenced by gravity, electricity, magnetism, capillary tensions and distortion of solid phases The phases of a system in equilibrium are said to be coexistent. The relative amounts of the coexistent phases of a system do not enter into the phase rule in any way. In the folloning discussion the term solid will always denote a crystalline solid and the terms vapour and gas will be used interchangeably. A system may consist of any number of solid and liquid phases but, in the absence of internal partitions, of only one gaseous phase A system is said to be nonvariant, univariant, bivariant, etc., when its variance v is zero, one, two, etc., respectively.

One-Component Systems.—The phase rule states that a system composed of a pure substance in two coexistent phases is univariant. Hence all of the intensive properties of each phase of such a system depend on a single intensive property, as, for example, pressure or temperature or the specific volume of one of the phases. Some of the relationships among pressure, temperature and specific volume are shown in fig. 1 and 2. Fig. 1(A) is a pressure-temperature plot, or phase diagram, for water at low pressures. The curve AB is the sublimation pressure curve of ice I (one of the crystalline forms of solid water) and BC is the vapour pressure curve of liquid water. These curves always have a positive slope and are concave upward. For completeness the fusion curve BE of ice I is also drawn. The three curves have the point B in common and divide the plane in the neighbourhood of B into three parts. The co-ordinates of a point in one of the regions labeled ice I, liquid or vapour represent the pressure and temperature at which water exists in the aggregation state indicated. A point on one of the curves AB or BC gives the conjugate values of pressure and temperature at which vapour coexists with solid or with liquid, respectively. If the temperature is arbitrarily specified, there is only one pressure at which two specified phases coexist, namely the pressure read from the appropriate curve. Increasing the pressure above this value will cause the vapour phase to disappear; and decreasing the pressure below this value mill cause the condensed phase to disappear. At the point B the liquid and solid phases have the same vapour pressure, all three phases can coexist, and the system is nonvariant. This is the ice I-liquid-vapour triple point. The values of pressure and temperature at a specified triple point are unique. For example, the triple point ice I-liquid water-water vapour is at 0.0060 atm. and +0.01° C. Any variation of either temperature or pressure with the other variable held constant will cause two of the coexistent phases at a triple point to disappear.

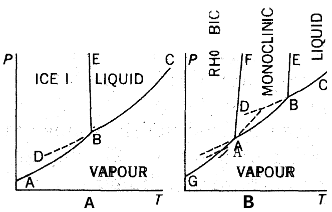


FIG. I.—PHASE DIAGRAMS AT LOW PRESSURES: (A) WATER AND (B) SULFUR

In general, equilibrium between liquid and vapour can be realized experimentally below the freezing point of the liquid, and this is inbicated by'the dotted curve DB, which is a continuation of BC. When a speck of ice I is introduced into a system of undercooled liquid and vapour ahile the volume and temperature are maintained constant, all of the liquid freezes and the pressure drops to the sublimation pressure corresponding to the specified temperature. A system at equilibrium in regard to small changes in the states of existing phases but not to the formation of an entirely new phase is said to be in metastable equilibrium. When one of the phases is a vapour, the pressure of the metastable univariant system is always greater than that of the stable univariant system at the same temperature. The vapour pressure curve of the liquid extends upward to the critical point where it ends. At this unique temperature and pressure all of the intensive properties of the liquid and vapour become identical. In the neighbourhood of this point the distinction between liquid and vapour ceases to exist and the substance is said to be a fluid. The critical point of water is at 218 atm. and 374° C. The sublimation curve of a solid does not extend above the triple point B, since in general a solid cannot be heated above its melting point. The curve AB continues downward to the absolute zero of temperature unless a new solid phase forms

Fig. 1(B) is the phase diagram for sulfur, and this substance undergoes a change in crystalline form from monoclinic to rhombic at A on the sublimation curve. There are three triple points, A, D and B, at which one of the phases is a vapour, the triple point rhombic-liquid-vapour at D being metastable. The triple points are at about 0.01 mm. of mercury and 95° C., 0.02 mm. and 110° C. and 0.03 mm. and 115° C. Not all triple points which include a vapour phase are at low pressures. For example, the solid-liquid-vapour triple point of carbon dioxide is at five atmospheres and $-57°$ C., and this accounts for the fact that carbon dioxide gas condenses directly to a solid at one atmosphere.

The slope dp/dT of any sublimation or vapour pressure curve at any point is given by the Clapeyron equation:

$$\frac{dp}{dT} = \frac{\Delta S}{AV} = \frac{\Delta H}{TAV} \tag{2}$$

where ΔS, ***AH*** and ΔV are the increase in entropy, heat content (or enthalpy) and volume accompanying the vaporization of a definite mass of solid or liquid at a constant pressure and temperature, and T is on the absolute thermodynamic temperature scale. These quantities are all positive for vaporization and sublimation except at the critical point where ***AS,*** ΔH and ΔV are all zero. The slope of the vapour pressure curve for the stable condensed phase at the right of a triple point is less than the slope of the corresponding curve at the left. At a triple point ***AS, AH*** and ΔV all change abruptly, but the decreases in ΔS and ***AH*** when we pass from left to right through this point have a greater effect on dp/dT than the increase or decrease in ΔV. Equation (2) is an exact thermodynamic relation. An approximate form of equation (2) can be obtained by assuming that the volume of the condensed phase is negligible and that the vapour is a perfect gas; and this expression can be integrated on the assumption that ΔH is constant.

These forms are

$$\frac{d\ln_e p}{dT} = \frac{\Delta \tilde{H}}{RT^2},\ \ln_e p = -\frac{\Delta \tilde{H}}{RT} + B \tag{3}$$

where B is an integration constant, $\Delta\tilde{H}$ is the molar heat of vaporization or sublimation and R is the universal gas constant (1.987 cal./° K.-mole). Actually a plot of $\ln p$ against $1/T$ is very nearly a straight line over a wide range of temperature for most solids and liquids. This unexpected linearity must arise through a compensation of errors of the approximations and the slope of this line cannot be interpreted as $-\Delta\tilde{H}/R$ except at low pressures where ,the approximations do apply. Equation (3) is made more accurate as an empirical relation by addition of the terms $CT + DT^2 + \ldots$ to the right-hand member.

Fig. 2 is a portion of the pressure-volume diagram of a pure substance, for example water. Here the curves ***T,,*** T_1, T_2 are plots of the conjugate values of the pressure and volume of a unit mass for each of three temperatures: the critical temperature T,, a lower temperature T_1 and a higher temperature T_2. In this diagram the curve BC of fig. 1(A) becomes the region underneath the curve ABC, this curve being known as the steam dome, the limit of absolute stability or the binodal curve. It passes through the critical point B. A single point in the curve BC of fig. 1(A) is now a horizontal line, as G'G". The co-ordinates of G' and G" represent the vapour pressure and the so-called saturated or orthobaric specific volumes of unit mass of liquid and vapour respectively, at T,; and points in the line G'G" represent the volumes of various mixtures of liquid and vapour under the same conditions of pressure and temperature.

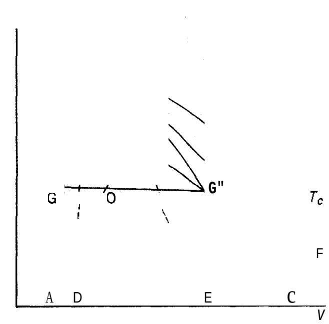


FIG. 2.—PRESSURE-VOLUME GRAM FOR UNIT MASS OF WATER NEAR ITS CRITICAL POINT

The curve FG″OG′H is the normal course of an isotherm at a temperature T_1. The segment FG" represents the states of the vapour during isothermal compression; G″OG′ represents states of the system during condensation to a liquid at constant pressure and temperature; and G'H represents isothermal compression of the liquid. This entire curve becomes simply a vertical line in fig. 1(A). The curves G″K″ and G'K' represent states of a vapour compressed above its condensation point and states of a liquid below its vapour pressure, respectively. Parts of these curves can be realized experimentally. If we suppose that a vapour can be completely transformed into a liquid isothermally without the system's becoming heterogeneous, the course of an isotherm T_1 below the critical temperature would be that indicated by the curve FG″K″OK′G′H, known as the Thomson continuous isotherm. The segments G'K' and G″K″ represent metastable states, but the segment K'OK represents unstable states where the compressibility is negative. Such states can have only fleeting existence, but there is theoretical and experimental evidence to indicate that when a fluid near its critical state is expanded rapidly and adiabatically it passes into unstable states and exists in these states momentarily. The curve DBE passes through all the minima and the maxima of the continuous isotherms. It is called the limit of essential instability or the spinodal curve. For each isotherm the areas G'K'O and G″K″O must be equal by thermodynamic necessity. All analytical equations of state such as that of J. D. van der Waals (1878) give curves below the critical temperature resembling the continuous isotherm. The critical isotherm T_c has a horizontal tangent and a point of inflection at the critical point, that is, $(\partial p/\partial V)_T = 0$ and $(\partial^2 p/\partial V^2)_T = 0$; and a second inflection point without zero slope at a lower pressure, $(\partial^2 p/\partial V^2)_T = 0$, and $(\partial p/\partial V)_T < 0$. Isotherms above the critical, as T_2, may also have inflection points without zero slope. At high temperatures an isotherm approximates a rectilinear hyperbola with the equation $pV =$ a constant.

Other types of plots are used to exhibit the properties of condensed and gaseous phases and of the liquid-vapour region of a pure substance. Gibbs (1873) discussed the energy-entropy-volume surface, the temperature-entropy diagram and the volume-entropy diagram; and R. Mollier (1904) introduced the heat content-entropy diagram which is much used in engineering work.

The saturation heat capacity C_{sat} of a phase is related to its heat capacity at constant pressure C_p by the relation

$$C_{sat} = C_p - T\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{dp}{dT}\right)_{sat} \tag{4}$$

At each point on a vapour or sublimation pressure curve there are two such equations: in one every quantity except $(dp/dT)_{sat}$ refers to the vapour phase, and in the other each corresponding quantity refers to the condensed phase. If the symbol Δ refers to the value of a quantity for a vapour minus its value for the coexistent condensed phase, we can derive by thermodynamics the following relations that hold along a saturation curve:

$$T\left(\frac{d(\Delta H/T)}{dT}\right)_{sat} = T\left(\frac{d\Delta S}{dT}\right)_{sat} = \Delta C_{sat} \tag{5}$$

$$\left(\frac{d\Delta H}{dT}\right)_{sat} = \Delta C_p + \frac{\Delta H}{T}[1 - \frac{T}{\Delta V}\left(\frac{\partial \Delta V}{\partial T}\right)_p] \tag{6}$$

In these relations the subscript $_{sat}$ denotes that the pressure varies along the vapour pressure curve (AB or BC of fig. 1[A]) and the subscript p denotes that the pressure remains constant.

The most direct and accurate methods for the measurement of vapour pressures are: (1) the dynamic method in which a liquid is boiled in a vertical tube nith a thermometer (shielded against radiation) placed in the condensing vapour and the pressure transmitted to a pressure gauge by means of a gas of smaller molecular weight than that of the vapour; and (2) the static method in which the coexistent liquid and vapour are enclosed in a bomb maintained at a constant temperature T and the pressure transmitted to a pressure gauge through a capillary containing the vapour phase if T is below room temperature or the liquid phase (or an inert liquid, as mercury) if T is above room temperature. The static method is also applicable to the measurement of the sublimation pressures of solids. Exceedingly small vapour pressures are determined by measuring the rate of effusion of the vapour through a small hole and applying the effusion equation of kinetic theory. Because of the difficulty of measuring temperatures in the liquid helium range, the International Committee on Weights and Measures in 1958 proposed as the international standard of thermometry a scale in the range from 1° to 5.2° K. based on the vapour pressure of liquid He^4.

Univariant Systems in General.—A system of c components is univariant when there are c + 1 coexistent phases present. In all such systems every intensive property of each phase is a function of a single independent variable. In particular, when one of the phases is a vapour, the vapour pressure depends on temperature alone and can be represented by a curve in the pressure-temperature plane. Examples of such a system are: (1) solid $CaCO_3$, solid CaO, gaseous CO_2; (2) solid NaCl, a saturated solution of NaCl in water, water vapour; (3) a saturated solution of ether in water, a saturated solution of water in ether, vapour containing both water and ether. The Clapeyron equation gives the slope dp/dT of the pressure-temperature curve along which all three phases coexist and AS, AH and ΔV are the increase in entropy, heat content and volume accompanying the formation of any definite mass of the gaseous phase.

Bivariant Systems.—A system of c components in c coexistent phases has a variance of two. Thus the intensive properties of each phase of a system of two components in coexistent liquid and vapour phases are fixed only if two intensive properties are specified; for example, pressure and temperature, or pressure (or temperature) and the mole fraction of one of the components in either the liquid or the vapour phase. Some of the properties of such systems may be exhibited on a pressure-composition diagram for a specified temperature and on a temperature-composition diagram for a specified pressure (see fig. 3 and 4, which are simply the traces of the pressure-temperature-composition surfaces; fig. 5, in planes corresponding to a specified temperature or to a specified pressure).

Fig. 3 is a pressure-composition diagram at a constant temperature and a temperature-composition diagram at a constant pressure for a pair of liquids, say benzene and toluene, which do not have a maximum or minimum boiling mixture. In the diagrams the solid curves are plots of the vapour pressures P or of the boiling points T of various liquid mixtures against the mole fraction X, of component 2 in the liquid phase, the so-called bubble point curves; and the dotted curves are plots of these same values of P or T against the mole fraction Y_2 of component 2 in the coexistent vapour phase, called the dew point curves. A point outside the lens-shaped area represents a homogeneous liquid or vapour in the state P,T,X_2 or P,T,Y_2. A point B inside the lens-shaped area represents a heterogeneous system consisting of coexistent liquid and vapour at a definite pressure and temperature. The horizontal co-ordinate of B is the average composition X_2 of the entire system, and the co-ordinates of the intersections A and C of a horizontal line (a tie-line) through B with the vapour and liquid curves give the actual compositions of the two coexistent phases. The ratio of the number of moles of liquid to the number of moles of vapour is equal to the ratio of the length of the line AB to the length of the line BC. If the temperature of a liquid in the state D is increased slowly at constant pressure in a closed system of variable volume, boiling starts at E and the first portion of vapour has the composition indicated by F. As the temperature is further increased the liquid continues to boil away and the two coexistent phases each become richer in the higher boiling component. When the system has reached the state indicated by the point G it consists of a very small proportion of the liquid H and a large proportion of vapour G. At K the system is a homogeneous vapour. During this process there has been a large increase in volume.

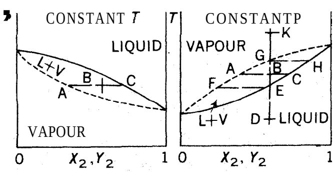


FIG. 3.—PRESSURE-COMPOSITION AND TEMPERATURE-COMPOSITION DIAGRAMS FOR A PAIR OF LIQUIDS THAT DO NOT HAVE A MAXIMUM OR A MINIMUM BOILING MIXTURE

Fig. 4 is a pressure-composition and a temperature-composition diagram for a two-component system, as water and nitric acid, which exhibits a minimum in the vapour pressure curve and hence a maximum in the boiling point curve. At the point M the coexistent liquid and vapour phases have the same composition and the system is said to be an azeotrope or in an indifferent state. A liquid of the azeotropic composition can be completely converted into vapour at a constant pressure and temperature, and in this respect it behaves like a pure substance. Some pairs of substances, as for example benzene and ethyl alcohol, have a maximum in the vapour pressure curve and a minimum in the boiling point curve (see fig. 5).

A simple experimental method for determining the temperature-composition curves for a pair of substances at one atmosphere pressure is to distill and condense a small portion of vapour from a relatively large quantity of liquid and then determine the compositions of the residue and of the distillate by measuring some property, as density. A thermometer in the vapour phase measures the equilibrium temperature. A plot of these two composition points against the temperature gives one point in the TX_2-curve and one point in the

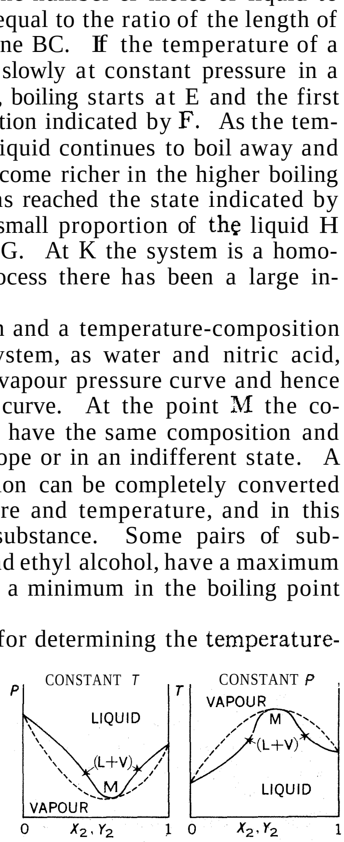


FIG. 4.— PRESSURE-COMPOSITION AND TEMPERATURE-COMPOSITION DIAGRAM FOR A PAIR OF LIQUIDS THAT HAVE A MAXIMUM BOILING MIXTURE

TY_2-curve. The complete curves can be plotted from similar measurements on a number of liquids of different compositions. The points for $X_2 = 0$ and $X_2 = 1$ are the boiling points of the pure components 1 and 2, respectively.

Azeotropes.—A system in which a finite phase transformation can take place at constant pressure, constant temperature and constant composition of every phase is called an azeotrope. When heat flows from the surroundings to such a system and the volume is suitably varied, one group of phases, called the low entropy complex, decrease in amount, and the remaining phases, called the high entropy complex, increase in amount; and during this process pressure, temperature and all compositions remain constant. All univariant systems (that is, systems in which $s = c + 1$) are necessarily azeotropes. Gibbs proved that a system of c components in s phases where s is equal to or less than c is an azeotrope when all of the determinants of the s by s matrices of the composition matrix

$$\left\| \begin{matrix} X_1' \; X_2' \cdots X_c' \\ X_1'' \; X_2'' \cdots X_c'' \\ \cdots\cdots\cdots\cdots \\ X_1^s \; X_2^s \cdots X_c^s \end{matrix} \right\| \qquad s \lesseqgtr c \qquad (7)$$

are zero. Here X_i^k is the mole fraction of the i-th component in the k-th phase. This means that the quantities of the s phases in an azeotropic system can be so adjusted that when heat flows to the system at constant pressure and temperature the low entropy complex of phases is converted to the high entropy complex without a residue of any phase, and the converse change takes place when heat flows to the surroundings. Moreover in an azeotropic system with $s \lesseqgtr c$ the pressure is a maximum, a minimum or a minimax (a saddle point) at constant temperature, and conversely.

One example of an azeotrope was mentioned above. Fig. 5 is the pressure-temperature-composition diagram for the liquid and vapour regions of a two-component system that has a minimum boiling mixture, as for example benzene and ethyl alcohol. The upper surface represents liquid compositions and the lower surface vapour compositions.

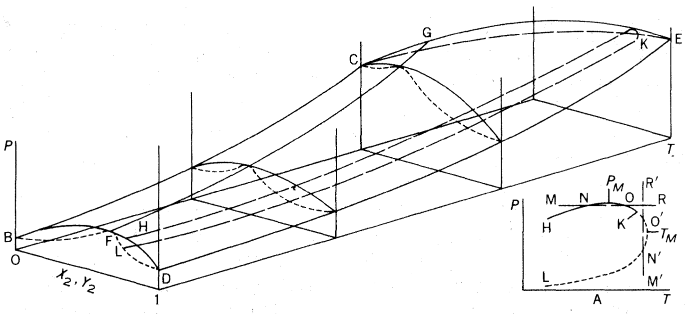


FIG. 5.— PRESSURE-TEMPERATURE-COMPOSITION DIAGRAM FOR A PAIR OF LIQUIDS THAT HAVE A MINIMUM BOILING MIXTURE

Tie-lines joining coexistent phases are parallel to the X_2 axis. The curves BC and DE are the vapour pressure curves for the pure components, and FG is the corresponding curve for the azeotropes. Although the composition of the azeotropic mixture varies along the curve FG, the slope dp/dT of this curve is given by the Clapeyron equation.

Water, ethyl alcohol and benzene provide an example of a three-component system that has an azeotrope of three coexistent phases, two liquids and a vapour (see DISTILLATION).

A system of variance three or greater can also form azeotropes; for example, a liquid mixture of three or more components that coexists with a vapour of exactly the same composition.

Retrograde Vaporization and Retrograde Condensation.—In fig. 5 the curve CKE represents the critical states of various binary mixtures and HKL is the pressure-temperature trace of the pressure-temperature-composition surface in a plane representing mixtures of constant composition. An enlargement of the critical region for this mixture is shown at the lower right. In contrast to a pure substance the critical point K of the mixture is neither the maximum temperature T_M nor the maximum pressure P_M of the PT curve. If the temperature of a liquid in the state M (at a pressure between P_M and K) is slowly increased at constant pressure, its state moves along the line MNOR. At N the liquid begins to boil. At first the proportion of vapour increases with increasing temperature, but then it decreases, and finally at O all of the vapour has condensed, since the point O lies in the liquid composition curve. This behaviour is called retrograde vaporization. Similarly if the pressure of a vapour in the state M' (at a temperature between K and T_M) is increased slowly at constant temperature, it starts to condense at N', but on further increase in pressure the liquid begins to boil and has all boiled away at O′ which lies in the vapour composition curve. This is called retrograde condensation.

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VAR, a de'partement of France, formed in 1790 of a part of lower Provence. but in 1860 reduced by the transfer of the district of Grasse to the newly formed *département* of the Alpes-Rlaritimes. It is bounded north by the de'partement of the Basses-Alpes, east by that of the Alpes-Maritimes, south by the Mediterranean. and west by the de'partement of the Bouches-du-Rhône. Pop. (1954) 413.012. Area 2,326 sq.mi. The east of the de'partement is built up of the Estérel and the Massif des Maures, a block of Archaean and Palaeozoic rocks, the two parts named being separated by the Argens river. The rest of the *département* is mostly made up of the east-to-west lines of the Alpes de Provence. The valley lines for the most part run east and west between the hills. The coast shows evidences everywhere of a recent sinking movement and has numerous islands. The harbour of Toulon is a case of a sunken valley.

The chief industries are spinning and weaving of silk, manufacture of soap, paper, cork, pottery and tanning. Tobacco is grown and there is much fishing for tunny and anchovy. Trade is in wood and coal. Cut flowers are largely exported from Hyhres. The principal towns are Toulon, La Seyne, Hyhres, Draguignan, its political capital, Brignoles and Fréjus.

VARALLO SESIA, a town of Piemonte, Italy, in the province of Vercelli, from which it is 34 mi. N.N.W. by rail, situated in the valley of the Sesia, 1,480 ft. above sea level. Pop. (1957 est.) 7,743 (commune). The churches of S. Gaudenzio, Sta. Maria delle Grazie and Sta. Maria di Loreto all contain works by Guadenzio Ferrari (1471–1546). The Sacro Monte, above the town. is approached by a path leading past 45 chapels.

VARANASI (BENARES; BANARAS), a city, tehsil (administrative subdivision), district and revenue division in Cttar Pradesh. India, is of great antiquity and was the capital of the ancient janapad (kingdom) of Kashi. In a commanding position on the concave crescent formed there by the left bank of the Ganges, it lies 435 mi. N.W. of Calcutta, 941 mi. N.E. of Bombay and 503 mi. S.E. of Delhi. Situated in the middle Ganges valley, not far from the Vindhya mountains to the south, it communicates with the surrounding region by the navigable Ganges (crossed there by the Dufferin bridge), by rail and by road. The city owes its importance to its peculiar site and the nature of the Ganges bank at this point. Pop. (1961) 573,553; the remainder in the cantonment, university area and suburban township of Sheopur.

The riverside presents a magnificent panorama of multistoried buildings in many varieties of architectural design. The crescent-shaped bank is entirely lined with stone and has several broad flights of ghats or steps; an array of shrines, temples and palaces (of Hindu nobles and princes) rise tier over tier from the water's edge. but few of the buildings are of great antiquity. Among the most conspicuous are the Aurangzeb mosque (lying in the middle of the Hindu quarter), Madhodas Ka Dharahara, Vishveshwara (or Vishwanath) golden temple, Durga temple (a 17th-century Maratha building noted for the swarms of monkeys inhabiting the trees nearby) and the observatory of Raja Jai Singh (Man Mandir). The beautifully carved temples (mostly small) are placed in the street angles under the shadow of tall houses.

The general plan of the city resembles a crescent with radial streets. the outer edge being formed by the Grand Trunk and Yidyapeeth-Durgakund roads. The inner streets of the town are winding, narrow and impassable for motor traffic; only two of the ghats (the Dashahwamedh and Harishchandra) are accessible by car. Few of the streets are wider than 60 ft. The streets of the central parts form the main residential area, or "true living streets." With the establishment of the City Improvement trust, some of the streets have been widened, with footpaths. grassy roundabouts (traffic circles) and modern street lighting. The chief means of conveyance are bicycle-rickshas. After 1950 the state government provided some bus services within the city limits. The level of the roads is considerably lower than the ground floors of the houses. which generally have arched rooms in front with little shops behind them and above these they are richly embellished with verandas, galleries, oriels and broad overhanging eaves supported by carved brackets. Western-style houses with simple architecture are also in evidence.

Varanasi is by far the most crowded city of Uttar Pradesh. It possesses national characteristics since people from different parts of the country have settled there. Although it is a stronghold of Hinduism. the Muslim population is conspicuous, being about one-third of the total and concentrated in the middle zone of the city. Many of the people are engaged in commerce, industry and transport. The core of the commercial activity corresponds more or less to the heart of the city; the old business quarter, which lay to the north near Rajghat, has declined. New shopping areas have grown up along some principal roads; the main areas are Lanka. Assi. Madanpura (south) and Chetanj, Jagatganj, Nadeshuar and Orderly Bazar (north), as well as several shopping plazas.

In the northwest of the city are the cantonment of Sikraul (once of considerable military importance) and the suburb of Sigra, the seat of the chief missionary institution. The principal modern buildings are the Sheo Prasad hospital (previously known as the Prince of Wales Hospital in commemoration of the visit of the prince [later King Edward YII] to the city in 1876), the town hall and the old mint house occupied by the maharaja. The Sanskrit college, opened in 1791, has now formed the nucleus of the Sanskrit university established in 1957. Toward the south in Malviyanagar stands the premier university of India. the Banaras Hindu university (1916), with 14 colleges of different faculties (including a women's college), a university library, Sir Sundar Lal hospital and the hostels for students and quarters for the staff. An attractive temple of Shiva has been erected on the university campus. which has an architectural beauty of its own; the crescent-shaped plan of the university with radial and concentric roads is imposing. In the northwest of the city is the Udai Pratap degree-granting college, founded in 1909 as a public school for Rajput boys by Raja Udai Pratap Singh of Bhinga (a state of Bahraich district of Uttar Pradesh). Kashi Vidyapeeth (college) gives training in social sciences up to degree standard. Besides various technical colleges of the university, there are other technical institutions in the city: the government toy institution. Khojwa; the government Central Weaving institute, Chowkaghat; and the municipal leather school at Pieree. The city has a large number of Brahmins and scholars of sanctity and learning. through whom Varanasi has become the most famous centre of Sanskritic studies. The sacred area of Varanasi is bounded by a road 50 mi. in circuit known as "Panchkosi road" which every Hindu hopes to tread once in his life. Varanasi draws considerable revenues from pilgrims who come from almost every part of the country as well as from Tibet. Burma and elsewhere for religious salvation.

Most areas in the city have electricity and telephone services. Varanasi is served by railways (both metre and broad gauge) and by roads. It also has air services to Delhi and Calcutta. Varanasi is known for silk fabrics, gold and silver thread, gold filigree work, German-silver work, embossed brass vessels, lacquered wooden toys and tobacco manufacturing. The brassware, once famous, is now not so important as other leading industries. In the mid-20th century Varanasi developed industries such as cotton textiles. oil crushing, iron and steel rolling, general engineering and the manufacture of chemicals, aluminum, soda ash and ice. which employ more than 6.000 permanent workers. But cottage industries are still predominant and employ more than 71,000 people. Among these, silk fabrics are largely concentrated in the areas of Muslim settlement.

History. — The early history of Varanasi is that of the first Aryan settlements in the middle Ganges valley. By the 2nd millennium B.C. it was a seat of Aryan philosophy and religion. Royal patronage also made it a commercial and industrial centre. Even during the pre-Buddhist period it was famous for its soft and thin muslins, silk fabrics, perfumes, ivory works and sculpture. The Hindu kingdom of Varanasi lost its identity as an independent state about 650 B.C., being annexed to the kingdom of Koshala. It then came under Magadha domination during the reign of Chandragupta Maurya (321–296). It was under the rule of Asoka (c. 274–232) that the Buddhist township of Isipattana or Sarnath (5 mi. N. of Varanasi) reached its zenith. Varanasi did not fall under foreign yoke until the third quarter of the 1st century A.D., when Kanishka (king of Kabul) annexed it to his empire. During the first half of the 7th century, it was part of Harsha's kingdom. Hsuan Tsang, the celebrated Chinese pilgrim (7th century), observed that the kingdom of Varanasi was 667 mi. in circuit and the capital was 3 mi. long and 1 mi. wide along the western bank of the Ganges. The city changed hands on several occasions until, in 1033. it suffered Muslim invasion by Nialtagin. It was then occupied by the Gaharwar kings up to the end of the 12th century. Archaeological excavations (begun in 1957) in the Rajghat plateau area (north of the city) have unearthed some findings of this period. The city was conquered in 1193 by Mohammed of Ghor and was included in the dominions of the sultans of Delhi, later becoming the headquarters of their deputies. Under the Sharki dynasty of Jaunpur (*q.v.*), Varanasi lost its importance. During Akbar's rule, the famous Vishveshwara temple was reconstructed by Raja Todarmal, his finance minister. Varanasi suffered a period of harsh treatment and destruction at the hands of Aurangzeb (1618–1707). A succession of philosophers, reformers and holy men like Chaitanya, Ramanand, Kabir and Tulsi Das kept the lamp of scholarship burning even during this dark period, and the lack of royal patronage was made good'by the industrial and commercial contribution of the Muslim settlers in the city. The spinning and weaving of silk, cotton and wool, which are now the legacy of the Julaha (Muslims), were perhaps at their zenith under the Moguls.

With the decline of the Mogul empire, Hindu rule was re-established by Mansa Ram, who obtained the management of its zamindari about 1725. His son Balwant Singh established an independent state of Varanasi by the mid-18th century and built several forts, including that of Ram Nagar on the right bank of the Ganges. The Nadeshwar palace, mint house, Raja bazaar and the raja's house at Kamachha were some of the many buildings constructed during the Varanasi raj period. The Marathas, Sikhs and Nepalese also contributed to its buildings and religious centres. In the early British period. Varanasi remained a chief centre of commerce. It felt the impact of improvements in the communications together with a close contact with Europeans through military settlement and missionary institutions. After the reinstatement of the famous Chet Singh's nephe by the East India company. the tracts around Varanasi. which had been managed on behalf of the Oudh wazirs, were taken over by the British and the raja was confirmed in the possession of his own "family domains" for which Balwant Singh had received a grant from the Delhi emperor.

In 1911 Varanasi was recognized as a separate state and Prabhu Narayan Singh was given full ruling power. It was finally merged with Uttar Pradesh in Oct 1949.

VARANASI TEHSIL has a population of 1,043.466 (1951) and its area is about 596 sq mi.

VARANASI DISTRICT extends over both sides of the Ganges and has an area of 1,965 sq mi. and a population of 1,978,634 (1951). Except for Chakia *tehsil*, it forms part of the Ganges plain. Chakia *tehsil* contains a large area of hilly jungle land and is a part of the Vindhyan plateau. The surface of the plain area is remarkably level with several deep ravines in the calcareous kankar formations. The soil is mostly clay and sandy loam. It is very fertile except where covered with reh (saline efflorescence). The Ganges, Barna (Varuna), Gumti, Nand, Hathi, Karamnasa, Gangi and Chandraprabha rivers form the main drainage system of the district. The cultivated area comprises 61.2%, cultivable waste 9.4%, current fallow 3.4% and forest 15.2% of the total area. The chief crops are barley, rice. wheat, pulses and sugar cane.

The district has 631 villages and 12 towns. Of the total population. 400,000 live in towns; 85.6% of the urban population is in Varanasi city. About 40.3% of the total population of the district depends on nonagricultural resources. The two *tehsils*, Bhadohi (west) and Chakia (southeast), that formerly made up the princely state of Benares were merged in the district in Oct. 1949. A chemical factory was established on the bank of the Ganges near Moghal Sarai, employing about 1,500 persons; and a railway workshop has been set up at Maruadih.

VARANASI DIVISION. with an area of 10,378 sq.mi., comprises the districts of Varanasi, Mirzapur, Jaunpur, Ghazipur and Ballia. In 1951 the population was 6,849,031. (R. L. SI.)

VARDANES, the name of two Parthian kings.

VARDANES I succeeded Artabanus II, probably his father, in A.D. 39, but had continually to fight against his rival Gotarzes (*q.v.*). The coins show that he was in full possession of the throne from 42 to 45. In 43 he forced Seleucia on the Tigris to submit to the Parthians again after a rebellion of seven years. Ctesiphon, the residence of the kings on the left bank of the Tigris, opposite to Seleucia, profited by this war; and Vardanes is therefore called founder of Ctesiphon by Ammianus Marc. xxiii, 6, 23. He also prepared for a war against Rome, with the aim of reconquering Armenia, but did not dare to face the Roman legions In a new war with Gotarzes he gained a great success against the eastern nomads. In the year 47 he was assassinated while hunting, and Gotarzes became king again.

VARDANES II rebelled against his father Vologaeses I in A.D. 54 (Tac. *Ann* xiii, 7). We know nothing more about him.

VARENIUS, BERNHARDUS (BERNHARD VAREN) (1622–1650), one of the most famous geographers of his time, whose influence lasted for more than a century, was born in the district of Hanover in 1622. He trained in medicine at Konigsberg and Leyden, and settled in Amsterdam where he wrote his two books, *Descriptio Regni Japoniae* (1649) and *Geographia Generalis* (1650). The first was reprinted at Cambridge in 1673; the second went through four editions at Amsterdam (1650, 1664, 1671 and 1672), was edited by Sir Isaac Newton and published at Cambridge in 1672 and 1681, was further edited by J. Jurin at Cambridge in 1721, and was translated into Italian (1716), Dutch (1750) and French (1755). There were English translations by R. Blome (1693) and Dugdale and P. Shaw, the last of these appearing in 1765. Varenius died at Leyden in 1650.

The *Descriptio* consists of five works: a description of Japan, a Latin translation of J. Schouten's description of Siam, a discourse on Japanese religion, some excerpts from Leo Africanus on religion in Africa and a short *Dissertatio de Republicis in Genere*. The *Geographia* dealt with what would now be called systematic geography on a scale not previously attempted, and because of its scholarly character and orderly arrangement had a wide influence. It also contained a scheme for "special," now known as "regional," geography of which the *Description of Japan* was a sample. Varenius collected other material and wrote of "several volumes to come" but died before anything was published, and the content of these volumes is unknown. But without these his reputation is secure for he was one of the first to see the subject of geography as a whole and to emphasize its importance "both in the world of letters and for everyday use."

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VARESE, capital of the province of the same name in Lombardia, Italy. The town, 1.253 ft., is near Lake Varese, 30 mi. N.W. of Milan. Population (1957 est.) 59,501 (commune). The basilica of S. Vittore (1580–1615) has a 12th-century baptistery and a campanile 246 ft. high. There is also an 18th-century *palazzo communale* (former ducal palace). To the northwest is the pilgrimage church of the Madonna del Monte (2,885 ft.). Varese province had a populafion in 1951 of 477,055.

VARGAS, GETULIO DORNELLES (1883–1954), president of Brazil (1930–45, 1951–54) and the dominant personality on the Brazilian scene during the quarter-century after 1930. Vargas was one of the most capable politicians and contradictory public figures that Brazil has produced. His name is closely associated with the major political and socio-economic transformations that occurred in Brazil after 1930. His policies contributed to many of these changes, such as the expansion of power by the central government, the growth in the size and influence of the bureaucracy, the political emergence of the urban working class, industrialization of the economy and the rise of nationalism.

Vargas was born at Sbo Borja, Rio Grande do Sul, on April 19, 1883, into a family prominent in state politics. He joined the army as a private at the age of 16. He entered politics in 1908 shortly after studying law and graduating from the University of Pôrto Alegre. He practised law and held various positions in the executive and legislative branches of the state government until 1922, when he was elected to the national congress, in which he served four years. In 1926 Vargas became minister of finance in the cabinet of Pres. Washington Luis, a post he retained until his election as governor of Rio Grande do Sul in 1928. From his position as state governor Vargas campaigned unsuccessfully for the presidency of Brazil in 1930. Failing in his bid, he led the revolution in October of that year which overthrew the republic. For the next 15 years Vargas was chief executive of Brazil. He held power as provisional president from Nov. 3, 1930, until July 17, 1934, when he was elected president by the constituent assembly. On Nov. 10, 1937, Vargas presided over the coup d'état that destroyed the constitutional government and set up the avowedly totalitarian "New State" *(Estado Novo)* that in turn was overthrown by coup d'état on Oct. 29, 1945. Although he was forced from office, Vargas retained wide popular support. In Dec. 1945 he was elected both as senator and congressman from several states and he chose the position of senator from Rio Grande do Sul. However, he went into semiretirement until 1950, when he emerged as the successful presidential candidate of the Brazilian Labour party. He took office on Jan. 31, 1951. Faced with overpowering opposition from the armed forces, Vargas committed suicide on Aug. 24, 1954, rather than accept forced retirement.

Vargas' reputation rests largely on the accomplishments of his first regime, which effected a controlled social revolution. Prior to 1930 the national government had been in effect a federation of autonomous states, dominated by rural landholders and financed largely by the proceeds of agricultural exports. Under Vargas this system was destroyed. The tax structure was revised to make state and local administrations dependent upon the central authority, extensive social reforms were enacted, the electorate was quadrupled, labour was organized and controlled by the government, and a program of rapid industrialization was undertaken. For his role as the champion of the common man, Vargas came to be called "Father of the Poor."

During World War II Vargas cast his lot with the democracies and Brazil contributed large quantities of raw materials as well as fighting forces to the war effort.

Removed from office in the wave of democratic sentiment that swept over postwar Brazil, Vargas was recalled five years later, largely by a working-class vote. His reputation for political wizardry led the public to expect easy solutions to the problems of underemployment, inflation and widespread demands for economic expansion at a rising rate. As an elected president restrained by congress, a profusion of political parties and public opinion, Vargas was unable to satisfy his labou: following and resorted increasingly to ultranationalistic appeals to hold popular support. By mid-1954 criticism of the government was general, and the armed forces joined in the call for his withdrawal. This pressure led to his suicide. (R. E. P.)

VARIATION. All kinds of living organisms vary. It is the business of the biologist to find out the range of such variation in wild and domesticated animals and plants; to decide what share of variation is due to hereditary and what to environmental causes; and to see whether heritable variations, the raw material of evolution, can be artificially produced in the laboratory. (See also SELECTION; EVOLUTION, ORGANIC; HEREDITY.) (X.)

VARIATION IN NATURE

The variation of animals and plants in nature is, so far as known, subject to the fundamental laws revealed by experiment and pedigree-breedings (see HEREDITY). Only by such experiments and culture is it possible to decide authoritatively how a given variation is produced and whether it is heritable or not. Nevertheless it is desirable to know—(a) the actual kinds of variation that occur in nature, (b) which of these we may assume to be heritable and (c) the effect which isolation (topographical, habitudinal, etc.) and interbreeding may have on the distribution of variant characters in nature. Variation in the habits of animals, the food they eat, their breeding-seasons and all their complex inter-relationships is moreover of cardinal importance in evolutionary studies and can only be effectively observed among animals in nature. The kinds of structural variation that occur in nature will be best illustrated by means of the following classification which, although it is not exhaustive, will show the circumstances in which such variation typically occurs.

1. Variation regularly occurring in the presence of a given environmental condition or factor.

(a) Gross variation in form and 'size associated with the excess or deficiency of some tissue-forming substance.

The periwinkle, clam and mussel when living in water of reduced salinity (*e.g.,* in the Baltic Sea) are found to be smaller than in normal sea-water. Low night-temperature and inferior soil render various hawkweeds (Hieracium) living at high altitudes more stunted than those living at lower altitudes.

(b) Special modifications.

The tail-lamellae of the brine shrimp (Artemia *salina*) are reduced in water of high salinity. The shape of the common cockle (Cardium edzcle) is more elongate in water of salinity above that of normal sea-water. Terrestrial animals living in damp situations or in humid atmosphere are often darker than representatives of the same species which live in drier conditions. This is recorded among slugs, birds and mammals. The greater part of the variation exemplified by (a) and (b) is in all probability non-heritable. Experiment has however shown that in a few cases variation induced by external causes may be inherited either permanently (Lepidoptera, Harrison and Garrett) or temporarily (Amphibia, Kammerer; Crustacea, Agar). Similarly the colour-differences recorded by Sumner have been shown to be hereditary.

A series of allied varieties or races which replace each other in succession, either in time or place, will sometimes exhibit progressive modification. Such variation may be simply correlated with a change in geographical position, the causes of structural change being obscure.

2. Variation resulting from adaptation to diverse conditions.

In the arrow head (Sagittaria) the same plant may have some leaves adapted for aerial and others for aquatic conditions. Protective "mimicry" affords some striking examples of this type of variation among animals (see MIMICRY).

3. Variation known to be heritable but not referable to known external causes.

Many variations in colour, form and pattern that are known by experiment to be hereditarily stable have been recognized in nature. Such variations may be distributed at random through a large natural population, or the latter may be divided into topographically isolated races or colonies, each of which has a more or less distinct appearance. These divergences may likewise be associated with other modes of isolation, *e.g.,* with mutual sterility, difference in breeding-period, etc. Other examples of this kind of variation are to be found in the "colour-phases" of mammals (*e.g.,* foxes) and birds. Stresemann's important work on the occurrence and heredity of such colour-phases in the latter should be consulted. It is also known in flowers.

4. Variation due to accident, interference with growth-processes, etc.

It is not always easy to differentiate between this type of variation and that described in (1). For example the shells of the water snail Planorbis seem to assume the uncoiled ("scalariform") form in water of unusually high temperature. This may be described as an accidental malformation, but it is actually produced by a particular state of the medium in which these snails live.

Scalariformity is more obviously "accidental" when produced in the Gastropod Trochus by parasitic infection. Plant lice sometimes produce green colour in flowers and the attacks of a rust fungus (Aecidium) produce shorter and broader leaves in Euphorbia *cyparissias.*

5. Seasonal Variation.

This is a familiar phenomenon among vertebrate animals, and is also known among invertebrates (Insects, Cephalopods). The change of coat-colour in the mountain hare from "smoky-brown" in summer to white or "blue" in winter is a notable example. In the rufous horseshoe bat of India (*Rhinolophus rouxii*) the fur after the spring and autumn moults is mouse-brown on the upper surfaces. This changes in course of time into brighter colours, probably owing to oxidation of the pigment.

6. Variation due to sexual dimorphism and growth-changes.

Strictly speaking this should not come under the rubric of variation as described here; but it is important to notice that some of the differences in size, colour and shape among animals of the same species may be due to these causes.

The data presented above relate only to the structure of animals and plants. Although the distinction between structural characters and those of physiological constitution and habits is arbitrary, it is convenient to retain the distinction in a survey of this kind. Our knowledge concerning modes of variation other than that of structure is less complete. Each species is probably as variable in its physiological constitution as it is in its structure. This has been shown by exact tests, and also may be inferred from such facts as the infection of hosts belonging to different families and genera by individuals of the same species of parasite, the occupation by members of the same species of habitats radically different in physical and bionomic factors, varying susceptibility to disease and so on. The variability of habits may be illustrated by Darwin's observations on the behaviour of the great titmouse, certain individuals of which species sometimes behave as birds of prey.

A number of highly important considerations are omitted from this discussion. The problem of intermediacy, the degree of variability in different species of the same genus, the relation between natural variation and classificatory units, observations on the effect of Natural Selection and on the first appearance, increase or decrease of variant individuals are dealt with in the undermentioned works. (G. C. R.)

EXPERIMENTAL VARIATION

The Types of Variation.—Not everything differentiating an offspring from its parents can be handed down to later generations (see above). Only the alterations occurring in the hereditary determiners, or genes (*q.v.*), can furnish actually new materials for the permanent fabric of a race, and these changes in the genes, called gene-mutations, are remarkably rare. However, after the mutations have occurred, the changed or mutant genes enter into varying combinations with each other and with the old genes, in successive generations, and so the actual degree of variation becomes increased. Individuals having assortments of characteristics different from their parents are thus formed, by recombination, in somewhat the same way as, by drawing some cards out of each of two given hands, we might obtain new hands, having one or another new assortment of cards. Besides the above two kinds of variation, which involve the genes, there are also many important variations not due to the genes, but to the environment. These variations may be grouped together under the term *modifications.* For detailed consideration we may best treat these three classes of variations in an order the reverse of the above.

Modifications Caused by Environment — The common question, "Which is more important, heredity or environment?" permits of no answer, except that both are equally and absolutely essential. We are related to our heredity and environment more nearly as an arithmetical product of the two than as a sum, and, with either annulled, the product must be zero. The genes provide the egg, not with the guarantees of developing certain characters, but only with the possibilities of reacting in certain ways so as to produce given adult structures and peculiarities, provided food and other conditions are appropriate. Change the environment (it cannot really be abolished completely) and these genes may exercise their possibilities of reacting in very different ways, to produce a different type of development, or disintegration.

It is, however, more pertinent to put our question in the form, "Which set of factors are ordinarily responsible for a larger part of the *variation* which actually occurs, *differences* in heredity or *differences* in environment?" If, now, we take variation in the larger sense, to include differences between all living things, it is obvious that, all in all, differences in environment are an insignificant cause of the existing variation as compared with hereditary differences, and this is usually true even of two individuals chosen from closely related yet different species. On the other hand, within a given population of one species, the variation due to environment is sometimes comparable to, or even much greater than, that dependent on the genes. Which sort of variation predominates, and to what extent, will depend on many circumstances, and to answer our question will therefore require separate study, and often elaborate experimentation and measurement, in the case of each population considered and even in the case of different characteristics in the same population. The unravelling of any intimate combination of hereditary and environmental effects will usually demand either that we hold the effective features of the environment constant (often an impossible operation), or else that we secure a set of individuals identical in their genes (as a result of inbreeding, twinning or asexual reproduction) ; under such circumstances the residual variation, due to the influence that was not held constant, may then be ascertained.

It is especially desirable to discover not only the extent of variation due to environmental differences, but the principles governing the production of this variation. This quest, however, leads to a study of all the intricacies of embryonic development, physiology and mechanistic biology in general. Although the details of the chemistry and physics comprised in these phenomena are for the most part scarcely guessed, we at least know, from our observations on the grosser visible occurrences, that the processes whereby most adult organs and characteristics are formed are highly involved, interdependent in a complicated way and composed of many successive reactions. Make one change, and effect follows effect until the final result bears no resemblance to the initial one. So, for example, a quantitative change in some primary process may appear in the adult as a qualitative change, and vice versa. It should also be observed that there are often regulatory mechanisms which automatically compensate for effects produced, as in regeneration of a lost limb or in the accelerated growth of a child following temporary stunting.

Genetics has adduced cogent evidence that, despite the strong influence of the environment in modifying the body as a whole, and even the protoplasm of its cells, the genes within the germ-cells of that body retain their original structure without specific alterations caused by the modification of the body, so that when the modified-individual reproduces it transmits to its offspring genes unaffected by its own "acquired characters." The offspring, then, will not tend to repeat the parental modifications, unless the same peculiar environment is itself repeated. Our sins and our successes are not reborn in our children, though the latter may inherit our original tendency and capacity for these. Modifications, therefore, unlike mutations, cannot be a cause of biological evolution or degeneration. Now, if modifications acquired before the conception of children are not visited upon the latter, it certainly holds true that any modifications acquired by the mother after the embryos are partly developed, but prior to their birth, would not be transmitted to them. Mothers may rest assured that there is no more ground either *a priori* or in observation, for supposing that a fright received during pregnancy (or before) will give their child a fearsome disposition than that it will give him spots.

Variation Due to Segregation and Recombination of Genes. — Whenever an individual breeds, having received a different hereditary contribution from its two parents, its offspring will tend to vary from one another. Thus, if we had received a gene for brown eyes from our mother, and one for blue eyes from our father, then, although we ourselves would have brownish eyes (brown being said to be "dominant" and blue "recessive"), nevertheless we would transmit our gene for brown only to half of our reproductive cells, and the gene for blue, unalloyed by brown, to the remainder. This process of separation is called segregation (*see* **HEREDITY**). If our parents had given us different genes for hair-form also, we would produce reproductive cells having all the possible assortments of the two pairs of genes, namely, some having "brown curly," others "blue straight," still others "brown straight" and the rest "blue curly." This phenomenon is recombination. Since such variation can be produced in our children only in respect to genes which already differed from one another in our parents, it is evident that the primary cause of this variation lies in the events whereby these genes came to differ in the first place, that is, in the gene-mutations such as originally changed a gene for brown eyes into the gene for blue. These mutations, that make possible the recombinations of to-day, may have happened in the remote past.

The explanation of segregation and recombination is to be found in the behaviour of the chromosomes, those tiny separate filamentous bodies, visible under the microscope, which contain the invisible genes "linked" together within them, like beads in so many separate chains. Several or many chromosomes, each probably containing hundreds of different genes of distinctive natures and effects, are contained in each of the two uniting reproductive cells derived from the two parents. While the majority of the genes from one parent are always like those from the other; since the parents are in general similar organisms, yet in the case of most matings there are some gene-differences, and these give an opportunity for the operation of the segregation and recombination processes above mentioned, after the individual formed by the union of the two cells in question develops and reproduces reproductive cells for a still later generation.

It will be seen that the more gene-differences exist the more different combinations can then be formed. The numerical relations resulting from recombination are calculable according to definite laws, provided the effects of the genes concerned, and their positions in the chromosomes, have been determined by prior experimentation. The character-effects of untried combinations cannot, however, be predicted with certainty, as unexpected developmental results, including even new traits, are occasionally produced by recombination. As some new combinations may be more advantageous for the race than the original combinations, the function of recombination, of segregation, and in fact of sexual reproduction itself, becomes explained in terms of their value in evolution.

The development of most characters depends on the combined action of numerous genes. A difference in any one of these genes may affect either the quality, or the degree of development of the character in question. Now, when a number of mutations, in different genes all concerned with the same character (*e.g.,* stature), have some time previously occurred in a population, random crossing and recombination will result in the transmission, to different offspring, of many different assortments of the mutated and non-mutated genes. Thus the population may tend to exhibit many different grades of expression of the character. These grades will often differ only by small steps, which become blurred into an apparently continuous gradient through the effect of environic modifications. Such quantitative variation, as well as all other variation of recombinational origin, is of course especially evident when individuals are bred which resulted from the crossing of widely different stocks, in which many differing gene-mutations had become established since these stocks diverged from their common ancestor.

Many abnormal types of recombination occasionally occur, owing to such disturbances of chromosome-behaviour as the loss or reduplication of a chromosome or section of a chromosome, or the reduplication of one or more entire sets of chromosomes. When such an occurrence alters the proportions existing between the different kinds of genes (by changing the numbers of some and not of others) there generally results a combination of various (usually detrimental) abnormalities at once. At other times, a chromosome may become broken in two, or two chromosomes unite to form one, or a piece broken off one chromosome and united to another. The genes thereby become rearranged, but the characteristics of the individual probably remain little affected, since they depend rather on the kind and numbers of different genes present than on their arrangement. X-rays, cold and other influences are known to induce such disturbances of chromosome behaviour.

Mutations in the Genes.—It has been found in fruit flies (*Drosophila*) that any given gene, existing in a fly at the present day, has probably remained constant in its composition for several thousand years. This stability is not passive, for, as every organism grows and reproduces through a process of repeated cell growth and cell division, each gene must repeatedly reproduce itself, and in so doing it must each time construct a daughter-gene that possesses exactly its own peculiar structure. Occasionally, however, something goes wrong, and either the mother-gene becomes altered in its composition or else the daughter-gene is not formed exactly in the image of the old gene. As a result of this mutation there arises a new type of gene, having a different effect upon the organism, and this mutant gene is then capable of reduplicating its own new type—a process which it usually performs with as constant accuracy as that which the old gene had exhibited. It is this peculiarity of the gene—its retention of the power of self reduplication despite the occurrence of alterations (mutations) in its composition—which makes heritable variations possible, and hence organic evolution.

There is evidence that, when one gene in a cell mutates, the thousands of others, even including the similar or identical gene derived from the other parent, remain unaffected and constant. The mutation, then, may be regarded as an "accident" of submicroscopic dimensions, dependent on the occurrence of certain "chance" configurations of atoms, electrons and energy-quanta within or near the gene in question. It is not strange, in view of this, that it has not yet been proved possible, by particular external conditions, to dictate the occurrence of specified types of gene mutations in preference to others.

Though the kind of mutation which shall occur has not been brought under control, experiments with a number of different organisms have shown that heavy treatment with X-rays will make the mutational accidents in general occur far more frequently than otherwise, so that gene mutations of varied kinds may be produced at a rate in some cases more than a hundred times higher than that at which they previously were found to occur. This raises the conjecture, as yet untested, that possibly the y-rays (related to X-rays) which originate in minerals of the earth's crust have played an essential role in the causation of the varied "natural" mutations through ahich evolution has come about. However, there is evidence that temperature, genetic composition, and perhaps other factors, also affect the general frequency of gene mutations. No particular stage in the life cycle is known to be especially favourable for the occurrence of gene mutations; certainly they may happen either in embryos or in adults, and in somatic as well as in germinal tissue, though of course only mutations in germ cells can be inherited.

Though most gene mutations seem, in the sense above explained, to be accidents, some genes appear to be less stable than others, and a few are definitely known to be exceedingly mutable (ever-sporting). In the latter cases, which may represent changes of a different sort from most gene mutations, the stability of the mutable gene may be much affected by specific conditions. These effective conditions differ in different cases. Some are determined by the nature of the tissue and developmental stage in question, others by the external environment, and still others by the genetic composition.

A given gene has the capability of mutating in various ways so as to form a number of different kinds of genes (multiple allelomorphs). Usually the effects of these differing changes in a given gene resemble each other strongly, and often, though not always, the discernible differences between them lie chiefly in the degree of change produced. There are also numerous cases on record of mutations that seem quite identical in kind with other mutations which occurred independently in homologous genes of other individuals belonging to the same or a related species. Not infrequently, too, different kinds of genes (nonhomologous) will, on mutating, produce similar or indistinguishable final effects on the characteristics of the organism. In this connection it is found that certain character changes can be produced by mutations in a greater number of different genes, and hence tend to occur more commonly, than others.

The most frequently produced effect, so far as known, is the lethal effect; that is, mutant genes are usually so deleterious in their action that they tend to kill the organism. When they are not positively lethal they are usually retrograde in direction, and hinder rather than help the organism to fulfil the functions of its existence. Such results are to be expected of accidental changes occurring in any complicated organization. A race, therefore, will tend gradually to undergo degeneration in any respect in which selection (natural or artificial) does not persistently weed out the degenerative mutations that continue to occur. It can be only the rare mutations that are helpful which furnish material for evolution. These latter, however, when they show, will tend to multiply.

As a matter of fact, most gene mutations never show. For most (though not all) mutant genes are recessive to the type from which they arose, and in their cases an obviously mutant individual cannot appear unless—usually many generations subsequently to the original gene mutation—two reproductive cells, each bearing the identical mutant gene, meet in fertilization.

Both conspicuous and inconspicuous, minor and major, fundamental and superficial character changes are produced by gene mutation, and either one character or several at once may be altered by a single gene change. The more far-reaching the change, the more apt it is to be deleterious rather than advantageous. Hence geneticists are returning to a view essentially similar to Charles Darwin's, namely, that the origin of one species from another usually involves the accumulation of numerous selected small steps of heritable variation.

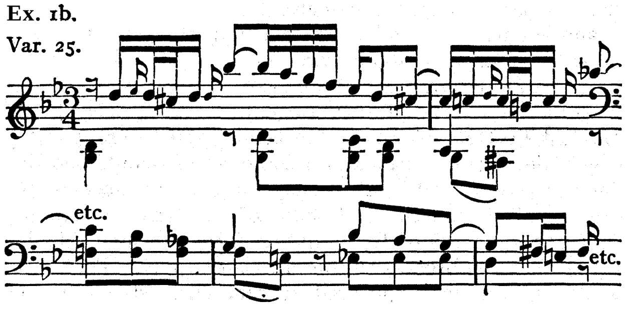
See ANIMAL BREEDING; CHROMOSOME; CYTOLOGY; DARWINISM; GENE; HEREDITY; PLANT BREEDING. (H. J. M.)

VARIATIONS, in music, the term given to groups of progressively developed versions of a complete self-contained theme, retaining the form of that theme though not necessarily its melody. This is the classical sense of the term, but there are modern developments of the variation form to which this definition is at once too broad and too precise to apply. The aesthetic principle of variations appeared at very early stages of music. During the 16th century an artistically mature variation form automatically rose in the polyphonic treatment of Gregorian hymns verse by verse. Accordingly, the hymns and Magnificats of Palestrina might be described as contrapuntal sets of variations on ecclesiastical tunes, like rich and free examples on the simple plan shown later by Haydn's variations on his Austrian national anthem in the "Emperor" quartet (opus 76, no. 3). Already in the 16th century instrumental music was climbing up the trellis of a primitive variation form. A favourite plan (*see* the *Fitzwilliam* Virginal Book, passim) was to put together several popular or original tunes, with an ornamental variation sandwiched between. Sometimes sets of variations on a single tune were produced, with excellent effect, as in Byrd's variations on "The Carman's Whistle." Such variations were naturally grouped in order of increasing brilliance, and they often include passages that would catch the greatest pianoforte players.

In the 17th century a highly artistic form of variation solved with great simplicity the problem of expanding instrumental pieces to a length admitting of growth to a big climax. This was the ground bass, a single phrase placed in the bass and repeating itself ad infinitum. It originated in the dance forms of the *passacaglia* and the ***chaconne.*** Both were in slow triple time, the chaconne having a strong accent on the second beat, while the passacaglia, by some chance, developed the liberty to transfer its theme to other parts than the bass. The genius of Purcell was cruelly hampered by the non-existence of large musical forms in his time, and he seized upon the ground-bass with avidity. By the time of Bach and Handel lighter sets of variations, consisting essentially of embroidery on a melody, had come into vogue. Bach's *Aria variata alla maniera Ztaliana* tells us where this fashion began; and in France the *air et doubles* was taken over from early English virginal music. Doubles are variations each of which divides the rhythm into quicker notes than the one before. The most familiar example is that known as "The Harmonious Blacksmith" in Handel's E major suite. Sometimes the air itself was stated in a tangle of ornamentation, while the doubles simplified the melody and varied the accompaniment. But Bach had meanwhile applied the principle of the ground-bass to variations on a complete symmetrical movement in binary form. His Air and 30 Variations, commonly known as the "Goldberg" variations, is (with the exception of Beethoven's 33 *Veranderungen* on a waltz by Diabelli) the most gigantic set of variations in the world. A melodically interesting ground-bass could not be maintained on so large a scale; but the 32 bars of Bach's theme are so many clear harmonic steps which can be represented by many analogous progressions, without loss of identity. (Ex. 1a.) There is no question of retaining or varying the melody of the aria, which is a tissue of ornaments that will bear neither development nor simplification.

Ex. 1a. Harmonic theme. (**BACH.** "*Goldberg*" *Variations.*)

Ex. 1b.
Var. 25.



The rise of the sonata style again brought the melodic embroidery variation into prominence; for in sonata forms we identify themes entirely by their melodies. Now, with not more than three or four exceptions, the best sets of variations by Mozart and Haydn are movements in their sonata works; and their independent sets are either early or perfunctory exercises and encore-pieces. Two common mistakes of professional and amateur criticism are, first, the judging of Haydn's and Mozart's variations by these parerga, and secondly, the much graver error of despising the embroidery variation on principle. It is either vulgar or sublime. And it is handled lovingly by precisely the greatest masters of deep harmonic and rhythmic variation, Beethoven and Brahms. Haydn is fond of a special form first known in Philipp Emanuel Bach. It consists of alternating variations on two themes, alternately major and minor; the first a rich and complete binary melody, and the other a shorter binary melody, often beginning with the same figure as the first. The first theme usually returns as if it were going to be unvaried, but its first repeat is an ornamental variation. The form is rarely worked out far enough to include more than one variation of the second theme; and sometimes (as in the famous "Gypsy" trio) there are new episodes instead of variations of the second theme, so that the form becomes a sectional rondo. The only strict example of Haydn's type of alternating variations in later music is the first allegretto of Beethoven's pianoforte trio in E flat (op. 70, No. 2); but a magnificent application of it, without change of mode, though with a wide range of key, is shown in the slow movement of his C minor symphony.

Beethoven, in his last works, invented another variation-form on two themes, of which the second is in a different key and time. The examples of this are the slow movement of the 9th symphony and the Lydian figured chorale in the **A** minor quartet. In the slow movement of Brahms's F major string quintet (op. 88), the alternation of the two keys gives rise, in the last line of the movement, to one of the most astonishing dramatic strokes in all music. Beethoven uses embroidery variations as means of obtaining extraordinary repose in slow movements. The extreme case of this is the slow movement of the sonata op. 57 (commonly called "Appassionata"), which is described in the article on SONATA FORMS. In this, and in many other instances, his method is that of the **air** *et doubles,* which grows to a natural climax which can subside into the rhythm of the plain theme. Until his latest works, such sets of variations are never finished. Their dramatic intent is that of a repose which is too unearthly to last; and at the first sign of dramatic motion or change of key the sublime vision "fades into the light of common day," a light which Beethoven is far too great an idealist to despise. *See* the andante of the B flat trio (op. 97); and the slow movement of the violin concerto, which contains two episodic themes in the same key. In his later works Beethoven found means, by striking out into foreign keys, of organizing a coda which finally spins down in fragmentary new variations, or even returns to the plain theme. Thus he was able to end his sonatas, opp. 109 and 111, with solemn slow movements.

Beethoven also found other applications of the variation forms. Thus the finale of the Eroica symphony has not only the theme but many other ideas in common with the brilliant set of variations and fugue for pianoforte on a theme from *Prometheus* (op. 35); and the fantasia for pianoforte, chorus and orchestra, and the choral finale of the 9th symphony, are sets of melodic variations with freely-developed connecting links and episodes. In the case of the 9th symphony, a second thematic idea eventually combines with the figures of the first theme in double fugue.

But Beethoven's highest art in variation-form is independent of the sonata. From his earliest display of pianoforte playing, the wonderful 24 variations on a theme by Righini, to his supreme variation-work, the 33 on Diabelli's waltz, he uses and transcends every older means of variation and adds his own discoveries. Before Beethoven the basis of variations might be a ground bass, a melody or a harmonic scheme. Beethoven discovered that rhythm and form can, with a suitable theme, be a solid basis for variations. The aria of Bach's Goldberg variations is in its phrasing as uniform as a chess-board; and if its harmonies had not a one-to-one correspondence with each variation the form would be lost. But there are themes, such as Haydn's Chorale St. Antoni, which Brahms varied, where the phrasing is interesting in itself. A similar example is the theme by Paganini (Ex. 2a) which inspired Brahms to compose two complete sets on it.

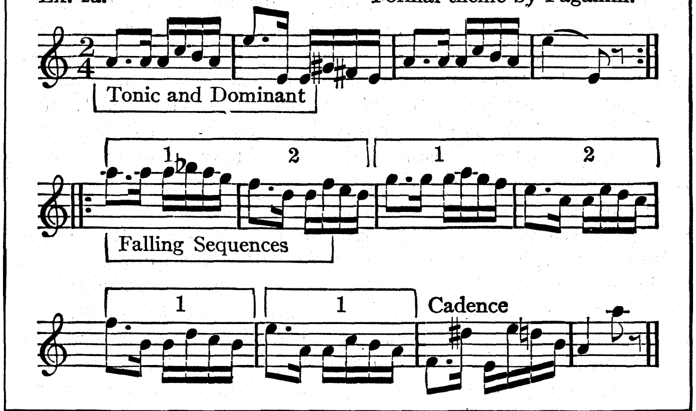
The climax in the history of variations dates from the moment when Beethoven was just about to begin his 9th symphony, and

received from A. Diabelli a waltz which that publisher was sending round to all the musicians in Austria, so that each might contribute a variation to be published for the benefit of the sufferers in the late Napoleonic wars. Diabelli's theme was absurdly prosaic, but it happened to be, perhaps, the sturdiest piece of musical anatomy that Beethoven (or any composer since) ever saw; and it moved Beethoven to defer his work on the 9th symphony! The shape of Diabelli's waltz may be illustrated by a diagram which represents its first 16 bars; the upright strokes (not the spaces) being the bars, and the brackets and dots (together with the names underneath) indicating the rhythmic groups. The second part also consists of 16 bars, moving harmonically back from the dominant to the tonic, and rhythmically the same as the first part. This plan is astonishingly elastic. The alternation of tonic and dominant in the first eight bars may be represented by another familiar form in which three bars of tonic and a fourth of dominant are answered by three bars of dominant and a fourth of tonic; as in variation 14 (which must be reckoned in half-bars). Again, when the theme answers the tonic by the dominant it raises the first melodic figure by one step, and this may be translated by the answer on the supertonic harmony. In the course of 50 minutes a few of these 33 variations become vague as to more than the beginnings and cadences of the theme; and there are three simple variations in which one would like to ask Beethoven whether he had not inadvertently omitted a bar; but the momentum of the theme is never lost; and after a group of three slow and rather free variations this momentum breaks into an entirely free fugue (variation 32) on a salient feature of what must by courtesy be called Diabelli's melody. A free fugue is a favourite solution of the problem of the coda in a set of variations. The momentum produced by the revolution of true variations in the orbit of the theme gives the key to the whole problem. A fugue solves it by flying off at a tangent. Very sublime is the way in which Beethoven, after letting his fugue run its torrential course, returns to the orbit of his theme in an ethereal little minuet with a short coda of its own which, 16 bars before the end, shows signs of beginning to revolve again.

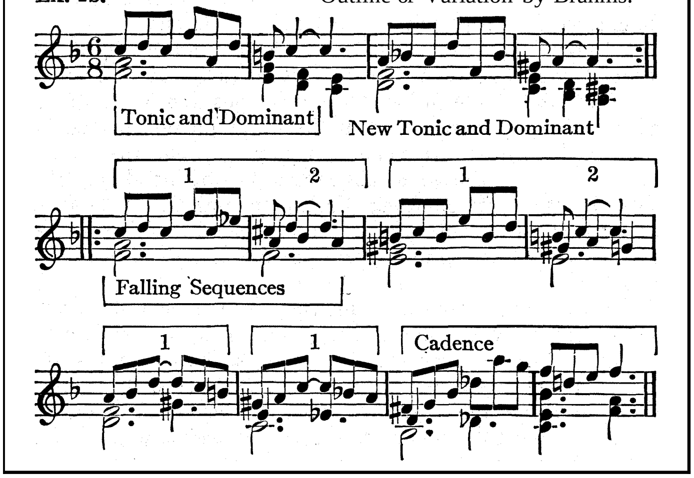
Again, let us regard the period of the theme not as an orbit but as diurnal rotation. We can then describe the codas of Brahms's Paganini-variations as produced by accelerating the spin till it breaks away for a while and then resumes for a few final catastrophic whirls; exactly like a dying top (though this, of course, does not accelerate its spin). Without acceleration Beethoven ended his wonderful C minor variations (most perfect of passacaglias) in this way. Brahms found in Haydn's Chorale St. Antoni the opportunity for another method. He took the first five bars as a ground-bass, within which narrow orbit the finale moves until its climax broadens out into the rest of the glorious theme, and so rounds off the whole work.

Bach poised the contrasts and climaxes of the Goldberg variations so accurately that the ending of the whole by a simple *da capo* of the theme is astonishingly effective. It is as if a charming old ancestress of a living line of great folk were to step from the frame of her Holbein portrait and bow to her assembled posterity.

To speak of the progress in variation-form since Beethoven is like speaking of the progress in reinforced concrete since the Parthenon. The classical variation-form is limited only by the composer's imagination and technique; and the removal of its foundations does not enlarge it at all. There is no reason to condemn other kinds of variation; and many great and beautiful works in non-classical variation-form exist, from Schumann's *Etudes Symphoniques* to Elgar's "Enigma" variations and Dohnányi's *Variations on a Nursery Tune.* But no "free" variation that breaks down the phrasing of its theme and follows its own discursive ways will ever achieve anything externally so unlike the



Ex. 2a. Formal theme by Paganini.



Ex. 2b. Outline of Variation by Brahms.

theme as a strict harmonic and rhythmic variation on classical lines. (*See* Ex. 2b.) Nor will a series of such variations acquire anything like the classical momentum. On the contrary, in clumsy hands the free variation becomes apologetic in the way in which it offers raw chunks of the original melody as evidence that it has not forgotten its duty, like Lewis Carroll's poetic *Tema con Variazioni,* the preface to which is an unconscious epitome of modern misunderstandings of the form.

Variation writers may be scientifically classified into those who know their theme and those who do not. There is no reasonable doubt that many very clever composers, from Mendelssohn onwards, have completely misunderstood the nature of the deeper classical variations, and have thought that anything so unlike the original tune must be quite independent of it. Mendelssohn's *Variations sérieuses* have a beautiful theme with a structure that might have given rise to splendid features; but Mendelssohn simply ignores this structure and replaces it by weaker things in almost every variation. Schumann shows more insight. He has no great grip of his theme, but he tries to distinguish by titles those variations which are true from those which are episodic; thus in the *Études Symphoniques* the etudes are numbered separately from the variations; the andante of the F major quartet is called *quasi variazioni;* and the strictest set he ever wrote (on a theme by Clara Wieck) is called Impromptus.

Brahms stands alone in his grip of his theme. Reger is no nearer the classical form in his variations than in his other works. The present state of the form seems to indicate that if the composer does not aim at strict variations his most vital results will be on the line of melodic development, as in the above-mentioned works of Elgar and Dohnányi, the Symphonic Variations of Dvořák, and those variations of Reger which are closest to this type. (D. F. T.)

VARICOSE VEINS, the term by which is meant an abnormal dilatation and tortuosity of the superficial veins of the limbs, particularly of the lower extremities. This condition is widespread throughout the population, being one of the most important afflictions of the venous system. It has been recognized since the time of Hippocrates and probably dates back to the time when man first assumed the erect position. The disease has never been found in quadrupeds. Although it is rarely a serious threat to life or limb, its complications may result in the loss of many productive hours from industry or household duties.

Among the causative factors in the production of varicosities are (1) an inherited weakness of the fibrous structure of the bicuspid valves in the veins; (2) absence of the valves in strategic locations in the deep veins; (3) prolonged standing, and (4) an increase of abdominal pressure due to such mechanisms as chronic straining (from constipation or persistent cough), tumours in the bony pelvis, pregnancy and tight foundation garments. Even when the pregnancy group is removed from the statistical studies, women still show a much higher percentage of varicosities than do men. The possibility of an unidentified endocrine factor, as well as periodic congestion of the pelvic area during menstruation, has been suggested as explanations for such a difference.

Blood normally flows out of the lower extremities by entering superficial veins and then deep ones through communicating vessels. For this to take place in the erect position, in the face of gravity tending to keep blood in the lower portion of the limb, certain mechanisms must come into play. Among these are the action of valves in the veins, allowing a flow of blood only in the upward direction, the pumping effect of the muscles in the legs as in walking, and the continuous stream of blood entering the veins from the arterial tree, moving the portion already in the vessels forward.

Varicosities result from an inefficiency in the action of the valves in the superficial veins, due to the causative factors already enumerated. As a consequence of the changes, the free edges of the valves no longer meet in the lumen of the vessels, thus allowing a backward flow of blood in the direction of the leg and foot. This produces an overdistention of the superficial veins, which contributes even further to the incompetency of the valves, and hence to an exaggeration of the existing pooling of blood in the vessels. The resulting rise in pressure in the veins is responsible for such complications of varicosities as smelling of the feet and ankles at the end of the day and changes in the skin, such as a weeping type of eczema and the serious complication of ulcers of the skin around the ankle. Furthermore, the walls of the superficial varicose veins may become so thinned out that they may rupture, leading to serious hemorrhage unless the limb is immediately elevated and simple compression applied to the bleeding point. Another relatively frequent complication is a clot in a varicose vein

The severity of the varicosities and the complaints of the patient are not necessarily related directly. Some individuals have very large, tortuous and dilated veins and little or no symptoms, while others with relatively small varicosities experience aching pain, night cramps, fatigue and fullness in the legs

For many years various types of sclerosing solutions have been injected into varicose veins in order to produce a chemical inflammation that changes the vessels into fibrous cords or in order to cause them to fill nith clots. The great disadvantage of such a procedure is that frequently the obstructed vein becomes recanalized (without valves), resulting in a return of the condition. For the most part, therefore, this type of treatment has been largely superseded by surgical therapy, which involves either multiple ligation of the varicosities or their actual removal by means of an instrument called a stripper. Elastic stockings or bandages are used only as a temporary measure. (D I. A)

VARIOLITE, a basaltic or doleritic rock with prominent spherulitic (variolitic) texture, the spherulites or varioles consisting usually of radial aggregates of feldspar. These varioles. especially on weathered surfaces, appear as pale-coloured spots, giving the rock a pockmarked appearance. The name is from Lat. *variola* ("smallpox"), in allusion to this characteristic feature.

The variolitic texture of the basic rocks is closely akin to the spherulitic texture of the acid lavas, as seen in rhyolites, etc

Variolites frequently form the tachylytic selvages of dolerite dikes (*see* TACHYLYTE), and also appear in the form of pillow lavas (*see* SPILITE). The varioles are usually rounded in outline and are often about ¼ in. in diameter, but may much exceed this size. With few exceptions they are built up of divergent fibres of feldspar embedded in dark brown glass.

As variolites are frequently much decomposed, the glassy matrix is represented by secondary alteration products or has been devitrified. (C. E. T.)

VARNA (formerly STALIN), a fortress, seaport, district capital and episcopal city of Bulgaria; on the Stalin gulf, an inlet of the Black sea, in 40° 12′ N. and 27° 56′ E. Pop. (1956) 124,951. Varna is built on the hilly north shore of the bay, overlooking the estuary of the Devna river. It is the eastern terminus of the railway to Rustchuk and Sofia. The "Varna quadrilateral," so important in Bulgarian military history, consists of the fortresses of Varna, Shumla, Rustchuk and Silistra (*q.v.*). Varna ranks with Burgas as one of the two principal seaports of Bulgaria. Its deep and capacious bay is sheltered from northerly and north-easterly winds, and the harbour works are modern.

The principal exports include cattle and dairy produce, grain, lamb and goat skins, and cloth (*shayak*); the imports include coal, iron and machinery, textiles. petroleum and chemicals. The headquarters of the Bulgarian Steamship Co., which traded with Turkey, Greece and Russia, were established there. Its trade was affected by the cession of the Dobruja to Rumania until 1940, but it became a popular seaside resort. During World War II, Germany used the port as a shipping supply base to provision axis armies fighting in the U.S.S.R.

Varna mas the ancient Milesian colony of *Odessos*, founded 585 B.C. Close by was fought in 1444 the battle in which Murad II slew Wladislaus III of Poland and Hungary, and routed his forces under Hunyadi János. Varna was occupied in 1828 by the Russians, in 1854 by the allies, who there organized the invasion of the Crimea, and in 1877 by the Egyptian troops summoned to the defense of Turkey against the Russians. By the treaty of Berlin (1878) it was ceded to Bulgaria. Long the seat of a Greek metropolitan, it became in 1870 the seat of a Bulgarian bishop.

In 1949 it was renamed Stalin and made the capital of a newly formed district of the same name. In 1956 it was renamed Varna.

VARNHAGEN VON ENSE, KARL AUGUST (1785–1858), German man of letters who, with his wife, Rahel (*see* below), played a small but influential part in literary life in the romantic period, was born on Feb. 21, 1785, in Düsseldorf and died in Berlin on Oct. 10, 1858. He studied medicine in Berlin, Halle and Tübingen and then entered upon a military and later a diplomat, career. He served as an officer in the struggle against Napoleon, first in the Austrian and then in the Russian army; he was adjutant to General von Tettenborn, recording his experiences in *Geschichte der Hamburger Ereignisse* (1813) and *Geschichte der Kriegszüge des Generals von Tettenborn* (1815) He accompanied the Prussian chancellor, Prince von Hardenberg. to the congress of Vienna and to Paris and became Prussian resident minister in Karlsruhe until, being suspected of "democratic intrigue," he was recalled and pensioned in 1819.

He then lived in Berlin where he pursued the literary activities he had begun in 1804 when with Adalbert von Chamisso he founded and edited the *Berliner Musenalmanach.* He produced a variety of work including poems, but his most important books were elegantly written biographies and memoirs, where he used the material gathered during a varied life in which he strove to meet as many of the famous as possible. These are a valuable source of information though not to be used uncritically. He was an enthusiastic admirer of Goethe and an acquaintance and correspondent of the poet: *Goethe in den Zeugnissen der Mztlebenden* (1823) is one of his chief works. Varnhagen's *Biographische Denkmale,* 5 vol., was published during 1824–30; seven volumes of *Denkwürdigkezten und vermischte Schrzften* appeared during 1837–46, and two further volumes following posthumously in 1859 (new ed. by J Kühn, *Denkwürdigkeiten des eigenen Lebens,* 1922–23; by K. Leutner, 1950). *Blätter aus der preussischen Geschichte,* 5 vol., appeared in 1868–69. His diaries and much correspondence were also published.

As a personality, however. Varnhagen is overshadowed by his wife RAHEL. Rahel Levin (1771–1833) was a Jetvess by birth though she professed Christianity before her marriage with Varnhagen in 1811. Of acute intuitive intelligence and sensibility, Rahel was one of the foremost women of her time and the *salon* she initiated in Berlin became a centre of literary life and the meeting place of writers of both the romantic and the Young Germany groups. She too was a Goethe worshiper and J. P. Eckermann records that Goethe called her one of the first people in Germany to understand his work. Her husband published a memorial volume for her in 1831, *Rahel, ein Buch des Andenkens,* and many of her letters have been printed. Rahel's brother was the poet who wrote under the name of Ludwig Robert.

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VARNISH is a transparent, homogeneous, heat-treated blend of drying oils, resins. driers and volatile solvents. R⁷hen varnish dries, its solvent portion evaporates and the remaining materials oxidize or polymerize to form a hard, continuous. transparent film that protects against weather, insulates against electricity or can be made to serve other useful purposes.

In recent years the meaning of varnish has been broadened to include any transparent, homogeneous film-forming composition such as alkyd resins, oil-modified polyurethanes, polyesters. copolymerized oils, hydrocarbon polymers and epoxy esters. These modern coating materials are called varnishes because their general appearance, performance characteristics and end uses resemble those of the classical and historical oil varnishes', which they have displaced to a large extent. In addition, several other coating materials that are quite different from the oil and synthetic varnishes in composition, application and other respects are frequently called varnishes because they, too, give a continuous. hard. transparent finish; such materials include: (1) Spirit varnishes. which are solutions of resins in volatile solvents. These dry entirely by evaporation of the solvent, leaving a hard coating of resin that remains soluble in the original solvent. Spirit varnishes include shellac, lacquer and asphalt, pyroxylin or nitrocellulose. dammar and japan varnishes *(see* also BRUNSWICK BLACK; JAPANNING; LACQUER). (2) Lithographic varnishes, which are usually linseed oils that have been oxidized and polymerized to high viscosity. These are used primarily for the manufacture of printing inks. *(See* also INK.) *(3)* Water varnishes, which are solutions or emulsions of resins or glues in water. These become more or less water insoluble on drying and are used to seal or bind powdery surfaces.

History.— The use of varnish dates from prehistoric times. The name itself is a corruption of Berenice. the name of an ancient Egyptian queen. When Egyptian warriors brought a gift of amber (a natural resin and early varnish ingredient) to Ptolemy III Euergetes. king of Egypt, *c.* 250 B.C.. the colour of the specimens matched the hair of his queen, Berenice. and the material was named for her. The word developed into the Latin *vernis,* later into the Italian *vernice* and finally into the English varnish.

The ancient Egyptians melted soft resins, such as sandarac, mastic or pitch. with oil to form a varnish that could be applied while warm. Early artists painted with oleoresins, linseed oil. gums, glues and the like. Galen *(c.* A.D. 130–*c.* 200) wrote of the use of the nut, hempseed and linseed oil as drying oils. The use of oil varnish and resins was described by Theophilus in the 11th century; these finishes were used largely on works of art. By the 16th century, varnishes were used on furniture and in home finishing. What may be called the modern varnish era dates from the late 18th century, when the first printing of Jean Felix Watin's formulary appeared (about 1772). Few technological changes were made during the following century, so that a varnish manufacturer of 1900 used formulas and procedures hardly different from those described by Watin At the beginning of the 20th century, tung oil (*q.v.*) and other drying oils began to be used as replacements for linseed oil, and synthetic resins began to replace the naturally occurring resins.

Uses.––Furniture, floor, marine spar and label overprint varnishes are used on surfaces that are to remain visible but need protection and enhancement; *e.g.,* wood surfaces such as those of fine furniture and violins. Other. less expensive types of varnishes are employed to protect less valuable surfaces that also do not need to be hidden by pigments; *e.g.,* bottle caps and can interiors. Certain varnishes have unusual physical and chemical properties that are utilized in insulating varnishes, wire coatings, marine varnishes, sandpaper binders and floor varnishes. Tremendous quantities of varnish are used in the manufacture of paints and enamels, which are essentially varnishes that are coloured and opacified with pigments. In many of these products, particularly enamels. varnishes made with synthetic resins, such as the alkyd and epoxy resin.;, have almost completely displaced the classical oil varnish. *(See* also PAINT.)

Properties.— The classical oil varnish contains the following ingredients, which produce the indicated properties: (1) Resins or gums—to impart hardness and lustre, shorten drying time and improve chemical resistance; (2) drying oils—to impart flexibility and toughness; (3) volatile solvents—to thin the varnish to a consistency suitable for application; (4) driers and other modifiers—to hasten the rate of drying, control lustre and prevent skinning; *i.e.,* the formation of a skin over the liquid surface of a partly filled container.

Generally. a high proportion of resin will produce harder, faster drying, more brilliant but less durable varnishes, whereas a high proportion of oil will provide more elastic, more durable, more waterproof but softer varnishes. The oils and resins are blended in proportions designed to give the properties desired for specific applications. The ratio of oil to resin is expressed in gallons of oil per 100 pounds of resin and is called the oil length of the varnish. Varnishes are usually classified in terms of oil length, as well as according to the major type of oil and resin used in the preparation.

Varnish Classes by Oil Length

Oil length	Examples
Short (5–15 gal.)	Furniture varnishes that dry quickly and produce good hardness and sanding qualities
Medium (15–30 gal.)	Floor varnishes where hardness and flexibility (toughness) are required
Long (35–50 gal.)	Exterior varnishes where elasticity is important to enable the film to withstand atmospheric variations
Extra long (60–200 gal.)	Usually known as fortified oils and used where extreme flexibility is needed, *e.g.,* cable coatings

The ultimate property to be achieved in any varnish is a high molecular weight—by either a chemical and/or physical interaction of oil and resin. Oils and resins are unsaturated esters of high molecular weight that are capable of entering into many types of chemical reactions including ester interchanges, ethylenic polymerizations and oxidation processes. Varnishes based on run, or "fused," natural resins incur thermal decomposition reactions such as depolymerization and formation and recombination of reactive by-products. Physical dispersion of one component in another is also a distinct possibility. Because they consist of so many complex, competing factors, varnish reactions are poorly understood.

Manufacture.— The art of combining oils, particularly linseed. with hard gums developed over many centuries. Practices and recipes varied from country to country and were often shrouded in secrecy. Early varnish kettles, generally made of copper, were about three feet in both height and diameter, with the bottom riveted on so that it could be replaced when necessary. The kettle was set on a small frame truck to permit easy handling. Heat was provided by a fire of coke, gas or fuel oil situated below the floor level. While the varnish resins were heated, they were stirred with a large. mooden-handled iron rod thrust through a hole in the loose-fitting cover. This cover also had a short central chimney to lead off fumes. and sometimes a thermometer. 'lhe manufacturing process usually began uith the melting of a hard fossil gum; the latter was crushed to approximately ½ in. lumps and 50 to 150-lb. charges of it were placed in the varnish kettle. As the kettle was heated to a final temperature of 330°–340° C., the gums, insoluble in oils before this running process, became pasty and eventually liquid. This was accompanied by a loss in weight varying from 20% to 35%.

At a critical point in the resin running process, which was determined solely by the judgment of the varnish maker. preheated linseed oil was added slowly while the gum was stirred vigorously. Because of the danger of fire, the gum kettle was removed from the fire while the oil was added. When all the oil was incorporated into the molten resin, the cooking was resumed until solution was complete; this point was judged to have been reached when a drop of solution appeared clear after it had cooled on glass. The driers (consisting of oxides or salts of lead, manganese or cobalt, or combinations of them, in amounts sufficient to provide from about 0.03% to 0.6% of metal based on the oil) were next added and the mixture further boiled until these were converted into soluble soaps and until, again in the judgment of the varnish maker, the desired degree of bodying, or polymerization. was obtained. The kettle was cooled at a safe distance from the fire, and the contents were thinned to a suitable consistency. The varnish was strained or filtered to remove insoluble material, pumped into storage tanks and allowed to age.

With the advent of the closed kettle method of alkyd resin processing in the late 1930s. varnish manufacture was modernized so that the resin was synthesized and combined with the oil in one operation. In this uniphase or in situ process, the basic oil components such as glycerol, fatty acids and the basic varnish resin components such as rosin, polyol, maleic anhydride or phenolic syrups were charged and processed in a reaction kettle in a definite order, heated. cooled and thinned to a desired viscosity. The final product, prepared in one operation, is essentially the same as the varnish prepared classically. Performance properties differ slightly, but because of better control, favourable economics and availability of closed kettles, the in situ process is the preferred varnish-making process today.

Raw Materials.—Resins.—The term resin designates solid or semisolid mixtures of complex polymeric substances of closely related structure (see also RESINS). Hard fossil gums are natural resins that were exuded from ancient trees (some species of which are no longer extant) and were made hard, brittle and lustrous by centuries of burial or exposure.

Natural resins (other than shellac or rosin) originate mainly in the Congo, Zanzibar and north coast districts of Africa, in New Zealand. Malaya, the East Indies, the Philippine and nearby islands, and in South America. They are classified in various categories: as spirit soluble or (potentially) oil soluble; as fossil (such as animé from Zanzibar, kauri from New Zealand, Congo and East Indian copals), semifossil (East India, of the dammar family) and recent, or from living trees (dammar, sandarac, accroides, soft Manilas, elemi and mastic); and according to degrees of hardness and insolubility, depending usually upon their age. Amber, from the shores of the Baltic, has long been too rare for use in varnish.

Ester gum, the earliest synthetic resin, was made (about 1900) by esterifying rosin (essentially abietic acid) with glycerin. By cooking the gum with tung oil in lengths of 40 gal. to 50 gal., it was possible to make spar varnishes (so named because they were suitable for use on spars and masts of ships) that dried hard overnight and were not injured by boiling water or long immersion in cold water. About 1910, coumarone-indene polymers (made from coal-tar light oil) and phenol-formaldehyde-rosin-glycerin (modified phenolic) resins were introduced. These brought still faster drying rates, embodied in the so-called four-hour varnishes. but they tended to discolour on exposure. In 1928 the first "100% phenolic" oil-soluble resin appeared, a thermoplastic condensate of para-phenylphenol with formaldehyde: this was followed later by the introduction of a number of resins of better colour retention made from alkyl-substituted phenols. With these resins, 20-gal. varnishes were more durable than longer ones, reversing the usual rule; compared with the other varnishes of that period, they showed remarkable resistance to water and chemicals.

Similar in general properties to the modified phenolics are the maleic ester gums or maleic alkyds (glycerides of an adduct of rosin with maleic or fumaric acid). They are pale, hard, colour-retentive and find use in lacquers as well as oil varnishes. New ways were found of improving rosin by (1) hydrogenation or dehydrogenation; (2) polymerization; or (3) esterification with pentaerythritol, sorbitol and other polyhydric alcohols.

The most important group of synthetic resins are the alkyds, basically the chemical combination of a polyhydric alcohol (*e.g.*, glycerol, ethylene glycol, pentaerythritol) with a polybasic acid (such as phthalic, maleic or sebacic acid) and a fatty acid (or mixture of acids such as those of linseed, soybean or castor oils). The alkyd resins can replace, in part or in whole, the blend of natural fossil or other hard gum with drying oils of the earlier varnish type. By changing each of the three types of ingredients and their relative proportions, the properties of alkyds can be modified over a wide range extending from hard and brittle to extremely flexible, tough and durable. In the late 1940s, epoxy resins, made by polymerizing the product that results from reacting bisphenol A with epichlorohydrin, provided additional hardness, adherence, flexibility and alkali resistance. This polymer has residual hydroxyl groups and may be combined with fatty acids, amines or polyamides to enhance these properties. Because of the superior performance of the modern synthetic resins, the classical oil varnishes were slowly replaced by their synthetic counterparts.

Varnish Oils.—Varnish oils are film formers consisting of naturally occurring triglycerides of unsaturated fatty acids. These comprise slow-drying oils with isolated double bonds (soft oils, *e.g.*, linseed, fish, safflower, soybean, tobacco seed oils) and reactive oils containing conjugated double bonds (hard oils, *e.g.*, tung, oiticica. dehydrated castor oils). (Double bonds are conjugated when separated from one another by a single bond.) In addition, there are the chemically modified oils such as the soft oils modified by maleic anhydride, copolymer oils, nonglycerin synthetic oils and isomerized oils.

For the manufacture of varnish, the natural oils (other than tung and oiticica) are refined by heating them with small amounts of lye or sulfuric acid, which precipitates the traces of chlorophyll and mucilaginous matter (chiefly phosphatides) remaining when the oil is pressed from the seed; otherwise a discolouring break, or cloud, forms during the cooking of the varnish. Sometimes the oils are bodied (polymerized) before incorporation into varnishes; or they may be blown with air, introduced through perforated pipes, at temperatures of 60° to 120° C., causing partial oxidation and thickening. Boiled oil is usually made by dissolving small amounts of soluble driers in linseed oil and then heating the mixture at moderate temperatures. In the early stages of the varnish-cooking process, the oils serve as resin solvents. This property of the oils is directly related to their degree of unsaturation; tung oil is the best and unbodied soybean oil the poorest. When soft oils are bodied, the relation is reversed.

Solvents.—The combined resin-oil blends are quite viscous, hence they must be diluted with volatile organic liquids. Historically, spirits of turpentine was the earliest and most commonly employed solvent. By 1930 it became too scarce and expensive to be used generally as a paint and varnish solvent. Distillates from petroleum in approximately the same boiling range (155°–175° C.), called white spirits or mineral spirits, almost entirely replaced it. These distillates, consisting mostly of aliphatic hydrocarbons, are weaker solvents than turpentine for some of the highly polymerized synthetic resins or oxidized oils and may produce cloudiness or precipitation. The tendency to produce cloudiness can be offset by the use of toluene, xylene or high-boiling aromatic hydrocarbons either alone or in conjunction with the aliphatic thinner. Special application conditions, such as spraying, dipping, tumbling, roller coating, etc., require that the thinner employed be the one most suitable for the method.

Miscellaneous.—As catalysts for the oxidation and polymerization reactions, soluble salts or soaps (*e.g.*, resinates, linoleates, naphthenates) of metals with two valence levels (especially cobalt, manganese and lead) are effective. Other elements, such as iron, vanadium, zinc (for hardening) and calcium (to minimize wrinkling), are sometimes employed. Waxes or ultrafine silica produce flat or matte finishes without reducing transparency. Modern varnishes may include minute amounts of surface-active agents to modify application properties; antioxidants to reduce the tendency to skinning; and other additives for special purposes.

See also references under "Varnish" in the Index volume.

See H. F. Payne, *Organic Coating Technology,* vol i *(1954)*
(C. R. BN.; P. HE.)

VARNISH TREE, a name applied to various trees that yield a milky juice from which varnish or lacquer is prepared, including such genera as *Ailanthus, Aleurites, Firmiana* and *Koelreuteria.* The name is, honever, most correctly applied to the varnish or lacquer tree *(Toxicodendron verniciflmum)* of China and Japan. On being tapped this tree exudes a thick milky emulsion which has the peculiar property of drying only in a moist atmosphere. From this is obtained the lacquer used in producing the highly polished woodenware of China and Japan with the hard and durable coats that are unaffected by water. This tree is a close relative of poison ivy (*q.v.*) and poison sumac, and is also highly poisonous. *See* also POISONOUS PLANTS. (J. M. BL.)

VARNUM, JAMES MITCHELL (1748–1789), American Revolutionary War general, was born at Dracut, Mass., on Dec. 17, 1748. He graduated from Rhode Island college (later Brown university) in 1769 and two years later was admitted to the bar. He soon became known for his courtroom eloquence. After serving as colonel and later as brigadier general of Rhode Island troops, he was appointed brigadier general in the Continental army in 1777. He held various commands and won commendations, though he was unsuccessful in defending Fts. Mercer and Mifflin on the Delaware river. During the winter of 1778 he was with George Washington at Valley Forge and then served in the campaign in Rhode Island. Varnum resigned from the Continental army in March 1779 but served as major general of Rhode Island militia from 1779–88. He was also a member of the continental congress at various times. In 1787 he was appointed U.S. judge in the Northwest Territory, migrated there and helped write a code of territorial laws. He died at Marietta, O., on Jan. 10, 1789. (H. H. P.)

VARRO, MARCUS TERENTIUS (116 B.C.–27 B.C.), a man of immense learning and a prolific Latin writer mostly of works of scholarship, was born probably at Reate in the land of the Sabines in 116 B.C. He was a pupil of the earliest Roman philologist, L. Aelius Stilo, and at Athens of the Academic philosopher Antiochus of Ascalon. He was not attracted to a political career, but he played some part in public life and became a praetor. He served under Pompey in the campaign against the rebel Sertorius in Spain in 76 and was Pompey's pro-quaestor in that country. In 67 he served under Pompey in the war against the pirates.

In 59 Varro wrote a political pamphlet entitled *Trikaranos* ("The Three-headed") on the coalition of Pompey, Caesar and Crassus. In this year also he was a member of the Board of Twenty charged with the assignment of grants of land to veterans in Campania. He fought for Pompey in Spain in 49 but without success Caesar pardoned him and in 47 Varro dedicated to him his *Antiquitates rerum divinarum* (the second part of the *Antiquitates rerum humanarum et divinarum*) and was appointed by Caesar librarian of a collection of books which he intended to establish. In 43 Varro was outlawed by Antony; his books were plundered, but his life was spared. He spent the rest of his life in study and writing.

Works. — It has been estimated that Varro wrote about 74 works which together formed about 620 books. They included works on agriculture, grammar. Roman history and antiquities, geography, law, rhetoric, philosophy, astronomy, education, history of literature and drama; also included were satires, poems, orations and letters.

The only complete work of Varro which has survived is his Res *rusticae* in three books, a work written in Aristotelian dialogue form when he was in his 80th year. The first book is concerned with agriculture proper, the second with the larger animals and the third with the smaller stock of a farm such as birds, bees and fish. Each of the three books has its own setting. Varro's aim was to foster a love of country life and to produce a work of practical instruction; but he took pains to give it literary merit. He is no great artist and his liking for headings and subheadings is tedious, but the introductions are particularly attractive, the dialogue is sometimes brisk and a vein of rough humour runs through the work. Varro owed something to his own experience and to what others had told him, but he depended much on Greek and Latin authors.

Of Varro's *De lingua Latina,* a dry discussion in 25 books of etymology, accidence and syntax in an unpolished style, there remain, apart from short fragments, only books v to x and there are considerable gaps in these six books. Books ii to iv were dedicated to Varro's quaestor P. Septimius and probably formed an earlier smaller work. The other books and the work as a whole were dedicated to Cicero. The work was in three main parts after an introduction (book i). The first consisted of six books in two triads concerning etymology. The first triad discussed what was to be said for and against etymology as a branch of learning and examined its usefulness and its nature. The second triad, books v to vii, discusses the origin and sources of words, words referring to places and objects in places, words referring to time or having some idea of time and poetic expressions. The second part was concerned with derivations of words from other words, including stem derivation, the declension of nouns and the conjugation of verbs.

The first triad discusses in particular the principles of anomaly based on usage and of analogy based on relation of form to form and presents a resolution of the conflicting views of anomalists and analogists. The second triad discussed, in the light of the conclusions of the first triad, nouns of place and similar terms, words concerned with time, especially verbs, and poetic words. The last 12 books were given to syntax. Varro was ignorant of the principles of phonetic change and he produced absurd derivations because he was guided by superficial resemblances. But sometimes his knowledge of old forms led him to true identifications.

Although he was an analogist, he saw the limitations of analogy. His work is not only of interest as a study of language but it also contains valuable incidental information on many subjects.

Of the *Saturae Menippeae* in 150 books some 90 titles and nearly 600 fragments have survived. They are humorous medleys in mixed prose and verse in the manner of the Cynic philosopher Menippus of Gadara of the 3rd century B.C. The titles of these treatments of serious matters in comic form in lively and varied settings are often Greek with, or without, a Latin title as well. Some are drawn from mythology, as *Meleagri, Endymiones, Tithonus, Eumenides;* some are proverbs or maxims, as *Dis paides hoi gerontes* ("Old Men Are in Their Second Childhood"), *Gnothi seauton* ("Know Thyself"), *Nescis quid vesper serus vehat* ("You Do Not Know What Evening May Bring"). The subjects of the satires range from eating and drinking ("The Pot Has Its Limit or On Drunkenness"; "On Eatables"; "The Water-Dog") to literature ("Parmeno") and philosophy ("The Voyage"; "On Philosophical Sects"; "A Battle of Words"; "Shadow-Boxing"; "The Award of the Arms"). Varro shows himself a man of the old stamp making fun of the follies and absurdities of modern times. He preaches a simple life of old-fashioned Roman virtue and piety and opposes luxury and philosophic dogmatism. He freely uses archaic and colloquial words and proverbial expressions.. His use of Greek has parallels in the satires of Lucilius and the letters of Cicero. He shows considerable skill in handling several metres and poetic manners. In his styles both the new and the old are found.

Varro can write like this (fragment 36):

> non fit thesauris, non auro pectus solutum;
> non demunt animis curas ac religiones
> Persarum montes, non atria divitis Crassi

("Neither treasure nor gold can set free the heart, nor can the golden mountains of Persia or the halls of rich Crassus cure worry and fear") and like this (fragment 111):

Vino nihil iucundius quisquam bibit:
hoc aegritudinem ad medendam inuenerunt,
hoc hilaritatis dulce seminarium,
hoc continet coagulum conuivia

("Nobody has drunk anything more pleasant than wine. Men found this a cure for sickness, a sweet nursery of mirth. Wine is the bond that binds the banquet")

and like this (fragment 375):

ante auris modo ex subolibus parvuli intorti demittebantur sex cincinni, oculi suppaetuli nigellis pupulis liquidam hilaritatem significantes animi, rictus parvissimus ut refrenato risu roseo

("Before her ears just six little curls hung down from close-bound hair. Her eyes with dark pupils sideways glancing showed the bright gaiety of her spirit. Her mouth was tiny and as if she was checking a rosy smile")

The loss of all but fragments of these satires is much to be regretted both by the historian and by the student of language and literature.

It is possible to mention here only a few of Varro's many lost works. His most famous work in the field of scholarship was his *Antiquitates rerum humanarum et divinarum,* in *41* books, the fullest work on Roman antiquities in Latin literature. Another work which had great influence in later generations was an encyclopaedia of *artes liberales.* The work was entitled *Disciplinae* (in nine books) and embraced grammar, dialectic, rhetoric, geometry, arithmetic, astronomy and music (the subsequent *trivium* and *quadrivium, i e.,* groups of three and four sciences) with medicine and architecture. Varro's *Hebdomades vel de imaginibus,* in 15 books, was an illustrated biographical dictionary containing 700 portraits of Greeks and Romans in equal numbers each with an epigram and a text in prose. It seems to have been the first illustrated book in Latin. Varro may have been influenced by some contemporary Greek illustrated botanical books. Varro's *Logistorikoz,* in 76 books, consisted of discussions on such matters as education, fortune, health, history, probably enlivened by evidence drawn from history or personal experience. Each aork had a double title—the name of a person and the theme, as *Sisenna de historia* or *Marius de fortuna.* Varro's works on literary subjects included a work on Plautus.

Purpose and **Influence.**—Varro was Rome's greatest scholar and his eminence was recognized in his lifetime. In the library founded at Rome by Asinius Pollio his was the only statue of a living person, and Cicero paid him a warm tribute in the course of which he says that he enabled the Romans at last to realize who and where they were when they were straying about like visitors (*Academica* i: *3,* 9). He was astonishingly many-sided. He invented the new literary form of the *Logistorikos* and was a capable writer of verse. His vast learning extended beyond the nine disciplines of his encyclopaedia to law and geography. But his greatest interest was in Latin philology and Roman antiquities. Unlike the Hellenistic scholars, whose methods of investigation he followed, he was inspired by a deep patriotism. Written not only with a love of learning but also with a warm feeling for Rome's past history, his work was intended by its moral and educational quality to further Roman greatness He desired to link a coming epoch with the glorious past of the Roman people and his works must have greatly influenced men's minds before and after the founding of the principate.

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See also H. Dahlmann in Pauly-Wissowa, *Real-Encyclopadie der classischen Altertumswissenschaft,* suppl. vol. vi (1935); Schanz-Hosius, *Geschichte der romischen Literatur,* vol. i, 4th ed. (1927); G. Boissier, *Étude sur la vie et les ouvrages de M. T. Varron* (1861); H. Dahlmann, *Varro und die hellenistische Sprachtheorie* (1932); J. Collart, *Varron grammairien latin* (1954); F. della Corte, *Varrone—il terzo gran lume romano* (1954). (G. B. A. F.)

VARTHEMA (BARTHEMA, VERTOMANNUS, etc.), **LUDOVICO** DI, of Bologna (*fl.* 1502–1510), Italian traveller and writer, left Europe near the end of 1502; early in 1503 he reached Alexandria and ascended the Nile to Cairo. From Egypt he sailed to Beirut and thence travelled to Tripoli, Aleppo and Damascus, where he managed to get himself enrolled, under the name of Yunas (Jonah), in the Mameluke garrison—doubtless after adopting Islam. From Damascus he made the pilgrimage to Mecca and Medina as one of the Mameluke escort of the Hajj caravan (April–June 1503); he describes the sacred cities of Islam and the chief pilgrim sites and ceremonies with remarkable accuracy, almost all his details being confirmed by later writers. With the view of reaching India, he embarked at Jidda and sailed down the Red sea and through the Straits of Bab-el-Mandeb to Aden, where he was arrested and imprisoned as a Christian spy. He gained his liberty—after imprisonment both at Aden and Radaa—through the partiality of one of the sultanas of Yemen, made an extensive tour in south-west Arabia (visiting Sana, etc.), and took ship at Aden for the Persian Gulf and India. On the way he touched at Zaila and Berbera in Somaliland; he then (early in 1504?) ran across to the Indian port of Diu in Gujarat, afterwards famous as a Portuguese fortress. From Diu he sailed up the Gulf of Cambay to Gogo, and thence turning back towards the Persian Gulf made Julfar (just within the entrance of the gulf), Muscat and Ormuz. From Ormuz he seems to have journeyed across Persia to Herat, returning thence south-west to Shiraz, where he entered into partnership with a Persian merchant, who accompanied him during nearly all his travels in South Asia.

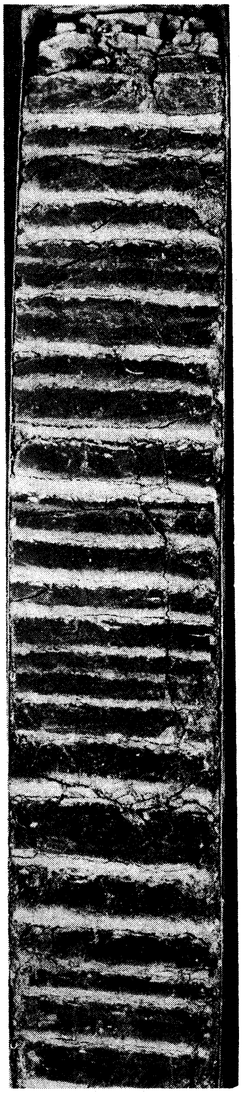
After an unsuccessful attempt to reach Samarkand, the two returned to Shiraz, came down to Ormuz, and took ship for India. From the mouth of the Indus Varthema coasted down the whole west coast of India, touching at Cambay and Chaul; at Goa, whence he made an excursion inland to Bijapur; at Cannanore, from which he again struck into the interior to visit Vijayanagar on the Tungabudra; and Calicut (1505?), where he stopped to describe the society, customs and institutions of Malabar, as well as the topography and trade of the city. Passing on by the "backwater of Cochin," and calling at Kulam (Quilon), he rounded Cape Comorin, and passed over to Ceylon (1506?). Though his stay here was brief (at Colombo?), he learnt a good deal about the island, from which he sailed to Pulicat, slightly north of Madras, then subject to Vijayanagar. Thence he crossed over to Tenasserim in the Malay peninsula, to Banghella, perhaps near Chittagong, at the head of the Bay of Bengal, and to Pegu, in the company of his Persian friend and of two Chinese Christians (Nestorians?) whom he met at Banghella. After some successful trading with the king of Pegu, Varthema and his party sailed on to Malacca, crossed over to Pider (Pedir) in Sumatra, and thence proceeded to Bandan (Banda).

From the Moluccas he returned westward, touched at Borneo, and there chartered a vessel for Java, the "largest of islands," as his Christian companions reckoned it. He notes the use of compass and chart by the native captain on the transit from Borneo to Java, and preserves a curious, more than half-mythical, reference to supposed Far Southern lands. From Java he crossed over to Malacca, where he and his Persian ally parted from the Chinese Christians; from Malacca he returned to the Coromandel coast.

Varthema was now anxious to resume Christianity and return to Europe; after some time he succeeded in deserting to the Portuguese garrison at Cannanore (early in 1506?). He fought for the Portuguese in various engagements, and was knighted by the viceroy Francisco d'Almeida, the navigator Tristan da Cunha being his "sponsor." For a year and a half he acted as Portuguese factor at Cochin, and in 1507 (?) he finally left India for Europe by the Cape route. Sailing from Cannanore, Varthema apparently struck Africa about Malindi, and (probably) coasting by Mombasa and Kilwa arrived at Mozambique, where he notices the Portuguese fortress then building, and describes the negroes of the mainland. He finally arrived safely in Lisbon.

Varthema's work (*Itinerario de Ludouico de Varthema Bolognese . . .*) was first published in Italian at Rome in 1510 *(ad instãtia de Lodouico de Henricis da Corneto Vicẽtino).* Other Italian editions appeared at Rome, 1517, at Venice, 1518, 1535, 1563, etc. The first English translation was of 1576–77 (in Richard Eden's *History of Travayle)*; an extract from Varthema was inserted in Samuel Purchas's *Pilgrimage* (1625–26); and in 1863 appeared the Hakluyt Society edition by J. W. Jones and G. P. Badger (*Travels of Ludovico di Varthema*). (C. R. B.)

VARVE ANALYSIS. A varve is the distinguishable annual deposit of a sediment. It consists of two or more laminas of different grain-size, material, chemical composition or colour. Simple varves superficially resemble annual rings in wood.



BY COURTESY OF ERNST ANTEVS

SAMPLE OF VARVED GLACIAL CLAY FROM STEEP ROCK LAKE, ONTARIO, SHOWING (LIGHT) SUMMER LAYERS AND (DARK) WINTER LAYERS

Varves form under various conditions: *e.g.,* by seasonal changes in organic or chemical sedimentation; as a result of a spring flood and of otherwise moderate stream flow (postglacial varves in bays of the northern Baltic); by summerly influx of mud from a glacier into a lake with the coldest water (less than 39.2' F.) at top (normal glacial varves).

Varves of any kind may be counted, and from this count the rate of sedimentation and the time represented can be determined. Varves of some kinds may be used for chronology building. The most important are Gerard de Geer's chronology of the last ice retreat from Sweden, Ragnar Lidén's postglacial chronology of northern Sweden (the past 8,560 years), and Ernst Antevs' partial chronology of the deglaciation of North America. The method devised by De Geer is described below.

Glacial varves formed in cold lakes from mud brought by glacial streams. The relatively coarse fractions of the mud sank quickly, making a silty summer lamina, while the fine: colloidal portions settled to form a greasy, usually dark-coloured lamina during the quiet of the winter. A lamina couplet is a varve. This frequently averages one inch in thickness. Since the proximal limit of a varve was the ice edge, and since this normally receded, the varves cover each other as the shingles on a roof, and they may extend for tens of miles from the ice.

Series of varves can be measured in stream bluffs, brickyard clay pits and other exposures. The clay wall, for example, is smoothed so that the varve limits stand out sharply. A strip of thick, tough paper is pinned to the wall, and the varve limits are marked on the strip. It is desirable. if possible, to measure long continuous series of varves from the substratum.

These measurements are graphed on paper with lines spaced exactly 5 mm. Each consecutive varve is marked on a line from the edge of the paper, and the marks are connected. The resulting curve has characteristic features. maxima and minima reflecting the amount of deposition and ice melting during the individual years. Therefore. varve graphs of measurements made up to tens of miles apart may be correlated. If the bottom varves were measured, the number of those present only at the site first uncovered gives in years the time of the ice retreat from the distal to the proximal site. Since the amount of the annual ice melting was largely controlled by the total warmth, the varve graphs and the rate of the ice retreat furnish data on the summer temperatures.

See GEOCHRONOLOGY; MAN, EVOLUTION OF: *Estimation of Geological Antiquity.* (ER. AN.)

VASA (VAASA or NIKOLAISTAD), a seaport of Finland in 63° 6' N., 21° 36' E., on the east coast of the Gulf of Bothnia. Pop. (1960) 42.688. It is the chief town of a department of the same name. Vessels enter from the sea at Rönnskär, 26 mi. distant, and the channel is safe for vessels drawing 22 ft. The exports are timber, tar, etc., and the imports coal and salt, and there is a ship-repairing yard. The town was founded in 1606, and after its destruction by fire in 1852 was rebuilt'nearer the shore.

VASARI, GIORGIO (1511–1574), Italian painter, architect and writer, whose main distinction rests on his valuable history of Italian art, was born at Arezzo on July 30, 1511. At a very early age he became a pupil of Guglielmo da Marcilla, a skillful painter of stained glass. At the age of 13 he went to Florence, where he studied under Michelangelo, Andrea del Sarto and Baccio Bandinelli, aided by the patronage of the Medici princes. In 1531 he visited Rome in the suite of Ippolito Cardinal de' Medici and studied the works of Raphael and others of his school. The paintings of Vasari were much admired, and many still exist, the most important being the wall and ceiling paintings in the great hall of the Palazzo Vecchio in Florence and his frescoes on the cupola of the cathedral. He died at Florence on June 27, 1574, and was buried in the chapel of S. Giorgio in the Pieve of Arezzo.

Personally Vasari was a man of upright character, always ready to appreciate the works of others; in spite of the very different taste of his time, he expressed a warm admiration of the works of Giotto, which is very remarkable.

As an art historian of his country he must always occupy the highest rank. His great work, *Delle Vite de' più eccellenti pittori, scultori, ed urchitettori (Lives of the Most Excellent Italian Architects, Painters and Sculptors),* was first published in 1550, and afterward partly rewritten and enlarged in 1568. It was dedicated to Cosimo de' Medici, and was printed at Florence by the Giunti; it is a small quarto illustrated with many woodcut portraits. This first edition of the complete work is usually bound in three volumes, and also contains a very valuable treatise on the technical methods employed in all branches of the arts: entitled *Le Tre Arti del disegno, cioè architettura, pittura, e scoltura.* Vasari's biographies are written in a very pleasant style, interspersed with amusing stories. With a few exceptions his judgment is acute and unbiased. The work in any case remains a classic; however. it may be supplemented by the more critical research of modern days.

Vasari gives his own biography at the end of his *Vite*, and adds further details about himself and his family in his lives of Lazzaro Vasari and Francesco Salviati.

The first edition of his *Vite* was issued by the Torrentino Press (1550). The best edition is that published at Florence by Milanesi (1878–82), which embodies the valuable notes in the earlier edition by Le Monnier (1846). The *Lives* has been translated into French, German and English.

VASCO DA GAMA: *see* GAMA, VASCO DA.

VASCULAR SYSTEM: *see* CIRCULATION OF BLOOD; CIRCULATORY SYSTEM.

END OF VOLUME TWENTY-TWO

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